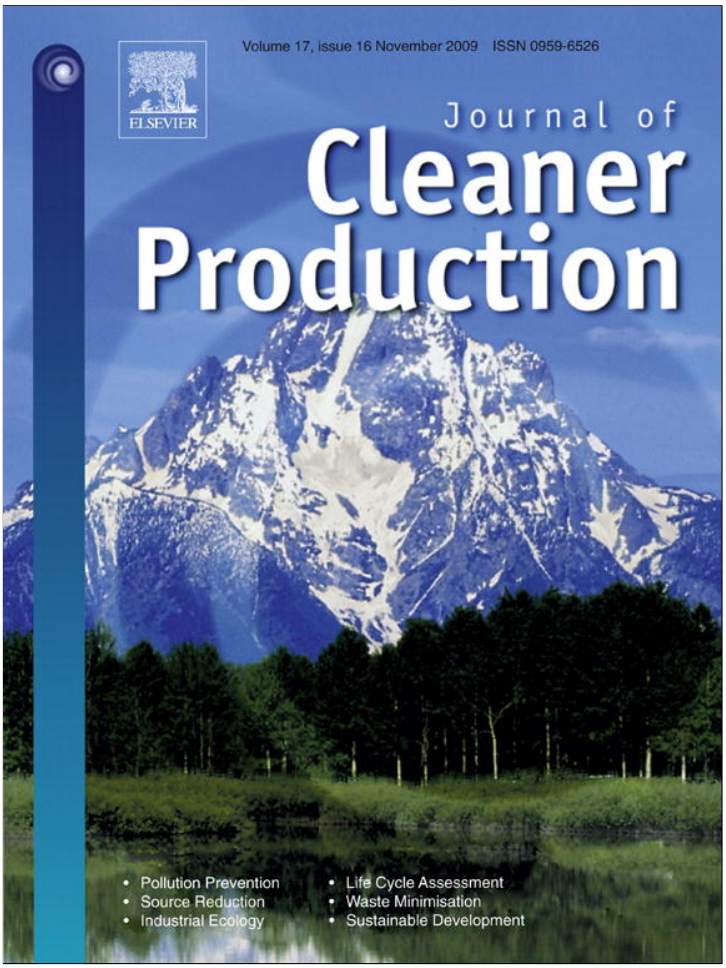

Journal of Cleaner Production 17 (2009) 1444–1452

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Is an environmental management system able to influence environmental and competitive performance? The case of the eco-management and audit scheme (EMAS) in the European union

Fabio Iraldo [a,b], Francesco Testa [a,*], Marco Frey [a,b]

[a] The Sant'Anna School of Advanced Studies, Piazza Martiri della Libertà 33, 56127 Pisa, Italy
[b] IEFE – Institute for Environmental and Energy Policy and Economics, Bocconi University, Milan, Italy

ARTICLE INFO

Article history:
Received 11 December 2008
Received in revised form
21 May 2009
Accepted 31 May 2009
Available online 9 June 2009

Keywords:
Environmental management system
EMAS
Environmental performance
Competitiveness

ABSTRACT

The EMAS Regulation (Reg 761/01 EC) is EU scheme implemented by the European Commission since 1993 and it is for the implementation of an Environmental Management System (EMS) by any organization. The EMS was originally proposed by the European Commission and by the ISO as the frontrunner of a series of policy tools that enable companies to simultaneously pursue environmental objectives and competitive targets in a synergetic way.

Based on the unique dataset of the EVER project, this paper investigates whether or not an EMS implemented within the EMAS Regulation has any effect on firm performance both from an environmental and a competitive point of view. Our econometric analysis shows the positive impact of a well-designed environmental management system on environmental performance and, as a consequence, on technical and organizational innovations. Effects on other competitive variables such as market performance, resource productivity and intangible assets are not strongly supported.

1. Introduction

The Environmental Management System (EMS) is an increasingly diffused tool among organizations operating in different sectors, thanks to the drive and impulse from voluntary certification schemes such as EMAS and ISO 14001. These schemes provide a third-party guarantee of environmental "excellence", which is able to give an advantaged position (with respect to their competitors) to those organizations that, by adopting EMAS or ISO 14001, commit themselves to improve the environmental performance.

This article departs from the starting point of these three basic principles and tries to demonstrate the link between (a) EMAS, one of the most diffused and credible environmental voluntary certification schemes, (b) the environmental performance that it can provide as a result of its management system implementation and (c) the advantages that EMAS-registered organizations can have when facing their competitors in the market arena.

Extensive theoretical and empirical research on the benefits of EMS has been carried out to date. Most of the empirical research analyzed the effect of formal and informal EMSs on environmental and economic performances, focusing on best practices and case studies [1–3] or using descriptive analysis of samples [1,4,5] of firms. These approaches provided very useful evidence and indications to practitioners for implementing effective EMSs, but do not provide sufficient proofs to generalize their findings and, therefore, to understand if a managerial tool, such as the EMS, is really able to guarantee environmental and competitive improvements.

Moreover, the evidences emerging from these studies are not always univocal. Most of them, based on best practices, found that formal EMS implementation, such as ISO 14001 or EMAS, provide benefits on environmental and economic performances [1,3–5], but other studies revealed that the proclaimed benefits are sometimes very far from being quantifiable or even really perceived [6].

In order to overcome the limits of the abovementioned studies, according with the recent literature on EMSs [7–10], we applied econometrical tools for testing the effects of EMAS adoption on environmental and competitive performance using a representative sample of firms.

More specifically, our work is a two-step model that aims at identifying and evaluating the positive influence connecting EMAS to competitive performance. The first step aims at testing if EMAS and, more in general, an Environmental Management System, are really able to produce an improvement in environmental

* Corresponding author. The Sant'Anna School of Advanced Studies, Piazza Martiri della Libertà 33, 56127 Pisa, Italy. Tel.: +39050883829.
E-mail address: f.testa@sssup.it (F. Testa).

0959-6526/$ – see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jclepro.2009.05.013

performance as perceived by the organization. The second step aims at investigating if and how this performance, especially when strengthened by a third-party registration such as EMAS, can really give an organization better position on the four most important competitive leverages: innovation, marketing, productivity and intangible assets (Fig. 1).

2. Theory and hypothesis

2.1. Using EMAS as a managerial tool to improve the environmental performance of a firm

The adoption and use of environmental management systems by companies have awaken a considerable interest in scholars and researchers in the recent years, especially when considering the increased popularity and diffusion of EU and international standards such as EMAS and ISO 14001.

