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DETERMINANTS AND EFFECTS OF GREEN SUPPLY CHAIN MANAGEMENT (GSCM)

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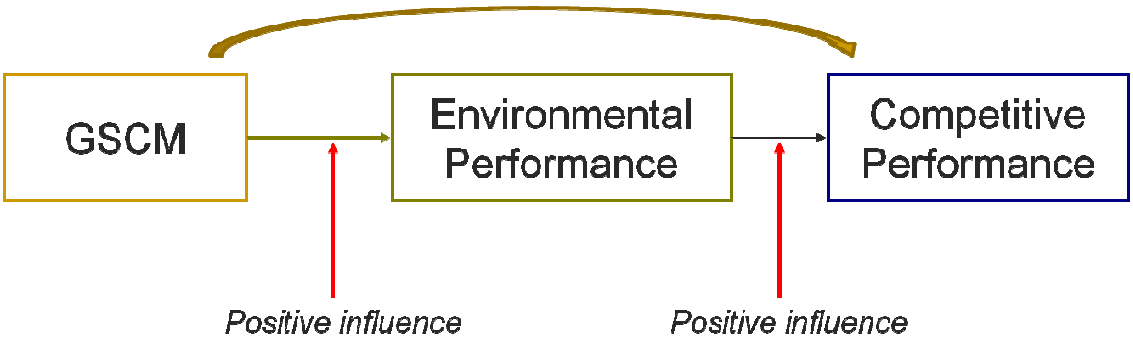
Introduction

Green Supply-Chain Management (GSCM) is an increasingly widely-diffused practice among companies that are pursuing environmental excellence. 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). Notwithstanding its growing diffusion and success, many factors are still hindering the adoption of GSCM by companies, especially SMEs. In the present article we carry out an analysis of GSCM benefits and costs, starting from the strategic drivers that encourage an organization to adopt it and then testing its effectiveness both from an environmental and economic perspective. According to the main findings in literature, we presume that GSCM is able to positively influence a company's environmental performance and, also owing to this, to effectively support its competitive strategies based on environmentally sound reputation (see Fig.1). Our work looks at the two typical actions that an organization can adopt for influencing the environmental performance of its suppliers and, as a consequence, indirectly also of its own production process or products: assessing their environmental performance and requesting that they undertake environmental measures.

Figure 1 The conceptual framework



Theory and hypotheses

The determinants of green supply chain management adoption at firm level

At the empirical level, several studies identified a wide range of factors that can persuade an organization to extend environmental management criteria and practices to its supply chain. This can be stimulated by customers' requests, induced by the need to guarantee a full compliance with more stringent environmental regulation, or even prompted by strategic motivations linked to the opportunity to get a competitive advantage on the market [1-3].

In the literature, the determinants of GSCM adoption can be basically distinguished between: "external factors", mostly linked to stakeholders' pressure; and, "internal factors", i.e. to 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 of these practices with customers and suppliers. With respect to "external factors", many authors focused, for instance, on the effects of institutional and regulatory pressure on an organization's decisions to adopt such practices [4, 5]. The "institutional" 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, while "regulatory" pressures arise from threats of noncompliance penalties and fines or from requirements to publicly disclose information concerning the organization environmental impacts [6].

On the other hand, "internal factors" can be defined as those strategic motivations that can encourage managers to adopt actions that aim at designing (or rationalizing), implementing and better managing business relations in the supply chain, and that are not spurred by external stimuli, and not even necessarily pursuing external objectives (e.g.: customer satisfaction or market penetration). Examples of "internal" factors driving GSCM-oriented actions are the following:

the engagement of inter-firm cooperation, aiming 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 [7];

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 because there is an expectation that the environmental risks associated with these vendors is lessened [8].

Supply chain-oriented environmental management is therefore developed by organizations not just as an *ad-hoc* operational response to external pressures, but can be a key-element of a business strategic vision, aimed at pursuing better environmental and commercial results (most of the times in a synergetic way).
Pursuing a better "competitive performance" can have different meanings and can be done in many ways. The three most diffused strategic approaches that are able to spring and favor the adoption GSCM practices by firms are the following:

1) *"reputation-led"*: to improve the environmental performance of the whole product life-cycle, e.g. by setting up a co-operative "green" logistic system involving suppliers to reduce transport emissions, and make the customers and consumers aware of this system, can significantly contribute in maintaining or creating a positive corporate image;

