Environmental management, labour productivity and innovation

Preliminary results from a survey of Italian firms using Coarsened Exact Matching

Abstract

Purpose: Environmental issues are often the top priorities in the agenda of managers and police makers. However, recent systematic literature reviews suggest that there is little evidence for whether it is profitable to be green. This research empirically investigates the impact of green management intensity on the business performance of Italian firms.

Design/methodology/approach: In the framework of the counterfactual analysis, this research implements the CEM Coarsened Exact Matching (Iacus et al. 2011, 2012) in order to compare outcomes of firms with similar characteristics but different green management strategies. The outcomes of interest are labour productivity and innovation, while the treatment is the green intensity (i.e. environmental management systems, simple rules, no environmental strategies). A rich set of covariates is included to match threats and controls. The analysis is performed on a separated sample of high and low energy-consuming sectors.

Findings: Firms with green management are not performing any better than peers with no environmental management strategies, especially in high energy-consuming sectors. However, higher levels of green management do outperform lower intensity levels of green management.

Implications: Integrated and systematic green management is advisable for managers.

Moreover, as green strategies are not paying off, other tools are needed to push firms toward more environmentally friendly operations.

Originality: While most of the existing research compares two groups of firms, this research addresses the intensity of green management. The paper is the first application of the CEM method to survey data.

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Keywords: Environmental management, labour productivity and innovation, survey, Italian firms, Coarsened Exact Matching. **JEL:** O3; L2, L5, D2.

1 Introduction

Environmental issues are often the top priorities in the agenda of policy makers. The 2012 United Nations Conference on Environment and Development (also known as Rio+20) emphasises the importance of sustainable development and promotes the implementation of proper policies to achieve environmental goals. In Europe, the green economy is expected to increase employment and growth, supporting economic recovery after the financial crisis of recent years (Eco-Innovation Observatory, 2013).

Many firms adopt environmental management systems to deal with environmental issues. At a global level, almost 267,000 firms are ISO 14001 certificated. Italy is the second country for growth of certificates, after China (ISO, 2012). ISO 14 000 standards were issued by ISO following the Rio 1992 United Nations Conference on Environment and Development. These standards have been implemented around the world (ISO, 2012).

Along with the potential impact on the environment (e.g. reduction of CO2 emissions), it is particularly relevant for managers and policy makers to understand whether green management has any financial benefits. Paralleling the debate between green regulation and business performance (Porter and Linde, 1995; Palmer et al., 1995), and when seen from a theoretical point of view, both positive and negative relationships between green management and business performance are plausible. On one hand, green management that aims to reduce production inputs (e.g. energy, raw material, waste) can reduce operational costs. Moreover, by attracting environmentally-friendly customers, greener companies can potentially increase their revenue. However, additional costs to reduce pollution or cut emissions can detriment business performance (Porter and Linde, 1995; Ambec and Lanoie, 2008).
The existing empirical literature reflects the mixed results of the theoretical literature. According to a recent and exhaustive literate review (De Vries et al., 2012), the majority of empirical papers have found a mainly positive link between the certification of environmental management systems and business and environmental indicators, even if some studies found a neutral or negative impact. As pointed out by Ambec and Lanoie (2008, p. 48) in their systematic review of the literature, “Is it profitable to be green? There is little evidence to that effect.” Due to the mixed results of previous research, the impact of green management on business performances remains unclear, and further research is required.

This paper contributes evidence to the current debate in several ways. Firstly, while most previous research compares two groups of firms (certified vs. not certified), the current study considers the intensity of green management. More precisely, on the basis of environmental strategies, this research identifies three groups of firms. Firms in the first group implement complex environmental management systems in order to save energy and resources (e.g. ISO 14000). The firms in the second group implement only simple rules or devices. The firms in the third group do not adopt any specific environmental strategies. Secondly, this study compares both the labour productivity and the innovation propensity of firms that have different environmental strategies. Thirdly, this research explicitly accounts for different energy consumption levels between sectors and addresses

Small Medium Enterprises, including firms with between one and nine employees. Finally, this paper focuses its investigation on a representative sample of Italian firms, while other studies have focused on a specific sector, such as the automotive industry (Comoglio and Botta, 2012), heavy metal industry, (Arena et al., 2012) and pulp and paper industry (Gasbarro et al,. 2013).

