

# The Management of Environmental Performance in the Supply Chain: An Overview

Enrico Bracci and Mouhcine Tallaki

**Abstract** The Environmental Supply Chain Management (ESCM) has become a buzz-word nowadays. This is in part due to the increasing awareness of companies that the environmental performances need to be managed beyond the organizational boundaries. The present paper aims at contributing to the extant literature through a comparative analysis of some frameworks that attempted to connect the performance measurement with the ESCM. From a methodological point of view, the paper is based on a literature review using as keywords the environmental performance management system and supply chain. Three main frameworks for the performance measurement ESCM were analyzed, in details: the Beamon Model (Logistics Information Management 12(4):332–342, 1999), the Hervani et al. (2007) and the Balanced Scorecard variation proposed by Epstein and Wisner (Balanced Scorecard Report 3(3):8–11, 2001). In so doing, we suggest possible commonalities and differences, arguing the need for further research to develop and understand the way companies manage the environmental performance of their supply chain.

**Keywords** Supply chain · Environmental performance · Supply chain management

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The paper can be attributed to the authors in the following manner: Sects. 1 and 2 to Mouhcine Tallaki, Sects. 3 and 4 to Enrico Bracci.

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## 1 Introduction

The Environmental Supply Chain Management (ESCM)<sup>1</sup> has become a buzz-word nowadays. This is in part due to the increasing awareness of companies that the environmental performances need to be managed beyond the organizational boundaries. The ESCM is derived from the integration of environmental management and supply chain management concepts (Srivastava 2007; Thun and Muller 2010; Testa and Iraldo 2010). The environmental management is based on the principles of prevention, environmental protection, transparency and participation. Its basic goals are the identification of environmental issues at the enterprise level, the adoption of best environmental technologies, the reduction of environmental impacts and the use of prevention systems to avoid and/or treat adequately the potential environmental hazards due to specific production activities processes.

The supply chain management, instead, is defined as *The systemic, strategic coordination of the traditional business functions and tactics across these business functions within a particular company and across businesses within the supply chain, for the purpose of improving the long-term performance of the individual companies and the supply chain as a whole* (Mentzer et al. 2001). This definition recognizes explicitly the strategic nature of coordination between trading partners and it explains the twofold objective of supply chain management that are improving the performance of a single organization and of the entire supply chain (Gunasekaran et al. 2004; Bratic 2011). The ESCM is a management approach that has attracted the attention of the scientific community only recently. Srivastava (2007) pointed out that this approach is gaining increasing attention and interest among researchers and practitioners engaged in supply chain management and operations. This is mainly due to the progressive deterioration of the environment, the decrease in raw material resources, increase of pollution levels and of to the current issues related to waste management. In addition to attention to the environment, the use of ESCM practices could lead to improve economic as well as that of the environment performance, this justifies their adoption by firms (Srivastava 2007).

However, the ESCM needs to be integrated with the other managerial systems and in particular the performance measurement system. This is relevant in order to support managers in the decision-making, in the evaluation of performance and to assess the efficacy and coherence of output with the strategy. In the literature ESCM and the performance measurement tend to be studied in a separate way, despite having several contact points and calls are made to study them in conjunction (Melnik et al. 2014).

The present paper aims at contributing to the extant literature through a comparative analysis of some frameworks that attempted to connect the performance measurement with the ESCM. From a methodological point of view, the paper is

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<sup>1</sup> In the literature ESCM is also referred as Green Supply Chain Management. We are going to use the two concepts (ESCM and GSCM) as synonymous.

based on a literature review using as keywords the environmental performance management system and supply chain. Three main frameworks for the performance measurement ESCM were analyzed, in details: the Beamon Model (1999), the Hervani et al. (2005) and the Balanced Scorecard variation proposed by Epstein and Wisner (2001). In so doing, we suggest possible commonalities and differences, arguing the need for further research to develop and understand the way companies manage the environmental performance of their supply chain.

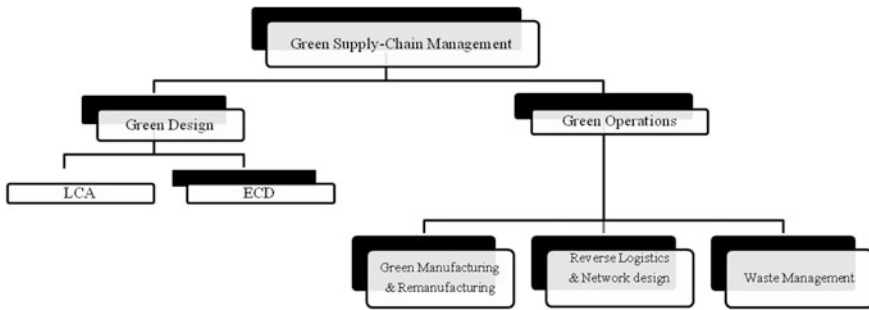
The rest of the paper will be structured in the following fashion: the next section will present a literature review of the ESCM concept. The third section will analyze the literature related to the performance measurement in the supply chain before describing the three models proposed to measure the environmental performance, while the fourth section will compare and discuss the models. The paper will conclude with some indications for further research.

## 2 The Environmental Supply Chain Management

Given the relative novelty of the ESCM discipline, there is no exhaustive definition and nor a consensus on what are the set of practices that can be adopted by companies (Zhu and Sarkis 2004). The concept of ESCM is considered as part of the Sustainable Chain Management (SCM) discipline. Seuring and Muller (2008) defined the ESCM *as the management of material, information and capital flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of sustainable development (i.e. economic, environmental and social), into account which are derived from customer and stakeholder requirements, In sustainable supply chains environmental and social criteria need to be fulfilled by the members within the supply chain, while it is expected that competitiveness would be maintained through meeting customer needs and related economic criteria.* This definition frames the ESCM within the broader Sustainable Supply Chain Management. The latter has the objective to improve the social policies and the environmental and economic impact through the supply chain management, the exchange of information, knowledge and resources and the sharing of common objectives between the stakeholders involved.

Some authors proposed the concept of Green (or Environmental) Supply Chain Management (GSCM) (e.g. Srivastava 2007). The GSCM considers the environment in its traditional functions and processes. In particular those functions related to supply chain management, plan, source, make, deliver and return (based on the classification of the Supply Chain Council). Srivastava (2007) highlighted the importance of the new management approach and the existence of two others research topics on GSCM: the first focuses on green design, the second instead emphasizes on the green operations (see Fig. 1).