With regards to the effects of EMS on the overall environmental performance, a substantial amount of evidence has been collected. We report some of the most recent and interesting evidence, emerged by studies that used an econometrical approach.

By examining a sample of 7899 facilities drawn from the population of US manufacturing facilities from the years 1995–2001, King et al. [11] found evidence that EMS adoption results in improved environmental performance, measured as a logarithm of the toxicity-weighted sum of all Toxic Release Inventory. In another study using Japanese facility-level self-reported data from an OECD survey, Arimura et al. [9] estimated the positive effects of ISO 14001 on three environmental impact improvements.

Yet, a small amount of contrasting evidence has also been collected. Findings have emerged from other studies that formal EMSs (e.g.: ISO 14001 and EMAS) do not substantially affect a firm's environmental performance [12,13]. One of the most significant empirical studies used a panel data of 37 pulp and paper plants in Quebec over the period 1997–2003 which identified no meaningful evidence of reductions in pollution after obtaining ISO 14001 certification [8].

Whether or not an EMS proves to be beneficial, can strongly depend on time. It must be taken into consideration that an organization will need time to adapt an EMS to its specificities. That is, in order to obtain effective operation and achieve positive results in terms of environmental improvement, an organization must set objectives and plan managerial activities and technological investments. A structured EMS, as defined by the ISO 14001 standard and the EMAS Regulation, is a part of the overall management system which include organizational structure, planning activities, responsibilities, practices, procedures, processes and resources. Consequently, all of these elements must work together in order to guarantee the continuous improvement of environmental performance. This inevitably brings about changes in a firm's managerial and operational structure. These widely agreed-upon considerations may give rise to the simple argument that formal EMS implementation (e.g.: according to EMAS Regulation) needs time to generate positive effects on environmental performance. Our analysis aims to provide empirical evidence of the positive relations between the maturity of a certified EMS and environmental performance improvement.

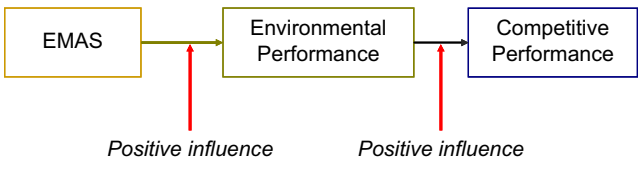

Fig. 1. The conceptual framework.

Hypothesis 1: organizations with a mature and certified EMS (i.e.: EMAS registered) have better environmental performance than those without.

2.2. Environmental planning and EMS

The application of an EMS scheme may not be a sufficient condition to guarantee improvements in an organization's environmental performance. In order to render it an effective tool, a "new philosophy" must permeate all the hierarchical levels in the organization that adopts an EMS: from the upper management to operational personnel.

First, this new philosophy rests on the capability to identify and analyze the critical elements of management, define adequate *corrective actions* and carrying out effectively what is planned. The planning concept includes all these elements, representing, in fact, the first step of the so-called "Deming cycle" (PDCA Plan–Do–Check–Act) and, therefore, a cornerstone of an EMS.

When we look at the concept of "planning", we should interpret it in an extended way: planning means organizing resources and defining the ways for their utilization, setting up the innovative operational activities and developing the relations with stakeholders or anything else effecting the firm's environmental performance. In other words, a firm's "planning capabilities" is a crucial factor for implementing a really effective EMS [14].

The adoption of more innovative activities or tools, which is often correlated to EMS adoption, can be interpreted as an evidence of planning capabilities and, consequently as a way to strengthen the effectiveness of an EMS.

For instance, in a study on Italian facilities between the years 1994 and 1997, evidence emerged that with the implementation of specific environmental management tools such as compensation schemes and award schemes, SO_x and NO_x pollution rates strongly improved [15]. In similar studies, Arimura et al. [9] and Annandale et al. [16] demonstrated the positive effect of the publication of environmental reports on environmental performance at firm level. Publishing environmental reports enhances communication between a firm and its stakeholders (e.g.: employees, shareholders, financial institutions, investors, consumers, environmental NGOs, governments, and local residents) and improves its corporate image [9]. This transparency shows a high level of awareness and involvement of an organization towards environmental management approach and, as a result, towards the effectiveness of the EMS itself.

Moreover the level of competence and awareness of personnel performing tasks which might have a significant environmental impact is a key-indicator of an effective planning capability within an EMS [17]. Both ISO 14001 and EMAS schemes provide thorough descriptions of environmental training activities: "The organization shall identify training needs with its environmental aspects and its environmental management system; it shall provide training or other action to meet these needs" [18]. In their analysis of Mexican manufacturing facilities, Dasgupta et al. [19] found that environmental training to non-environmental workers as well as environmental specialists resulted in positive effects on self-reported degree of compliance.

As mentioned above, previous studies have investigated only in an indirect way the effectiveness of "planning" (and of the whole EMS), meanwhile our study focuses directly on the organization's planning capability and, more specifically, on the way in which it can influence the EMS effectiveness. The ability of an organization to achieve its environmental targets strongly depends on its ability to pursue the continual improvement of the environmental

performance by effectively planning the organizational activities, the economic investments and the technological measures that are needed to achieve it.

Hypothesis 2: organizations that are able to plan effectively their environmental targets have better environmental performance improvement.

2.3. Green supply chain management and EMS

EMAS, differently from other EMS standards, stresses the fact that, in order to be registered, an organization has to manage and improve not only direct environmental aspects, but also "indirect" ones [20]. The EMAS Regulation defines an indirect environmental aspect *as an element of an organization's activities, products or services that has or can have an impact on the environment and which can result from the interaction of an organization with third parties and which can to a reasonable degree be influenced by an organization* [21]. The role of the third-party (usually an "intermediate" actor such as a supplier or a contractor) with whom the organization shares management control (or whom it can influence), is therefore crucial in guarantying the improvement of the environmental performance relating to indirect aspects.

Indirect environmental aspects may include, for example: product-related issues (design, Research & Development, packaging, transportation, use and waste recovery/disposal), capital investments, granting loans and insurance services; choice and composition of services (e.g.: transport or the catering trade), product range compositions and the environmental performance and practices of contractors, subcontractors and suppliers.

By focusing their EMS on the supply chain management, some organizations in recent years have begun relying on their suppliers to improve their environmental performance and create value for themselves and their customers [22].

