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The management of greenhouse gas emissions and its effects on firm performance

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ABSTRACT

Climate change is a reality and the dramatic reduction of greenhouse gas (GHG) emissions by developed countries is a moral obligation. It represents also a unique opportunity to modernize the economy and to improve the competitiveness of firms. The purpose of this study is to analyze how greater consideration to the impact of their activities on the environment, as well as the control and reduction of CO_2 emissions can improve the economic performance of firms. A modern and efficient approach to the management of emissions helps to identify the activities with high-energy consumption which can lead to potential savings and also to maximize image return to customers sensitive to environmental issues. An econometric model that quantifies these effects is here applied to a sample of large Italian firms and evidence demonstrates that the adoption of an EMS (Environmental Management System) together with an appropriate control of emissions could lead to profits through an increase in demand and productivity. However, the improvement of productivity is weaker than the increase in demand suggesting that there is a delay between the start of the environmental efforts and the realization of economic performances.

1. Introduction

The phenomenon of global warming and climate changes, due to the accumulation of uncontrolled emission of greenhouse gases (especially CO_2) into the atmosphere, can have potentially disastrous and irreversible effects. The fifth Report on Climate Change of IPCC (Edenhofer et al., 2014) stresses the fact that urgent actions are required to curb global warming within tolerable limits. This goal will only be achieved by reducing emissions significantly throughout the next century (Bernstein et al., 2007; Bradford and Fraser, 2008). In 1997 more than 160 nations adopted the *Kyoto Protocol*, an international agreement for the reduction of GHG emissions. The target was a reduction of 5.2% from 1990 levels, within the year 2012. Afterwards, Europe has approved the "Climate-Energy Package" (2009) that defines the "European Strategy 20-20-20". The objective is to lead Europe towards a climate-compatible development, based on a combination of technologies and energy sources with low emissions of carbon dioxide (greenhouse gas emissions reduction by 20% by 2020 compared to 1990 levels), which tends to increase the use of renewable energy sources (+20%), which modernize the transport sector and promote energy efficiency (reduction of 20% of energy consumption). Between 1990 and 2012 emissions of greenhouse gases fell by 18% in Europe due to the current policies on climate and energy and the economic crisis. In line with these encouraging developments in recent years, the European Council approved in October 2014 new targets for 2030, aiming to reduce the emissions of greenhouse gases by 40% and increase by 27% the renewable and energy efficiency. In particular, the EC Directive 2003/87 (European Union Emissions Trading Scheme - EU ETS) regulates all the Member States on the exchange of "allowances"; each allowance gives the holder the right to emit one tonne of CO_2 equivalent. The plants emitting more than 25,000 tonnes of CO_2 equivalent are subject to the commitments of the Kyoto Protocol and must notify their emissions yearly to the *Union Registry*, an electronic database of the shares used to track the issue, holding, transfer, return and cancellation of allowances. Thanks to this scheme, in 2020 emissions from stationary installations will be 21% lower than in 2005 (Ellerman and Buchner, 2006; Gaudioso et al., 2009). Companies are required to identify efficient plans of action and intervention in order to reduce emissions. Among these, the Environmental

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Management System (EMS) is an operational tool to manage business activities aimed at the prevention and improvement of everything related to the environmental impact. The adoption of an EMS is voluntary. The main standards for the implementation of EMS are two, namely the ISO 14001: 2004 and the EC Regulation n.1221/2009 (Eco Management and Audit Scheme - EMAS). ISO 14001 is an international standard applicable to all organizations, which specifies the requirements for an environmental management system. EMAS is an EU regulation that recognizes the achievement of excellent results in environmental improvement.

In the past the issue of environmental aspects and impacts aimed to reduce and prevent pollution was perceived by businesses as a cost generated by activities such as waste disposal, maintenance of water treatment plants and fumes removal, reclamation and restoration of sites, etc., and only rarely it was seen as an opportunity. Conversely, many current studies have shown how greater consideration to the impact of their activities on the environment, as well as the control of CO_2 emissions, can allow the reduction of costs (from the management of waste, consumption of water, the purification of effluents, consumption of electricity, purchase of raw materials and insurance premiums) and generate a series of benefits (positive image return towards those customers sensible to environmental issues and increase of revenues and levels of competitiveness) (Boiral and Sala, 1998; Rondinelli and Vastag, 2000; Bansal and Bogner, 2002; Jiang and Bansal, 2003). These results encourage firm to apply GHG emissions management voluntarily (Welch et al., 2000; Arimura et al., 2008, 2011); this is true also for small and medium-sized enterprises that are not regulated by the European Directive EU ETS. Cogan (2006) identifies the risks that companies run if they don't address climate change. First of all the physical risk because their profitability is affected by changes in consumer habits that follow changing weather patterns and their physical consequences (Khanna et al., 1998). Then, the regulatory risk: national and international regulations on emission reduction are putting increasing pressure on companies and the compliance with them is significantly more costly for companies with the poorest climate governance (Khanna, 2001). Finally, the competitive risk: climate risk preparedness will be a key factor in companies' ability to compete (Lash and Wellington, 2007). In addition many other empirical studies show that GHG emission management increases a firm's value added and other indices of economic performance (Nishitani et al., 2011; Nishitani, 2011; Nishitani and Kokubu, 2012; Iwata and Okada, 2011; Hibiki and Managi, 2010; Jacobs et al., 2010; Zeng et al., 2010) and it may identify opportunities for process innovations (Ziegler, 2005). According to these studies, this positive effect generally results from an increase in demand and improvement in productivity, although most of them did not separate these effects theoretically and empirically.

Thus the purpose of this study is to analyze whether a firm's GHG management (namely the adoption of an EMS and the emission reduction) improves economic performance through two separated effects: an increase in demand and/or an improvement in productivity. This analysis is carried out on Italian firms in the period 2008–2013. To achieve this purpose, this paper applies a simple theoretical model based on that proposed by Nishitani (Nishitani et al., 2014) derived from a Cobb–Douglas production function and an inverse demand function to identify how these effects influence a firm's economic performance. GHG management brings about an increase in sales through an increase in demand by environmentally conscious customers and through cost reductions given by the improvement in productivity. The choice of the Cobb–Douglas production function has its advantages and disadvantages. It is a highly restricted model, but advantages outweigh its disadvantages, especially given that most existing empirical studies that have analyzed the relationship between environmental and economic performance have not developed a theoretical model to guide the empirical estimation of the related parameters (Nishitani et al., 2014). Besides, it enables researchers to develop, by combining with the inverse demand function and taking logarithms, a theoretical linear model that explains the effects of GHG management on economic performance through both an increase in demand and an improvement in productivity, which is empirically analyzable with a small number of estimated parameters. In contrast, estimating a more flexible functional form, such as a translog or CES production function, would make it very difficult to obtain unique estimates. Because none of the previous studies theoretically and empirically analyzed the effects of EMS and emission reduction simultaneously in Europe, this paper provides a further new contribution. Moreover data on environmental certifications (EMAS and ISO) clearly show that Italy represents the leading country in Europe for the efforts towards a right environmental management. Thus, our finding represents a new contribution regarding the roles (i.e. an increase in demand and improvement in productivity) of GHG emissions management on economic firms performance in Europe.

The paper is organized as follows: after this introduction, Section 2 presents a brief literature review on the relationship between environmental strategies and firm economic performance. Section 3 provides descriptions of the main environmental certifications, ISO 14001 and EMAS. The model used in this study is presented in Section 4 and the dependent and independent variables involved in the analysis are described in Section 5. The results are shown in Section 6 and Section 7 concludes the paper.

2. Literature review

It was a widespread opinion among economists, politicians and managers that any measure to protect the environment only leads to additional costs for the firms and hurt their competitiveness globally. According to this traditional view, environmental regulations force firms to allocate some inputs such as labour and capital to reduce pollution, which is unproductive from a business perspective but provides environmental benefits for society. However, the new paradigm of competitiveness is moving away from this static model. Porter and van der Linde (1995) hypothesize that a binding environmental regulation stimulates innovation and counterbalance the compliance costs incurred by firms. Without regulations companies are left free to act, but they would not be able to assess the amount of the costs necessary to innovate, they may decide not to proceed in this direction. Instead the regulation provides an opportunity to eliminate inefficiencies in the exploitation of resources and the ability to reduce the uncertainty of environmental investments, determining or a Pareto improvement (i.e., lower environmental impact without reducing corporate profits) or a “win-win” situation (lower environmental impact, higher profits and business competitiveness) (Jaffe and Palmer, 1997; Ambec et al., 2013). Furthermore, by stimulating greater awareness to environment of public and private citizens, it could result in the birth or in a growth of environmentally clean goods and services. Many studies have investigated to what extent it pays or not to “be green”, or, in other terms, whether firms are getting (losing) economic opportunities in improving (not improving) their environmental performances (Ambec and Lanoie, 2008). Mixed results have been found in empirical works aimed at assessing the links between environmental strategies and economic implications, some of them find positive effects (Al-Tuwaijri et al., 2004; Dowell et al., 2000; Russo and Fouts, 1997), negative effects (Sarkis and Cordeiro, 2001) and non-significant correlations (Elsayed and Paton, 2005; Jaggi and Freedman, 1992; Telle, 2006).