2) *"efficiency-led":* a supply chain-oriented business strategy can aim at reducing the use of raw materials per unit of product or the weight and thickness of the packaging thanks to innovative solutions, leading to cost savings and, therefore, enabling the company to supply a cost-competitive product to the market

3) *"innovation-led":* GSCM can be also seen as the result of an innovation leader's strategy. Those companies that are front-runners in developing product and process innovations, both from the technological and from the organizational points of view, can find in pioneristic GSCM-related practices an opportunity to strengthen their leadership and to create a gap with respect to their competitors. And vice-versa, by adopting GSCM practices, innovation leaders find new stimula for developing further innovation patters. For instance, Vachon and Klassen [9] found that resources were increasingly allocated towards pollution prevention when plants developed extensive strategic-level integration with suppliers, including environmental aspects linked to product development and knowledge sharing.

Even when they are not generated within one of the above-mentioned approaches, GSCM practices in some cases can be considered as an outcome of a "strategic" process. This happens when environmental "external factors" become such strong and comprehensive competitive pressures that

they inevitably induce the adoption of GSCM also by followers. The wide diffusion of GSCM practices in the last years, especially in specific industrial sectors (e.g.: food and beverages, textile, chemicals, etc.) encouraged many organizations to follow the strategy of the *first-movers*. in order to compensate their competitive disadvantage compared to the early-adopters of environmental practices in coordination with their suppliers. We can define this last case as an "imitation-led" approach.

In order to better understand the dynamics that are able to originate GSCM, we focused our analysis on "strategic determinants", i.e. 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 they are an integral part of a strategic process, even if this choice is merely determined by a "follower" strategy.. We analyzed what 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) brings a firm to adopt GSCM practices
H1c: A products and/or process development strategy (innovation-led) induces a firm to adopt GSCM practices
H1d: A "follower" strategy forces a firm to adopt GSCM practices

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. In particular, a shared vision among scholars and practitioners is that the "supply-chain dimension", as well as the so-called "life-cycle approach", are a necessary complement to environmental management systems. 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" (i.e.: responsibilities and tasks to correctly manage site-specific environmental aspects, including procedures and operational instructions, monitoring systems and training activities), today these companies are increasingly looking "beyond the boundaries" of their production process and organisation [10] towards the whole life-cycle of their products and services and, therefore and firstly, to their supply-chain.

In recent years, a wide experience in applying EMSs showed that these "tools" can be effective not only for the adopter to manage its own environmental aspects, but also as a wider approach, particularly useful in coping with the environmental impacts originating from the supply-chain relations and from the different phases of a product life-cycle [11]. An increasing number of researches and empirical studies tend to prove that "expanding" an EMS by way of a life-cycle approach has a great potential for "*inter-organisational environmental management*" [12], i.e. for an 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. The 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 [13].

By focusing their EMS on supply-.chain management, some organizations in recent years have begun relying on their suppliers to improve their environmental performance and were able to create value for themselves and for their customers [14]. For instance, IBM has designed a tool for monitoring and analyzing its products emissions throughout the life-cycle. This allows all the IBM business partners to adjust their operations and see how changes in packaging, transportation and inventory policies can affect CO_2 emissions. The aim of this tool is to quantify the trade-offs between carbon reductions and other factors affecting competitiveness (such as on-time delivery, packaging solutions, costs, etc.), share this awareness with its suppliers / customers and identify, develop and apply in co-operation with them the most sustainable and feasible solutions from both an environmental and an economic perspective.

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 [2].
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

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 face up to significant environmental challenges that cannot be tackled by relying on their own resources (technical, managerial or even economic ones), but call for the involvement of other actors that are co-responsible of their generation. The intensive use of raw materials and natural resources, the escalating production of waste caused by consumer goods and their packaging, the impacts connected with the transportation of intermediate and consumer goods to their final markets are only some examples of environmental aspects that cannot be improved without the active participation of suppliers, retailers, clients and even final consumers [15]. Therefore, the main objective of GSCM, as well as the main measure of its effectiveness, must be its capability of improving the environmental performance of those companies that adopt this approach and of their business partners.

This result has been ascertained by a large part of the literature, mostly on a case-to-.case basis. Just to mention an example, the global leader in the home furnishing, IKEA, is reported to have adopted a system to analyze and improve the environmental impact of its products, starting from the design phase. By implementing this system, IKEA asks its suppliers to undertake the commitment to apply a set of strategic and operational rules, included in the so-called "Code of Conduct IWAY", clustered in four level of performance. The aim is that 30% of suppliers achieve the fourth level of performance within the end of 2009, specifically by obtaining the FSC - Forest Stewardship Council - Certification.