Generally, the most common Green Supply Chain Management (GSCM) practices consist in assessing the environmental performance of suppliers, in requiring suppliers to undertake measures that ensure the environmental quality of their products or in evaluating the cost of waste in their operating systems [20]. The relationship between EMS and GSCM practices has potentially complementary and significant 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 sustainability among organizations networks [23].

The positive effect of GSCM practices on environmental performance is relatively supported by empirical evidence. Geffen and Rothenberg [24] analyzed three case studies of US assembly plants and stated that strong partnerships with suppliers, supported by appropriate incentive systems, help the adoption and development of innovative environmental technologies. In addition to this, interaction with suppliers' staff, partnership agreements and innovation development lead to improvements in environmental performance, maintaining production quality and cost goals. The improvement in environmental performance provided by intensive inter-firm relations could be facilitated by firms proximity [25]. Using empirical results from 186 respondents on GSCM practice in Chinese manufacturing enterprises, Zhu and Sarkis [26] found that a higher level of adoption of GSCM practices (environmental audit for suppliers' internal management, environmental requirements for purchased items, ISO 14001 certification, cooperation with suppliers and customers for environmental objectives) leads to higher environmental performance improvement.

Our analysis intends to provide a further contribution to empirical evidence already existing in literature on positive relations between encouraging suppliers to adopt environmental measures and environmental performance improvement.

Hypothesis 3: organizations which encourage their suppliers to adopt environmental measures have better environmental performance improvement.

2.4. EMAS as a managerial tool for improving competitive performance at firm level

The economic literature provides different perspectives and theories on the relationship between environmental policies and corporate environmental performance on the one hand and, on their effects on firms' competitive performance, on the other. The debate in the last fifteen years over a wide range of theoretical questions investigates *whether, under what circumstances* and *how exactly* environmental issues are related to competitiveness. Summarizing, we can identify three major theoretical approaches in the literature.

The "traditionalist" view of neoclassical environmental economics argues that the purpose of environmental regulation is to correct negative externalities, and that, consequently, environmental regulation (internalising the costs of the negative externality) corrects a market failure, while burdening companies with additional costs. Firms complying with regulation (by increasing expenditures in environmental protection) face higher production costs and reduce the management time devoted to pursuing other tasks. This is deemed to have effects on the competitiveness at firm and sectoral level [27–29].

As opposed to the neoclassical perspective, a "revisionist" view states that improved environmental performance is a potential source of competitive advantage, as it can lead to more efficient processes, improvements in productivity, lower costs of compliance and new market opportunities [30–32].

A third and more recent interpretation of the impact of environmental policies on competitiveness is proposed by the so-called "Resource-based view" approach. According to this approach, the competitiveness of companies and industries depends on the quality and quantity of the resources available and by the ability of companies/industries to optimise them [33]. This approach is an evolution of the Porter approach, as it enlarges the typologies of resources that the companies and industries can rely on.

According to this revisionist view, environmental regulation is mainly considered to be "an industrial policy instrument aimed at increasing the competitiveness of firms; the underlying rationale for this statement being that *well-designed* environmental regulation could force firms to seek innovations that would turn out to be both privately and socially profitable" [31].

An abundant literature analyzes the *forms of regulation* as well as the *design of environmental policy instruments* for their impact on innovation and competitiveness [34,35]. Economists have traditionally placed environmental policy instruments into two categories: those providing firms with relatively less flexibility (e.g.: Command & Control instruments) and those providing firms with incentives to look for more effective ways of achieving the environmental objective.

EMSs, and in particular the EMAS Regulation, belong to the second category (the so-called "soft instruments") based on a voluntary approach, negotiation and shared responsibility of the actors involved.

The general impression deriving from the analysis of the evidence emerging from previous studies is that EMS adoption, and in particular certified EMS, is actually able to exert a positive influence on competitiveness, even if the effective relevance in supporting it is not certain.

For instance, with reference to the direct effects of EMAS adoption on competitiveness, a recent European study [7] investigated the impact of its different characteristics on technical environmental innovations and economic performances in Germany, by analyzing data from a unique dataset of EMAS-registered sites. The study identified a weak relationship between EMAS and some indicators of market success. However, a positive impact on the increase of turnover and exports is found, especially when a company is able to achieve significant learning by adopting EMAS. Hence, the authors concluded that a better linkage between environmental management and innovation management could improve competitiveness.

On the other hand, the findings emerging from literature that show a positive relation between EMS, or certified EMS and competitiveness, are mainly anecdotal and just few empirical research found generalizable results [36].

The fact is that simply adopting EMS, even if in compliance with a *third part designed* standard, such as ISO 14001 or EMAS, does not *per se* assure an improvement in competitive performance. The relation is neither direct nor "automatic", but depends on the effects of the EMS on the organization environmental performance. In other words, if only an EMS achieves the aim for which it was designed, or the continuous improvement of environmental performances, a positive effect on firm competitiveness could be attained.

Following this conceptual framework, we therefore argue that EMAS represents an effective tool in improving organization's environmental performance and, only as a consequence, its competitiveness.

The few empirical studies addressing the relation between environmental performance and competitiveness focused, mainly, on the economic performance at firm level. The evidence is very mixed on this subject: some studies found a weak or a non-statistically significant relation between economic and environmental performances, while other studies reached the opposite conclusion.

For example, Jaggi and Freedman [37], by analyzing data from American pulp and paper plants, investigated the association between water pollution and economic and market performances. Using the Pearson correlation test for three different time periods, the study provides weak evidence that firms with good pollution performance are not being viewed positively by the market because of the negative association between pollution and economic performances in the short period. The results show that market performances indicate that the price–earnings ratio is negatively associated with pollution performance over a short period of time.

Similar findings emerge from the study carried out by Levy [38]. Using data from several sources, Levy found 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 contrary, there is also evidence to suggest that good environmental performance can help enterprises get better economic result. Hart and Ahuja [39] report that efforts to prevent pollution and reduce emissions drop to the "bottom line" (ROS, ROA, ROE) within 1–2 years of initiation: operating performance (e.g.: resource productivity or savings leading to efficiency) is benefited in the following year, while at least 2 years are needed before financial performance is affected. Klassen and McLaughlin [40] used the "financial event methodology" to prove the positive link between environmental and financial performances. Also Al-Tuwaijiri et al. [41] demonstrate, by a simultaneous equation model, that good environmental performance is significantly associated with good economic performance.

