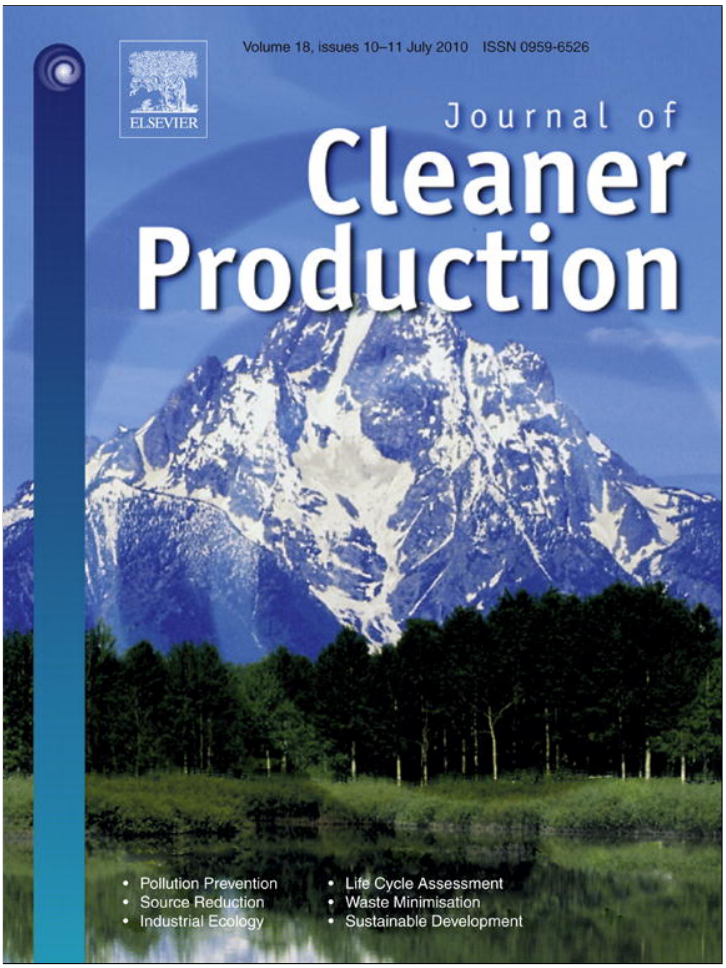

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Shadows and lights of GSCM (Green Supply Chain Management): determinants and effects of these practices based on a multi-national study

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ABSTRACT

Green Supply Chain Management (GSCM) is an increasingly widely-diffused practice among companies that are seeking to improve their environmental performance. The motivation for the introduction of GSCM may be ethical (e.g., reflecting the values of managers) and/or commercial (e.g., gaining a possible competitive advantage by signalling environmental concern). Drawing upon a database of over 4000 manufacturing facilities in seven OECD countries this paper assesses the determinants and motivations for the implementation of GSCM. We find that GSCM is strongly complementary with other advanced management practices, and that it contributes to improved environmental performance. The effects on commercial performance are more ambiguous.

1. Introduction

Green Supply Chain Management (GSCM) is an increasingly widely-diffused practice among companies that are seeking to improve their environmental performance. The motivation for the introduction of GSCM may be ethical (e.g., reflecting the values of managers) and/or commercial (e.g., gaining a competitive advantage by signalling environmental concern). Notwithstanding its growing diffusion and success, many factors are still hindering the adoption of GSCM by companies, especially SMEs.

At the empirical level, several studies have investigated the factors which encourage an organization to extend environmental management criteria and practices along its supply chain. They have found that GSCM can be stimulated by market demand, induced by the need to guarantee full compliance with more stringent environmental regulations, and by community groups (Darnall et al., 2008a; Nawrocka, 2008; Delmas and Toffel, 2004; Zhu and Sarkis, 2007).

Since an analysis which focuses on such external factors does not allow for a complete understanding of firm behaviour, in the present article we focus on the internal strategic motivations that can encourage an organization to adopt environmental practices with respect to its supply chain in order to obtain a competitive advantage (Sharfman et al., 2009). We carry out an analysis of the benefits and costs of GSCM, taking into account the strategic drivers that encourage an organization to adopt GSCM, and then testing its effectiveness both from an environmental and commercial perspective.

The effect of GSCM on both environmental and competitive performance has been analyzed in several previous studies, but these studies mainly relied on case studies (Geffen and Rothenberg, 2000) or on very limited geographical areas (Zhu and Sarkis, 2004) and industrial branches (Zhu and Sarkis, 2007). In the present article, we test whether GSCM is able to positively influence a company's environmental performance, and support its competitive strategies as a consequence of its improved environmental reputation. Our work assesses two measures that an organization can adopt to influence the environmental performance of its suppliers and, as an indirect consequence, also of its own production process or products: assessing their environmental performance and requesting that they undertake environmental measures.

Different from previous researches, in our study we analyze the determinants and effects of GSCM on environmental and business performance. Moreover, we apply a rigorous multivariate statistical approach, using data from over 4000 manufacturing facilities operating in many sectors in seven OECD countries.

This article is organized as follows: first, we provide an overview of the main findings emerging from the literature related to the hypotheses of the study. The following section describes the data set and the estimation methodology. We used a database of 4188 facilities, applying ordered probit models. Subsequently, we present

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the statistical results. The probit models clearly show that GSCM is linked to specific companies' strategies and is strongly complementary with other advanced management practices. It contributes to improved environmental performance while the effects on commercial performance are more ambiguous. After discussing the results, in the final section of the article we conclude with some indications for future research and managerial implications.

2. Determinants of GSCM

2.1. The determinants of green supply chain management adoption at firm level

In the literature, the determinants of GSCM adoption can be broadly divided into: "external factors", mostly linked to stakeholders' pressure; and "internal factors", i.e., a specific business-led strategic process. These differ according to the source of the "stimulus" that drives the development of GSCM practices, and that encourages their diffusion through the supply chain, and the sharing with customers and suppliers. With respect to "external factors", Di Maggio and Powell (1983) argue that managerial decisions to adopt environmental management initiatives may be influenced by three institutional mechanisms: normative, coercive and mimetic. Normative pressures, such as customer requirements, cause organizations to conform to be perceived as more legitimate (Zhu and Sarkis, 2007). In addition to this, several external stakeholders can impose coercive pressures on companies, depending on their power. For instance, by means of stringent environmental regulation government bodies may affect the adoption of environmental practices by firms (Delmas, 2002). "Regulatory" pressures arise from threats of penalties and fines for non-compliance, or from requirements to publicly disclose information concerning the organization's environmental impact (Konar and Cohen, 1997). Other examples are community and environmental interest groups (Henriques and Sadorsky, 1996) and industrial associations (Guler et al., 2002). These kinds of pressures can encourage managers to undertake supply chain-oriented strategic actions, in order to increase their external reputation, improve the influence on the supply chain decision processes and upgrade their image on the market. The moderating effect of institutional pressures on GSCM adoption was recently tested by Zhu and Sarkis (2007): their results revealed that firms facing higher regulatory pressures tend to implement green supply chain practices.