According to Thun and Muller (2010), the supply chain management implies a greater inter-organizational cooperation, the concept of the GSCM follows the same approach. Adding the prefix of “green” this concept includes, then, all the efforts



**Fig. 1** Classification based on problem context in supply chain design. *Source* Authors' elaboration on data from Srivastava (2007)

that minimize the environmental impact of the company's products and processes. Thus, the key element of GSCM and ESCM alike is the integrated design of inter-organizational processes which improve environmental efficiency. Hervani et al. (2005) defined the GSCM as the management of the effects of SCM on the environment with the goal to eliminate and reduce waste and environmental impacts (energy, emissions, chemicals substances and solid waste) along the supply chain. In particular, the GSCM is defined according to set of activities like green purchasing, green manufacturing and material management, green distribution, marketing and reverse logistics. Liu et al. (2011) consider the GSCM as an advanced system of Corporate Environmental Management. The latter aims to provide greener products and services through communication and cooperation. Handfield et al. (2005) proposed a definition of ESCM considering it as an environmental system that focused on relationships with suppliers and on the production of internal and external environmental information.

Therefore, there is not a single definition of ESCM, which sometimes is defined as GSCM. Some definitions show more than others the importance of appropriate relations with those involved along the supply chain, and other place attention on particular initiatives related to the environmental performance (Ninlawan et al. 2010). The initiatives and the extension of ESCM practices inside and outside the organization depend on many factors. They depend on the goals that are defined consistently with other business strategies, and also on sharing of these strategies between different organizations along the supply chain. As well as on the firm's ability to select, influence and control their business partners and then to design the supply chain. These initiatives, as has been identified, should be concentrated to make processes and products more environmentally friendly and to reduce the environmental impacts of the organization and the supply chain through strategies such as Green Design, Green Procurement (or Green Purchasing), Green Manufacturing (or Green Production), Green Logistics (or Green Distribution) and Reverse Logistics (Srivastava 2007).

### 3 ESCM and Performance Measurement Systems

The implementation of ESCM practices requires its formalization at the strategic level (Zhu et al. 2008). Because competitive strategies significantly influence the effectiveness of supply chain integration (Huo et al. 2014). In this way, it is possible to identify the objectives of reducing environmental impacts, in a perspective of supply chain, coherent with the other strategies of the company. This enables the new management philosophy to gain legitimacy in all levels of the organization. To do that it is necessary to have an unwavering support and commitment of the top management (Zhu et al. 2008).

The role of the supply chain should be considered by the companies in the formulation of its strategic plans. The use of outsourcing and de-verticalization strategies increase the importance of developing appropriate relationships with suppliers in order to achieve new and efficient forms of coordination. It is, thus, necessary to measure and define clear goals to be achieved, identify the means and the time to do so, identify and communicate the various responsibilities, modify the organizational structure and roles, implement systems that control the achievement of the objectives also through the choice of appropriate indicators of environmental performance and adopt a management control able to measure them. In addition, it will be interesting to balance various qualitative and quantitative, economic-financial and non-monetary measures, providing information at both management and operational level.

An ESCM incorporates the traditional mechanisms of management, including budgeting, performance measurement systems and risk management processes, which are commonly used in the management, but that are designed to treat and manage the specific problems and issues relating to the environment (Zhu et al. 2008). These tools are increasingly popular in the environmental strategies of the organizations to coordinate, monitor and manage the information, thus they represent an effective management control system (Arjaliès and Mundy 2013). If the environmental strategy is considered as a new dimension of the supply chain, the systems that manage the environmental strategy such as environmental management systems have to be properly extended and modified to support the new perspective embraced by the company. Some authors (i.e. Hervani et al. 2005) highlighted the need to design performance measurement systems integrated with the ESCM (Melnyk et al. 2014). However, the consideration of environmental issues at the strategic level, in particular within the supply chain perspective, involves a deep organizational change. The control systems needs to be designed and used to align the organizational behavior towards the achievement of new strategic objectives.

Management control systems is defined as “*the formal, information-based routines and procedures managers use to maintain or alter patterns in organizational activities*” (Simons 1995). Their use could be expressed through control levers such as diagnostic, interactive, belief and boundary levers. The use of these levers together could facilitate the implementation and achievement of the strategic

objectives of the organization (Arjaliès and Mundy 2013). The management control systems can be used as a means to implement, monitor and discuss the business strategy relating to Corporate Social Responsibility (CSR). This field of study has been extensively studied by the scientific community. Not equal attention was given to the activities of ESCM. Arjaliès and Mundy (2013) used the framework of the control levers to analyze the way in which 40 companies listed in France implement and manage strategies of CSR. The authors showed that, for example, the diagnostic processes are used to manage the key variables of outcome. The purpose of the authors was to define and measure key performance indicators of CSR strategy regarding the internal and external objectives. This purpose is achieved through the use of CSR reports that manage the activities at the operational level in relation to the CSR performance activities which considered as critical. According to Arjaliès and Mundy (2013) management control systems have the potential to contribute to the achievement of greater sustainability through processes that enable the innovation, communication, reporting and identification of opportunities and threats. These levers of control could also be used to achieve the objectives defined by ESCM strategies.

Performance measurement systems have a high importance within companies because they allow to manage the organization through the analysis of the results achieved. They also enable to identify the business areas that are below expectations, and also contribute to their subsequent improvement through the implementation of corrective actions. Melnyk et al. (2014) argued recently that performance measurement systems of the future will need to take particular attention to the new business and organizational models based on extended supply-chain and networks. They are also important to influence behavior, so these systems have to be designed to measure, along with others, the results of the ESCM initiatives and to guide the actions of managers in order to achieve strategies. The indicators (mainly environmental) that constitute the core of the system could also be used as interactive tools when they promote dialogue and constant comparison (Rodrigue et al. 2013). Several studies made calls to study performance measurement throughout the supply chain (Melnyk et al. 2014; Bititci et al. 2012; Gunasekaran et al. 2004). So, Supply chain management is considered as key strategic factor for increasing organizational effectiveness and for better realization of organizational goals such as enhanced competitiveness, better customer care and increased profitability (Gunasekaran et al. 2001). Generally, the adoption of ESCM practices leads to improved environmental performance and economic performance, which, in turn, positively impact on operational performance (Green et al. 2012). Several studies have analyzed the relationship between performance and ESCM. Rao and Holt (2005) identified that greening the different phases of the supply chain leads to an integrated green supply chain, which ultimately leads to competitiveness and economic performance. Zhu and Sarkis (2004), using empirical results from 186 respondents on GSCM practice in Chinese manufacturing enterprises, examined the relationships between GSCM practice and environmental and economic performance. The authors argued that GSCM practices tended to have win-win relationships in terms of environmental and economic performance. Then, being

proactive on environmental issues can bring companies a great number of benefits that improve their competitiveness and firm performance (Femenias et al. 2013).