In our study, as we aforementioned, we focus on EMAS and on its capability to improve the environmental performance of registered organizations and, consequently, their competitiveness on the market. The aim is to gain insights on how the environmental performance improvements enable the EMAS-registered organizations to obtain positive feedbacks from the final consumer or the intermediate client. In order to measure the competitive performance at firm level, we refer to the conventional variables used in the literature, such as market shares [28], increase of sale and turnover [38], innovation [42], image and customer satisfaction [43], etc. Hence, some dimensions are closely linked to the market (e.g.: market shares and sales) or to internal efficiency (resource productivity), while others refer to "immaterial" and non-quantifiable assets (e.g.: image, customer satisfaction, innovation), being nevertheless crucial for the overall competitive performance of organizations.

Hypothesis 4: EMAS-registered organizations with higher environmental performance have better competitive performance

3. Empirical analysis

3.1. Data description

In order to evaluate the abovementioned hypotheses, we rely on data collected within the EVER study (*Evaluation of EMAS and Ecolabel for their Revision*) carried out by a consortium of universities, research institutes and consultants coordinated by IEFE (the Institute for Energy and Environmental Policy and Economics of the "Bocconi" University in Milan, Italy) on behalf of the European Commission – DG Environment. The aim of the EVER study [44] was to provide recommendations to the European Commission for the second revision of the Eco-Management and Audit Scheme. The results of the study, especially those related to the effects of EMAS on environmental performance and competitiveness, have been considered by the European Commission and by the Member States as a milestone on which to ground the revision process (the study is cited in the Explanatory Memorandum of the new Regulation proposal – see Ref. [21] for details).

Data were collected between spring and summer 2005 by way of interviews ("on-site" and by telephone), based upon a standard questionnaire. The questionnaire is composed of approximately 40 questions distributed in four sections: the first section focuses on the organization characteristics, the second investigates the adoption of environmental practices and their effects on environmental performance, the third section identifies the barriers for EMAS adoption and the last section evaluates the effects of these instruments on the adopters' competitive performance.

Moreover, the standard questionnaire was adapted, in a modular way, to several different typologies of interviewees, according to their specificities. In particular, the interviewed subjects were EMAS stakeholders, EMAS adopters, EMAS no-adopters and EMAS public institutions. Some of the questions were, indeed, reformulated to investigate specific aspects relating to each typology of interviewee, and others are identical, in order to guarantee a certain comparability between different typologies.

In our analysis, we take into account just the results of interviews with EMAS adopters and no-adopters, which constitute a sub-sample of 101 observations.

The EMAS adopters were selected by random sampling (from EMAS registered private organizations population) according to the following criteria:

- representative territorial distribution;
- representative distribution according to organization's size;
- representative distribution according to the type of organization.

In order to determine the statistic relevance of the sample, a distribution of binomial probability for the population was assumed and a value for the standard error was fixed. As the variance is unknown, the most disadvantaged case was considered (i.e.: the value that maximizes the function (p), and that therefore corresponds to $p = 0.5$) and a level of confidence equal to 95% was settled.

At the moment of the composition of the sample[1], the population was constituted by 3072 EMAS adopters, while the selected sample counts 70 private organizations.

On the other hand, the sample of EMAS not adopters is constituted by 31 organizations and was selected with the same criteria as the EMAS adopters.

At statistical level, if a sample of firms is selected using an adequate sample method, it can be considered representative of the population of firms and therefore the conclusion obtained by the analysis can be generalized, keeping in mind the degree of error, determined by the sampling method.

The combined sample – EMAS adopters and not adopters – is used to test the Hypotheses 1–3. While Hypothesis 4 was evaluated considering only the EMAS adopters sample (56 observations after cleaning up the missing values). The main characteristics of the sampled organizations are summarized in Table 1.

Since the data from the EVER study were collected using survey techniques, it is important to address the limitations of the survey data. 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 they consider socially desirable [6]. In order to limit the potential issue associated with this kind of bias, all respondents were guaranteed anonymity and the interviewers were adequately trained to inform them to be objective. Moreover our pre-test analysis of the survey did not find any indication of social desirability bias.

Furthermore, the EVER survey was not affected by the bias due to the lack of generalizability, since it targeted industrial and service sectors in several European countries. This approach differs from typical research survey examining organizations' environmental practices, which focus on a single industry within a single country [10].

3.2. Econometric model

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

$$\begin{aligned}\text{ENVPER} &= \alpha_0 + \beta_1\text{EMASAGE} + \beta_2\text{ENVTARGET} + \beta_3\text{GSCM} \\ &\quad + \beta_4\text{SIZE} + \beta_5\text{SECTOR} + \varepsilon_1 \end{aligned} \tag{1}$$

$$\begin{cases} \text{MKTPERF} = \gamma_0 + \gamma_1\text{ENVPERFORMANCE} + \gamma_2\text{EMASAGE} + \varepsilon_2 \\ \text{INNOVPERF} = \delta_0 + \delta_1\text{ENVPERFORMANCE} + \delta_2\text{EMASAGE} + \varepsilon_3 \\ \text{RESEFF} = \phi_0 + \phi_1\text{ENVPERFORMANCE} + \phi_2\text{EMASAGE} + \varepsilon_4 \\ \text{INTASS} = \lambda_0 + \lambda_1\text{ENVPERFORMANCE} + \lambda_2\text{EMASAGE} + \varepsilon_5 \end{cases} \tag{2}$$

With regards to testing Hypotheses 1–3, we utilize a binary probit model (equation (1)). At this stage, we test whether EMAS maturity and specific indicators of environmental practices increase the probability of improving environmental performance. To construct an organization's environmental performance rating (i.e. the dependent variable in equation (1)) we use the EVER survey question "*How has the environmental performance of your organization changed in recent years?*". Although it would be ideal to use quantitative data on environmental impacts, the use of self-reported data is not uncommon in related literature [see for instance Refs. [8,16,45,46]].

Table 1
Samples' description.

		Total	EMAS adopter
Regional distribution	Baltic	14	8
	Mediterranean	35	24
	Central	39	30
	Atlantic	13	8
Organization size	Small organizations	25	19
	Medium organizations	35	28
	Large organizations	41	23
Sector of activity	Manufacturing	47	36
	Other industrial sectors	24	13
	Service sectors	30	21

The explanatory variables for the binary probit model include different characteristics of EMS, especially regarding maturity and effectiveness. Similar to Rennings et al. [7], EMAS maturity was measured considering the age of registration (EMASAGE). A binary variable measuring the ability of an organization to attain its environmental targets (ENVTARGET) was constructed using the survey question "*Does your organization attain its targets for environmental improvement?*". In order to evaluate the relationship between encouraging suppliers to adopt environmental measures and environmental performance improvement, a binary variable (GSCM) was created on the basis of the survey question *"Do you support your suppliers to adopt environmental measures?"*.