The paper adopts a multivariate matching method (Iacus et al., 2011; Iacus et al., 2012) that is a monotonic imbalance bounding, in order to address potential causality issues related to the direction of the relationship between certification and business performances (Heras-Saizarbitoria et al., 2011). More precisely, this paper implements the Coarsened Exact Matching that was recently proposed in the literature (Iacus et al., 2011; Blackwell et al., 2009; Iacus et al., 2012) and which has generated interest among political science researchers (e.g. Carpenter et al., 2012). Cozza et al. (2012) investigated innovation, profitability and growth in medium-high tech Italian firms. The authors indicated the CEM method as a possible alternative to Propensity score matching.
This paper is the first to implement the CEM in the field of innovation and environmental management. Moreover, accounting for the sample weight of complex designed surveys, this paper extends the CEM method to the survey dataset. This contribution is particularly relevant because most studies about innovation are based on surveys, such as the Community Innovation Survey.

The rest of the research is organized as follows: a brief literature review, which presents the main results of the existing literature and develops a hypothesis. Thereafter, the methodological section presents the matching model and the CEM. The results are then presented, followed by a discussion and conclusions.

2 Previous studies

If the primary task of managers is to maximize profit for stakeholders, then managers should not care about social responsibility (Friedman, 1970) or environmental issues. This view is challenged by authors (Porter and Linde 1995; Hart, 1995) that consider productivity to be the efficient use of resources, and perceive environmental consciousness as an opportunity for long term competitiveness. A large strand of literature on the impact of environmental legislation on private business performance has stemmed from this debate.
Porter and Linde (1995) argue that both lower production costs and products with superior value can be stimulated by properly designed environmental legislation. The main idea is that appropriate green regulations can stimulate the introduction of more efficient technologies. This statement is often known in literature as the Porter hypothesis. However, Palmer et al., (1995) challenged this hypothesis, suggesting that it implicitly assumes the systemic failure of managers to recognize profitable opportunities for improvement. Ambec and Barla (2002) addressed this critique by formalizing the Porter hypothesis in an economic model, which includes asymmetric information within firms.

Another strand of the existing literature contributes to the debate on environmental management. Based on a resource-based view (Penrose, 1959), Hart (1995) proposed a Natural-Resource-Based View; developing a theory of competitive advantage based upon a firm's relationship to the natural environment. Russo and Fouts (1997) found empirical evidence that it pays to be green".

Some studies use some level of environmental performance in order to investigate the aggregate effects of green management and performance[1]. For example, measuring the level of waste produced, King and Lenox (2002) found a positive relationship between profitability and green management in the USA. Klassen and McLaughlin (1996) explicitly investigated the impact of environmental management on the financial performance of publically listed companies; distinguishing between market gain and cost savings. The same distinction is adopted in a comprehensive analysis provided by Ambec and Lanoie (2008), which identifies three main channels linking better environmental practices and growth of revenues, as well as four channels driving cost reductions. They are:

(a) Better access to certain markets: Customers concerned with environmental issues (including the public sector) can choose green suppliers. The green preference of the final consumer can influence all supply chain ("green supply chain").
(b) Differentiating products: Green management can push firms into market niches where consumers are willing to pay more for more environmentally friendly products or services.
(c) Selling pollution-control technology: Firms facing an environmental problem can internally develop environmental friendly technologies that can be attractive for other companies. This strategy is relatively rare, but can be particularly remunerative if new technologies are the reference of new stricter legislation.
(d) Risk management and relations with external stakeholders: Environmental management can improve communication between internal and external stakeholders and reduce risks related with these relations. Moreover, a proactive environmental management strategy can mitigate the risk of unattended and stricter regulations.
(e) Costs of material, energy, and services: If pollution is the result of imperfect use of production inputs, effective green management can reduce both the environmental impact and the costs of production inputs.
(f) Cost of capital: Environmentally friendly firms can access funds which are available for Social Responsibility Investments[2]. More generally, banks and financial markets can perceive green companies as being less risky (e.g. less likely of legal liability for environmental issues) and, therefore, green firm can benefit from lower financing costs.