In recent years research has faced extensively the matter because global warming is also tangible for the private citizen and it is raising awareness among governments and industry. One of the last works was made by Misani and Pogutz (2015), that measure, through the Tobin Q ratio, the financial performance as a result of the expected benefits in the long-term environmental management. Enterprises carrying substantial efforts are more likely to have better economic results when the environmental performances are very high or very low. When, however, companies have intermediate environmental performance (for example with CO_2 emissions close to the industry average), reduced efforts determine better economic performance. It is particularly large the literature of Eastern countries, including China, where air pollution is now critical. Xia et al. (2015) conducted an empirical study of 98 companies in the Chinese manufacturing sector using an integrated structure equation model; they have reported the positive effect of the adoption of green technologies on economic performance, also assuming a further increase in demand and an improvement in the social reputation by meeting the expectations of stakeholders. Wang and Zhao (2017) have evaluated the effectiveness of investment and management strategies to improve the environmental performance of industry of non-ferrous metals, using a DEA model non-radial. The results show that potentially it is possible to obtain a significant energy saving reducing emissions. Nguyen and Hens (2015) have empirically evaluated the response of the cement industry in Vietnam after the adoption of the ISO 14001 certification: in addition to the significant decrease of pollutants (SO_2, NO_2 and dust), they showed improvements both at management and operational levels and increased environmental awareness. Statistical results of the study addressed by Zhu et al. (2017) contribute to support the argument that a green supply chain management associated with a proper management of the customer relationship generates better performance both environmental and economic. The econometric study of Nishitani et al. (2014) founds a positive relationship between emission reduction and increase in demand and productivity for a sample of Japanese firms. In this paper, starting from Nishitani model, we decided to conduct a similar analysis of the Italian companies in the period 2008–2013 in order to assess the effects of the adoption of an EMS on economic performance and get an answer to the question that is often place on the economic attractiveness of environmental and emissions management in the Italian industrial system. Our paper goes in the same direction of those studies that found a positive relationship between implementation of EMS and environmental performance (Dasgupta et al., 2000; Melnyk et al., 2002; Potoski and Prakash, 2005; Russo, 2009; Capece et al., 2017).

3. Environmental management systems

ISO 14001 provides a framework for the implementation of an environmental management system of a firm by analyzing the environmental impact of its business, setting targets for improving environmental performance and the periodic verification of the achievement of these aims. It does not specify levels of environmental performance, which allows its application in organizations with different levels of "environmental maturity". It is the firm that sets the objectives to be achieved, improvements to be reached, depending upon their capacity and resources, but always in relation to the basic principle of the rules of management systems, the principle of continuous improvement, inducing the firm to continuously upgrade its environmental performance.

The European Community has issued in 1993 the EMAS regulation (Eco-Management and Audit Scheme), which was revised in 2001 and 2009 (Reg. CE. n.1221/2009 of 25/11/2009). EMAS is a voluntary system for firms and more generally for organizations, public and private of all economic sectors, which wish to commit themselves to evaluate and improve its environmental performance. EMAS requires the presence of an EMS, as for ISO 14001, and a periodic publication of the "Environmental Statement". This document describes the results achieved in improving the environmental efficiency of its activities and explicit goals and future plans. This declaration is validated by an accredited verifier and is designed to inform the public. Implementing EMAS companies then overcome situations of conflict and distrust that often characterized relations with the public, through a transparent attitude towards the management of environmental issues.

In Europe the number of organizations having achieved certification under ISO 14001 is more than 30 times the number of organizations registered under EMAS. There are several reasons for this difference, it is more demanding to achieve an EMAS registration than an ISO 14001 certification and ISO 14001 may be more widely recognised than EMAS in non-European markets. The number of organizations within the EU that are certified according to the international ISO 14001 standard for environmental management systems have increased by more than a factor 10 in the period 2001–2014. In 2013 Italy, United Kingdom and Spain account for more than 40% of certifications (Table 1).

Italy alone accounts for 18.4% of ISO certifications in Europe and 7.8% in the World. The number of organizations registered under the EMAS standard rose by 50% in the period 2003–2014. During the same period the number of individual sites registered to EMAS has grown by almost 100%. However, it should be noted that there are major differences between countries in terms of engagement in EMAS. Of the approximately 4500 registered organizations, approximately 3700 are spread between just three countries (Germany, Italy and Spain, Table 1). These large differences between countries may be a result of differences in national administrative rules for EMAS registration. These data confirm that Italy represents a relevant case study in Europe for the analysis of the relation between the implementation of EMS and the firm performance.

The significant increase in numbers of organizations with certified or registered environmental management systems indicates that private companies and public institutions in the EU are increasingly engaged in environmental management. In addition, due to the administrative burden of EMAS and ISO 14001 registrations and documentation it may be more an indication that large enterprises are engaging more in environmental management. Many SMEs in particular may be engaging in environmental management systems in order to ensure compliance with environmental regulations and/or to reduce costs of resource inputs and waste management, but may not be registering under EMAS or ISO 14001. Developments in these smaller companies may therefore not be being picked up by this indicator. This justifies the choice to consider in the simulations a sample of about 500 large or very large companies in Italy. An added complication is that some EU countries also have their own domestic EMS certification systems which are also not captured.

The database of firms and organizations with ISO 14001 is managed by ACCREDIA, which is the only national accreditation system appointed by the Italian government (operates under the

Table 1
The top five European countries for environmental certifications (%) - 2013.

ISO 14001		EMAS	
Italy	18.4	Germany	31.2
United Kingdom	14.6	Italy	25.1
Spain	13.9	Spain	24.0
Romania	7.6	Austria	7.8
Germany	6.9	Belgium	1.9

supervision of the Ministry of Economic Development) in order to inspect and validate the compliance with the standards. In Italy, the number of organizations with environmental management system certified under accreditation, under the ISO 14001, is growing and reached in December 2013, 16,519 units. The sectors with the highest concentration of certifications in the environmental management system are logistics (transport, storage and forwarding), other social services and the supply of electricity (Fig. 1).

The Italian accreditation system of EMAS was established by Decree 413/95 which entrusts this task to the Committee for Ecolabel and Ecoaudit - Section EMAS Italy, which uses ISPRA (Institute for Environmental Protection and Research) for technical competence. The number of registered organizations (1098 in 2013) is derived from the Register of EMAS Organizations held by ISPRA and fell, from December 2012 to December 2013, by 5.2%. The reduction of active registrations, due to the suspension/cancellation of registered organizations, remains a growing phenomenon in 2013, was not offset by the number of organizations that come into EMAS for the first time. The causes are likely to be found in the continuing difficult economic situation, the absence of expected returns in terms of visibility and the lack of procedural simplifications/economic benefits for this category of organizations. Compared to the breakdown by sectors NACE (EC Regulation 1893/2006: Classification of Economic Activities in the European Community), the most active registered organizations are Public Administration (258), followed by companies operating in waste disposal (235), with a net increase of 10 units in 2013 also confirmed the interest in EMAS, and by production of electricity (149) (Fig. 2).

To achieve environmental certification, organizations need to be legally compliant, run an environmental management system and report on their environmental performance through the publication of an independently verified (by a third party) environmental statement. Third party verification should guarantee the external and independent nature of the registration process. Notice that data for environmental certification are voluntary. These should decrease the necessity to provide false declarations and reduce the possibility that these certifications are only symbolic from the environment point of view.