According to Handfield et al. (2005), to manage adequately the objective of improving the environmental performance at the level of the supply chain we have to link the business strategy with supply strategy for classes of materials, components and products. The alignment between supply chain strategy and environmental uncertainty is positively associated with supply chain management performance (Sun et al. 2009). The idea is to define, at strategic level, the importance of pursuing an improvement of the environmental performance of the organization and the supply chain. The strategic formulation would lead to identify the objectives and general principles that inspire the action of the company and that will be pursued in the long term. However, these strategic objectives related to the environment should be declined in strategies at the functional level of business-unit and then at the operational level. This deployment system (Fig. 2) of the company strategy, regarding the environmental variable and the supply chain, has to focus particularly on the environmental performance of suppliers to reduce their environmental impacts along the supply chain. The idea highlighted by the authors is that the company inherits through purchasing decisions, the environment impacts (and risks) that have occurred along its supply chain. The company could control

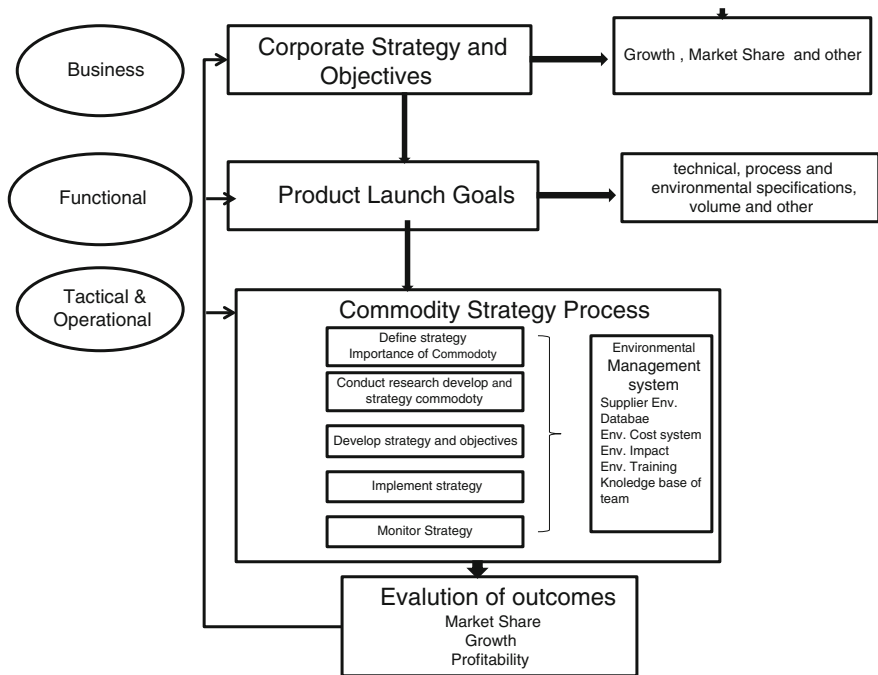


Fig. 2 Conceptual model of environmental role in supply chain decisions. Source Authors' elaboration on data from Handfield et al. (2005)

these impacts (with the aim to reduce them) through an appropriate process for selecting suppliers. Probably, the company that behaves in this way already adopts technologies and processes that are environmentally friendly. The interaction between companies and suppliers could potentially develop and implement more effective solutions to environmental challenges they are facing (Vachon and Klassen 2006). This occurs especially when there is a collaboration between companies and suppliers. Vachon and Klassen (2006) examined how the environmental collaborative activities impacts environmental performance. Environmental collaboration was defined by the authors specifically to focus on inter-organizational interactions between supply chain members, including such aspects as joint environmental goal setting, shared environmental planning, and working together to reduce pollution or other environmental impacts. The collaboration also implies cooperation to reduce the environmental impact associated with material flows in the supply chain (Bowen et al. 2001; Carter and Carter 1998).

The framework proposed by Handfield et al. (2005) is interesting because it integrates strategies of supply chain management with environmental management and it allows to highlight the links between ESCM and business strategy. The authors propose a system to achieve this objective by introducing the environmental strategy defined at the corporate at functional and operational levels of business unit. The objective is to ensure a consistency with all strategies at different levels. The operational level guarantees the achievement of a greater control of the environmental performance of their suppliers, because for each class of materials and products it has identified the critical level and then actions to better manage relationships with suppliers in order to reduce environmental impacts and improve environmental performance.

However, it is clear that companies, who engage in the implementation of ESCM practices in broad measure, and which also involve their business partners in the initiative to achieve greater environmental sustainability, need an integrated tools that allow them to guide the business activities through adequate measurement of different dimensions of business performance including environmental performance (possibly also suppliers to express the performance of the supply chain) and that provide an overview on what has been done towards achieving the objectives established (Franco-Santos et al. 2007). The PMS allows, if properly designed, to control the actions of the company by providing managers with the information that they need to conduct its business decision making (to lead) with reference to the environmental variable.

The criticisms of the traditional management control systems, which focus almost on measuring economic and financial performance, led to the development of advanced measurement and management control systems that consider simultaneously different dimensions of corporate performance (Kaplan and Norton 1992; Atkinson et al. 1997). Economic and financial performance are no longer sufficient to provide all relevant information to guide action of managers and in particular at operative level (although still important). Non financial measures include product quality or product characteristic (Perera et al. 1997) have non-monetary nature, they are sometimes associated only with the operational level, while they have also



strategic importance (which is usually underestimated), they also impact profit and profitability. Their operational nature is critical because they are taken into account for decisions at the operational level, however, the new context requires that this part of indicators is integrated in the directional systems of information to provide multidimensional and balanced performance management systems. Companies have to shift attention from cost and efficiency-based performance measures to ones which capture and reflect strategies (Perera et al. 1997). The quality characteristic, flexibility and speed of decision making are increasingly important in the new competitive environment and therefore these dimensions must also be captured and reported to management even if they originate at the operational level. This allows to give a true picture of the current performance and future prospects of the business. Among these dimensions we can incorporate also environmental performance.

Given the new dimensions of the competitive environment, organizations should innovate the traditional performance measurement systems by identifying new performance measurement systems that meet the multidimensional information needs. Several authors agree on the importance of new systems of performance measurement, although some criticize how is vague the concept of PMS (Azevedo et al. 2013). In fact, the definition of PMS is very general and for this reason they have been developed different models proposed by various authors to deal with the problem of performance measurement in a concrete way, identifying indicators, measures and perspectives of analysis, that have to be appropriate and standardize for each company. The advanced performance management systems measure and report a series of multi-dimensional indicators also operational. They should also report those who have an environmental nature where the environment variable has a strategic importance for company. Hence the need to adopt a performance measurement system adequate with the companies needs to have information about the ESCM. To ensure progress for environmental management, top management must be fully committed (Zsidisin and Siferd 2001). Support are needed also from mid-level managers for successful implementation of environmental practices (Bowen et al. 2001). The cooperation and communication between companies departments is important to successful environmental practices (Zhu and Geng 2001; Aspan 2000).

The studies on the performance measurement of the green supply chain and of the ESCM are still relatively few and sparse. At the same time, the principles of accounting are still far to be perceived by their internal environment variable (Bracci and Maran 2013). In the next sections we will analyze the main models of performance management from the perspective of ESCM.