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[1] See Wagner et al. (2001) and Ambec and Lanoie (2007) for a review of empirical work that can be grouped into the following main categories: event studies, portfolio, and multiple regression studies.

[2] El Ghoul et al. (2011) found that US firms with better Corporate Social Responsibility exhibited lower costs of capital. The Corporate Social Investment scheme is particularly relevant in the US, where "one out of every nine dollars under professional management in the United States is invested according to SRI strategies". (US Social Investment Forum 2013 http://ussif.org/resources/pubs/trends/documents/Trends2012FAQFINAL2.pdf. In Europe, particularly in Italy, the Corporate Social Investing has smaller figures (Forum per la Finanza Sostenibile 2013 http://www.finanzasostenibile.it/index.php?option=com_contentandview=articleandid=263andItemid=143

(g) Cost of labour: Ambec and Lanoie (2008) report anecdotes suggesting that green firms can provide increased job satisfaction and, therefore, reduce the costs associated with a less motivated workforce (e.g. high turnover, absenteeism). Quantitative evidence of this positive relationship is provided by Levine and Toffel (2010) for quality management certification and by Delmas and Pekovic (2013) for environmental management certification.

An important strand of the empirical literature operationalizes green management using the certification to the environmental quality management system ISO 14 001. Following the 1992 United Nations Conference on Environment and Development in Rio de Janeiro, ISO published the family of ISO 14000 standards in 1996 (ISO, 2009). These standards provide integrated guidelines for developing an effective environmental management system, in order to assist firms in their efforts to minimize environmental harm and reduce the use of resources. The adoption of the ISO 14000 standards family, along with the third-party certification system, is voluntary; that is there is no legal obligation to certify the management system (Potoski and Prakash, 2005). In this respect, environmental standard certification is more related to "incentive-based regulation" and is considered superior to "command- and-control" (Porter and Linde, 1995; Palmer et al., 1995). Being ISO 14001 certificated has the advantage of demonstrating to internal and external stakeholders that the management system of the firm respects the requirements of the ISO 14001. Many firms adopt and certify complex environmental management systems in order to cope with environmental issues. As shown by the most recent data, almost 267,000 ISO 14001 certificates had been issued around the world in 2011 (ISO, 2012).

In this literature strand, the first qualitative studies on ISO 14001 (e.g. Rondinelli and Vastag, 2000; Shrivastava, 1995; Morrow and Rondinelli, 2002) were followed by more recent quantitative investigations that have found strong evidence of a positive relationship (Delmas and Pekovic, 2013; Jong et al., 2013). However, Nishitani et al. (2012) found that, accounting for other activities designed to improve productivity, the voluntary implementation of environmental management activities is not strong. Boiral (2007) illustrates how the ISO 14001 system can have an ambiguous effect on environmental management practices and performances, along the strand of institutionalism literature (Meyer and Rowan, 1977; DiMaggio and Powell, 1983). It is important to point out that the ISO 14000 certified companies can benefit both from the signal effect of certification (Terlaak and King, 2006; Mangiarotti and Riillo, 2013) and from the effective implementation and integration of the environmental standard in daily routines, which is clearly explained in literature. This is in the case of ISO 9000 (e.g. Naveh and Marcus, 2005) and of ISO 14000 (e.g. Aravind and Christmann, 2011). In line with the results of Ziegler and Seijas Nogareda (2009), Heras-Saizarbitoria et al. (2011) found evidence that better performing companies are likely to be ISO 14000 certified. However, they found no evidence that better performing companies are following the certification.