Also Geffen and Rothenberg [16] 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, the interaction with

suppliers' staff, partnership agreements and innovation development leads to real and measurable improvements in environmental performance, maintaining production quality and cost goals.

Furthermore, in a case-study focused on the paper industry, Iraldo and Frey [17] demonstrated that improvement in environmental performance in the supply chain provided by an intensive inter-firm relation can be strongly facilitated by firms' proximity. There is other anecdotal evidence concerning the effectiveness of GSCM in improving environmental performance, while very few studies analyzed this relation by using quantitative approaches based on surveys. Among these, Zhu and Sarkis [18], by using analysing survey data from 186 respondents on GSCM practices in Chinese manufacturing enterprises, found that having higher level of adoption of GSCM practices (e.g.: environmental audit for suppliers' internal management, environmental requirements for purchased items, ISO 14001 certification, cooperation with suppliers and customers for environmental objectives) leads to better environmental performance. Moreover, a recent study carried out by Iraldo *et al*. [19], based on a sample of 100 interviewed organizations, found evidence of the effect of a proactive GSCM on environmental performance.
Our analysis aims at providing a further contribution to the scarce empirical evidence that is currently available in 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 supporting their suppliers to adopt environmental measures are able to obtain better environmental performance improvement

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

Economic benefits as "side-effects" of environmental improvement represent the most 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 [20].

In literature, the few empirical studies addressing the relation between environmental performance and competitiveness focused, almost exclusively, on the economic performance at the firm level. Evidence is not clear and univocal on this issue: some studies found a weak or a statistically non-significant relation between economic and environmental performance [21, 22], while other more recent studies achieved the opposite conclusion [19].

On the one hand, Levy [23], using data from several sources, emphasized that firms with more significant reductions in toxic emissions tended to have poorer financial performance - measured as "return on sales" and "return on equity and sales" -, although the relationship was not statistically significant. On the other hand, there is evidence to suggest that good environmental performance can help enterprises improve their commercial performance [24, 25]. For instance Al-Tuwaijiri *et al.* [26] demonstrate, by a simultaneous equation model, that good environmental performance is significantly associated with good commercial performance. Focusing on a particular environmental practice such as GSCM, many authors acknowledge that an effective supply chain- oriented management, not only generates environmental benefits, but significant business benefits as well.

Dodgson [27] and Dyer and Singh [28] 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 risks of delivering interruptions or delays

resulting from a critical supplier's compliance problem [29]. The adoption of GSCM practice can also protect the company's reputation from unlawful practices carried out by suppliers. Furthermore, specific procurement practices based on life-cycle costing can stimulate suppliers to develop environmental innovations, decreasing the operation costs and achieving significant input savings [14].

Beyond reducing risks and costs, GSCM practices can also provide strategic and competitive benefits: improvement of the brand's image, better relations with institutional stakeholders, increase of personnel motivation are possible effects of GSCM adoption described by the relevant literature.
More specifically, the relation between GSCM and competitiveness was investigated by very few empirical studies, that either generally analyzed the effects of a wider range of environmental management practices (including GSCM), or focused on limited geographical areas.
For instance, Welford [30] found that environmental protection activities such as GSCM are increasingly embedded in business operations and, thus, bring some benefits for firms as an improvement in reputation. In addition, Molina-Azorın [31] indicated that proactive environmental management such as GSCM has a positive relationship with an organization's performance on the market.

Those empirical studies concentrating on the competitive effects of GSCM adoption, manly focused on the South-East Asia Region where these practices seem to be more diffused. For instance, the already cited work of Zhu and Sarkis [18], relying on 186 respondents on GSCM practice in Chinese manufacturing enterprises, proves that the enterprises developing more GSCM practices have better competitive performance, Finally, the analysis carried out by Rao and Holt [32] identified that "greening" the different phases of the supply chain leads to a more integrated and co-operative supply-chain, which ultimately produces better competitive capabilities.