### ***3.1 The Beamon Model (1999)***

One of the early works aimed to integrate the environmental variable in the measurement of performance is Beamon (1999). The author highlighted the characteristics of the extended supply chain or green supply chain. In addition to traditional

links with various subjects involved (suppliers, manufacturers, distributors, retailers and customers), the author provided other links caused by the set of activities of recycling, reuse and remanufacturing. With the aim of reducing the environmental impacts of products and processes, from the raw material extraction to product disposal, and that allow to the creation of semi-closed loop supply chain. The author argued that it is important, for the design of the extended supply chain and its analysis, to develop appropriate performance measures. The measures have to reflect the dual purpose of the extended supply chain, that is, economic efficiency and environmental protection. So the traditional measures of supply chain performance based on cost, flexibility and quality are not sufficient to evaluate and to respond to companies needs. According to Beamon (1999), a performance measurement systems that respond to the needs of the extended supply chain have to include performance indicators related to different environmental categories. In particular, they should include measures of the quantity of waste generated by the system, measures about the use of energy resources and other natural resources (raw materials and other materials). In addition to the existing operational measures, these measures should be provided with regard to the life cycle of the product and processes. Figure 3 shows the performance measures identified by Beamon (1999) to evaluate the extended supply chain or green.

According to Beamon (1999), it is necessary to carry out a series of activities to implement the extended supply chain (or green). For each product of the supply chain it is necessary to identify all the inputs, outputs, by-products and resources. Then, after developing an adequate system of performance measurement, it is necessary to calculate the composite performance in each phase of the supply chain processes and for each product, assigning a single or matrix of value to the composite performance. This step serves to identify and determine the priorities of intervention between the various processes in order to improve the ecological performance of those with a lower score. From the analysis it should be identified and selected the improvement actions to be undertaken. Beamon (1999) does not specify what mean the supply chain processes. So, the author is unclear whether the identification process and the assignment of a composite measure of performance should also be extended to the production process (or other processes) of suppliers and distributors.

The author does not specify also if the analysis has to stop within the organizational boundary and evaluate processes of plan, source, make, deliver and return that allow to manage the supply chain for that part of activities that are related to the single company. However, with regard to performance measurement, the author has the merit to highlight the need for new measures, these measures have to be mainly related to the consumption and re-use (recovery, recycling, reuse) of the resources in the system and to be centered in details on the products and processes.

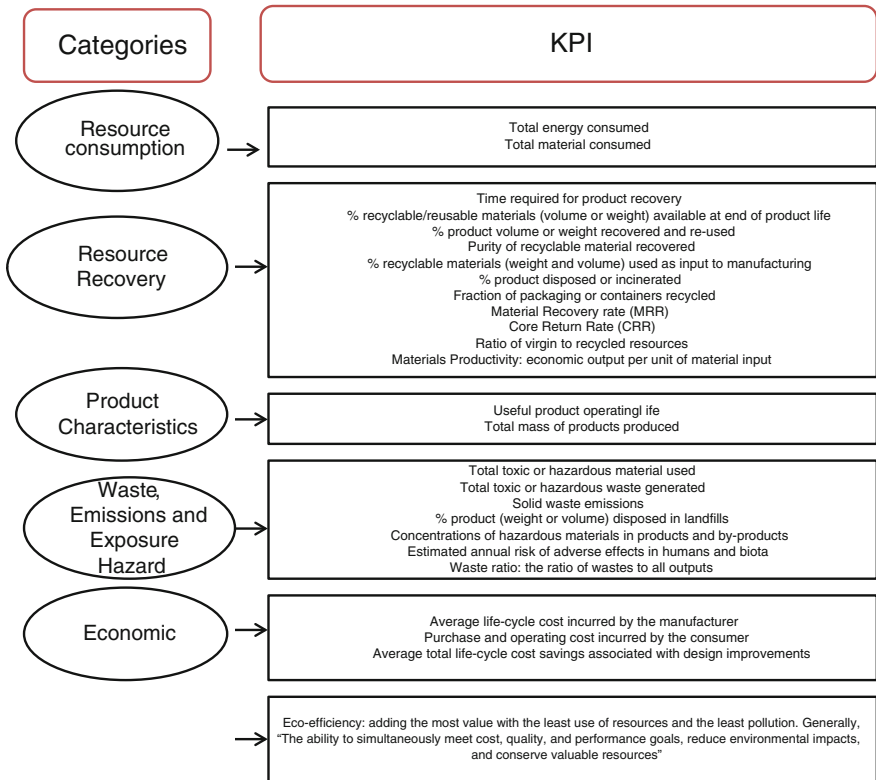


Fig. 3 Extended supply chain performance measures. Source Authors' elaboration on data from Beamon (1999)

### 3.2 The Framework of Hervani et al. (2005)

According to Hervani et al. (2005), performance measurement could be a difficult activity within the organization. When the focus shifts to considering the environmental performance of the supply chain, the performance measurement encounters new difficulties. According to the authors, these difficulties have to be overcome, because the viability of the company and its future competitiveness could depend on the effective adoption of performance measurement of ESCM. The difficulties highlighted by the authors are related to the broad objectives attributed to the system of Environmental supply chain management and performance measurement (ESCM&PM). In fact, according to the authors, every measure must assumed a supply chain perspective. Each entity in the supply chain should be measured and improved according to common goals, all of this requires a very extensive coordination between organizations and creative effort to design new measures.

The evaluation of the performance of supply chain is complicated because there is the need to overcome the distrust with their trading partners, to overcome the difficulties of control variables that are perceived as not to be influenced, to consider different organizations’ objectives and measures that some times are not shared between different organizations, to consider the existence of different information systems that not integrated. To develop a performance measurement systems that consider all those variables is necessary to identify effective indicators. These indicators represent the core of the system of ESCM&PM, and allow to evaluate the environmental performance of activities, processes, products and services. The environmental indicators used can be varied and could be related to the emissions, consumption of energy, other environmental impacts, and also include the results of activities for recovery, recycling. A special effort is required for the selection of environmental indicators that measure effectively not only the environmental impacts of operations but also the results of the activities designed to reduce them (suggestions for the choice of indicators can be derived from international standards such as ISO 14001, or from other guidelines such as those of the Global Reporting Initiative (Chiarini 2013).