Limiting the analysis only to "institutional pressures" does not allow for a complete understanding of why organizations operating within the same context (market or sector) pursue different strategies, despite experiencing similar institutional pressures (Delmas and Toffel, 2004). There can be strategic motivations that encourage managers to adopt actions that aim at designing, rationalizing, implementing and better managing business relations in the supply chain, and that are not just spurred by external stimuli.

Examples of these factors are the following:

- the engagement of inter-firm co-operation, aimed at identifying and carrying out environmental improvements, both on the input-side of the product life cycle (e.g., procurement, co-operation with main suppliers) and on the output-side (e.g., organizing recycling, information on proper use for final consumers, etc.). These are implemented to pursue cost-reduction and to increase efficiency (Corbett and DeCroix, 2001);
- the selection of providers who have adopted effective environmental practices (i.e., applying an environmental management system that complies with ISO 14001 requirements) can be carried out to reduce the environmental risks associated with their activities (Sarkis, 2003).

Supply chain-oriented environmental management is, therefore, developed by organizations not just as an *ad hoc* operational response to external pressures, but as a key-element of a business strategic vision, aimed at pursuing better environmental and commercial results (most of the time in a synergetic way).

Pursuing a better "competitive performance" can have different meanings and be achieved in many ways. The three most diffused strategic approaches that are able to favor the adoption of GSCM practices by firms are the following:

(1) *"reputation-led"*: the environmental performance of the whole product life cycle can be improved, for example, by setting up co-operative "green" logistics with suppliers to reduce transport emissions, and make the customers and consumers aware of the system. This can significantly contribute to positive corporate image;
(2) *"efficiency-led"*: a supply chain-oriented business strategy can reduce the use of raw materials per unit of product or reduce the weight and the thickness of the packaging thanks to innovative solutions. This leads to cost savings and enables the company to supply a cost-competitive product to the market.
(3) *"innovation-led"*: GSCM can also be seen as the result of an innovation leader's strategy. Those companies that are front-runners in developing product and process innovations can find in pioneristic GSCM-related practices an opportunity to strengthen their leadership and create a gap with respect to their competitors (Vachon and Klassen, 2007).

Even when they are not generated within one of the above-mentioned approaches, GSCM practices can be considered an outcome of a "strategic" process in some cases. This happens when "external factors" become so strong that they induce the adoption of GSCM by followers. The wide diffusion of GSCM practices in recent years, especially in specific industrial sectors (e.g., food and beverages, textile, chemicals, etc.) has encouraged many organizations to adopt the "*first-mover*" strategy, that is, they compensate for their competitive disadvantage compared to the early-adopters of environmental practices in co-ordination with their suppliers. We can define the latter as an "imitation-led" approach.

In order to better understand the factors that result in GSCM practices, we focused our analysis on "strategic determinants". We tried to isolate those cases in which GSCM practices are not just a single aspect of business strategy, or an accidental and "spot" response to an external stimulus, but an integral part of a strategic process, even if this choice is merely determined by a "follower" strategy. We analyzed which strategies are more likely to generate "green" initiatives in the supply chain.

Hypothesis 1. *The factors that influence an organization to adopt GSCM practices are linked to different strategic approaches:*

H1a: a corporate image strategy (reputation-led) encourages a firm to adopt GSCM practices

H1b: a cost saving strategy (efficiency-led) encourages a firm to adopt GSCM practices

H1c: a product and/or process development strategy (innovation-led) encourages a firm to adopt GSCM practices

H1d: a "follower" strategy encourages a firm to adopt GSCM practices

2.2. Green supply chain management and environmental management systems

Investigating the determinants of GSCM, one cannot dismiss the possibility that there are some complementary factors which can strongly influence the attitude of a firm to develop such practices.

This is especially true when a firm pursues environmental excellence by means of different tools or solutions that are strongly synergetic with (and might suggest the adoption of) GSCM practices. The main findings of the relevant literature emphasise that, while in the early stages of an EMS application the ISO 14001-certified or EMAS-registered companies mainly focused on "housekeeping", today these companies are increasingly looking "beyond the boundaries" of their production process and organization (Klinkers et al., 1999) towards the whole life cycle of their products and services and, therefore, and firstly, to their supply chain.

In recent years, widespread experience in applying EMSs have shown that these "tools" can be effective, not only for the adopter for the management of its own environmental aspects, but also in coping with the environmental impacts originating from supply chain relations and from the different phases of a product life cycle (Sharfman et al., 1997). An increasing number of theoretical and empirical studies have found that "expanding" an EMS by way of a life cycle approach has great potential for "*inter-organisational environmental management*" (Sinding, 2000), i.e., for effective co-ordination and co-operation between companies within the supply chain.

According to this view, EMSs are crucial when a large adopter needs to involve and support smaller companies operating in its supply chain to achieve common environmental objectives. The relevant literature on GSCM emphasises that many difficulties arise in applying a supply chain-oriented approach, in particular for SMEs. A company's management control on the environmental aspects emerging from the links and interactions with the other actors of the supply chain can be too weak, and its contractual power within these business relations not strong enough to influence the relevant decision-making (Fuller, 1999).

The influence of EMS implementation on organizations' decision to "push" their suppliers to adopt environmental practices was recently investigated by Gonzalez et al. (2008). Focusing on the automotive industry in Spain, the authors found a positive relation between the implementation of a certified EMS and the environmental demands that these organizations impose on their suppliers. Moreover, and symmetrically, EMS is one of the main (explicit or contract-based) customer's environmental performance requirements that an organizations require to their own suppliers (Simpson and Power, 2005; Simpson et al., 2007).

The relationship between EMS and GSCM practices, therefore, can be complementary, with positive implications for an organization's environmental performance, because when applied together (and in a synergetic way) they offer a more comprehensive means for defining and establishing sustainable actions among networks of business partners (Darnall et al., 2008a).