4. The model

This section presents a model to analyze how the GHG management influences the firm's economic performance increasing the demand and productivity (Nishitani et al., 2011, 2014; Nishitani, 2011; Nishitani and Kokubu, 2012). Economic performance is here measured by value added and the regression model is derived from a Cobb-Douglas production function and inverse demand function; the Cobb-Douglas production function with labour, capital, materials and energy for firm i is:

$$X_i = A_i L_i^{\alpha} K_i^{\beta} M_i^{\gamma} E_i^{1-\alpha-\beta-\gamma} \tag{1}$$

where X is output, L is labour, K is capital, M is materials, E is energy and A is total factor productivity, with $0<\alpha<1$, $0<\beta<1$, $0<\gamma<1$ e $0<\alpha+\beta+\gamma<1$. We assume returns to scale in production. Given total revenue $Y_i = p_i X_i$, where p is the price of output, labour cost $W_i = wL_i$, where w is the wage rate, capital cost $R_i = rK_i$, where r is the implicit rental rate of capital, materials cost $Q_i = qM_i$, where q is the price of materials, and energy cost $D_i = dE_i$, where d is the price of energy, it follows that:

$$\frac{Y_i}{p_i} = A_i\left(\frac{W_i}{w}\right)^{\alpha}\left(\frac{R_i}{r}\right)^{\beta}\left(\frac{Q_i}{q}\right)^{\gamma}\left(\frac{D_i}{d}\right)^{1-\alpha-\beta-\gamma} \tag{2}$$

The inverse demand function is:

$$p_i = a_i X_i^{-\lambda} \tag{3}$$

and substituting in (2) then total revenue is expressed as follows:

$$\begin{aligned} Y_i &= a_i X_i^{-\lambda} A_i\left(\frac{W_i}{w}\right)^{\alpha}\left(\frac{R_i}{r}\right)^{\beta}\left(\frac{Q_i}{q}\right)^{\gamma}\left(\frac{D_i}{d}\right)^{1-\alpha-\beta-\gamma} \\ &= a_i\left\{A_i\left(\frac{W_i}{w}\right)^{\alpha}\left(\frac{R_i}{r}\right)^{\beta}\left(\frac{Q_i}{q}\right)^{\gamma}\left(\frac{D_i}{d}\right)^{1-\alpha-\beta-\gamma}\right\}^{1-\lambda} \\ &= a_i A_i^{1-\lambda}\left(\frac{W_i}{w}\right)^{\alpha-\alpha\lambda}\left(\frac{R_i}{r}\right)^{\beta-\beta\lambda}\left(\frac{Q_i}{q}\right)^{\gamma-\gamma\lambda}\left(\frac{D_i}{d}\right)^{1-\alpha-\beta-\gamma-\lambda+\alpha\lambda+\beta\lambda+\gamma\lambda} \end{aligned} \tag{4}$$

where $1-\lambda>0$. Subtracting both sides of (4) the cost for raw materials and dividing by the cost of services we obtain

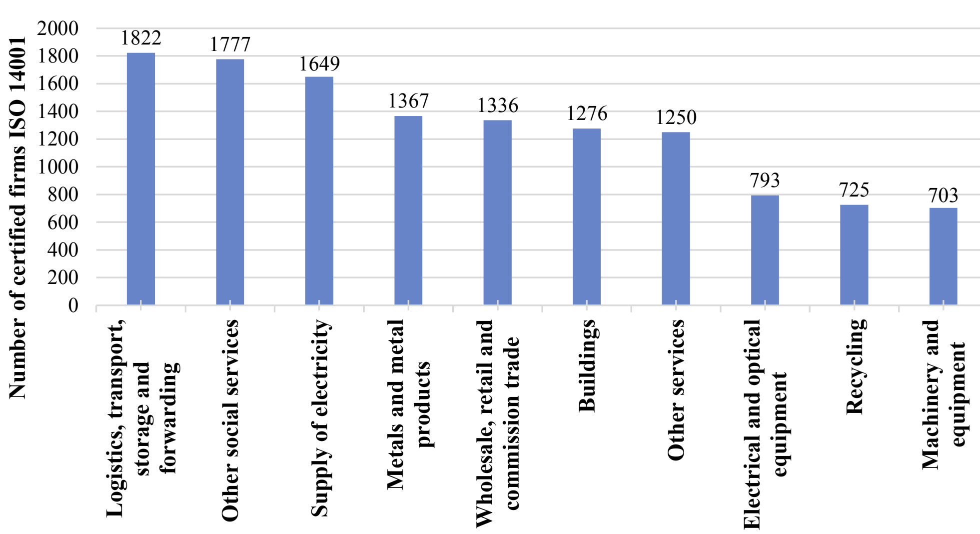

Fig. 1. The top ten sectors by number of ISO 14001 (2013). Font: ACCREDIA.

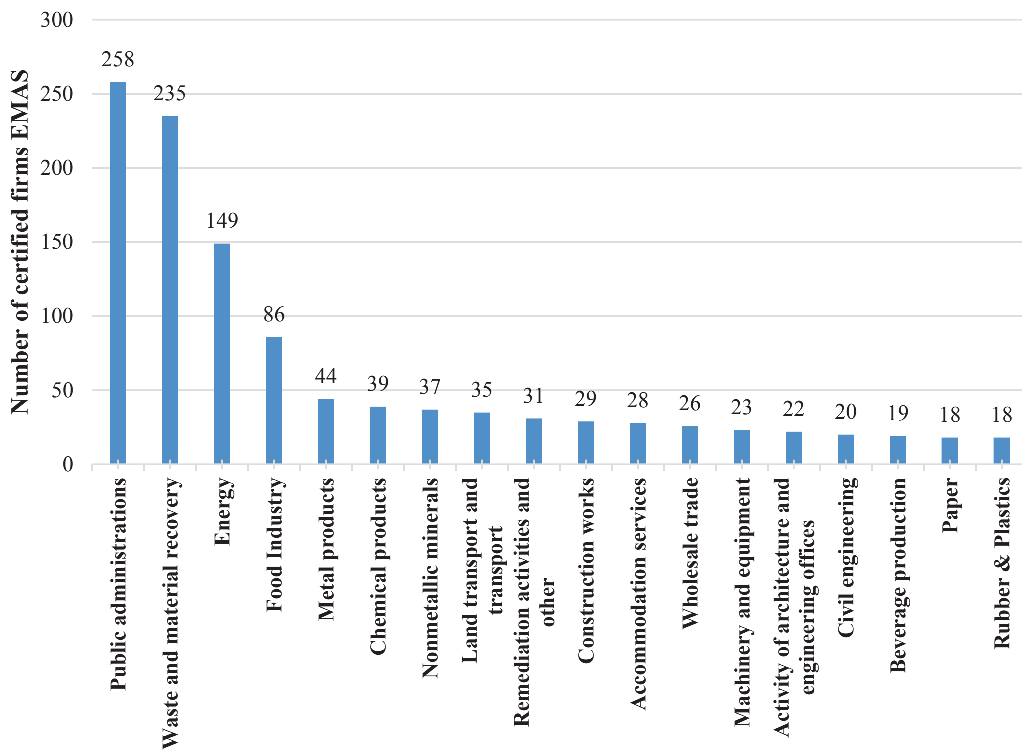

Fig. 2. Distribution of organizations/firms registered EMAS divided by NACE (2013). Font: ISPRA.

$$\frac{Y_i}{D_i} = a_i A_i^{1-\lambda} \left(\frac{W_i}{w}\right)^{\alpha-\alpha\lambda} \left(\frac{R_i}{r}\right)^{\beta-\beta\lambda} \left(\frac{Q_i}{q}\right)^{\gamma-\gamma\lambda} \times D_i^{-\alpha-\beta-\gamma-\lambda+\alpha\lambda+\beta\lambda+\gamma\lambda} d^{-(1-\alpha-\beta-\gamma-\lambda+\alpha\lambda+\beta\lambda+\gamma\lambda)} \tag{5}$$

where Y_i represents value added of firm i. Taking logarithms of both sides of (5) yields:

$$\begin{aligned}\ln\frac{Y_i}{D_i} &= \ln a_i + \ln A_i^{1-\lambda} + \ln\left(\frac{W_i}{w}\right)^{\alpha-\alpha\lambda} + \ln\left(\frac{R_i}{r}\right)^{\beta-\beta\lambda} + \ln\left(\frac{Q_i}{q}\right)^{\gamma-\gamma\lambda} + \\ &+ \ln D_i^{-\alpha-\beta-\gamma-\lambda+\alpha\lambda+\beta\lambda+\gamma\lambda} + \ln d^{-(1-\alpha-\beta-\gamma-\lambda+\alpha\lambda+\beta\lambda+\gamma\lambda)} \\ &= \ln a_i + (1-\lambda)\ln A_i + (\alpha-\alpha\lambda)\ln W_i + (\beta-\beta\lambda)\ln R_i + \\ &+ (\gamma-\gamma\lambda)\ln Q_i + (-\alpha-\beta-\gamma-\lambda+\alpha\lambda+\beta\lambda+\gamma\lambda)\ln D_i + \\ &- (\alpha-\alpha\lambda)\ln w - (\beta-\beta\lambda)\ln r - (\gamma-\gamma\lambda)\ln q + \\ &- (1-\alpha-\beta-\gamma-\lambda+\alpha\lambda+\beta\lambda+\gamma\lambda)\ln d\end{aligned} \tag{6}$$