2.1 Hypothesises development

Overall, it appears that a proactive environmental strategy has at least a positive impact on the environmental performance of the firm, but few studies have investigated the link between different degrees of green commitment. It is important to point out that firms can find certification and the integrated management system excessive and too complex for their needs. For this reason, some firms may adopt a more pragmatic green strategy to deal with environmental issues. These firms can implement simple rules or simple devices to reduce inputs in the production process and become more environmentally friendly[3].

However, when adopting an environmental system, firms can systemically and in a more comprehensive manner identify and exploit opportunities for improvement. Moreover, higher maturity of management makes third party certification (and the consequence signalling effect), less expensive and more likely. Therefore, environmental systems should be superior to "simple rules".

These different green strategies represent different tiers of the intensity of green management. They can be ordered in three levels: the highest level (i.e. environmental systems), the medium level (i.e. simple rules) and the lowest level (no green management at all). Based on the discussion above, the following main hypothesis can be formulated:

H1a: Firm with any green management system outperform firms without any green management system.
H2a: Firms with green management systems outperform firms with lower green management intensity.
H3a: Firms with environmental systems outperform firms with simple rules.

Among other business performance measures, particular attention should be given to innovation. Firstly, a green strategy can require the introduction of new technologies (Radonjic and Tominc, 2006) and the reengineering of existing organization and production processes (Gasbarro et al. 2013). Secondly, green initiatives, if properly associated with marketing activities (e.g. certification), can facilitate the commercialization of the invention, changing the perceptions of consumers. This is shown, for example, in the case of corporate social responsibility (Becker-Olsen et al. 2006). In Spain, Simon et al. (2012) found a positive relationship between quality and environmental management standards and innovation through the impact on consumer perceptions. Other evidence has been documented in France (Pekovic and Galia, 2009) and in Luxembourg (Mangiarotti and Riillo, 2010). In other words, influencing the perception of customers green management can facilitate the introduction of a new and improved product. Therefore, the three hypotheses can be reformulated to take innovation into account.

H1b: Firms with any green management have higher innovation than firms without green management.

[3] Small and medium-sized enterprises (SMEs) can face a particular lack of resources and less capability to implement environmental practices, as shown by Brammer et al. (2012) in the UK.

H2b: Firms with environmental systems have higher innovation than firms with lower green management intensity.
H3b: Firms with environmental systems have higher innovation propensity than firms with simple rules.

Besides the different impact that the intensity of green management can have on performance, it can be argued that, according to the Porter Hypothesis, firms operating in a highly polluting sector, with high demands of energy and raw material (e.g. the steel industry) should have more opportunities for improvement than firms in sectors with production processes that require fewer emissions. Therefore, firms in sectors with higher demands of energy should benefit more from green management at any level intensity of management.

H4: The benefits of green management are higher in firms in energy-consuming sectors than in firms in other sectors, at any green management intensity.

3 Methodology

This work investigates the effect of different degrees of green management on firm performance, in terms of labour productivity and innovation. This problem can be formalized in a model of counterfactuals[4]. Heckman (2008) defines counterfactuals as "possible outcomes in different hypothetical states of the world". An example would be the health outcomes for a mouse that are associated with receiving or not receiving a drug treatment. In our model, the outcomes are the performances of the firm and the treatment is the green management. It is important to point out that, while medical researchers can freely assign the drug, we cannot assign the "green management" but only observe it.
The state "green management" will be indicated with T, which can assume a value of T=1 if the firm has green management activity and T=0 if the company has no green management[5]. $\mathbf{Y}$ is the vector of outcome variables (i.e. productivity and innovation) for i, the generic company. The effect of green management on the individual firm can be formalized as $\boldsymbol{\tau}_i = \mathbf{Y}_{i1} - \mathbf{Y}_{i0}$, where $\mathbf{Y}_{i1}$ is the potential outcome of a green firm i and $\mathbf{Y}_{i0}$ is the potential outcome of the same company but with no green management engagement. Of course, for each company at any given time, only one state of $\mathbf{Y}$ is observable. If the "green management" would be randomly assigned, it can be estimated that the effect τ is the simple difference between treated and untreated. However, each firm decides to be green or not. As the treatment is not randomly assigned, the treatment and the control group will not necessarily have the same characteristics (i.e. covariates are balanced). Differences between treated and controls can confound the treatment effect. For example, if size is positively related with performance, and larger firms are more likely to be green than smaller firms, potential differences in $\mathbf{Y}$ could be attributed to the size and not to the green certification.