Starting from these considerations and using a wide sample covering different industrialized countries, our work aims at demonstrating that an environmental management system is a key-determinant and a facilitator for the adoption of GSCM practices.

Hypothesis 2. *EMS adopters are more likely to develop GSCM practices*

3. Effects of GSCM on performance

3.1. GSCM as a managerial tool for improving environmental performance at firm level

The increasing diffusion of GSCM is driven mainly by the need for companies to address significant environmental challenges that cannot be tackled only by relying on their own resources (technical, managerial or even economic ones), but require the involvement of other actors that are co-responsible for their generation. The intensive use of raw materials and natural resources, the escalating production of waste caused by consumer goods and their packaging, the environmental impacts of the transportation of intermediate and consumer goods to their final markets are only some examples of environmental aspects that cannot be fully addressed without the active participation of suppliers, retailers, clients and final consumers (Srivastava, 2007). Therefore, the main objective of GSCM, as well as the main measure of its effectiveness, must be its ability to improve the environmental performance of the companies that adopt this approach and of their business partners.

This result has been confirmed by a large part of the literature which is based on case studies. For example, Geffen and Rothenberg (2000) analyzed three case studies of US assembly plants and stated that strong partnerships with suppliers, supported by appropriate incentive systems, aid the adoption and development of innovative environmental technologies. In addition to this, interaction with suppliers' staff, partnership agreements and innovation development leads to real and measurable improvements in environmental performance and maintain production quality and cost goals.

There is further anecdotal evidence concerning the effectiveness of GSCM in improving environmental performance, but very few studies have analyzed this relation using quantitative approaches based on surveys. Zhu and Sarkis (2004) analyzed survey data from 186 respondents on GSCM practices in Chinese manufacturing enterprises and found that higher levels of adoption of GSCM practices (e.g., environmental audit for suppliers' internal management, environmental requirements for purchased items, ISO 14001 certification, co-operation with suppliers and customers for environmental objectives) lead to better environmental performance. Moreover, a recent study carried out by Iraldo et al. (2009), based on a sample of 100 interviewed organizations, found evidence of the effect of a proactive GSCM on environmental performance.

Our analysis aims to contribute to the scarce empirical evidence that is currently available in the literature on positive relations between supporting suppliers in adopting environmental measures (i.e., an important facet of GSCM) and environmental performance improvement.

Hypothesis 3. *The organizations that encourage their suppliers to adopt environmental measures are able to improve their environmental performance*

3.2. GSCM as a managerial tool for improving competitive performance at firm level

The realisation of commercial benefits as "side-effects" of environmental improvement represent the most important motivating driver for companies to initiate more sustainable production patterns. It has been argued that success in addressing environmental issues may provide new opportunities for competition and innovative ways to add value to core-business activities (Hansmann and Kroger, 2001).

In the literature, the few empirical studies addressing the relationship between environmental performance and competitiveness have focused, almost exclusively, on commercial performance at the firm level. Evidence is not clear and univocal on this issue: some studies have found a weak or a statistically non-significant relation between economic and environmental performance (Jaggi and Freedman, 1992; Hamilton, 1995), while more recent studies have reached the opposite conclusion (Iraldo et al., 2009). For instance, Al-Tuwaijiri et al. (2004) demonstrate, through the implementation of a simultaneous equation model, that good environmental performance is significantly associated with good commercial performance.

Many authors acknowledge that an effective supply chain-oriented management not only generates environmental benefits, but significant business benefits as well. Dodgson (2000) and Dyer and Singh (1998) argue that inter-firm relations provide formal and informal mechanisms that promote trust, reduce risk and in turn increase innovation and profitability. Some of the key-elements of GSCM, such as involvement, analysis and control systems along the supply chain, based on environmental criteria, can reduce the risks of delivering interruptions or delays resulting from a critical supplier's compliance problem (Lipman, 1999).

Beside reducing risks and costs, GSCM practices can also provide strategic and competitive benefits: the improvement of the brand's image, better relations with institutional stakeholders and increase of personnel motivation are possible effects of GSCM adoption described by the relevant literature. However, the relationship between GSCM and competitiveness has been investigated by very few empirical studies which either analyze the effects of a wider range of environmental management practices (including GSCM), or focus on limited geographical areas.

For instance, Welford (1995) found that environmental protection activities such as GSCM are increasingly embedded in business operations and, thus, bring some benefits for firms such as an improvement in reputation and strengthened business relationships. In addition, Molina-Azorin et al. (2009) indicated that proactive environmental management such as GSCM has a positive effect on an organization's market performance.

These empirical studies concentrating on the competitive effects of GSCM adoption, have mainly focused on the South-East Asia Region where it seems to be more diffused. For instance, the above-mentioned work of Zhu and Sarkis (2004), which analyses GSCM practice in Chinese manufacturing enterprises, proved that enterprises which develop many GSCM practices have better competitive performance, Finally, the analysis carried out by Rao and Holt (2005) found that "greening" the different phases of the supply chain leads to a more integrated and co-operative supply chain which ultimately results in greater competitiveness.

Our study aims at overcoming the limits of the existing empirical studies by analyzing the competitive effects on business performance of two particular GSCM practices, within the OECD area.

Hypothesis 4. GSCM adopters have better business and competitive performance

4. Methodology

4.1. Data description

To test our hypotheses we used data collected by means of a postal survey developed by the Organization for Economic Co-Operation and Development (OECD) Environment Directorate and university researchers. The survey was implemented in seven OECD countries (Canada, France, Germany, Hungary, Japan, Norway and the United States) at the facility level in 2003 by means of a standard questionnaire (see www.oecd.org/env/cpe/firms for a discussion of sampling procedure and survey protocol).

The questionnaire is composed of approximately 40 questions distributed into six sections: the first section focuses on the management systems and tools adopted in the facility; the second and third sections investigate the adoption of environmental practices, the motivations for their adoption and the level of innovation and achieved performance; the fourth section aims at assessing the effect of environmental policy stringency on a firm's decisions; the last two sections are aimed at collecting information on the characteristics of facility and firm.

Table 1
Response rate by country.

	Response rate
Canada	25.0%
France	9.3%
Germany	18.0%
Hungary	30.5%
Japan	31.5%
Norway	34.7%
United States	12.1%
Total	24.7%

The data covers facilities in all manufacturing sectors and not only those in the more polluting sectors. The diversity in countries and sectors sampled implies a greater variation across policy frameworks, technological opportunities, and other factors that allow for the generation of more reliable estimates of different potential determinants and effects of GSCM practices.