Moreover, other survey information such as the size of the organization and sector of activities used as a set of exogenous variables are expected to affect both environmental performance and the adoption and effectiveness of voluntary practices.

The econometric model shown by equation (2) is used to verify whether EMAS-registered organizations with higher environmental performance also have better competitive performance (Hypothesis 4). Given that competitive performance might be achieved by relying on several competitive factors, a multivariate regression was used to estimate the simultaneous effects of the predictors variable on the different measures of competitiveness.

The basic assumptions for utilizing a multivariate regression are that the outcome variables shall be normally distributed and at least moderately correlated. The Shapiro–Wilk test was applied to verify the normal distribution of outcome variables.

According to the abovementioned literature, we have constructed four variables to measure competitiveness: market performance (MKTPERF), innovation capability (INNOVPERF), resource efficiency (RESEFF) and intangible assets (INTASS).

For each variable, we used two questions regarding the competitive advantages perceived by the organizations registered according to EMAS. The respondents were asked to rate the level of perceived benefits on a five-point Likert scale where, 1 = very low and 5 = very high.

Then, as Ambec et al. [35], we derived the variables by using a linear combination of specific answers to selected questions (see Table 2 for details).

All the variables are moderately correlated and the relation is highly significant (see Table 3). The same approach used for the dependent variables is applied to measure the improvement of an organization's environmental performance (ENVPERFORMANCE).

[1] On 31st January 2005.

Table 2
Dependent and explanatory variables for competitive and environmental performance (multivariate regression model).

Variable	Questions
MKTPERF	*By participating in EMAS, has your organization obtained higher customer satisfaction?* *By participating in EMAS, has your organization obtained an increase in market share?*
INNOVPERF	*By participating in EMAS, has your organization improved its technical innovation capability?* *By participating in EMAS, has your organization improved its capability to innovate organizational and/or managerial structure?*
RESEFF	*By participating in EMAS, has your organization experienced cost savings through the decrease in resource use, reuse or recycling?* *By participating in EMAS, has your organization experienced cost savings through waste reduction?*
INTASS	*By participating in EMAS, has your organization achieved greater motivation and participation of employees?* *By participating in EMAS, has your organization perceived an improved image and reputation?*
ENVPERFORMANCE	*How has the environmental performance of your organization changed in recent years?* *How does the environmental performance of your organization compare to other organizations in your sector?*

Finally, to capture the influence of EMAS maturity on competitive performance, the variable EMASAGE is considered in the model as a set of binary variables.

The Table 4 provides descriptive statistics for the study's variables.

4. Results

The results of the model application carried out in our analysis provide some evidence for the hypotheses described above.

First of all, the model seems to support Hypothesis 1, i.e. the number of years the EMS has been adopted has a positive effect on the level of environmental performance perceived by the organization itself. But, even if this relation is positive, we have to acknowledge that the effect of the age of the EMS is not very high (see the dF/dx value). This implies that the influence exerted in time by the EMS on the capability to improve environmental performance is counterbalanced by other factors. On one hand, organizations identify a strong stimulus towards a higher environmental performance in the EMAS main requirement to pursue the so-called "continuous improvement". Moreover, a "learning by doing" effect is detectable in the EMAS registered organizations, increasing year by year their ability to implement the EMS, to optimise the improvement opportunities and to maximise the cost-effectiveness of the money they invest in environmental improvement. On the opposite hand, some significant counter-effects hindering the capacity to positively affect environmental performance may emerge over time, as the EMS matures. Many organizations emphasised the problems of the increasing marginal cost of pollution abatement, as well as the difficulties in spotting new improvement margins and opportunities every year for their industrial sites, plants or corporate activities [44].

Table 3
Correlation matrix.

	MKTPERF	INNOVPERF	INTPER	RESPROD
MKTPERF	1.00			
INNOVPERF	0.40[a]	1.00		
INTASS	0.46[a]	0.58[a]	1.00	
RESEFF	0.41[a]	0.61[a]	0.60[a]	1.00

[a] $p < 0.001$.

Table 4
Descriptive statistics.

Variable	Observations	Mean	Std. dev.
1st MODEL			
ENVPERF	101	0.4554455	0.5004948
EMASAGE	101	3.485149	3.354441
ENVTARGET	101	0.8514851	0.3573832
GSCM	101	0.6732673	0.4713578
SMALLSIZE	101	0.2475248	0.4337267
MEDSIZE	101	0.3465347	0.4782393
LARGSIZE	101	0.4059406	0.4935224
MANIFACT.	101	0.4653465	0.5012855
OTHERIND	101	0.2376238	0.4277503
SERVICE	101	0.2970297	0.4592288
2nd MODEL			
MKTPERF	56	6.589286	2.535399
INNOVPERF	56	6.678571	2.240999
RESPROD	56	7.678571	1.820161
INTPER	56	6.589286	2.755337
ENVPERFOR	56	8.464286	1.159377
EMASAGE	56	4.5	2.879394

Among the independent variables that are included in the model, the ability to carry out effective planning and to achieve foreseen targets seem to have the strongest impact on environmental performance. Hypothesis 2, i.e. the existence of a positive influence of target-definition and successful planning on environmental performance, is fully confirmed by the results we achieved. In this case, the intensity of the detected impact is high (see the dF/dx value) and 95% significance is provided by the model. The most important indication emerging from this result concerns the organizations' approach in implementing their EMSs. The organizations involved in the EMAS scheme clearly showed different attitudes when considering their EMS. The two opposites being a "certificate-oriented" approach (to obtain EMAS registration and preserving it as a reputational tool) and a more "strategic" approach, aiming at using the EMS to guarantee legal compliance and gradually improving the environmental efficiency of corporate activities [44]. It is rather clear, from our results, that the more an organization considers its EMS as an integral part of its whole management system and includes the environmental targets and programmes in the day-to-day operational planning activities, the more it is able to effectively achieve a higher environmental performance.

On the contrary, the "certificate-oriented" approach, basically aimed at guaranteeing that the EMAS requirements are fulfilled in order to obtain the registration, proved to be rather ineffective. If an organization believes that renewing EMAS registration is enough to uphold its reputation over time, and it does not rely on real resource mobilisation and efficient planning, the effects on environmental performance will be poor.