Our study aims at overcoming the limits of the existing empirical studies, by analysing in-depth 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

Empirical analysis

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 the 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 in six sections: the first section focuses on the management systems and tool adopted in the facility; the second and third sections investigate the adoption of environmental practices, the motivations of their adoption and the level of innovation and achieved performance; the fourth section aims at assessing the effect of environmental policy stringency on firm's decisions; the last two sections are aimed at collecting information on the characteristics of facility and firm.

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.

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 [33] reports an average response rate of 21%.

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%

A total of 4188 facility managers were interviewed by the survey. More than half sample consisted of medium enterprises (about 62%), the 32% were large enterprises, while just the 6% were small enterprises (see Figure 2 for details). Figure 3 shows the distribution of interviews between the 7 countries involved in the survey.

Figure 2 Organizations' dimension

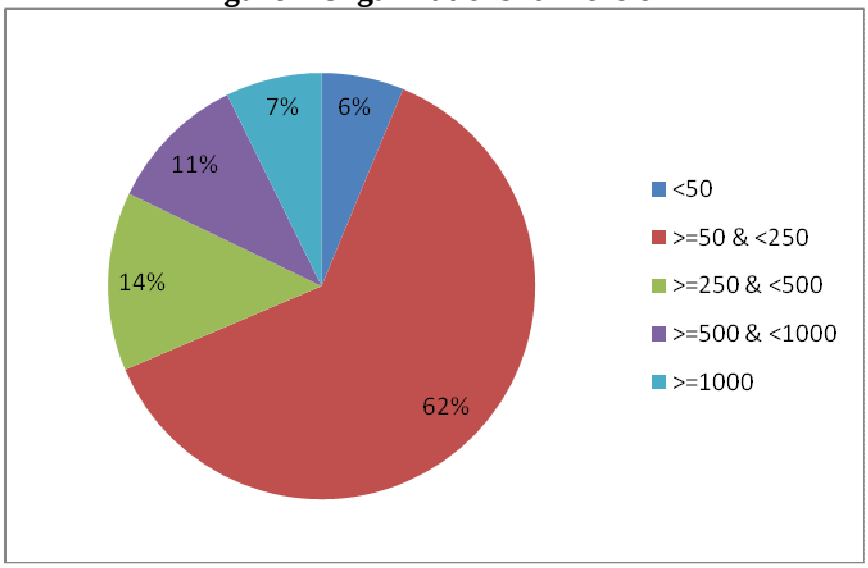
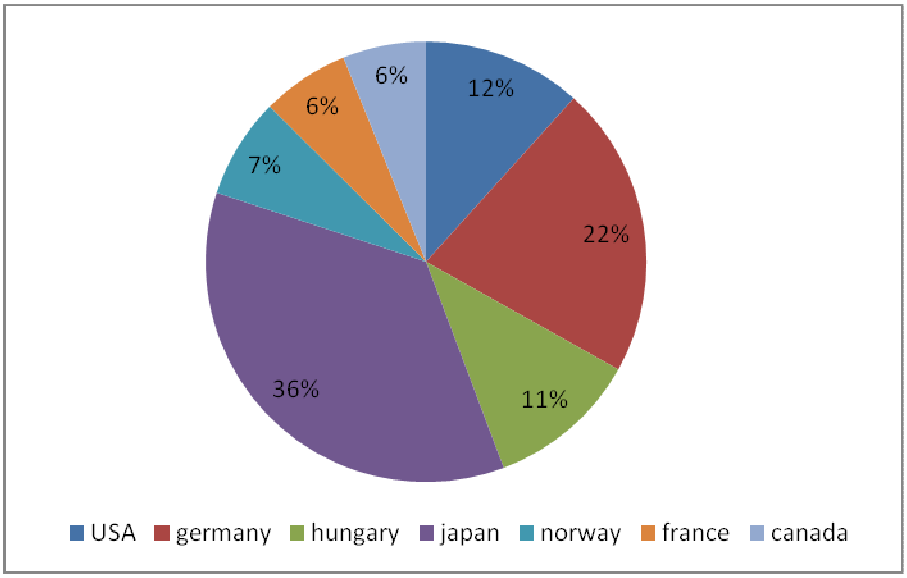


Figure 3 Geographical dimension



Since the data were collected using postal survey techniques, it is important to address their possible limitations. Two of the main standard drawbacks of survey data in general, 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 [2]. In order to limit the potential issue associated with this kind of bias, all respondents were guaranteed. Moreover our pre-test analysis of the survey did not find any indication of social desirability bias.