A total of 4188 facility managers were interviewed by the survey. The questionnaires were sent to CEOs or environmental managers in manufacturing facilities having at least 50 employees. Response rates range from approximately 9% to 35%, with a weighted mean of almost 25% (see Table 1). With respect to previous industrial surveys undertaken in the environmental area, this result is quite satisfactory for a postal survey. For instance, in a review of 183 studies based on business surveys published in academic journals Paxson (1992) reports an average response rate of 21%.

Given the nature of the data, and due to the relatively large non-response rate, the assessment of the presence of a sample selection bias was carried out. This assessment was performed by implementing a Heckman sample selection procedure. We followed the standard procedure and assume that the set of variables which explain respondents' decision to answer or not is the set of control variables (see (Davidson and MacKinnon, 2003) for a comprehensive treatment of the procedure). The coefficient of the inverse Mills ratio is largely non-significant (p-value of 0.958), which indicates that we could reasonably decide that selectivity is not a problem.

It is well known that two standard drawbacks of survey data are social desirability bias and lack of generalizability. The social desirability bias refers to the fact that individuals attempt to answer survey questions in ways that they consider socially desirable (Darnall et al., 2008a). In order to limit this kind of bias, all our respondents were guaranteed anonymity. Moreover, our pre-test analysis of the survey did not find any indications of social desirability bias[1].

Furthermore, the survey is not affected by the lack of generalizability, since it did not target a single sector in a country, but several industrial sectors in multiple countries. The general distribution of respondents (by considering industry representation and facility size) relative to the distribution of facilities in the broader population was assessed, indicating good representation (Johnstone et al., 2006).

4.2. Econometric model

Having defined the theoretical model, we now propose the following equations to the test our hypotheses.

[1] In order to minimize the common method bias that can affect a questionnaire survey, we used several procedural remedies in the questionnaire's design. In addition we applied the Harman's single factor test to evaluate the presence of biases. The results of the test highlighted the absence of a single factor or one general factor accounting for the majority of the covariance among the measures.

$$\begin{cases} \text{ASSSUPL} = \gamma 0 + \gamma 1\text{IMAGE} + \gamma 2\text{COSTSAV} + \gamma 3\text{PROD\_DEV} + \gamma 4\text{IMITATION} + \gamma 5\text{EMS} + \gamma 6\text{CONTROL} + \varepsilon 1 \\ \text{REGSUPL} = \delta 0 + \delta 1\text{IMAGE} + \delta 2\text{COSTSAV} + \delta 3\text{PROD\_DEV} + \delta 4\text{IMITATION} + \delta 5\text{EMS} + \delta 6\text{CONTROL} + \varepsilon 2 \end{cases} \quad (1)$$

$$\begin{cases} \text{USERES} = \phi 0 + \phi 1\text{ASSSUPL} + \phi 2\text{REGSUPL} + \phi 3\text{CONTROL} + \varepsilon 3 \\ \text{WSTPROD} = \lambda 0 + \lambda 1\text{ASSSUPL} + \lambda 2\text{REGSUPL} + \lambda 3\text{CONTROL} + \varepsilon 4 \\ \text{WSTWATER} = \omega 0 + \omega 1\text{ASSSUPL} + \omega 2\text{REGSUPL} + \omega 3\text{CONTROL} + \varepsilon 5 \end{cases} \quad (2)$$

$$\text{BUSSPERF} = \alpha 0 + \beta 1\text{ASSSUPL} + \beta 2\text{REGSUPL} + \beta 3\text{CONTROL} + \varepsilon 6 \quad (3)$$

4.2.1. Explanatory variables

In order to test Hypotheses 1 and 2, we utilized a binary probit model[2] (Eq. (1)). At this stage, we tested what business strategies increase the probability of adopting a specific GSCM practice. Furthermore, we tested if the adoption of an EMS can encourage an organization to analyze the environmental performance of its suppliers.

To define the dependent variables of the first model we used the two following survey questions: "*Does your facility regularly assess the environmental performance of own suppliers?*" and "*does it regularly require suppliers to undertake environmental measures?*". The use of these actions as a proxy for measuring, in more general terms, the GSCM practices adoption by companies is supported in the literature (see (Zhu and Sarkis, 2004)).

A set of binary variables was created to measure the strategic motivations of companies to adopt GSCM initiatives. Focusing on the strategic vision of environmental excellence as a competitive factor (and not only specifically GSCM adoption), we constructed the "determinants" variables using the answers to the following question: *How important do you consider the following motivations to have been with respect to the environmental practices of your facility?*". Among the several options included in the survey we used those that were better able to reflect the business strategy: improving corporate profile/image (IMAGE), saving costs (COST_SAV) developing new products/technologies (PROD_ DEV), imitating competitors (IMITATION). These variables correspond to the four approaches to GSCM defined above ("reputation", "efficiency", "innovation" and "imitation-led" approaches).

Moreover, we constructed a binary variable to measure the adoption of structured environmental management systems, including formal EMSs such as EMAS and ISO 14001 and informal EMSs (EMS). The econometric model set out in Eq. (2) was used to verify whether the adoption of GSCM practices is effective and, therefore, if it results in improved environmental performance of the adopters (Hypothesis 3).

In line with Arimura et al. (2008), in order to define facilities' environmental performance measures (i.e., the dependent variables in Eq. (2)), we used the survey question, "*Has your facility experienced a change in the environmental impacts per unit of output in the last three years with respect to the following (impact)?*" Using alternatives provided in the question, we constructed an ordered response variable (significant decrease, decrease, no change, increase, significant increase) for the three environmental impacts we studied: natural resource use (i.e., energy and water), solid waste generation and wastewater emission. Although it would be preferable to use quantitative data on environmental impacts, the use of self-reported data is not uncommon in the literature (see for instance (Iraldo et al., 2009; Darnall et al., 2008b; Khalid et al., 2004)).

With regard to Eq. (3), we used an ordered probit model[3] to test the influence of GSCM adoption on companies' business performance and competitiveness. In particular, we identified "profitability" as an effective proxy for the wider concept of competitiveness, measured by using OECD data relating to the question addressed to environmental managers that investigates if their company's profit had changed over the past three years. Respondents replied using a five-point scale, indicating whether revenue was "so low as to produce large losses," "insufficient to cover our costs," "at break even," "sufficient to make a small profit," or "well in excess of costs." Table 2 provides details on the dependent and explanatory variables; Tables 3 and 4 provide descriptive statistics for the study's variables.