The outcomes of the model application weakly support Hypothesis 3. Organizations that make an effort to correctly manage the environmental aspects in their supply-chain do not necessarily perform better in absolute terms. The effect of a proactive Green Supply Chain Management, as measured by the model, on environmental performance is positive and not negligible, but the low significance value shows that the relationship between the two variables is not statistically supported by our empirical evidence. This might be due to a relative immaturity in the GSCM tools available, as well as in their development and actual application by the interested companies.

Despite more than 50% of the surveyed organizations are adopting tools and methods to support the actors operating in their value-chain (mostly suppliers, but also service providers,

Table 5
Results of binary probit model predicting environmental performance improvement.

Dependent variable Environmental performance	Coefficient	d*F*/d*x*	Std. *err*	*p* value
CONSTANT	−1.6531		0.5397193	–[a]
EMASAGE	0.1003	0.0396	0.0444161	–[b]
ENVTARGET	0.8679	0.3054	0.4235474	–[b]
GSCM	0.5594	0.2142	0.3236967	–[c]
SMALLSIZE	0.3929	0.1456	0.3710019	
LARGSIZE	0.9274	0.3566	0.332258	–[a]
MANIFACT.	−0.6101	−0.2366	0.3814459	
SERVICE	−0.4903	−0.1881	0.5397193	
Log likelihood	−59.333511			
Correctly classified	68.32%			
Pseudo R2	0.1476			

[a] $p < 0.01$.
[b] $p < 0.05$.
[c] $p < 0.1$.

customers and retailing partners), the interviews and case-studies carried out in the EVER study clearly show that these strategies are still lagging behind with respect to many other areas of supply-chain management, especially by industrial firms [44].

What is virtually missing from our empirical evidence is the adoption of "front-running" supply-chain management activities which are being developed in other business areas, such as: product co-design strategies, common innovation patterns (e.g.: "learning by interacting" with the technology providers) or joint marketing campaigns, applied to environmental issues. This is a sign that the GSCM is still not very diffused among organizations and, consequently, is not able to provide effective stimuli to improve overall environmental performance, at least in a perceivable and measurable way. Such a situation might be due to the slow uptake of the so-called "indirect environmental aspects", foreseen both by EMAS and ISO 14001. It is widely recognised that these aspects are often undermined and/or not identified, assessed and managed in an effective way by the organizations adopting an EMS. Quite interestingly, the draft proposal of the new EMAS regulation (the so-called EMAS III) will strongly emphasise the need to further develop the managerial and technical issues of indirect aspects (especially those concerning the supply chain) [21].

Final evidence emerging from our analysis refers to the relative importance of an organization's size as an exogenous variable. In particular, the large size of an organization applying an EMS proves to be a strong determinant of its good environmental performance, as perceived in the survey. This is consistent with most part of the literature on EMS-related issues, which generally identifies barriers and drawbacks for smaller companies, owing to a wide range of factors (e.g.: lack of resources, low degree of competence and know-how, cultural gap, organisational lag, etc.). It is quite interesting to note that our analysis shows that these barriers are also preventing SMEs to achieve a better environmental performance, once they are able to implement an EMS and to eventually obtain a certification/registration (Table 5).

The second step of our model application tested Hypothesis 4, i.e. that EMAS-registered organizations with higher environmental performance have better competitive performance. Some conclusions can be drawn from the results of the multivariate regression model reported in Table 6.

Only one of the equations provides statistically significant evidence for this relationship. In fact, equation (2) proves that EMAS organizations that are perceived as better performing from an environmental viewpoint are also able to improve their innovation capabilities as a key competitive factor. If we compare this result with the first step of our model, the reasons for this are easily understandable. Since environmental performance is positively linked to the age of the EMS and the extent of investment planning and resources, then we can argue that this can produce a higher innovative-orientation in the organization, together with a "cumulating" know-how and an increased technical ability to sustain innovation patterns. In other words, the more the organization invests in environmental innovation, the more it is capable of developing new technologies and organizational solutions, and to manage them effectively. This makes it possible to improve the competitive factors based on innovation.

The outcome of our analysis does not allow us to elaborate definite conclusions regarding the other equations. The results are too weak to identify any relation between environmental performance and any of the other variables involved such as market performance, intangible assets and resource productivity.

In particular, as emphasised by many authors [14,22], an EMAS-registered organization very seldom obtains positive feedbacks directly from the market (final consumers or intermediate customers). This does not allow to get an undisputable advantage over competitors thanks to EMAS registration. The same can be said with reference to intangible assets, both of an internal and an external nature. The benefits that can be experienced as to employee motivations, human capital or better organizational roles and responsibilities are not easily measurable and, therefore, many

Table 6
Results of multivariate regression model predicting competitive performance of EMAS-registered organization.

Independent Variable	Equation 1		Equation 2		Equation 3		Equation 4	
	Market performance		Innovation capabilities		Intangible assets		Resource productivity	
	Coefficient	*Std. err*	*Coefficient*	*Std. err*	*Coefficient*	*Std. err*	*Coefficient*	*Std. err*
CONSTANT	0.3960108[b]	2.663971	−0.7299709	2.163735	3.565903[c]	1.871218	−0.1891199	2.805155
ENVPERFOR	0.6388674[c]	0.3108502	0.6388674[a]	0.3108502	0.4364561[c]	0.2183465	0.6087822[c]	0.3273246
EMASAGE-2	2.29305	1.33194	2.012019[c]	1.081831	1.342447	0.9355774	2.718862[c]	1.40253
EMASAGE-3	0.2192499	1.18934	0.2771291	0.9660079	−0.2446053	0.8354127	1.772241	1.252372
EMASAGE-4	0.4136974	1.192238	2.460737[b]	0.9683618	1.121615	0.8374484	2.256701[c]	1.255424
EMASAGE-5	0.9097297	1.334115	2.183173[c]	1.083597	1.680574[c]	0.9371049	2.953593[b]	1.40482
EMASAGE-6	0.5652767	1.329762	2.069071[c]	1.080062	−0.5448439	0.9340474	0.7971058	1.400236
EMASAGE-7	2.10973	1.334115	2.183173[c]	1.083597	0.2805737	0.9371049	1.953593	1.40482
EMASAGE-8	2.160675	1.922084	2.369391	1.561158	2.160675	1.350104	5.123253[b]	2.02395
EMASAGE-9	−0.4013642	1.376886	1.211378	1.118337	−0.0685912	0.9671483	1.866567	1.449858
EMASAGE-10	2.187516	1.62923	1.297275	1.323296	−0.1606754	1.144399	3767467	1.715575
R-squared	0.2058		0.3293		0.2397		0.2543	

[a] $p < 0.01$.
[b] $p < 0.05$.
[c] $p < 0.1$.