Hervani and colleagues underlined that *Environmental indicators are plentiful. Yet, there is a difficulty in determining which to use, when to measure them, and how to measure them. Many of these issues must be addressed* (Hervani et al. 2005). These problems may be encountered in the selection of environmental performance indicators with reference to a single company. As the authors reported, the level of complexity is even higher in ESCM PM perspective given the characteristics of inter-organizational and the focus on the life cycle of the product on which it is focused the system. Many of the proposed measures (Table 1) can also

**Table 1** Some measures of environmental performance

<ul style="list-style-type: none"> <li>• Air emission</li> <li>• Underground injection on-site</li> <li>• Release to land on-site</li> <li>• On-site and off-site energy recovery</li> <li>• On-site and off-site recycling</li> <li>• On-site and off-site treatment</li> <li>• Non production release</li> <li>• Source reduction activities</li> <li>• Spill and leak preventions</li> <li>• Raw material modification</li> <li>• Process modification</li> <li>• Product modifications</li> <li>• Pollution prevention opportunity audits</li> <li>• Materials balance audits</li> <li>• Employee and participative management</li> <li>• Management systems pertaining to social and environmental performance</li> </ul>	<ul style="list-style-type: none"> <li>• Number, volume and nature of accidental or non-routine release to land, air and water</li> <li>• Costs associated with environmental compliance</li> <li>• Major awards received</li> <li>• Total energy use</li> <li>• Total electricity use</li> <li>• Total fuel use</li> <li>• Total water use</li> <li>• Total materials use</li> <li>• Habit improvements and damages due to enterprise operations</li> <li>• Quantity of non-product output returned to process or market by recycling and reuse</li> <li>• Major environmental, social and economic impacts associated with life cycle of products and services</li> <li>• Procedures to assist product and service designers to create products and services with reduce adverse life cycle impact</li> </ul>
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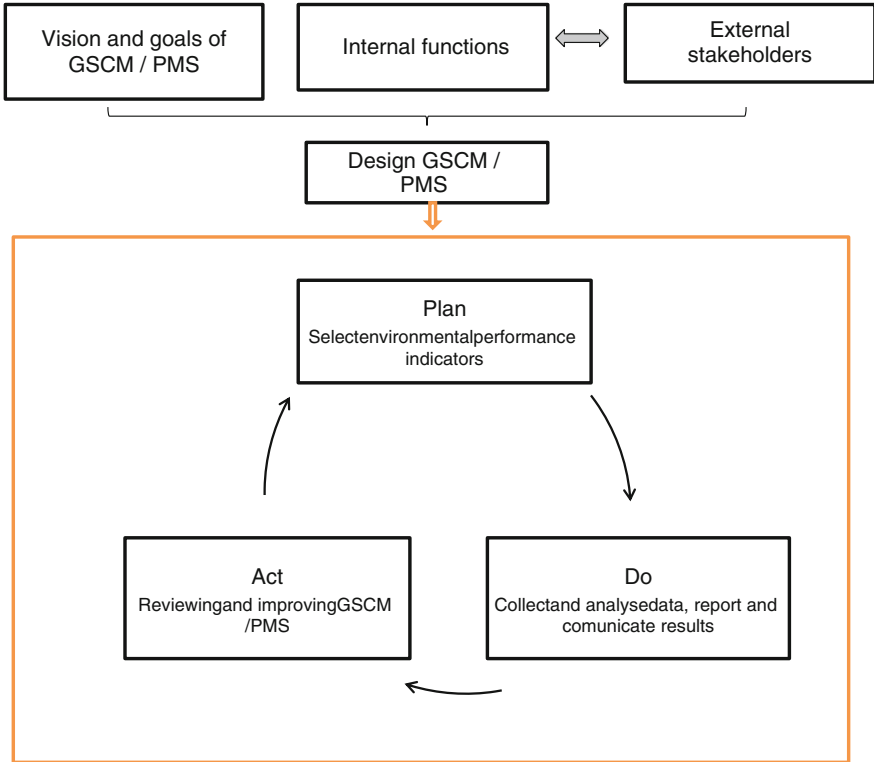
Source Authors’ elaboration on data from Hervani et al. (2005)

be used beyond the confines of a single organization with reference to the life cycle of the product, but for this purpose it is necessary to access to data information that must be provided as input by suppliers and customers. It is therefore necessary to reach an agreement on the measures to be used and the identification of sources of data between the main members of the supply chain to create the system. There may be difficulties to be overcome for the realization of a PM system extended to supply chain. This system should be refined gradually, as it is difficult for an organization to develop relationships with their trading partners that allow to immediate access to all the information that necessary their environmental performance. The indicators that will measure the performance of the external environment have be defined in consultation with the most important suppliers, whose activity can generate high impact on the environment and for which there is greater need to carry out a regular monitoring of activities. Such data may be derived from the information systems of the partner or be raised through external audits. Also there is necessity to select the effective indicators for their processes and internal activities to provide a complete picture of the environmental performance of the supply chain.

For the authors, the team responsible for the design of the system of ESCM&PM should not only be inter-functional, that is coming from various internal functions of an organization. But it is preferably to include representatives of suppliers and customers and other stakeholders. In designing the ESCM&PM system it should also consider the environmental management systems of organizations. The system has to be designed and modified according to the principle of continuous improvement based on the Deming wheel (Plan, Do, Check, Act) (Fig. 4) as highlighted by ISO 14031. The team which deals with the design of the system should, then, make sure that this system has the information necessary for an accurate assessment of the environmental performance. To respond to different purposes of external reporting and internal analysis, it may be necessary to modify and refine the system in continuous improvement. The output of ESCM&PM system can serve several purposes, such as external communication, internal analysis or compliance with the regulations. In particular for external communication, companies take the measures that can be compared over time in order to show the improvement of their environmental and the supply chain performance.

The performance measurement system in the ESCM identified by Hervani et al. (2005) focused on environmental issues and in particular on those regarding the supply chain. It can be separated from the other PM systems within the company. In fact, question which the top management have to respond in designing the system is its connection with other internal systems. Then, it could be configured as a model of inter-organizational performance measurement. The level of sophistication required by a system is high, and also the efforts to build and manage it, and the related costs may be particularly high.

This system although is interesting from a theoretical point of view but it might be difficult to be realized from the practical point of view. Mainly due to the difficulty of integrating data from different subjects, but good relations with other subjects involved in the supply chain can help to overcome many of these difficulties. This system is still in early stages, it should to be carried out more research



**Fig. 4** Performance measurement system and ESCM. *Source* Authors’ elaboration on data from Hervani et al. (2005)

to complete their field of study of inter-organizational performance measurement. Measurement systems available may still not be adequate for a comprehensive assessment of ESCM.

### 3.3 *Balanced Scorecard*

The model of the Balanced Scorecard (BSC) is suitable for a strategic perspective of control (Kaplan and Norton 1992, 1996). It can be used also to study the relevance to the environmental variable. The original formulation of this model goes back to the early work of Kaplan and Norton (1992). The authors observed that managers in making decisions and in monitoring the performance of the company do not generally rely on a single set of indicators (financial) performance. But they need different types of indicators that relate to different perspectives. So that no one-dimensional system can provide a clear and comprehensive presentation of the

results achieved by the organization and focus the attention of managers on all areas and critical dimensions for the future success of the business.