4.2.2. Exogenous variables

With the information in the survey, we constructed a set of exogenous variables that were expected to affect GSCM adoption and/or environmental and competitive performance (see Table 5 for details). These variables include some specific firm characteristics such as the number of employees in the facility (FACEMPL) (Gonzalez et al., 2008), whether the firm to which the facility belongs is listed on a stock exchange or not (FRMQUOT), and the presence of an environmental department within the facility (FRMDEPT), which reflects a structured management approach to environmental issues.

The position along the supply chain might also influence the adoption of environmental practices such as GSCM. A facility is more likely to adopt some actions on its own suppliers if its primary customers (such as other manufacturing firms) request some environmental requirements or if the final consumers show a high environmental sensitiveness in their preferences (Arimura et al., 2008). By taking "other manufacturing firms" as a reference case of primary customers, we constructed three dummy variables; PRIMECUST1, PRIMECUST2, and PRIMECUST3 which take the value one if the primary customers are wholesalers, households, and other facilities within the same firm, respectively.

[2] Probit analysis is a type of regression used to analyze binomial response. In statistics, regression analysis refers to techniques for the modelling and analysis of numerical data consisting of values of a dependent variable and of one or more independent variables. The dependent variable in the regression equation is modelled as a function of the independent variables, corresponding parameters ("constants"), and an error term. The error term is treated as a random variable and represents unexplained variation in the dependent variable.

[3] The ordered probit is a generalization of the popular probit analysis, used for ordinal multinomial dependent variables.

Table 2
Dependent and explanatory variables.

Variable abbreviation	Question
ASSSUPL	Does your facility regularly assess the environmental performance of own suppliers?
REGSUPL	Does your facility regularly require suppliers to undertake environmental measures?
IMAGE	How important do you consider improving corporate profile/image to have been with respect to the environmental practices of your facility
COSTSAV	How important do you consider saving costs to have been with respect to the environmental practices of your facility
PROD_DEV	How important do you consider developing new products/technologies to have been with respect to the environmental practices of your facility
IMITATION	How important do you consider imitating competitors to have been with respect to the environmental practices of your facility
EMS	Has your facility actually implemented an environmental management system?
USERES	Has your facility experienced a change in use of natural resources per unit of output?
WSTPROD	Has your facility experienced a change in solid waste generation per unit of output?
WSTWATER	Has your facility experienced a change in wastewater effluent per unit of output?
BUSSPERF	How would you assess your facility's overall business performance over the past three years

Another external factor is certainly the spatial scope of market where the firm competes on (MRKTSCP). At the global level the competition can be more stringent and the need to acquire a competitive edge is higher than in a local market, stimulating companies to look for new opportunities, such as environmental excellence and in particular GSCM, that might provide advantages from differentiation (Arimura et al., 2008).

Finally, in order to capture the effect of external context and its possible implications on the company decision-making (and on its performance), we also consider the facility's geographical location and the sector of operation (Darnall et al., 2008b).

5. Results and discussion

1. The determinants of GSCM adoption by companies and the relevance of EMSs

Most of the determinants that have been identified by the literature on GSCM are confirmed by our model. First of all, the approach that we defined as "reputation-led" seems to be the most effective in stimulating the adoption of the two analyzed GSCM practices. On the one hand, companies that are pursuing a better market image, are often confronted with the request by different clients (intermediate customers, large retailers and consumers) that the product/service they offer is "environmentally friendlier" than the alternatives in all the phases of its life cycle. This implies the producer's necessity to provide guarantees concerning not only its own activities, but also those of its network of business relations.

On the other hand, a company in many cases wishes to improve its reputation only within the circle of its business partners. Especially for a small producer that co-operates in a network of suppliers for a large company (a very diffused typology is the supply chain of a retailer or a big components assembler, such as in the automotive industry), the image and reputation perceived by the other suppliers operating in the same network is of paramount importance. Therefore, it is vital for these kinds of companies to learn to develop GSCM practices. However, according to our results, they still suffer the limitation linked to their small size.

These dynamics also explain why the "imitation-led" approach to prompt GSCM is very significant, according to our findings. The stimulus for a company to initiate such practices often comes from observing the strategies and the competitive "behaviour" of its partners and competitors. If a company chooses to be a "follower" in its sector, it almost inevitably decides to adopt innovative practices only when they have been tested, and its effectiveness is confirmed by a leader. This happens in most cases with environmental innovations, the outcome of which is very uncertain, with a large initial investment.

The results of our analysis confirm that the "innovation-led" approach strongly influences GSCM adoption. This is probably a reflection of the specificities concerning the environmental innovation process. Many studies on this issue emphasised that innovation dynamics in the environmental sector are characterised by a strong need for a "networking approach". This holds true both for technological (Khalid et al., 2004) and organisational "green" innovation (Geffen and Rothenberg, 2000).

The "efficiency-led" approach to GSCM is the only hypothesis not confirmed in the model. The objective of cutting costs or saving resources does not seem to be a determinant for these kinds of "green" practices. This is very consistent with the discussion proposed above. First of all, the adoption of environmentally-friendlier interactions with the supply chain implies a considerable initial investment by the "catalyst" company (i.e., the company that initiates the co-operation and promotes GSCM), both in terms of customer- and supplier-relationship management and in terms of operational costs for the proposed initiatives (e.g., a reverse-logistic system, the use of new materials as "greener substitutes", etc.). These costs often represent a barrier for companies to behave as catalyst, because the "payback" of GSCM practices (as all the other environmental management practices) is yielded only in the long run. Typically, it is the few companies that are already proposing a "green" product or service to their customers that are the keenest to develop a GSCM strategy (to further improve the environmental quality and efficiency of their life cycle), whilst the majority of companies, that do not have a "environment-oriented" market share, are not willing to invest in the greening of their supply chain management just for efficiency purposes.

The findings of our work strongly support Hypothesis N. 2: there is a statistically very significant relation between EMSs and GSCM adoption and, by analyzing the marginal effects, we can state that undoubtedly the EMS adoption is the most incident factor for GSCM. Confirming what was recently emphasised by Gonzalez et al. (2008), our model shows that developing GSCM practices within the context of an EMS proves to be particularly effective. For instance, by extending the management system to relations with small suppliers or subcontractors (or even by supporting these actors in developing their own EMS and in co-ordinating with the adopter's EMS), for instance, the barriers and drawbacks for a supply chain management, emphasised above, can be removed.