EMAS organizations tend to underestimate (or to ignore) them. The relationship with external stakeholders is linked to the effectiveness of EMAS as a communication tool, which emerged from the EVER study as one of the weakest point in the current Regulation [for more details see Ref. [44]].

Even if the model provides uncertain indications as to these three equations, a last interesting result must be mentioned.

Most of the studies and researches on EMAS implementation by companies pointed out that the competitive advantages of EMAS registration are perceived by adopters only in the long run [14,47]. Moreover, some studies emphasise that there is a strong relation between the extent to which these advantages are perceived and the degree of EMS implementation (i.e.: proportional to the experience in time) [7,10]. On the basis of these considerations, we implicitly tested another hypothesis in our model: the age of the EMAS-registered EMS (as an exogenous variable) can influence the way in which the organizations perceive the benefits from a competitive point of view. As it clearly emerges from Table 6, this hypothesis is falsified by the empirical evidence collected in the EVER study, since there is no explicit correlation in any of the equations of the model. It does not seem to be a matter of time if a company perceives competitive benefits linked to their environmental performance or not.

5. Conclusions

The EMSs, in spite of their application in many years, have not yet achieved a high degree of "maturity" in their implementation. Moreover, they are not fully integrated in those corporate management dynamics (e.g.: R&D, supply chain management, etc.) that would enable an organization to effectively exploit its operational tools and instruments. This is particularly clear with respect to "supply chain management" and its effect on an organizations' performance and on their abilities of valorizing the certification towards the market and the stakeholders.

For other aspects, the EMSs seem to be implemented in a more comprehensive and effective way by EMAS-registered organizations. For instance, environmental planning capabilities are usually stronger and better "rooted" in the EMAS-registered organization and, consequently, they are able to generate positive effects on environmental performance. This confirms that an actual performance improvement can be achieved only when those elements of an EMS which can be fully integrated in the management dynamics of a firm start to work effectively [14].

Another important result emerged from our study concerning the role of EMAS in improving the competitive performance of the registered organizations. Today, the effects on competitiveness are a top-priority issue for the research agenda of many institutions and still a very debated issue. The European Commission, for example, has recently funded a study to focus on costs and benefits of EMAS adoption for SMEs (and on their main determinants), in order to fill the gap of evidence on this aspects.[2] From our study it emerges that, with no doubt, the implementation of an EMS according to EMAS requirements provides a powerful impulse for an organization's innovation capabilities [7], but our work also clearly emphasises that simply adopting EMAS is not a sufficient condition. The outcome of our model application shows, in fact, that only if an organization obtains a real environmental performance improvement by way of its EMS, then it can achieve better innovation capabilities. Moreover, the EMS "maturity" is not a determinant *per se* of competitive performances (even if it has a positive effect on environmental performance improvement). To this end, it is the extent to which an EMS permeates into the organizational structure that it can strongly influence competitiveness. This implies that also a "young" EMS, if well-designed and implemented (as well as adequately supported by investments), can provide considerable competitive benefits.

With reference to other competitive performances, our study shows that a positive effect of a well-implemented EMS (complying with EMAS) on resource productivity, market performance and intangible asset is not strongly supported by the statistical analysis. Our sample size is certainly a relevant constraint of the analysis, but it is not the only reason. The competitive advantages linked to EMAS as well as to ISO 14001 adoption, are still scarcely perceived by the adopters also because EMAS and ISO 14001 are not properly designed to provide them. This is particularly true for market performance and intangible assets, as corporate reputation (we can mention, for example, the relevant constraints in the use of the EMAS logo for competitive purposes).

In order to improve the use of EMAS and ISO 14001 as competitive tools, on one hand, registered organizations should strengthen their external communication within the EMS and the policy makers should support the market potentials of these certification schemes, by increasing the awareness of customers and citizens on their environmental guarantees (e.g.: through public communication campaigns). It is particularly appreciable that the draft proposal of the new EMAS III Regulation presented by the European Commission is heading in this direction.

[2] Contract No ENV.G.2/ETU/2008/0084R; Object of the contract: Costs and benefits of EMAS-registered organizations.

Acknowledgements

We appreciate the helpful insights and suggestions provided by Chiara Seghieri and Michela Natilli.

References

[1] Fresner J, Engelhardt G. Experiences with integrated management systems for two small companies in Austria. Journal of Cleaner Production 2004;12:623–31.
[2] Hillary R. Environmental management systems and the smaller enterprise. Journal of Cleaner Production 2004;12:763–77.
[3] Newbold J. Chile's environmental momentum: ISO 14001 and the large-scale mining industry e Case studies from the state and private sector. Journal of Cleaner Production 2006;14:248–61.
[4] Zenga SX, Tamb CM, Tamb VWY, Dengb ZM. Towards implementation of ISO 14001 environmental management systems in selected industries in China. Journal of Cleaner Production 2005;13:645–56.
[5] Radonjic G, Tominc P. The role of environmental management system on introduction of new technologies in the metal and chemical/paper/plastics industries. Journal of Cleaner Production 2007;15:1482–93.
[6] Ghisellinia A, Thurston DL. Decision traps in ISO 14001 implementation process: case study results from Illinois certified companies. Journal of Cleaner Production 2005;13:763–77.
[7] Rennings K, Ziegler A, Ankele K, Hoffmann E. The influence of different characteristics of the EU environmental management and auditing scheme on technical environmental innovations and economic performance. Ecological Economics 2006;57:45–59.
[8] Barla P. ISO 14001 certification and environmental performance in Quebec's pulp and paper industry. Journal of Environmental Economics and Management 2007;53:291–306.
[9] Arimura T, Hibiki A, Katayama H. Is a voluntary approach an effective environmental policy instrument? A case for environmental management systems. Journal of Environmental Economics and Management 2008;55:281–95.
[10] Darnall N, Henriques I, Sadorsky P. Do environmental management systems improve business performance in an international setting? Journal of International Management 2008;14:364–76.
[11] King A, Lenox M, Terlaak A. The strategic use of decentralized institutions: exploring certification with the ISO 14001 management standard. Academy of Management Journal 2005;48:1091–106.
[12] Dahlstrom K, Howes C, Leinster O, Skea J. Environmental management systems and company performance: assessing the case for extending risk-based regulation. European Environment 2003;13:187–203.
[13] Andrews RNL, Amaral D, Keiner S, Darnall N, Gallagher DR, Edwards JD, et al. Environmental management systems: do they improve performance? Project