[4] Counterfactual model is usually attributed to Rubin and it is largely implemented in different fields of research (Heckman, 2008).
[5] In this case, the treatment is dichotomous but can be easily extended to the case of multiple treatments.

In other words, it is necessary to compare green firms with properly matched control firms. The scope of the matching is to make the covariates of the two groups (on average) balanced. The intuition is that, conditional to all relevant observable pre-treatment covariates, the treatment (i.e. green management) is random, and we can estimate the treatment effect[6]. A well-established method is to match treated and controls, accounting for all relevant covariates with the propensity score matching -PSM- (Rosenbaum and Rubin, 1983). However, a more recent matching method, monotonic imbalance bounding, has been proposed in literature (Iacus et al., 2011). This recent method is called Coarsened Exact Matching – CEM – and it is particularly suitable for causal inference (Iacus et al., 2012). For these reasons, the CEM, adjusted to the case of survey data with sample weights, is implemented in this analysis[7].

3.1.CEM

PSM requires the estimation of the propensity score, stratification of the observations according the propensity score, and a check *ex post* if, within the strata, the covariates of treated and controls are balanced. If balance is not achieved, there is a need to re-estimate the propensity score and repeat the procedure. One pitfall is that PSM is highly sensitive to the set of variables used to calculate the score (Smith and Todd, 2005).

The CEM method inverts this process. CEM bounds *ex ante* the maximum imbalance of covariates, creates the strata according these bounds, and retains only units exactly matched. That means that CEM prunes observations outside the strata that have both treated and controls. CEM-based causal estimates possess powerful statistical properties and can outperform other matching procedures (Iacus et al., 2011). In practice, CEM keeps the units of strata with at least one treated and one control. If there is more than one treated and one control in the strata, then the units are weighed according to the following formula:

$$w_i = \begin{cases} 1, & i \epsilon \mathcal{T}^s \\ \frac{m_C}{m_T}\frac{m_T^S}{m_C^S} & i \epsilon C^s \end{cases}$$

Where

$$\mathcal{T}^s = treated\ units\ in\ the\ stratum\ s$$
$$C^s = control\ units\ in\ the\ stratum\ s$$
$$m_C = sum\ of\ controls\ in\ each\ stratum$$
$$m_T = sum\ of\ treated\ in\ each\ stratum$$
$$m_T^S = number\ of\ treated\ units\ in\ the\ stratum$$
$$m_C^S = number\ of\ controls\ units\ in\ the\ stratum$$

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[6] Conditional Independence Assumption, Stable unit Treatment value Assumption and common support regions are assumptions of match models.
[7] Estimation are performed using the STATA Ado file introduced in Blackwell et al. (2009)

If unmatched, the $w_i = 0$. Consistent with Blackwell et al. (2009), we indicate these weights as CEM_weights.

3.2 CEM in survey data

As presented in the following section, the observations of the dataset are weighted to be representative of Italian firms. However, applying matching models to the case of the survey data is not straightforward. Leuven and Sianesi (2012), authors of one of the most common programs for implementing PSM, state that there is no clear guidance in the literature on how to use "sample weights", but some indications are provided. "Sample weights" are intended to make the weighted sample representative of the surveyed population.[8] They are different from the "CEM_weights" presented in the previous section. The authors report that "the recommendation to date seems to ignore sampling weights" and they invite researchers to consider using a logit and match on the odds, as suggested by Heckman and Todd (2009). Moreover, the authors report: "When interested in the effects of treatment on the treated, the sampling weights should refer to the treated alone". This approach was adopted in Zanutto (2006) and Dolton and Smith (2011). It can be argued that, within the CEM model, the use of the sample weight is more intuitive and allows the calculation of the overall impact of the treatment.