Furthermore, the survey is not affected by the bias due to the lack of generalizability, since it targeted several industrial sectors in multiple countries. OECD examined the general distribution of respondents (by considering industry representation and facility size) relative to the distribution of facilities in the broader population. It found no statistically significant differences [34].

Econometric Model

Having defined the theoretical model, we now propose the following equations as an empirical approach to the test four hypotheses of this study.

Equation N. 1

$$\begin{cases} ASSSUPL = \gamma_0 + \gamma_1 IMAGE + \gamma_2 COSTSAV + \gamma_3 PROD\_DEV + \gamma_4 IMITATION \\ + \gamma_5 EMS + \gamma_6 CONTROL + \varepsilon_1 \\ REGSUPL = \delta_0 + \delta_1 IMAGE + \delta_2 COSTSAV + \delta_3 PROD\_DEV + \delta_4 IMITATION \\ + \delta_5 EMS + \delta_6 CONTROL + \varepsilon_2 \end{cases} \quad (1)$$

Equation N. 2

$$\begin{cases} USERES = \phi_0 + \phi_1 ASSSUPL + \phi_2 REGSUPL + \phi_3 CONTROL + \varepsilon_3 \\ WSTPROD = \lambda_0 + \lambda_1 ASSSUPL + \lambda_2 REGSUPL + \lambda_3 CONTROL + \varepsilon_4 \\ WSTWATER = \omega_0 + \omega_1 ASSSUPL + \omega_2 REGSUPL + \omega_3 CONTROL + \varepsilon_5 \end{cases} \quad (2)$$

Equation N. 3

$$BUSSPERF = \alpha_0 + \beta_1 ASSSUPL + \beta_2 REGSUPL + \beta_3 CONTROL + \varepsilon_6 \quad (3)$$

Explanatory variables

In order to test Hypotheses 1 and 2, we utilized a binary probit model (Equation N. 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 he environmental performance of own suppliers?*" and "*does 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 well supported in the literature [see 18]

A set of binary variables was created to measure the strategic motivations of companies to adopt GSCM initiatives. Focusing on the strategic vision of a company on environmental excellence as a competitive factor (and not only specifically on GSCM adoption), we construct 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 surveys we used those that are 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 ones (EMS). The econometric model set out in Equation N.2 was used to verify whether the adoption of GSCM practices is really effective and, therefore it is able to improve the environmental performance of the adopters (Hypothesis 3).

According to Arimura *et. al* [35], in order to define facilities' environmental performance measures (i.e., the dependent variables in equation n.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 ideal to use quantitative data on environmental impacts, the use of self-reported data is not uncommon in the literature [see for instance 36-38].

With regard to the Equation n.3, we used an ordered probit model for testing 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 descriptive statistics for the study variables.

Table 2 Descriptive statistics

	Mean	Std.Dev.	Minimum	Maximum	NumCases
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

Exogenous Variables

Using information in the survey, we also constructed a set of exogenous variables that were expected to affect the GSCM adoption and/or environmental and competitive performance. These variables include some specific firm characteristics such as the number of employees in the facility (*FACEMPL*), whether the firm to which the facility belongs is listed 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. 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.

Another external factor is certainly the spatial scope of market where the firm competes (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.
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.

Results and discussion

The results of the model application carried out in our analysis provided some evidence relating to the Hypotheses described above.

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 analysed GSCM practices. On one hand, companies that are pursuing a better image on the market, 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 capability to provide guarantees concerning not only its own activities but also its network of business relations. A producer cannot achieve this objective without involving, or at least trying to keep under control, its partner-suppliers.

On the other hand, in many cases a company wishes to improve its reputation firstly within the circle of its business partners. Especially for a small producer that co-operates in a network of suppliers to a large company (a very diffused typology is the supply-chain of a retailer or a big assembler of components, such as in the automotive industry), the image and reputation perceived by the other suppliers operating in the same network is of paramount importance. Its competitiveness can depend, for instance, on the ability to keep up with the peace of the environmental innovations adopted by the other suppliers of the network, or to actively participate in environmental common programmes concerning the whole supply-chain (e.g.: reverse logistic, waste-packaging recovery, design for disassembling, etc.). Therefore, it is vital for this kinds of companies to learn to develop GSCM practices in order to gain a reputation in the eye of their (often larger) business partners.