Table 3
Descriptive statistics.

	Mean	Std. dev.	Minimum	Maximum	Num. cases
ASSSUPL	0.428	0.495	0	1	4033
REGSUPL	0.364	0.481	0	1	4007
IMAGE	2.430	0.607	1	3	3943
COSTSAV	2.384	0.623	1	3	3913
PROD_DEV	2.039	0.725	1	3	3472
IMITATION	1.694	0.694	1	3	2167
EMS	0.388	0.487	0	1	4002
USERES	2.481	0.761	1	5	3619
WSTPROD	2.432	0.764	1	5	3665
WSTWATER	2.541	0.729	1	5	3283
BUSSPERF	3.460	0.989	1	5	4017

Table 4
Correlation matrix (Spearman correlation).

	ASSSUPL	REGSUPL	IMAGE	COSTSAV	PROD_DEV	IMITATION	EMS	USERES	WSTPROD	WSTWATER
ASSSUPL										
REGSUPL	0.4592**									
IMAGE	0.1898**	0.1728**								
COSTSAV	0.0968**	0.0851**	0.3136**							
PROD_DEV	0.1759**	0.2024**	0.3369**	0.3960**						
IMITATION	0.1637**	0.1608**	0.3400**	0.2548**	0.3727**					
EMS	0.2628**	0.3180**	0.1785**	0.0140	0.0516**	0.0673**				
USERES	−0.1357**	−0.1374**	−0.0736**	−0.0786**	−0.0538**	0.0263	−0.1718**			
WSTPROD	−0.1433**	−0.1704**	−0.1129**	−0.0805**	−0.0566**	−0.0158	−0.2082**	0.4027**		
WSTWATER	−0.1028**	−0.0801**	−0.0698**	−0.0583**	−0.0381**	−0.0084	−0.1017**	0.4489**	0.3846**	
BUSSPERF	0.0374*	0.0359*	0.0844**	0.0077	0.0087	0.0220	0.0370*	−0.0296*	−0.0294*	−0.0430*

**$p < 0.01$; and *$p < 0.05$.

Our work strongly supports the idea that an EMS can be used as an "engine" to start up and boost the development of GSCM practices (Table 6).

2. GSCM as a managerial tool for improving environmental performance at the firm level

The results of the proposed model strongly support Hypothesis N. 3, indicating that the two GSCM measures considered significantly reduce the impact of the most common environmental aspects of an organization. Making specific requests to suppliers to assure a given performance, and involving them in GSCM initiatives can enable a company to better manage its own environmental performance. The result is consistent with most of the existing literature (see, for example, (Geffen and Rothenberg, 2000)). This is no surprise if one considers that in most cases the way in which a company affects the environment depends on productions choices and managerial decisions that are strongly influenced by suppliers.

Intensive use of natural resources is strongly related to the environmental performance of the suppliers' products and production processes. The electricity used as a primary production input has different environmental impacts depending on how it is generated by the supplier power plants. If a company chooses (as part of its GSCM strategy) to buy electricity from a provider with a significant share of renewables, its use of resources drastically decreases. When these requests by the GSCM adopter are standardized in a supply contract, the effects on environmental performance can be even more significant. Waste generation is the case in which this factor proves to be more effective (see Table 7). It is common practice among companies to manage waste-related issues by contracting service-providers and by including requirements on waste production in the contracts defined with subcontractors operating on-site. This enables the company to exert direct pressure and influence on the different suppliers and to obtain positive results on the quantity (and quality) of waste generated.

On the other hand, setting requirements and imposing rules on suppliers can be less effective if their performance is not monitored and assessed. This is the reason why the second variable considered in our model (ASSUPL) yields approximately the same results as REQSUPL. There are many different ways in which a company can assess its suppliers. The first (and most obvious one) is a direct consequence of the above-mentioned practices: many companies carry out a preliminary check on suppliers' environmental performance in order to decide if they can be qualified and included in their vendor-lists. This assessment is rather "weak" as it is often implemented on the basis of written evidence, and does not foresee on-site visits and direct inspections. A more incisive approach is to ask suppliers to periodically undergo an environmental audit or a life cycle analysis, carried out by the GSCM adopter or by a second-party auditor (e.g., a consultancy firm). This approach is particularly effective in assessing the compliance of the provider's operations with environmental criteria relating to the intermediate products supplied (e.g., the use of receipts and the application of consistent procedures and instructions), such as chemicals used as auxiliaries in water purification plants. This explains why, in our model, ASSUPL produces a significant effect also on the third dependent variable considered (WSTWATER).

3. GSCM as a managerial tool to improve competitive performance at the firm level

The last hypothesis to be tested by our model concerns the probability that GSCM practices affect the profitability of a firm, taken as a proxy for the more general concept of competitiveness. The results of our model identified a statistical relationship between both the assessment of suppliers' performance as well setting requirements for suppliers, and their effects on profits. However, this relationship is not strongly supported, and thus does not support the results of previous studies that emphasised a positive correlation between GSCM and firm profitability and competitiveness (see for instance: (Dodgson, 2000; Dyer and Singh, 1998; Rao and Holt, 2005)). Reasons for this can be numerous and of varied nature.

First of all, we have to consider that the concept of profitability is one of the stricter ways to measure the ultimate outcome of a competitive strategy. Many positive effects of environmental business strategies are able to affect more "intangible" assets that do not necessarily result in increased profitability in the short run. As emphasised above, most of the studies in the literature tend to associate positive competitive attributes to GSCM in terms of image

Table 5
Control variables.

Variable's abbreviation	Description	Equation
FACEMPL	Number of full-time employees	(1)–(3)
FRMQUOT	Firm listed on a stock exchange	(1)–(3)
FRMDEPT	Presence of an environmental department	(1)
PRIMECUST	Primary customers for facility's products (taking "other manufacturing firms" as a reference, wholesalers (1), households (2) and other facilities within the same firm (3))	(1)
MRKTSCP	Spatial scope of market where the firm competes (taking "national" as a reference, regional (neighbouring countries) (1) and global (2))	(1)
COUNTRY	Geographical location	(1), (2)
SECTOR	Sector of operation (textile, apparel and leather; wood and furniture; paper and publishing; refined petroleum, chemical and plastic products, non-metallic mineral products; basic and fabricated metals; machinery and equipment; transport; recycling)	(1)–(3)

Table 6
Results of binary probit models predicting GSCM adoption.