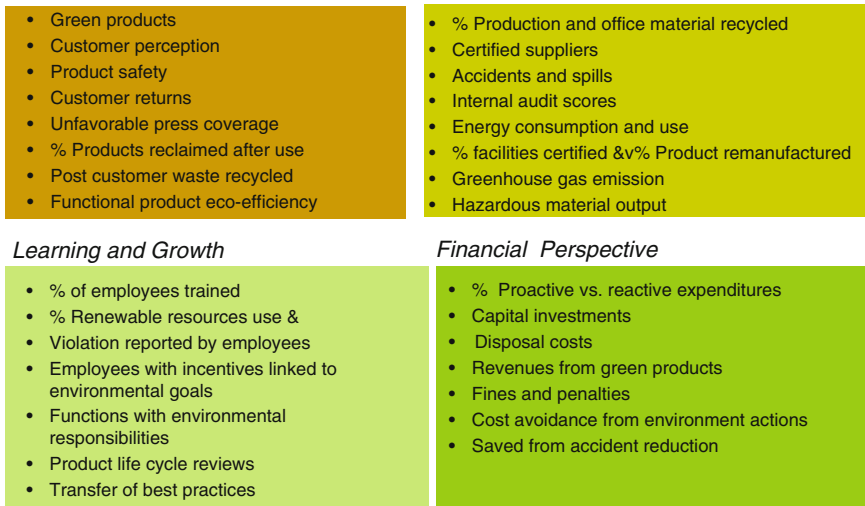
The perspectives may be different and customized for each type of business, those identified by the authors are the economic and financial perspective, customer perspective, internal processes perspective and learning and growth perspective. These perspectives are important for all businesses, which can add other perspectives. The addition of other perspectives is a process that have to be done carefully, because each perspective is linked with other, and because the indicators and objectives have to be coherent. The economic and financial perspective is indicative of the ability of the company to operate according to criteria of cost-effectiveness and achieve adequate profits. The customer perspective is indicative of the organization's ability to satisfy their needs creating value for the same. The internal process is indicative of the ability of the company to be efficient and to have adequate manufacturing processes. Learning and growth is indicative of the ability to develop skills and expertise, new technologies and innovation and is central to the improvement and growth of other prospects in the long term.

The BSC then serves to compose a balanced framework of indicators to guide the action of the manager and allows to control the firm's performance in different perspectives (all equally important to its future success). For Kaplan and Norton the BSC is not limited to be a tool for performance measurement, but it is also a management tool ("a core management system") that should guide the action of the management and guidance to organizational behavior (Kaplan and Norton 1996). The Balanced Scorecard system has to allow the communication of strategic priorities identified, direct the incentive systems (communicating and linking), decline the strategies into a coherent system of sub-goals to determine the good allocation of resources (planning and target setting), and to provide a feedback on the results achieved in all strategic perspectives to guide the process of organizational learning (strategic feedback and learning) (Kaplan and Norton 1996).

Summarized the main characteristics of the model, we can introduce the environmental variable in the discussion. Since the Balanced Scorecard highlights the importance of the strategic use of the indicators of performance in different perspectives (and in doing so it presents itself as a useful tool for the deployment of the strategy). Organizations, adopting a management approach of ESCM, will integrate their strategy considering the objectives related to improving the environmental performance of the organization and its supply chain. The environmental objectives take on strategic importance and are connected in a coherent way with other objectives of the company. Epstein and Wisner (2001) argued that the Balanced Scorecard is an effective tool to translate into action the desire of managers to integrate greater environmental and social sustainability in the strategy of company. The Balanced Scorecard is an appropriate instrument to establish clear links between the resources involved by companies in environmental and social responsibility initiatives and operating results (Epstein and Wisner 2001). For Epstein and Wisner (2001) the Balanced Scorecard can be customized according to the environmental and social objectives of any business, some will have a particular focus on internal processes (and thus may have environmental indicators within this

perspective), while others may build environmental performance indicators in all perspectives of the Balanced Scorecard identified by Kaplan and Norton. Other companies could still be able to create a new perspective of the Balanced Scorecard dedicated specifically to the environmental and social dimension. In particular, the adoption of a fifth perspective, according to the authors, is due to the desire to give even greater emphasis to environmental and social objectives, and will be used by those companies that identify in the ability to manage an excellent relationship with the environment the source of possible competitive advantages, or where the environment variable is critical for the type of activity.

In Fig. 5 we list the environmental indicators to be used in different perspectives reported by Epstein and Wisner (2001). The characteristics of these indicators and the objectives to be achieved are also important in the context of ESCM. In the context of ESCM the importance given to the environmental performance of suppliers is very high. Since the aim is to improve the environmental performance not only internal but also at the level of the supply chain, through selection of supplier more environmentally conscious, or through the implementation of environmental projects in collaboration. The BSC may also incorporate a perspective dedicated to suppliers, with the introduction of specific indicators that measure the progress taking place with them. Then, this allows to the evaluation and the subsequent identification of initiatives (of ESCM) to improve the performance in this sense. Examples of these indicators could be the number of suppliers with an environmental management system, the number of projects to be implemented with suppliers to improve environmental performance, the number of recycled packaging from suppliers, the number of production processes reviewed, the number external audits carried out.



**Fig. 5** Example of environmental measures in a Balanced Scorecard. *Source* Authors' elaboration on data from Epstein and Wisner (2001)



The BSC can be an effective tool to deploy the environmental strategy of the company and to recommend the action to be taken to improve the environmental performance of the company and its supply chain. It is therefore a useful strategic tool to support and to implement the initiatives of ESCM. The Balanced Scorecard, as a tool for deployment of the strategy and performance measurement, allows to connect the goal of greater environmental sustainability of company and supply chain management with other business strategies. In doing so, it provides to the management to indicate what are the strategic objectives on which to focus and the indicators to be monitored to assess the degree of their achievement. The managers, after identifying in a clear performance objectives, have to activate the necessary levers, including the practices of ESCM, to achieve its strategic objectives including more sustainable environmental impact of the supply chain.

### 3.4 *Integration, Comparison and Considerations About the Models Proposed*

In the previous sections, we introduced the concepts of ESCM and PM and some model proposed in the literature to meld the tow together. We are now going to compare and reflect upon the framework based on the BSC and the Hervani et al. (2005) and by Beamon (1999) model's. Table 2 summarizes the similarity and differences among the models in terms of link with the strategy, internal and external focus and link with other performance dimensions. The table has been drawn considering the commonalities and diversity of the various models analyzed. The table shows the differences between the various models respect to four characteristics: links with the strategy, internal focus, external focus and links with other performance dimensions. While all models give importance to the internal performance (internal focus) in a perspective supply chain, only the model of Hervani (2005) that broadens the scope of measurement also to suppliers. With regard to the relationship with the business strategy, both the balanced scorecard (Epstein and Wisner 2001) and the model of Hervani (2005) have tried to measure the performance of supply chain considering its relationship with business strategy. With regard to the relationship with other dimensions such as the financial performance,

**Table 2** The ESCM performance measurement models compared

	Beamon (1999)	Hervani et al. (2005)	Balanced scorecard (Epstein and Wisner 2001)
Links with the strategy	No	Yes	Yes
Internal focus	Yes	Yes	Yes
External focus (i.e. suppliers)	Limited	Yes	Limited
Links with other performance dimensions	Limited	Limited	Yes

and the customers perspective only the balanced scorecard (Epstein and Wisner 2001) that includes other dimensions in the analysis.