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 both its partners and competitors. Especially if a company chooses to be a "follower" in its sector, it almost inevitably decides to adopt innovative practices only when they are tested and its effectiveness is experimented by a leader before. This happens in most cases with environmental innovations, the outcome of which is very uncertain, compared to an initial considerable investment. These "laggards" are also favoured by the fact that, when at a later stage they decide to start a co-operation with their partners in the supply-chain on environmental issues, they find many actors that are ready to collaborate, since most likely they were already involved before by the "first movers" and they benefitted from a "learning-by-doing" phase.

The results of our analysis also confirm that the "innovation-led" approach strongly influences GSCM practices adoption. This is a quite reasonable effect 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 olds true both for technological [38] and organisational "green" innovation [16]. A company, especially if it is an SME, has to rely on the possibility to share resources with other actors in the supply-chain in order to sustain the "sunk costs" of some crucial phases of the innovation process (e.g.: market intelligence, R&D, process engineering, etc.) and the financial resource flow needed for its implementation and maintenance. Beyond the cost-related issues, the "burden sharing" between companies (especially SMEs) operating in the same supply-chain is often the only way to

overcome the lack of know-how, technical skills and information sources that are essential to develop the environmental innovation. This is the reason why innovation-oriented companies are keener to adopt GSCM strategies.

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 this kind of "green" practices. This is very much consistent with the discussion proposed here 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 starts the co-operation and promotes GSCM), both in terms of customer- and supplier- relationship management and in terms of operational costs to carry out 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, even because the "payback" of GSCM practices (as all the other environmental management practices) is yielded only in the long run.

The findings of our work strongly support Hypothesis n. 2: there is a statistically very significant relation between EMSs and GSCM adoption and, analyzing the marginal effect, we can state that with no doubt the EMS adoption is the most incident factor for GSCM. Developing GSCM practices within the context of an EMS proves to be particularly effective. By extending the management system to the 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 one), for instance, the barriers and drawbacks for a supply-chain management, emphasised above, can be removed.

The synergies and mutual benefits between supply-chain management and EMSs is even more pronounced when it comes to implementing a structured management system according to ISO 14001 and EMAS. These third-party certification schemes stress the fact that, in order to be certified or registered, an organization has to demonstrate it correctly manages and continuously improves not only the "direct" environmental aspects (connected to the activities under its full management control), but also the so-called "indirect" ones [40].
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 3 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	.2782254	.110	4.27***	.2876007	.106	4.24***
COST_SAVING	.0106531	.004	0.18	-.0392304	-.014	-0.65
PDT_DEVELOP	.1740259	.069	3.31***	.2330522	.086	4.34***
IMITATION	.1581454	.063	2.92***	.1067157	.039	1.97**
EMS	.733767	.286	9.69***	.5806438	.218	7.69***
EMPL	.0001082	.000	1.96*	.0001252	.001	2.29**
FRMQUOT	1339559	.053	1.50	.1579657	.059	1.77*
FRMEDPT	.2108082	.083	2.60***	.1640358	.060	2.00**
PRIMCUST_2	.0057982	.002	0.07	.0913004	.034	1.15
PRIMCUST_3	-.0285062	-.011	-0.21	- .0155529	.006	0.12
PRIMCUST_4	.0597996	.024	0.37	.0770148	.029	0.47
MKTCONC_2	.148171	.059	1.75*	.2914954	.109	3.34***
MKTCONC_3	.3016655	.120	3.43***	.288876	.109	3.20***
USA	-.0027758	-.001	-0.02	-.2066409	-.074	-1.48
HUNGARY	.6820586	.265	4.68***	.4296845	.165	2.98***
GERMANY	.3659147	.145	2.77***	-.2240597	.099	1.99**
NORWAY	.8309607	.316	5.71***	-.2240597	-.080	-1.49
CANADA	.1525581	-.060	-1.00	-.5169932	-.172	-3.32***
Textile, apparel and leather sector	.3514117	.139	1.94*	.1856968	.070	1.01
Wood and furniture sector	.4466544	.176	2.70***	.3078944	.118	1.80*
Paper and publishing sector	.5019121	.197	3.10***	.1342886	.051	0.80
Refined petroleum, chemical and plastic products sector	.3574832	.142	2.51**	.2362976	.089	1.62
Non-metallic mineral products sector	-.012234	-.005	-0.06	.1679852	.064	0.86
Basic and fabricated metals sector	.3098896	.123	2.20**	.2235845	.084	1.55
Machinery and equipment sector	.3161104	.125	2.31**	-.0600002	-.022	-0.42
Transport sector	.0665653	.026	0.38	.4164557	.161	2.36**
Recycling	.3046741	.121	1.07	.2268221	.087	0.80
Log likelihood	-969.55879			-938.36224		
Correctly classified	68,90%			71,32%		
Pseudo R2	.1594			0.1394		