Dependent variable	Assess suppliers' environmental performance			Require suppliers to undertake environmental measures		
	Coefficient	dF/dx	Z	Coefficient	dF/dx	Z
CONSTANT	−2.643631		−10.31***	−2.460871		−9.41***
IMAGE	0.2782254	0.110	4.27***	0.2876007	0.106	4.24***
COST_SAVING	0.0106531	0.004	0.18	−0.0392304	−0.014	−0.65
PDT_DEVELOP	0.1740259	0.069	3.31***	0.2330522	0.086	4.34***
IMITATION	0.1581454	0.063	2.92***	0.1067157	0.039	1.97**
EMS	0.733767	0.286	9.69***	0.5806438	0.218	7.69***
EMPL	0.0001082	0.000	1.96*	0.0001252	0.001	2.29**
FRMQUOT	1339559	0.053	1.50	0.1579657	0.059	1.77*
FRMEDPT	0.2108082	0.083	2.60***	0.1640358	0.060	2.00**
PRIMCUST_1	0.0057982	0.002	0.07	0.0913004	0.034	1.15
PRIMCUST_2	−0.0285062	−0.011	−0.21	−0.0155529	0.006	0.12
PRIMCUST_3	0.0597996	0.024	0.37	0.0770148	0.029	0.47
MRKTSCP_1	0.148171	0.059	1.75*	0.2914954	0.109	3.34***
MRKTSCP_2	0.3016655	0.120	3.43***	0.288876	0.109	3.20***
USA	−0.0027758	−0.001	−0.02	−0.2066409	−0.074	−1.48
HUNGARY	0.6820586	0.265	4.68***	0.4296845	0.165	2.98***
GERMANY	0.3659147	0.145	2.77***	−0.2240597	0.099	1.99**
NORWAY	0.8309607	0.316	5.71***	−0.2240597	−0.080	−1.49
CANADA	0.1525581	−0.060	−1.00	−0.5169932	−0.172	−3.32***
Textile, apparel and leather sector	0.3514117	0.139	1.94*	0.1856968	0.070	1.01
Wood and furniture sector	0.4466544	0.176	2.70***	0.3078944	0.118	1.80*
Paper and publishing sector	0.5019121	0.197	3.10***	0.1342886	0.051	0.80
Refined petroleum, chemical and plastic products sector	0.3574832	0.142	2.51**	0.2362976	0.089	1.62
Non-metallic mineral products sector	−0.012234	−0.005	−0.06	0.1679852	0.064	0.86
Basic and fabricated metals sector	0.3098896	0.123	2.20**	0.2235845	.084	1.55
Machinery and equipment sector	0.3161104	0.125	2.31**	−0.0600002	−0.022	−0.42
Transport sector	0.0665653	0.026	0.38	0.4164557	0.161	2.36**
Recycling	0.3046741	0.121	1.07	0.2268221	0.087	0.80
Log likelihood	−969.55879			−938.36224		
Correctly classified	68.90%			71.32%		
Pseudo R2	0.1594			0.1394		

***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

and reputation (which are also some of the motives that induce GSCM adoption, see Welford (Welford, 1995)), but these attributes do not necessarily translate into an increase in profit. Our work focused on profitability, therefore, it is not able to confirm or falsify these possible links.

Another advantage that GSCM can produce in terms of the adopters' ability to compete is their ability to continuously innovate products and processes, thanks to their co-operation with other actors in the supply chain. This ability gives the GSCM adopter greater chances to respond in a timely manner to market

Table 7
Results of ordered probit models predicting environmental performance improvement.

Dependent Variable	Use of natural resources		Waste production		Wastewater effluent	
	Coefficient	Z	Coefficient	Z	Coefficient	Z
ASSSUPL	−0.1693152	−4.87***	−0.1305837	−2.99***	−0.1452298	−3.03***
REQSUPL	−0.218369	−3.87***	−0.3040862	−6.80***	−0.1473254	−3.14***
EMPL	−0.0000582	−2.74***	−0.0001136	−4.61***	−0.0000888	−3.81***
PRIMCUST_1	0.0104361	1.11	−0.0247384	−0.54	−0.0171586	−0.35
PRIMCUST_2	0.0343373	0.47	−0.0773613	−1.06	0.0115184	0.15
PRIMCUST_3	−0.1964745	2.04**	−0.1637287	−1.69	−0.0712367	−0.68
USA	−0.1359422	−1.49	−0.0696987	−0.76	0.1953857	2.01**
HUNGARY	−0.2668473	−3.11***	0.0909424	1.98**	0.4374788	4.37***
GERMANY	−0.2375469	−2.50**	0.1879604	1.05	0.2798683	3.06***
JAPAN	−0.0416307	−0.50	0.0604547	0.73	0.5258139	5.98***
NORWAY	−0.168913	−1.63	−0.123002	−1.19	0.3066083	2.74***
FRANCE	−0.3234288	−3.00***	0.2103308	1.97**	0.1211085	1.04
Textile, apparel and leather sector	−0.0060695	−0.06	−0.143243	−1.34	−0.0263082	−0.23
Wood and furniture sector	−0.0278303	−0.27	−0.3415228	−3.36***	0.0392327	0.35
Paper and publishing sector	−0.0531662	−0.58	−0.2281161	−2.47**	−0.2077221	−2.16**
Refined petroleum, chemical and plastic products sector	−0.0310184	−0.40	−0.1785974	−2.28**	−0.0122565	−0.15
Non-metallic mineral products sector	0.0482629	0.43	−0.1566236	−1.39	−0.1049704	−0.91
Basic and fabricated metals sector	0.0030841	0.04	−0.104935	−1.36	0.1246226	1.57
Machinery and equipment sector	0.0469973	0.64	−0.1507205	−2.03**	0.0158013	0.20
Transport sector	0.0798264	0.83	−0.1894684	−1.97**	−0.0148538	−0.15
Recycling	0.1834007	1.11	−0.2151554	−1.35	0.0298226	0.17

***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

Table 8
Results of ordered probit models predicting business performance improvement.