The model proposed by Hervani et al. (2005) focused on the integration of environmental management and supply chain strategy. To create a green supply chain it is necessary to adopt a policy of supply chain that also considers the environment and that it is consistent with other corporate strategies. The authors answered to how this supply chain strategy have to be designed and realized. This system is mainly focused on the management of relationships with suppliers, their selection and evaluation. The model proposed by the authors provides guidance on how to implement a green procurement strategy consistent with the other objectives and strategies of organization. The model presented is useful in this context because it allows to control and better manage the environment variable since the input of the company through the management and development of suppliers. Several authors point out that the supply chain management in an environmental perspective, i.e. the creation of ESCM initiatives, should not be in conflict with other goals and other strategies of the organization. As reported by Hervani et al. (2005) the involvement of operational managers, in particular those involved in supply chain management, in the strategic planning process should lead to the formulation of a coherent supply chain strategy with the other strategies of the organization. Also the implementation of the sourcing strategy at the operational level, through the work of cross-functional team, should allow to consider and balance the needs of the various functions, and to a focus on management processes which is fundamental in SCM. Hervani et al. (2005) focused their research on the integration of the environmental management and supply chain strategy. Even if they highlighted the importance of identifying and monitoring appropriate performance indicators, they do not suggest a specific performance measurement system to be used. Since the activity of measuring and monitoring are handled primarily at the operational level by the team responsible of the commodity strategy, the measures for the monitoring and evaluation of the goals set by the specific commodity strategy have to be aggregated to show the results to higher management levels. To this end, the use of other tools such as the BSC could be useful both to support the planning and deployment of environmental strategy on the supply chain. Also it could be useful to show the results arising from the management of the various commodity strategies in aggregated level. The BSC could be a “core management system” useful within the model proposed in the ESCM literature.

As pointed by Epstein and Wisner (2001) the Balanced Scorecard can manage the environment performance, through which the system of performance measurement that focuses on the environmental performance of the supply chain could be created. The authors reported that they are necessary to modify and extend it. However, more research on the tools for measuring performance in inter-organizational perspective are desirable. The BSC was not developed to communicate information on environmental performance, even less at the level of the supply chain. But it can be customized and extended through the choice of key performance indicators relating to the management of the supply chain and different environmental indicators (also related to internal processes) that could be included in the different perspectives

identified by Kaplan and Norton perspectives. For example in the “learning and growth” perspective we could include the number of ecological projects undertaken jointly with the main trading partners, the number of analyzes on the environmental impacts associated with the life cycle of the products, research and development in collaboration with the suppliers, the number of hours of training and support provided to partners on environmental issues. For internal management the BSC can be useful tool, which can be integrated with some key measures of performance related to supply chain management and environmental performance. Because it provides information on the results under different analytical perspectives, including economic and financial, which is always important even in the pursuit of reducing environmental impacts. The measures of the BSC should be limited to give a balanced and concise on the achievement of strategic objectives, while at the operational level the measures and information to control and produce should to be more.

The performance measurement system suggested by Hervani et al. (2005) and Beamon (1999) could also be used for external reporting and could have an inter-organizational dimension. In particular the Hervani et al. (2005) model has a specific external focus, in the sense that each performance indicator should have a dimension of supply chain. The system of ESCM PM can be separated from other systems of performance measurement and other corporate information systems, and it could constitute parallel system to those already used by the organization. The performance measurement system can communicate with other managerial processes, provide relevant information to other systems, or used data and information generated by other systems. The architecture and the interface of the system have to be specifically designed by the expert of information systems, according to the objectives and needs of employers and based on the level of collaboration between other subjects of the supply chain. Data and information of the supply chain could be collected by the various operational managers, which also ensure their transmission and sharing, or they could be collected by the company that promote the system. PM systems can gradually rise to its inter-organizational dimension with time and with the increase of commitment in environmental management. Also with the increase of the level of collaboration and integration with other subjects in the supply chain. To provide a system for measuring the performance of such inter-organizational it is necessary to have high level of trust, high integration and collaboration with business partners. The difficulty to manage the system is proportional to the number of subjects involved and therefore depends also on the length and breadth of the supply chain. At the same time, the performance measurement system integrated with the supply chain management may be affected by other operational strategy, such as lean production or six-sigma (Chiarini and Bracci 2013). A system able to generate information about the environmental performance of the supply chain is certainly a useful tool for companies for the purpose of disclosure of their level of commitment in the environment conservation. The information obtained at the level of the supply chain can be communicated together with the other environmental outcomes in the sustainability reports, which has become a useful tool to communicate social activity to the stakeholders.

## 4 Discussion and Conclusions

We can propose some general reflections on the measurement of performance regarding ESCM. The to ESCM leads companies to reduce the environmental impacts associated with their products in a supply chain perspective. The choice of how to achieve this goal can be different from company to company, it's dependent on the capabilities and available resources. Some organizations will adopt a broader spectrum of activities than others (for example, between those of green design, green procurement, green manufacturing, green distribution and reverse logistics, and within these categories can accomplish different tasks), while some other may seek greater collaboration with suppliers or will have a focus on the control and the imposition of requirements and specifications in their selection and will have other focus mainly internal, even if the creation of strong relationships with other subjects in the SC is crucial to embrace this new management philosophy. Thus, some companies may want to check in detail the environmental impacts of suppliers and their improvement, to collaborate with them in the design of products and processes or new technologies. The focus of the measurement and the evaluation of results in the ESCM system have to be on the environmental performance (but not only), it can be internal or external depending on the circumstances and objectives. For the other subjects involved the measurement and evaluation will be based on the specific relations among them, on the objectives and on the requirements that are required in the implementation of the green supply chain. Some company will be interested to develop an inter-organizational system as suggested by Hervani et al. (2005), while others may decide to control the internal performance, through a BSC for example, and manage suppliers through the application of standards for procurement and environmental certifications of various types.

We can conclude that the system of performance measurement in ESCM have to be coherent with the objectives of the organization looking for a fit with the environment (Melnyk et al. 2014). The extension of this system depends on the degree of involvement and the level of collaboration between all subjects in the supply chain. The collection of data on the environmental impacts of all those involved in the supply chain can be useful mainly for communicating the results of the supply chain to external stakeholders interested in environmental values. This allows to improve its reputation, and to measure progress and its improvement.

More research are desirable to propose more considerations on the structure ad characteristics that systems of PM a supply chain environment are required to have, as well as their effect and uses (Franco-Santos et al. 2007; Melnyk et al. 2014). The research should study and analyze the systems used in practice by those companies that are most committed in the implementation of the ESCM. That organizations have already integrated aspects of environmental management in their strategic business. At present, researches have focused study on performance measurement systems used by companies to manage CSR initiatives, or environmental strategy, less attention given to the ESCM (Arjaliès and Mundy 2013; Rodrigue et al. 2013).