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

The results of the proposed model strongly supports Hypothesis n. 3, showing that the two GSCM actions considered have a strong effect in reducing the impact of the most common environmental aspects of an organization. Making specific requests to suppliers concerning the need to assure a given performance can enable a company to better manage its own environmental aspects. This is no surprise, if one considers that in most cases the way in which a company impacts the environment depends on productive choices and managerial modalities 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 employed as a primary production input has different environmental impacts according to the means by which it is generated by the supplier power plants. If a company chooses (as a part of its GSCM strategy) to buy electricity from a "renewables-oriented" provider, its use of resources drastically decreases. The same can be said, for example, if a company selects its suppliers of copy-paper or corrugated board for packaging according to environmental criteria and sets the requirement of 100% recycled material as an hurdle to entering its vendor-lists. When these kinds of requests by the GSCM adopter are standardized in a supply contract, the effect on environmental performance can be even more significant. As one could expect, waste production is the case in which this factor proves to be more effective (see Table 4). 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 a direct pressure and influence on the different suppliers and, therefore, to obtain positive results on the quantity (and quality) of waste produced.

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

Table 4 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	-.1693152	-4.87***	-.1305837	-2.99***	-.1452298	-3.03***
REQSUPL	-.218369	-3.87***	-.3040862	-6.80***	-.1473254	-3.14***
EMPL	-.0000582	-2.74***	-.0001136	-4.61***	-.0000888	-3.81***
PRIMCUST_2	.0104361	1.11	-.0247384	-0.54	-.0171586	-0.35
PRIMCUST_3	.0343373	0.47	-.0773613	-1.06	.0115184	0.15
PRIMCUST_4	-.1964745	2.04**	-.1637287	-1.69	-.0712367	-0.68
USA	-.1359422	-1.49	-.0696987	-0.76	.1953857	2.01**
HUNGARY	-.2668473	-3.11***	.0909424	1.98**	.4374788	4.37***
GERMANY	-.2375469	-2.50**	.1879604	1.05	.2798683	3.06***
JAPAN	-.0416307	-0.50	.0604547	0.73	.5258139	5.98***
NORWAY	-.168913	-1.63	-.123002	-1.19	.3066083	2.74***
FRANCE	-.3234288	-3.00***	.2103308	1.97**	.1211085	1.04
Textile, apparel and leather sector	-.0060695	-0.06	-.143243	-1.34	-.0263082	-0.23
Wood and furniture sector	-.0278303	-0.27	-.3415228	-3.36***	.0392327	0.35
Paper and publishing sector	-.0531662	-0.58	-.2281161	-2.47**	-.2077221	-2.16**
Refined petroleum, chemical and plastic products sector	-.0310184	-0.40	-.1785974	-2.28**	-.0122565	-0.15
Non-metallic mineral products sector	.0482629	0.43	-.1566236	-1.39	-.1049704	-0.91
Basic and fabricated metals sector	.0030841	0.04	-.104935	-1.36	.1246226	1.57
Machinery and equipment sector	.0469973	0.64	-.1507205	-2.03**	.0158013	0.20
Transport sector	.0798264	0.83	-.1894684	-1.97**	-.0148538	-0.15
Recycling	.1834007	1.11	-.2151554	-1.35	.0298226	0.17

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

The last hypothesis to be tested by our model concerned 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 relation between both the assessment of and setting requirements for suppliers and possible effects on profits, but this relation is not strongly supported (as signaled by the Z value). Reasons for this can be numerous and of a different 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 the environmental business strategies are able to affect other and more "intangible" competitive assets, not necessarily resulting in increased profitability. As emphasized above, most of the studies in literature tend to associate positive competitive attributes to GSCM in terms of image and reputation (which is also one of the motives that induces GSCM adoption), but these attributes do not necessarily translate into an increase in profit. Another advantage that GSCM can produce in terms of capability to compete by the adopters is the ability to continuously innovate products and processes, thanks to the tight co-operation with other actors of the supply-chain. This ability gives the GSCM adopter better chances of timely responding to market expectations concerning environmentally sound products, anticipating the evolution of consumer preferences towards sustainability, better satisfying intermediate customers interested in the environmental performance of the supplied products and services, etc… but does not immediately yield profit. Also in this case, it is difficult to capture the competitive benefits in terms of profitability especially in the short-medium run, when the company has to invest money and time (while the return on this investment is expected to emerge in the long run).