Dependent variable: business performance	Model 1		Model 2	
	Coefficient	*Z*	Coefficient	*Z*
ASSSUPL	0.0884696	2.46**		
REQSUPL			0.0705855	1.90*
EMPL	0.0000629	2.93**	0.000062	2.89**
FRMQUOT	0.2458692	5.04***	0.249693	5.09***
PRIMCUST_1	0.1288465	2.98**	0.1215465	2.80**
PRIMCUST_2	0.0622262	0.93	0.0564187	0.84
PRIMCUST_3	−0.0186896	−0.21	−0.0137928	−0.15
Textile, apparel and leather sector	−0.3686574	−3.84***	−0.3637219	−3.78***
Wood and furniture sector	−0.14864	−1.56	−0.1642878	−1.72*
Paper and publishing sector	0.1647071	−1.93*	−0.1616702	−1.89*
Refined petroleum, chemical and plastic products sector	0.1024422	1.37	0.0940245	1.25
Non-metallic mineral products sector	0.0004854	0.00	−0.0276496	−0.25
Basic and fabricated metals sector	−0.1186417	−1.65*	−0.1190874	−1.65
Machinery and equipment sector	−0.2154836	−3.08**	−0.2275135	−3.24**
Transport sector	−0.0217265	−0.24	−0.0399028	−0.24
Recycling sector	−0.0340339	−0.24	0.0086677	−0.24

***$p < 0.01$; **$p < 0.05$; and *$p < 0.1$

expectations concerning environmentally sound products, to anticipate the evolution of consumer preferences towards sustainability, to better satisfy intermediate customers interested in the environmental performance of the supplied products and services, etc… but it does not immediately yield profits.

More importantly, the decision to adopt GSCM practices does not necessarily produce a proportional payback in the market. This is especially true if we focus on sectors producing consumer goods. In these cases, profitability is tightly linked to the market response for "greener products", which is still weak in many countries, and to the possibility of applying a significant mark-up on production costs. The lack of payback in the short run is often linked to the fact that the costs connected with a "greener product" reflect into a higher price, which decreases the price-competitiveness on the market.

Last but not least, the problem of using "profitability" as an estimate for the whole concept of competitiveness is due to the fact that this variable is strongly influenced by financial aspects. This is an evident limitation of the model, because this particular way of measuring competitiveness by its ultimate outcome (besides not being able to fully capture all its facets) can be influenced by contingent "speculative bubbles" or crises of the financial markets. A confirmation of this can be found in our model by considering the very high *Z* value for the FRMQUOT dummy variable, indicating if the company (to which the sampled facility belongs) is listed on the stock market. (Table 8).

6. Conclusions

The analysis of the determinants and effects of GSCM proposed in our work provides some useful indications on how to improve its adoption and diffusion.

First of all, our findings confirm the main impulses that can effectively motivate a company to approach and develop GSCM. On the one hand, they are sparked by a leadership-oriented strategy in environmental management when a "front-runner" company needs to go beyond the boundaries of its facility (or production site) in order to carry out effective innovations or to build a stronger image for itself or its products/services. The main managerial implication stemming from this outcome of our work is the need to develop approaches and tools that can support and facilitate the extension of environmental management to supply chain relations. The set of strategic and operational levers to be implemented within a company for GSCM is today still rather poor and needs to be enriched in order to provide systematic managerial approaches. Interesting prospects for further research are to identify and analyze in-depth the tools and operational approaches that companies have informally implemented, and to assess what kind of strategy will lead to a greater level of adoption of GSCM.

On the other hand, GSCM is frequently adopted by "followers" as a strategic response to stimuli coming from customers and consumers, or to pressures deriving from the other more proactive actors of a supply-network, which have initiated a GSCM initiative. This has particular implications for SMEs since they are very often involved in supply chain networks and they need to respond in a timely manner to environment-targeted strategies by large partners (especially if they are customers). Future research should focus on the best available approaches that SMEs can undertake to face up to the "follower" challenges, such as the "environmental networking" within clusters of small suppliers and customers (as it already happens in the so-called "industrial districts", see for instance: (Daddi et al., 2010)).

Based on our findings, it appears that "cost-efficiency" is a very weak driver for GSCM. It is not a lever for these kinds of environmental management practices because, especially in the "start up" phase, the investments and the "sunk costs" largely prevail (especially for the first movers). This strengthens the needs for "easy-to-use" managerial approaches and tools for GSCM, emphasised above.

The most interesting result of our model concerns the role of EMSs as a "nest" in which GSCM can easily originate and effectively grow. The key to the development of GSCM practices, according to our findings, seems to be that of promoting the adoption of EMSs, also through the diffusion of the connected certifications schemes in order to facilitate and support their gradual extensions towards supply chain activities. We should emphasise that this is a key-issue for further research. The existing literature has mostly focused on the relationship between EMSs and GSCM as if they were separate managerial tools. Recent developments, both in the business strategies and in the standardisation field, are showing that they should increasingly be considered as an integrated approach.

Another insight emerges from our findings, with respect to the ability of GSCM to produce environmental improvement. We find that the more a company is able to involve its business partners in the development of co-operative environmental plans, the more it is able to achieve the expected results and improve its performance. The most significant consequence concerning green management strategies seems to be that a real "environmental quality" of a product or service cannot be guaranteed to the customer or to the final consumer if a company does not make efforts to stimulate and involve its suppliers (and partners operating in other phases of the product life cycle) in its improvement actions. As emphasised by the literature (Sinding, 2000), the GSCM is a necessary outcome of

the evolution in environmental management from "housekeeping" to product-related approaches (such as LCA), when a company really wants to gain an environmental and competitive advantage.

There are also some limitations to our study: we focus on just two GSCM practices, namely supplier assessment and supplier requirements; as well as the use of self-reported data. At a strategic level, GSCM includes other measures such as developing long-term relationships with the suppliers through collaboration, contribution to eco-design initiatives, supplier development programs, etc. Moreover, quantitative information should be used to verify the determinants and effects of GCSM at a later stage of adoption. Further research should take into account these limitations.

A final result of our work pertains to the latter aspect, i.e., the relationship between GSCM and competitiveness. In this case, the findings are much less positive than expected. Not only is GSCM a rather "expensive" approach, and often results in increased prices, it also seems incapable of yielding profits, at least in the short-medium run. Since GSCM cannot support competitiveness in the short run, GSCM should be seen as a long-term process, that takes time to be effectively applied within a company. There is unlikely to be a market response if the companies are not given the proper competitive instruments to value their efforts in GSCM. Further research will be valuable in identifying those marketing, communication, customer-management and retailing-channel management instruments that can really make all the market actors perceive the benefits and advantages of the environmental excellence of a whole supply chain behind a "green product".

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