The main contribution of the paper to the extant literature is the attempt to critically analyzing the patchy literature on the performance measurement within an ESCM, proposing the need to look at the two elements in an integrated and connected way. In so doing, three specific models proposed by the literature were analyzed stressing the differences and similarities, but calling for a better understanding of their functioning and use within organization. Further research is thus recommended in order to understand how organization manage their environmental performance along the supply chain and the way it is integrated at the strategy level and performance management systems. Besides, it would be interesting to focus on the intended and unintended consequences in the implementation of performance measurement system to manage the environmental performance along the supply-chain.

## References

- Arjaliès DL, Mundy J (2013) The use of management control systems to manage CSR strategy: a levers of control perspective. *Manag Acc Res* 24(4):284–300
- Aspan H (2000) Running in nonconcentric circles: why environmental management isn't being integrated into business management. *Environ Qual Manage* 9(4):9–75
- Atkinson AA, Waterhouse JH, Wells RB (1997) A stakeholder approach to strategic performance measurement. *Sloan Manag Rev* 38:25–38
- Azevedo S, Carvalho H, Cruz-Machado V (2013) Using interpretive structural modeling to identify and rank performance measures: an application in the automotive supply chain. *Baltic J Manag* 8(2):208–230
- Beamon BM (1999) Designing the green supply chain. *Logistics Inf Manag* 12(4):332–342
- Bititci U, Garengo P, Dorfler V, Nudurupati S (2012) Performance measurement: challenges for tomorrow. *Int J Manag Rev* 14(3):305–327
- Bowen FE, Cousins PD, Lamming RC, Faruk AC (2001) Horse for courses: explaining the gap between the theory and practice of green supply. *Green Manag Int Autumn* 41–60
- Bratic D (2011) Achieving a competitive advantage by SCM. *IBIMA Business Review*
- Bracci E, Maran M (2013) Environmental management and regulation: pitfalls of environmental accounting? *Manag Environ Qual Int J* 24(4):538–554
- Carter RC, Carter JR (1998) Interorganizational determinants of environmental purchasing: initial evidence from the consumer products industry. *Decis Sci* 29:28–38
- Chiarini A (2013) Designing an environmental sustainable supply chain through ISO 14001 standard. *Manag Environ Qual Int J* 24(1):16–33
- Chiarini A, Bracci E (2013) Implementing Lean Six Sigma in healthcare: issues from Italy. *Publ Money Manag* 33(5):361–368
- Epstein M, Wisner P (2001) Good neighbours: implementing social and environmental strategies with the BSC. *Balanced Scorecard Rep* 3(3):8–11
- Femenias LB, Llach J, Almeida MMA (2013) Is the adoption of environmental practices a strategical decision for small service companies? *Manag Decis* 51(1):41–62
- Franco-Santos M, Kennerley M, Micheli P, Martinez V, Mason S, Marr B, Gray D, Neely A (2007) Towards a definition of a business performance measurement system. *Int J Oper Prod Manage* 27(8):784–801
- Green KW, Zelbst PJ, Meacham J, Bhadauria VS (2012) Green supply chain management practices: impact on performance. *Supply Chain Manag Int J* 17(3):290–305
- Gunasekaran A, Patel C, Tirtiroglu E (2001) Performance measures and metrics in a supply chain environment. *Int J Oper Prod Manag* 21(1/2):71–87

- Gunasekaran A, Patel C, McGaughey RE (2004) A framework for supply chain performance measurement. *Int J Prod Econ* 87(3):333–347
- Handfield R, Sroufe R, Walton S (2005) Integrating environmental management and supply chain strategies. *Bus Strategy Environ* 14(1):1–19
- Hervani AA, Helms MM, Sarkis J (2005) Performance measurement for green supply chain management. *Benchmarking Int J* 12(4):330–353
- Huo B, Qi Y, Wang Z, Zhao Z (2014) The impact of supply chain integration on firm performance. *Supply Chain Manag Int J* 19(4):369–384
- Kaplan RS, Norton DP (1992) The balanced scorecard—measures that drive performance. *Harvard Bus Rev* 70(1):71–79
- Kaplan RS, Norton DP (1996) Linking balanced scorecard to strategy. *Harvard Bus Rev* 39(1):53–79
- Liu X, Wang L, Dong Y, Yang J, Bao C (2011) Case studies of green supply chain management in China. *Int J Econ Manage Eng* 1(1):22–34
- Melnyk MA, Bititci U, Platts K, Tobias J, Andersen B (2014) Is performance measurement and management fit for the future? *Manag Acc Res* 25(2):173–186
- Mentzer JT, DeWitt W, Keebler JS, Min S, Nix NW, Smith CD, Zacharia ZG (2001) Defining supply chain management. *J Bus Logistics* 22(2):1–25
- Ninlawan C, Seksan P, Tossapol K, Pilada W (2010) The implementation of green supply chain management practices in electronics industry. In: *Proceedings of the international multicongference of engineers and computer scientists*, vol 3
- Perera S, Harrison G, Poole M (1997) Customer-focused manufacturing strategy and the use of operations based non-financial performance measures: a research note. *Acc Organ Soc* 22(6):557–572
- Rao P, Holt D (2005) Do green supply chains lead to competitiveness and economic performance? *Int J Oper Prod Manag* 25(9):898–916
- Rodrigue M, Magnan M, Boulianne E (2013) Stakeholders' influence on environmental strategy and performance indicators: a managerial perspective. *Manag Acc Res* 24(4):301–316
- Seuring S, Müller M (2008) From a literature review to a conceptual framework for sustainable supply chain management. *J Clean Prod* 16(15):1699–1710
- Simon R (1995) *Leverage of control: how managers use innovative control systems to drive strategic renewal*. Harvard Business School Press, Boston
- Srivastava SK (2007) Green supply-chain management: a state-of-the-art literature review. *Int J Manag Rev* 9(1):53–80
- Sun SY, Hsu MH, Hwang WJ (2009) The impact of alignment between supply chain strategy and environmental uncertainty on SCM performance. *Supply Chain Manag Int J* 14(3):201–212
- Testa F, Iraldo F (2010) Shadows and lights of GSCM (Green Supply Chain Management): determinants and effects of these practices based on a multi-national study. *J Clean Prod* 18(10):953–962
- Thun JH, Müller A (2010) An empirical analysis of green supply chain management in the German automotive industry. *Bus Strategy Environ* 19(2):119–132
- Vachon S, Klassen RD (2006) Green project partnership in the supply chain: the case of the package printing industry. *J Clean Prod* 14(6–7):661–671
- Zhu Q, Geng Y (2001) Integrating environmental issues into supplier selection and management: a study of large and medium-sized state-owned manufacturers in China. *Green Management International*, Autumn 27–40
- Zsidisin GA, Siferd SP (2001) Environmental purchasing: a framework for theory development. *Eur J Purchasing Supply Manag* 7(1):61–73
- Zhu Q, Sarkis J (2004) Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises. *J Oper Manag* 22(3):265–289
- Zhu Q, Sarkis J, Lai KH (2008) Green supply chain management implications for “closing the loop”. *Transp Res Part E Logistics Transp Rev* 44(1):1–18