Suppose that a_i and A_i are functions describing the GHG emissions management, and that they are described as

$$a_i = e^{\omega^{(0)} + \omega^{(1)} G_i^{(a)}} \tag{7}$$

where $G_i^{(a)}$ is the i-th score of the firm for the eventual obtaining EMAS and/or ISO 14001 certification. In particular $\omega^{(1)} > 0$ is the effect of the adoption of a certification that occurs by means of the increase in demand. Moreover:

$$A_i = e^{\delta^{(0)} + \delta^{(1)} G_i^{(A)}} \tag{8}$$

where $G_i^{(A)}$ is the i-th score of the firm for the CO_2 emission reduction e $\delta^{(1)} > 0$ is its effect that occurs through an improvement in productivity. Substituting (7) and (8) in (6) yields:

$$\begin{aligned}\ln\frac{Y_i}{D_i} &= (\alpha-\alpha\lambda)\ln W_i + (\beta-\beta\lambda)\ln R_i + (\gamma-\gamma\lambda)\ln Q_i + \\ &+ (-\alpha-\beta-\gamma-\lambda+\alpha\lambda+\beta\lambda+\gamma\lambda)\ln D_i + \omega^{(1)} G_i^{(a)} + (1-\lambda)\delta^{(1)} G_i^{(A)} + \\ &+ \omega^{(0)} + (1-\lambda)\delta^{(0)} - (\alpha-\alpha\lambda)\ln w - (\beta-\beta\lambda)\ln r - (\gamma-\gamma\lambda)\ln q + \\ &- (1-\alpha-\beta-\gamma-\lambda+\alpha\lambda+\beta\lambda+\gamma\lambda)\ln d\end{aligned} \tag{9}$$

Equation (9) indicates how the growth of demand and productivity obtained from the GHG management influence a firm's value added. Moreover Equation (9) allows to estimate the parameters of environmental management, $\omega^{(1)}$, and emission reduction, $(1-\lambda)\delta^{(1)}$, where $B_0 = \omega^{(0)} + (1-\lambda)\delta^{(0)} - (\alpha-\alpha\lambda)\ln w - (\beta-\beta\lambda)\ln r - (\gamma-\gamma\lambda)\ln q - (1-\alpha-\beta-\gamma-\lambda+\alpha\lambda+\beta\lambda+\gamma\lambda)\ln\ d$ is the constant term.

Equation (9) can be written as

$$\ln\frac{Y_i}{D_i} = B_0 + B_1 \ln W_i + B_2 \ln R_i + B_3 \ln Q_i + B_4 \ln D_i + B_5 G_i^{(a)} + B_6 G_i^{(A)} \tag{10}$$

where $B_0 - B_6$ are the variables to be estimated. $\delta^{(1)} = B_6(1-\lambda)^{-1}$ can be estimated directly obtaining λ from the following equations system:

$$\begin{cases} \alpha - \alpha\lambda = B_1 \\ \beta - \beta\lambda = B_2 \\ \gamma - \gamma\lambda = B_3 \\ -\alpha - \beta - \gamma - \lambda + \alpha\lambda + \beta\lambda + \gamma\lambda = B_4 \end{cases} \tag{11}$$

Being $0 < \alpha < 1$, $0 < \beta < 1$, $0 < \gamma < 1$, $1 - \lambda > 0$, $\omega^{(1)} > 0$ and $\delta^{(1)} > 0$, the predicted signs of these parameters are positive for $(\alpha - \alpha\lambda)$, $(\beta - \beta\lambda)$, $(\gamma - \gamma\lambda)$, $\omega^{(1)}$ and $(1 - \lambda)\delta^{(1)}$, and negative for $(-\alpha - \beta - \gamma - \lambda + \alpha\lambda + \beta\lambda + \gamma\lambda)$.

5. Data

The sample of Italian firms analyzed in this paper is found in the *Union Registry* of ETS. The study focuses on about 500 firms from 2008 to 2013 for a total of 2904 observations. Most of them are companies of large or very large size, however there are also firms of medium size. Emission data collected annually cover about 50% of total emissions monitored in Italy in 2013 (438Mt of CO_2). The remaining 50% corresponds to the emissions of companies for which data on emissions are not available or with incongruous data in the balance sheets necessary to implement the model. Also in relation to the observed sample about half of the companies has an annual emission output below the threshold of ETS regulation and is on the market emissions trading as volunteer (Fig. 3).

The data required for the implementation of the model are for the generic firm i:

- Value added Y_i, service expense D_i, wage expanse W_i, the capital cost R_i and raw materials expense Q_i, deduced from the balance sheets contained in the database AIDA. AIDA provides detailed accounts following the scheme of the 4th Directive CEE. The capital cost (book value of tangible fixed assets) is formed by the following components: land and building, plant and machinery, industrial and commercial equipment, other asset, additions in progress and advances and depreciation provision. The material costs widely vary among firms and sectors. AIDA database shows that there are large differences between economic sectors and firms in values and in the shares of raw material costs in total production costs.
- Tons of CO_2 emitted, verified and communicated to the Union Registry for Emissions Trading.
- The score $G_i^{(a)}$ for the environmental management, associated with the release of environmental certifications. For each company is assigned a score from 0 to 2: 1 if it has at least an ISO 14001 or EMAS certification, 2 if has both certifications and 0 otherwise. The list of certified companies is available on the register of ACCREDIA regard to ISO 14001 and on the register of ISPRA for EMAS.

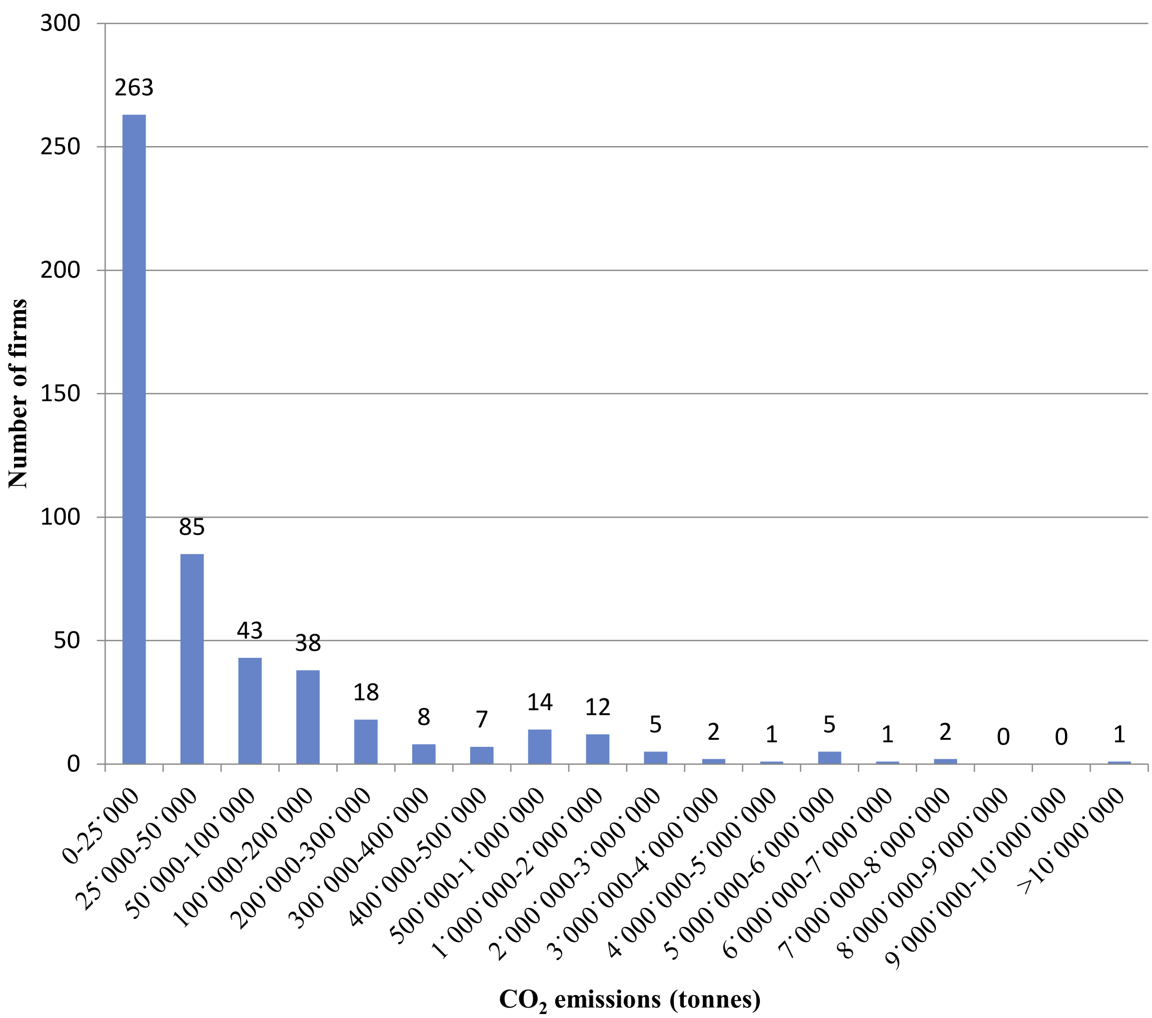

Fig. 3. Frequency distribution of the amount of CO_2 emissions for the sample of firms observed in year 2013.

Table 2
Model variables.