Final Report for US EPA, Office of Water and Office of Policy. Economics and Innovation. Available form: http://www.cota.vt.edu/ 2003.
[14] Biondi V, Frey M, Iraldo F. Environmental management systems and SMEs: barriers, opportunities and constraints. Greener Management International 2000;29.
[15] Siniscalco D, Borghini S, Fantini M, Ranghieri F. The response of companies to information-based environmental policies. FEEM Working Paper Milan 2000.
[16] Annandale D, Morrison-Saunders A, Bouma G. The impact of voluntary environmental protection instruments on company environmental performance. Business Strategy and the Environment 2004;13:1–12.
[17] Ferreira AJD, Lopes MAR, Morais JPF. Environmental management and audit schemes implementation as an educational tool for sustainability. Journal of Cleaner Production 2006;14:973–82.
[18] European Commission. Commission Regulation (EC) No. 196/2006 of 3 February 2006 amending Annex I to Regulation (EC) No 761/2001 of the European Parliament and of the Council to take account of the European Standard EN ISO 14001:2004, and repealing Decision 97/265/EC. Brussels: European Community; 2006 (OJEC, 4-02-2006, L 32/1).
[19] Dasgupta S, Hettige H, Wheeler D. What improves environmental performance? Evidence from Mexican industry. Journal of Environmental Economics and Management 2000;39:39–66.
[20] Handfield R, Walton S, Sroufe R, Melnyk S. Applying environmental criteria to supplier assessment: a study in the application of the analytical hierarchy process. European Journal of Operational Research 2002;141:70–87.
[21] European Commission. Proposal for a regulation of the European Parliament and of the council on the voluntary participation by organizations in a community eco-management and audit scheme (EMAS). Brussels: European Community; 2008 (COM 402/2).
[22] Carnimeo G, Frey M, Iraldo F. Integrated product policy at the company level: how to create synergy between the product dimension and the environmental management system. Milano: FrancoAngeli; 2002 (published only in Italian).
[23] Darnall N, Jason Jolley G, Handfield R. Environmental management systems and green Supply chain management: complements for sustainability? Business Strategy and the Environment 2008;18:30–45.
[24] Geffen C, Rothenberg S. Suppliers and environmental innovation: the automotive paint process. International Journal of Operations and Production Management 2000;20:166–86.
[25] Iraldo F, Frey M. A cluster-based approach for the application of EMAS Working Paper M&I 03, M & I Laboratory Sant'Anna School of Advanced Study; 2007.
[26] Zhu Q, Sarkis J. Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises. Journal of Operations Management 2004;22:265–89.
[27] Gollop FM, Roberts MJ. Environmental regulations and productivity growth: the case of fossil-fuelled electric power generation. Journal of Political Economy 1983;91:654–74.
[28] Gray W, Shadbegian R. Plant vintage, technology, and environmental regulation. Journal of Environmental Economics and Management 2003;46:384–402.
[29] Ederington J, Minier J. Is environmental policy a secondary trade barrier? An empirical analysis. Canadian Journal of Economics 2003;36(1):137–54.
[30] Gabel LH, Sinclair-Dresgagné B. Managerial incentives and environmental compliance. Journal of Environmental Economics and Management 1993;24:940–55.
[31] Sinclair-Dresgagné B. Remarks on environmental regulation, firm behaviour and innovation, Scientific Series 99s-20, Montreal, Cirano; 1999.
[32] Porter ME, van der Linde C. Toward a new conception of the environment competitiveness relationship. Journal of Economic Perspectives 1995;9:97–118.
[33] Fouts PA, Russo MV. A resource-based perspective on corporate environmental performance and profitability. The Academy of Management Journal 1997;40:534–59.
[34] Andersen MS, Sprenger RU. Market-based instruments for environmental management — politics and institutions. Cheltenham, UK: Edward Elgar Publishing; 2000.
[35] Ambec S, Johnstone N, Lanoie P, Laurent-Lucchetti J. Environmental policy, innovation and performance: new insights on the Porter hypothesis, Working Paper GAEL.07, Laboratoire d'Economie Appliquée de Grenoble; 2007.
[36] Clausen J, Keil M, Jungwirth M. The state of EMAS in the EU: eco-management as a tool for sustainable development – final report for european commission. Brussels: European Community; 2002.
[37] Jaggi B, Freedman M. An examination of the impact of pollution performance on economic and market performance: pulp and paper firms. Journal of Business Finance & Accounting 1992;19:697–713.
[38] Levy DL. The environmental practices and performance of trasnational corporations. Trasnational Corporations 1995;4:44–67.
[39] Hart SL, Ahuja G. Does it pay to be green? An empirical examination of the relationship between emission reduction and firm performance. Business Strategy and the Environment 1996;5:30–7.
[40] Klassen RD, McLaughlin CP. The impact of environmental management on firm performance. *Management Science* 42 1996:1199–214.
[41] Al-Tuwaijri S, Christensen T, Hughes K. The relations among environmental disclosure, environmental performance, and economic performance: a simultaneous equations approach. Accounting, Organizations and Society 2004;29:447–71.
[42] Jaffe AB, Palmer K. Environmental regulation and innovation: a panel data study, the review of economics and statistics, vol. 79. MIT Press; 1997. p. 610–619.
[43] Hall R. The strategic analysis of intangible resources. Strategic Management Journal 1992;13:135–44.
[44] IEFE Bocconi, Adelphi Consult, IOEW, SPRU e Valor & Tinge. EVER: evaluation of eco-label and EMAS for their revision – research findings, Final report to the European Commission – Part I-II, DG Environment European Community; Brussels; 2006, available from www.europa.eu.int/comm/environment/emas.
[45] Henriques I, Sadorsky P. The adoption of environmental management practices in a transition economy. Comparative Economic Studies 2006;48:641–61.
[46] Khalid A, Babakri KA, Bennett RA, Rao S, Franchetti M. Recycling performance of firms before and after adoption of the ISO 14001 standard. Journal of Cleaner Production 2004;12:633–7.
[47] Hillary R. Evaluation of study reports on the barriers, opportunities and drivers for small and medium sized enterprises – the adoption of environmental management systems Report for DTI Envirodoctorate 5th October, 1999, NEMA, London; 1999.