Secondly, we have to acknowledge that environmental excellence (as reflected in the choice of adopting GSCM practices) does not necessarily produce a proportioned payback on the market. This is especially true if we focus on sectors producing consumer goods: in these cases, profitability is strictly linked to the market response for "greener products", that is still weak in many countries, and to the possibility of applying a significant mark-up on production costs (which include the supply-chain management sunk costs and investments, emphasized above).

Last but not least, a problem in using "profitability" as an estimate for the whole concept of competitiveness is due to the fact that this variable is strongly influence by financial aspects. This is a strong 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 5 Results of ordered probit models predicting business performance improvement

Dependent Variable: Business Performance	**Model 1**		**Model 2**	
	Coefficient	**Z**	**Coefficient**	**Z**
ASSSUPL	.0884696	2.46**		
REQSUPL			.0705855	1.90*
EMPL	.0000629	2.93**	.000062	2.89**
FRMQUOT	.2458692	5.04***	.249693	5.09***
PRIMCUST_2	.1288465	2.98**	.1215465	2.80**
PRIMCUST_3	.0622262	0.93	. 0564187	0.84
PRIMCUST_4	-.0186896	-0.21	-.0137928	-0.15
Textile, apparel and leather sector	-.3686574	-3.84***	-.3637219	-3.78***
Wood and furniture sector	-.14864	-1.56	-.1642878	-1.72*
Paper and publishing sector	.1647071	-1.93*	-.1616702	-1.89*
Refined petroleum, chemical and plastic products sector	.1024422	1.37	.0940245	1.25
Non-metallic mineral products sector	.0004854	0.00	-.0276496	-0.25
Basic and fabricated metals sector	-.1186417	-1.65 *	-.1190874	-1.65
Machinery and equipment sector	-.2154836	-3.08 **	-.2275135	-3.24**
Transport sector	-.0217265	-0.24	-.0399028	-0.24
Recycling	-.0340339	-0.24	.0086677	-0.24

Conclusions

The analysis of the determinants and effects of GSCM proposed in our work provides some useful indications to improve the adoption and diffusion of such practice. First of all, our findings confirm the main impulses that can effectively motivate a company to approach and develop GSCM. On one hand, they are naturally sparkled 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. In these cases, the company needs to rely on the relations and co-operative opportunities offered by its supply-chain, in order to strengthen the credibility and effectiveness of its actions. On the other hand, GSCM is frequently adopted by "followers" as an inevitable strategic response to stimula coming from customers and consumers, or to pressures deriving from the other more proactive actors of a supply-network, that already decided to start up a GSCM initiative.

Basing on our findings, it appears that "cost-efficiency" is a very weak driver for GSCM. This is not a lever for developing this kind of environmental management practices because, especially in the "start up" phase, the investments and the "sunk costs" largely prevail, especially for the first movers.

The most interesting result of our model concerns the role of EMSs as a "nest" in which GSCM can easily originate and more effectively grow. The key to the development of GSCM practice, 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 the supply-chain activities. GSCM reveals all its power and effectiveness when the relations with the partners operating in the supply-chain are progressively included as an integral part of the EMS and are managed by means of the foreseen tools (i.e.: the components of the "plan-do-check and act" approach).

Another confirmation emerges from our findings, with respect to the capacity of GSCM to produce environmental improvement. The most common environmental impacts of industrial companies can (and are) ameliorated by making suppliers and customers actively participate in the programs and actions that a company sets to this aim. We can therefore deduct 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 to improve its performance.

A final result of our work pertains the relationship between GSCM (and environmental management practices at large) and competitiveness. In this case, the findings are much less positive than expected. Not only GSCM is a rather "expensive" approach to be implemented by a company, but it also seems incapable of yielding profits, at least in the short-medium run. Even if this result does not mean that GSCM cannot support competitiveness (since there are other ways to do this, that we did not measure), a final and crucial indication stemming from our work is the need to work on the "market-response" for initiatives like GSCM (and for environmental excellence in more general terms), in such a way to foster the profitability of these strategies and to stimulate companies to increasingly adopt them.

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