Variables	Definition
$\ln(Y_i/D_i)$	Logarithm of net sales on service expense
$\ln W_i$	Logarithm of wage expense
$\ln R_i$	Logarithm of the book value of tangible fixed assets
$\ln Q_i$	Logarithm of raw materials expense
$\ln D_i$	Logarithm of service expense
$G_i^{(a)}$	Score based on environmental management
$G_i^{(A)}$	Score based on emission reduction

- The score $G_i^{(A)}$ for the emission reduction, associated with the classification of the amount of CO_2 emissions in a given year: the companies are divided into 20 groups according to the ratio of their CO_2 emissions and net sales and attributed a score that ranges from 1 to 20 points from the lowest to the highest level of the ratio. This variable captures the effects of the emission reduction selecting firms maintaining low emissions level.

We adopt the classification of economic activities ATECO 2007, used by Istat (Italian National Institute of Statistics). Most of the investigated companies can be grouped under the manufacturing sector (377 firms with a total of 2121 observations from 2008 to 2013) and that of suppliers of electricity, gas, steam and air conditioning called energy sector (71 companies with a total 378 observations from 2008 to 2013), only a small part represents other categories (agriculture, mining and quarrying, water supply, construction, wholesale and retail trade, transportation and storage, etc.), which we will simply call other sectors (76 companies with a total of 405 observations from 2008 to 2013). The list of dependent and independent variables used in the model is shown in Table 2.

Table 3
Estimation results.

Variable	Economic Activity	Coefficient	SE
$\ln W_i$	Total	0.059	***0.008
	Manufacturing	0.144	***0.008
	Energy	0.009	*0.019
	Others	0.108	***0.031
$\ln R_i$	Total	0.079	***0.005
	Manufacturing	0.048	***0.005
	Energy	0.081	***0.013
	Others	0.063	***0.010
$\ln Q_i$	Total	0.425	***0.005
	Manufacturing	0.483	***0.005
	Energy	0.309	***0.013
	Others	0.361	***0.014
$\ln D_i$	Total	−0.578	***0.009
	Manufacturing	−0.673	***0.009
	Energy	−0.417	***0.023
	Others	−0.578	***0.033
$G_i^{(a)}$	Total	0.049	***0.011
	Manufacturing	0.008	*0.009
	Energy	0.026	*0.030
	Others	0.038	*0.043
$G_i^{(A)}$	Total	0.003	***0.001
	Manufacturing	0.004	***0.001
	Energy	−0.020	***0.004
	Others	0.011	**0.004
Constant	Total	1.468	***0.063
	Manufacturing	1.154	***0.052
	Energy	2.104	***0.206
	Others	2.152	***0.199

*, ** and *** imply that the coefficient is significantly different from zero at the 10, 5 and 1% levels, respectively.

Table 4
Results (relevance).

R^2	Total	0.733
	Manufacturing	0.840
	Energy	0.708
	Others	0.688
stat F	Total	1328.717
	Manufacturing	1851.756
	Energy	149.760
	Others	146.560
p value	Total	$4.675 \cdot 10^{-91}$
	Manufacturing	$3.898 \cdot 10^{-90}$
	Energy	$6.842 \cdot 10^{-96}$
	Others	$1.586 \cdot 10^{-97}$

6. Results

The analysis of the influence of environmental management and emission reduction of Italian firms on economic performance, was initially implemented on the whole sample of companies, then they were divided into three main sectors. The obtained estimation results are shown in Table 3. In the analysis of the whole sample it is important to note that all coefficients estimated by the model are significantly different from zero, then the introduction of EMS and the emission reduction significantly affect the economic performance of the sample of companies considered. The sign of the coefficients of the cost of personnel, tangible fixed assets and material costs for commodities is positive and therefore consistent with the values predicted by the model. Even the negative value related to cost of the services is consistent with the predictions, in fact for a reduction in emissions is plausible that companies have reduced their energy consumption through actions improving the energy efficiency of the production process. In particular, the sign of the coefficients of environmental management and emission reduction is positive and the estimated values are significant. This behavior indicates that the focus on the environment as demonstrated by an environmental management is effective on increasing demand, while maintaining the lowest possible emissions level has effects on productivity growth. This translates into opportunities for image return to those customers aware of environmental issues and an increase in profits, efficiency and competitive level. Table 4 provides some statistical results useful to assess the quality of the estimated regression coefficients: the model is adequate to explain 73% of the data and the F statistic and p-values are significant. In order to handle endogeneity it is a good practice to compare OLS (Ordinary Least Squares) and IV (Instrumental Variables) estimates to study the correlation between dependent variable and error term. Including residuals as additional regressor in the original equation it is possible to note that new added residuals are not statistically significantly different from zero, so concluding that there is no endogeneity bias in the estimates (this is called the Wu-Hausman Test for endogeneity). Results of Table 4 give strength to the validity of the obtained results; they confirm that the proposed estimation instruments are valid and that the estimated model is

Table 5
Results (performance).

Demand Growth	Total	4.901%
	Manufacturing	0.794%
	Energy	2.620%
	Others	3.821%
Productivity Growth	Total	0.354%
	Manufacturing	0.359%
	Energy	−2.103%
	Others	1.237%

Table 6
Estimation results.

Variable	Economic Activity	2008		2009		2010	
		Coefficient	SE	Coefficient	SE	Coefficient	SE
$\ln W_i$	Total	−0.006	0.025	0.068	***0.020	0.066	***0.020
	Manufacturing	0.120	***0.022	0.160	***0.018	0.146	***0.017
	Energy	0.000	*0.060	0.000	*0.055	0.024	*0.047
	Others	0.070	*0.098	0.120	*0.067	0.107	*0.088
$\ln R_i$	Total	0.042	***0.014	0.069	***0.011	0.073	***0.011
	Manufacturing	0.002	***0.014	0.062	***0.013	0.050	***0.012
	Energy	0.098	**0.044	0.095	***0.035	0.062	**0.029
	Others	0.028	*0.029	0.001	*0.021	0.065	**0.029
$\ln Q_i$	Total	0.426	***0.014	0.412	***0.013	0.422	***0.013
	Manufacturing	0.522	***0.014	0.440	***0.012	0.474	***0.012
	Energy	0.257	***0.035	0.277	***0.037	0.382	***0.034
	Others	0.395	***0.035	0.374	***0.030	0.326	***0.039
$\ln D_i$	Total	−0.482	***0.026	−0.558	***0.023	−0.569	***0.023
	Manufacturing	−0.646	*0.024	−0.655	***0.020	−0.664	***0.019
	Energy	−0.361	***0.065	−0.417	***0.065	−0.482	***0.059
	Others	−0.539	***0.091	−0.502	***0.069	−0.550	***0.090
$G_i^{(a)}$	Total	0.034	*0.033	0.023	*0.025	0.030	*0.027
	Manufacturing	−0.015	*0.025	−0.031	*0.020	−0.009	*0.020
	Energy	0.022	*0.111	0.040	*0.074	0.031	*0.071
	Others	0.020	*0.115	0.006	*0.084	0.028	*0.114
$G_i^{(A)}$	Total	0.002	*0.004	0.000	*0.003	0.002	*0.003
	Manufacturing	0.003	*0.003	0.003	*0.002	0.004	*0.002
	Energy	−0.008	*0.013	−0.023	**0.010	−0.023	***0.008
	Others	0.003	*0.014	0.004	*0.009	0.008	*0.013
Constant	Total	1.568	***0.186	1.436	***0.146	1.408	***0.149
	Manufacturing	1.226	***0.146	1.111	***0.121	1.106	***0.115
	Energy	2.657	***0.748	2.577	***0.513	1.994	***0.476
	Others	2.215	***0.547	1.487	***0.424	2.317	***0.541
Variable	**Economic Activity**	**2011**		**2012**		**2013**	
		Coefficient	SE	Coefficient	SE	Coefficient	SE
$\ln W_i$	Total	0.068	***0.018	0.088	***0.020	0.089	***0.021
	Manufacturing	0.138	***0.016	0.139	***0.018	0.181	***0.021
	Energy	0.035	*0.040	0.045	*0.049	0.028	*0.043
	Others	0.135	*0.080	0.150	**0.069	0.134	*0.073
$\ln R_i$	Total	0.092	***0.011	0.093	***0.011	0.103	***0.011
	Manufacturing	0.056	***0.011	0.063	***0.012	0.050	***0.013
	Energy	0.091	***0.032	0.091	***0.033	0.105	***0.032
	Others	0.074	***0.028	0.090	***0.028	0.118	***0.024
$\ln Q_i$	Total	0.432	***0.012	0.449	***0.012	0.412	***0.013
	Manufacturing	0.492	***0.011	0.492	***0.012	0.477	***0.013
	Energy	0.356	***0.038	0.349	***0.033	0.312	***0.031
	Others	0.345	***0.037	0.391	***0.036	0.299	***0.039
$\ln D_i$	Total	−0.604	***0.022	−0.646	***0.023	−0.617	***0.024
	Manufacturing	−0.682	***0.020	−0.689	***0.020	−0.711	***0.023
	Energy	−0.474	***0.060	−0.462	***0.057	−0.449	***0.050
	Others	−0.599	***0.086	−0.692	***0.084	−0.580	***0.080
$G_i^{(a)}$	Total	0.049	*0.026	0.073	***0.026	0.072	***0.026
	Manufacturing	−0.011	*0.020	0.004	*0.021	0.013	*0.023
	Energy	0.002	*0.076	0.003	*0.072	0.016	*0.070
	Others	0.081	*0.107	0.049	*0.114	0.039	*0.101
$G_i^{(A)}$	Total	0.004	*0.003	0.005	*0.003	0.007	**0.003
	Manufacturing	0.003	*0.002	0.004	*0.002	0.005	**0.002
	Energy	−0.018	*0.009	−0.020	**0.008	−0.013	*0.007
	Others	0.010	*0.012	0.012	*0.012	0.022	**0.011
Constant	Total	1.425	***0.148	1.460	***0.148	1.407	***0.150
	Manufacturing	1.140	***0.117	1.090	***0.127	1.254	***0.134
	Energy	1.644	***0.540	1.472	***0.502	1.767	***0.484
	Others	2.140	***0.505	2.452	***0.480	1.794	***0.443

*, ** and *** imply that the coefficient is significantly different from zero at the 10, 5 and 1% levels, respectively.

adequate.

Therefore the adoption of a GHG management confirms a profit growth through an increase in demand (approximately 4.9%) and productivity (approximately 0.4%) (Table 5). The effect of implementation of the GHG management by improving productivity is weaker than through an increase in demand, suggesting that there is a delay between the start of the environmental efforts and the realization of economic performance. These results encourage the investments in technologies for producing "cleaner" while also reducing costs and environmental risks. In literature the only comparable results are those obtained in their analysis by Nishitani et al. (2014). The results are based on a sample of firms with similar size (about 500) although the Japanese sample is formed only by manufacturing firms. The reality of Japan is completely different from the Italian both as regards the characteristics of the firms and the market. Japan uses for the environmental certification ISO

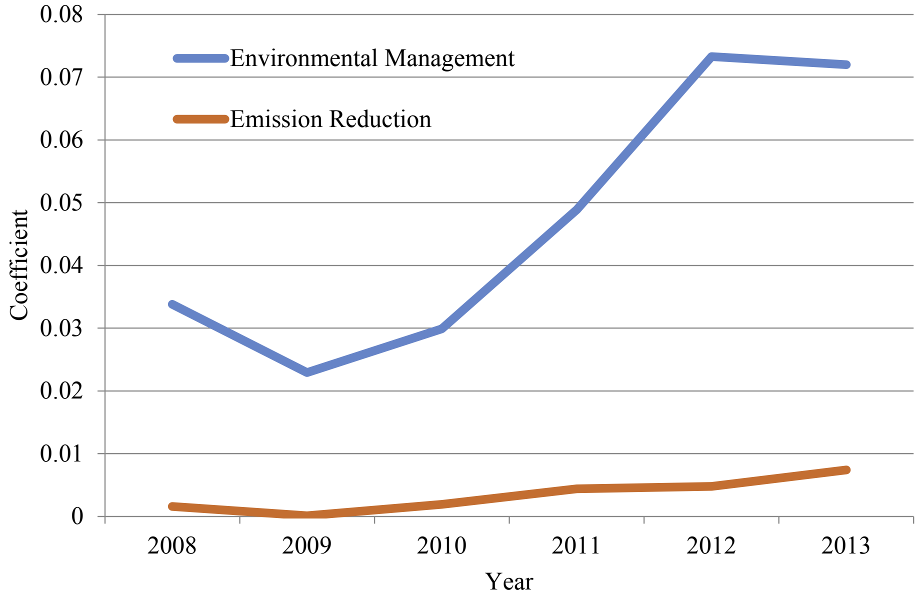

Fig. 4. Coefficients of environmental management and emission reduction obtained for the entire sample of Italian firms observed in the range between 2008 and 2013.

Table 7
Results (relevance).

	Economic Activity	2008	2009	2010	2011	2012	2013
R^2	Total	0.713	0.739	0.720	0.739	0.764	0.748
	Manufacturing	0.832	0.839	0.844	0.855	0.850	0.840
	Energy	0.697	0.684	0.779	0.701	0.747	0.749
	Others	0.796	0.767	0.603	0.644	0.715	0.697
stat F	Total	179.375	215.946	214.252	242.213	277.907	219.111
	Manufacturing	268.415	291.880	325.147	360.314	349.321	278.539
	Energy	16.906	18.408	35.178	25.006	30.515	27.358
	Others	32.499	30.670	16.421	20.533	28.804	21.116
p value	Total	$3.690 \cdot 10^{-114}$	$4.330 \cdot 10^{-130}$	$1.370 \cdot 10^{-134}$	$3.860 \cdot 10^{-146}$	$6.390 \cdot 10^{-158}$	$3.71 \cdot 10^{-129}$
	Manufacturing	$6.971 \cdot 10^{-123}$	$3.383 \cdot 10^{-130}$	$5.309 \cdot 10^{-142}$	$1.891 \cdot 10^{-150}$	$5.024 \cdot 10^{-149}$	$1.384 \cdot 10^{-123}$
	Energy	$5.268 \cdot 10^{-10}$	$3.056 \cdot 10^{-11}$	$6.893 \cdot 10^{-18}$	$4.719 \cdot 10^{-15}$	$9.409 \cdot 10^{-17}$	$7.456 \cdot 10^{-15}$
	Others	$1.262 \cdot 10^{-15}$	$5.240 \cdot 10^{-16}$	$2.074 \cdot 10^{-11}$	$1.466 \cdot 10^{-13}$	$5.482 \cdot 10^{-17}$	$1.127 \cdot 10^{-12}$

14001 only while Europe is using also EMAS. However the number of ISO 14001 certifications is similar (23,723 and 21,300 for Japan and Italy), the two countries take the second and third places in the world in terms of ISO 14001 certifications presented behind China with more than 100,000. Nishitani et al. analyze only the manufacturing sector and estimate a growth in demand of 1% against the 0.8% obtained for Italy in our simulations and a productivity growth of 2.6% for Japan against 0.4% for Italy (see Table 5). It is not possible to compare results obtained for the other sectors in our simulations because they are not observed by the Japanese analysis. Notice that the scores of environmental management $G_i^{(a)}$ are not defined in our simulation in the same manner as in the Nishitani et al. paper; in fact in the former they are associated with environmental certifications whereas in the latter they are derived from a survey on the promotion of countermeasures against global warming.

Tables 3–5 also show the results of repeated estimations for the three sectors, the manufacturing sector, the supplier of electricity, gas, steam and air conditioning and other firms. As was found with the whole sample, the positive signs of the coefficients of the cost of personnel, tangible fixed assets, costs for raw materials and the negative costs of services are consistent with the values predicted by the model. Similarly to the results of the total sample, the coefficients of environmental management are significant, which

Table 8
Results (performance).

	Economic Activity	2008	2009	2010	2011	2012	2013
Demand Growth	Total	3.375	2.293	2.987	4.891	7.335	7.204
	Manufacturing	−1.453	−3.147	−0.944	−1.133	0.416	1.318
	Energy	2.212	4.045	3.058	0.171	0.273	1.579
	Others	2.001	0.637	2.800	8.115	4.888	3.887
Productivity Growth	Total	0.164	0.015	0.188	0.450	0.483	0.747
	Manufacturing	0.304	0.249	0.382	0.294	0.377	0.516
	Energy	−0.867	−2.360	−2.344	−1.809	−1.970	−1.292
	Others	0.355	0.418	0.884	1.063	1.274	2.310

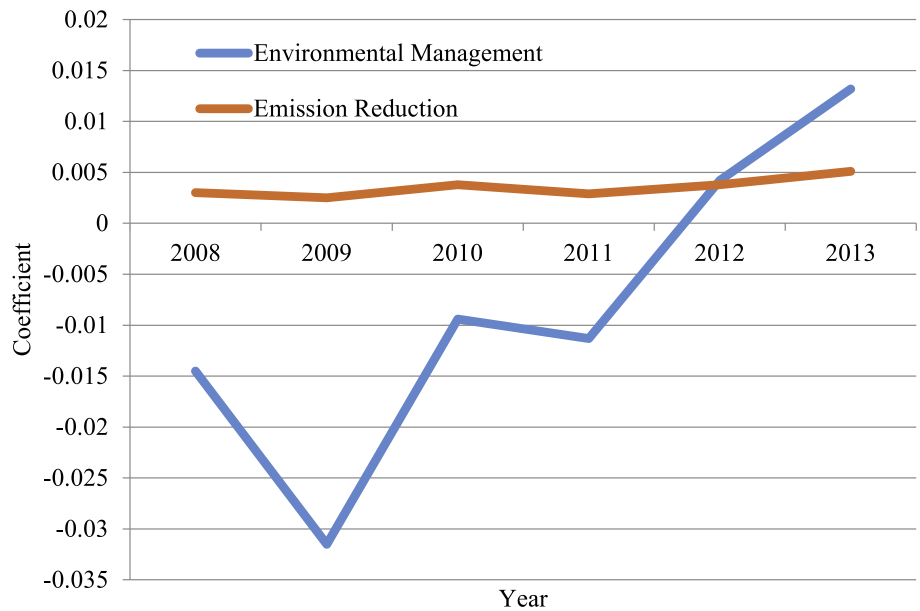

Fig. 5. Coefficients of environmental management and emission reduction produced by the manufacturing sector in the range between 2008 and 2013.

means that the adoption of EMS has significant effect on the demand. Notice that the coefficient of emission reduction in particular is positive for the manufacturing sector and other sectors, while it is negative for the supplier of electricity. In this case, the management of GHG emission decreases profits through a decrease in productivity and could indicate a difficulty for the sector to improve productivity by reducing emissions. The CO_2 emissions are mainly related to the amount of energy consumed and it is therefore obvious that any enterprise would like to achieve energy efficiency that allows itself directly to reduce the production costs and, indirectly, to obtain lower emissions.

However, this argument does not work for all the energy firms. In fact, energy consumption can be divided into three components, the fixed (which includes all amounts to be paid as a fixed amount, that is, regardless of consumption, with respect to network services), the power (that is the amount you pay in proportion to the power used) and variable (including all amounts to be paid in relation to the amount of electricity transmitted over the network to meet the demand for energy). It is reasonable to assume that it is difficult to get better productivity from the reduction of emissions for those firms that have difficulty in reducing fixed energy consumption (and power) and for which it represents the main burden of the cost of energy. In addition, many companies have already opted for energy efficiency (e.g. to obtain white certificates), so achieve further reductions in energy costs means investing heavily in energy-efficient technologies. The additional costs for an operation of this kind conceal the possible effect of increased productivity resulting from lower emissions. At best, this effect can be assessed only in the long run. For other sectors may be easier to lower energy costs, for example by redesigning the production

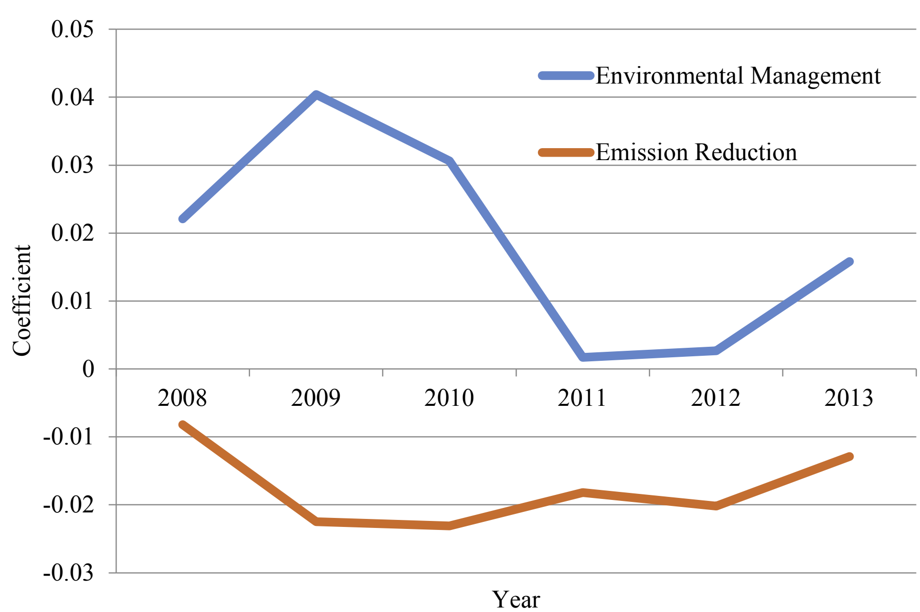

Fig. 6. Coefficients of environmental and emission reduction achieved by suppliers of electricity, gas, steam and air conditioning in the range between 2008 and 2013.

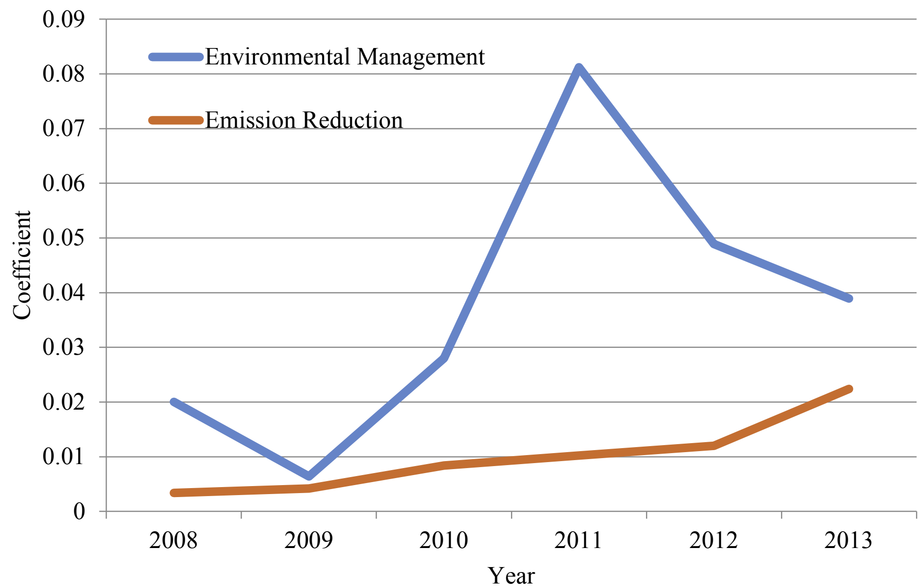

Fig. 7. Coefficients of environmental and emission reduction achieved in other sectors (agriculture, mining and quarrying, water supply, construction, wholesale and retail trade, transportation and storage, etc.) in the range between 2008 and 2013.

process. So the adoption of a management of GHG emissions confirms profit growth through an increase in productivity for the manufacturing sector and other sectors (respectively 0.4% and 1.2%) while there is a decrease in productivity for electricity suppliers (of approximately −2.1%). Demand growth in the same period appears to be greater for the other sectors (+3.8%), followed by the energy sector (+2.6%) and that of the manufacturing sector (+0.8%). In the sectoral analysis the model is adequate with an R^2 equal to 0.84, 0.71 and 0.69 respectively for the manufacturing sector, electricity suppliers and other sectors and the F statistic and p-values are significant.

Time analysis from 2008 to 2013 of the influence of GHG management on the economic performance of Italian firms, is performed before to the total sample of companies, then dividing them in sectors. Most of the investigated firms can be grouped under the manufacturing sector (333 observations in 2008, 344 in 2009, 367 in 2010, 374 in 2011, 377 in 2012 and 326 in 2013) and that of suppliers of electricity, gas, steam and air conditioning (51 observations in 2008, 58 in 2009, 67 in 2010, 71 in 2011, 69 in 2012 and 62 in 2013), only a small part is covered by other categories (agriculture, mining and quarrying, water supply, construction, wholesale and retail trade, transportation and storage, etc.), which we will simply call other sectors (57 observations in 2008, 63 in 2009, 72 in 2010, 75 in 2011, 76 in 2012 and 62 in 2013). As shown in Table 6 all coefficients estimated by the model are significantly different from zero for all the years of observation and the introduction of a GHG management has influence on economic performance of the sample of companies considered. The sign of the coefficients of environmental management and emission reduction is again positive and the trend of these coefficients is increasing from 2009 to 2013 (Fig. 4). This behavior indicates also in the temporal analysis that the focus on the environment as

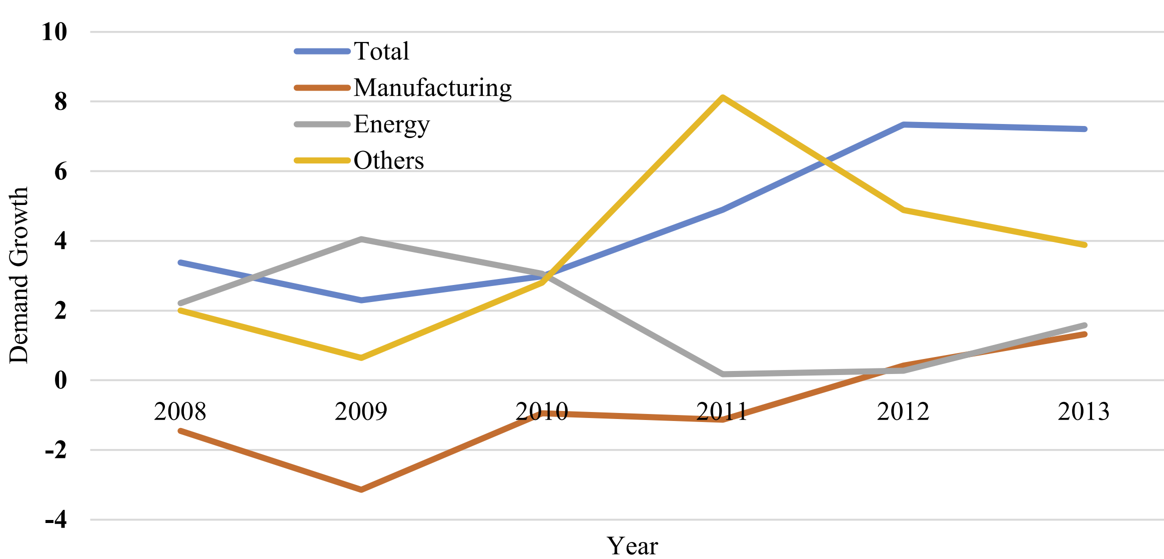

Fig. 8. Demand growth obtained for the entire sample of Italian firms and observed for different sectors in the range between 2008 and 2013.

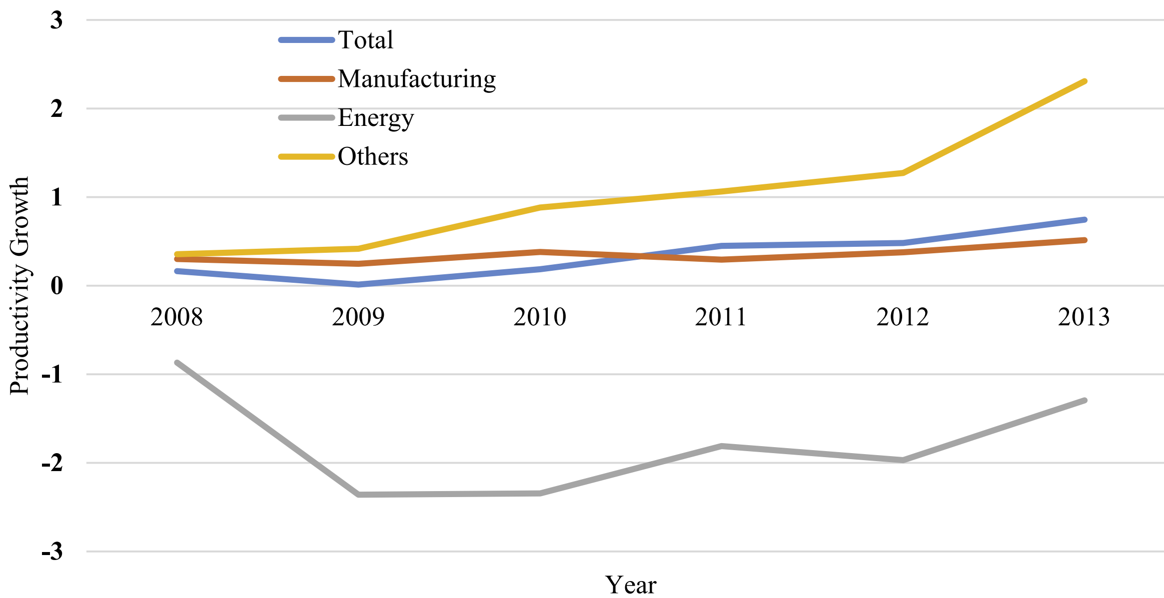

Fig. 9. Productivity growth obtained for the entire sample of Italian firms and observed for different sectors in the range between 2008 and 2013.

demonstrated by an environmental management is effective on increasing demand, while maintaining the lowest possible emissions level has effects on productivity growth. Image returns to those customers sensible of environmental issues increase profits, efficiency and competitive level. Table 7 gives some useful statistical results to assess the quality of the estimated regression coefficients: in this analysis model is adequate to explain between 71% and 76% of the data collected between 2008 and 2013 and the F statistic and the p-values are significant. So the adoption of a GHG management confirms profit growth from 2009 to 2013 through an increase in demand (from approximately 2.3%–7.2%) and productivity (approximately from 0.02 to 0.7%) (Table 8). The effect of implementation of the GHG management by improving productivity is weaker than through an increase in demand, suggesting that there is a delay between the start of the environmental efforts and the realization of economic performance. These results encourage then to invest in technologies for producing "cleaner" while also reducing expenses, costs and environmental risks. Tables 6–8 are also reported the results of the temporal analysis considering firms separated in the three sectors. As the results of the total sample, the coefficients of environmental management and emission reduction are significant, implying that the adoption of EMS has significant effect on demand and the actions of emission reduction have significant effect on productivity. Particularly in the manufacturing sector coefficient of emission reduction it is always positive from 2008 to 2013 and slowly increasing, while the coefficient of environmental management is negative in 2008, worsened in 2009, and then grow rapidly and become positive in 2012 and 2013 surpassing the corresponding coefficient of emission reduction (Fig. 5). In the case of suppliers of electrical energy (Fig. 6), whose sample is less representative than to the manufacturing sector, the coefficient of emission reduction is negative while the coefficient of environmental management is always positive but it is not growing. As regards the heterogeneous sample of the other sectors (Fig. 7) both coefficients are positive and in particular the effect of environmental management is greater than that of the emission reduction. In the annual analysis model is adequate to explain about 83%–86% of the data of the manufacturing sector, 68%–78% of the data of suppliers of electricity and 60%–80% of the data of the other sectors; also the F statistic and p-value are significant (Table 7).

The environmental management confirms a trend of increasing profits through an increase in demand (Fig. 8), with a not homogeneous behavior for the different sectors: the manufacturing sector in the early years is negative then increasing (from −1.4% to 1.3%), for electricity suppliers is positive although not increasing (from 2% to 1.6%), growing and positive for the other sectors (from 2.0% to 3.8%). The adoption of a management of GHG emissions confirms profit growth through an increase in productivity (Fig. 9) for the manufacturing sector (which ranges from 0.3% in 2008 to 0.5% in 2013) and other sectors (ranging from 0.4% in 2008 to 2.3% in 2013) while there is a decrease in productivity for electricity suppliers (around −2% from 2009 to 2012).

7. Conclusions

The challenges of climate change require a strong and coordinated global response that involves consumers, businesses and governments. On the one hand it is necessary to reduce emissions of greenhouse gases that are the cause of climate change and on the other one adapt to live with its consequences. In the era of sustainable development, firms play a key role in reducing and managing greenhouse gas emissions. The issue of environmental aspects and impacts aimed to reduce and prevent pollution was perceived by businesses as a cost, however many actual studies have shown how this one can generate a series of benefits (Lash and Wellington, 2007; Nishitani et al., 2011, 2014; Nishitani, 2011; Nishitani and Kokubu, 2012; Iwata and Okada, 2011; Hibiki and Managi, 2010; Jacobs et al., 2010; Zeng et al., 2010; Ziegler, 2005; Misani and Pogutz, 2015; Xia et al., 2015; Wang and Zhao, 2017; Nguyen and Hens, 2015; Zhu et al., 2017; Dasgupta et al., 2000; Melnyk et al., 2002; Potoski and Prakash, 2005; Russo, 2009; Capece et al., 2017).

In this paper we have tried to assess whether the proper management of emissions could represent a competitive advantage for firms by profit growth due to increased demand and productivity. Differently from other studies, this analysis is carried out on the Italian market in the period 2008–2013 and it is based on a theoretical model derived from a Cobb–Douglas production function and an inverse demand function that allows separating and evaluating the effects of GHG management (EMS adoption and emission reduction) on performance. The evaluation of the results confirms an improvement in the performance, something that would encourage firms to voluntarily apply an environmental emissions management regardless of their location or size. The main conclusions are as follows. EMS implementation increases a firm's value added through an increase in demand and an improvement in productivity, which supports the theoretical model. However, excluding the high aggregated sector considering firms representing the other categories, the positive effect of the implementation through an increase in demand occurs mainly for firms in the energy sector whereas the main effect in productivity is in the manufacturing sector. Firms conducting better GHG management are more likely to increase value added through an increase in demand because customers require green products and processes avoiding risks stemming from less environmentally conscious suppliers (Arimura et al., 2008).

This implies that firms came to be required by costumers not only to adopt EMS certifications, but also to conduct better specific environmental management activities including GHG emission reduction (Bansal and Bogner, 2002; Jiang and Bansal, 2003; Nishitani, 2011). Firms conducting better GHG management are more likely to increase value added through an improvement in productivity; this is in line with the literature (Porter and van der Linde, 1995), resource productivity and thus competitiveness could be improved by a more pushed environmental management. This underlines the necessity to promote an environmental policy in Italy to encourage firms to reduce emissions voluntarily and invest in environmental technology. Because this study used only Italian data for the analyses, it is possible that future research with a greater set of countries and a wider set of sectors will determine the relationship between a firm's GHG management and economic performance and associated policy implications more precisely. Actually authors do not have access to similar databases on the budgets of other European companies, thus preventing to extend this analysis to a larger number of countries. Moreover it will be useful to strongly investigate the rule of grants in aid and indirect regulation on the obtained results since these strategies provide economic incentives to firms in order to innovate for the sake of the environment and sustainability.

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