The intention of the weighting is to make the weighted sample representative of the wider population. As such, they need to be incorporated into the CEM if we want to estimate the Population Average Treatment on Treated. This point can be illustrated with an example: Let us assume that the population of firms is made of green and not green firms. Five firms are small green and one is large green. There are, in addition, one large no green, one medium no green and one small no green. The total population is nine. However, the sample is made of five firms: one large green, one small green, one large no green, one medium no green and one small no green. Therefore, the sample weight is one for all firms except small green, which has a weight of five. We assume that the effect of green management is one if large and two if small. That is:

$\mathbf{Y}_0$= 1 for small and large firms
$\mathbf{Y}_1$= 1 for large firms
$\mathbf{Y}_1$= 2 for small firms

Using the CEM, we drop the medium no green because there is no match. We correctly have two strata. The first strata includes 1 large green and 1 large no green, the second strata includes 1 small green and 1 small no green[9]. At this point, sample weights do not influence the pruning of the observation.

[8] They can be originated by a complex process. First base weights of the unit is the inverses of the probability of been selected in the survey sample. Second these weights are adjusted to account for non-response, and last weights are further adjusted to make sample totals equals to known population totals of same key variables such us NACE distribution (Kalton and Piesse, 2007).
[9] As there is one treated and one control in each cell, the CEM weights $w_i = 1$

Let us calculate the effect of green, ignoring the sample weights The average outcome of treated = 1*1 +2*1 / 2. The average outcome of not treated and matched = (1*1 +1*1) /2. The Sample Average Treatment on Treated is therefore: 1.5 – 1 = 0.5. Using the sample weight, the effect of the green management for the population treated is (1*1 + 2*5)/6, while the outcome for not treated is (1*1/3 + 1*5/3)/2. The overall average effect of the green management is 11/6 – 1 = 5/6 ≅ 0.84.

From this example, it can clearly be seen that it is important to account for sample weights, especially when sample weights are based on characteristics correlated with the effect of the treatment. Therefore, this research does not use sample weights, for pruning observation, but instead uses sample weights to calculate the causal effect, adjusting for the CEM weights. In formula, the CEM_weights adjusted for the sample weights $\mathrm{sw}_{i\_}w_i$ are:

$$\mathrm{sw}_{i\_}w_i = \begin{cases} \mathrm{sw}_i * 1, & i \epsilon \mathcal{T}^s \\ \dfrac{(sw * m_C)}{(sw * m_T)} \dfrac{(\mathrm{sw}_i * m_T^S)}{(\mathrm{sw}_i * m_C^S)} & i \epsilon C^s \end{cases}$$

$$\mathrm{sw}_i = sample\ weight\ of\ each\ unit$$
$$\mathcal{T}^s = treated\ units\ in\ the\ stratum\ s$$
$$C^s = control\ units\ in\ the\ stratum\ s$$
$$(sw * m_C) = weighted\ sum\ of\ controls\ in\ each\ stratum$$
$$(sw * m_T) = weighted\ sum\ of\ treated\ in\ each\ stratum$$
$$(\mathrm{sw}_i * m_T^S) = weighted\ number\ of\ treated\ unit\ in\ the\ stratum$$
$$(\mathrm{sw}_i * m_T^S) = weighted\ number\ of\ \ of\ controls\ units\ in\ the\ startum$$

If unmatched, the $\mathrm{sw}_{i\_}w_i = 0$.

3.3 Data and variables

Focusing on Italian firms, the hypotheses developed in the previous section are tested on the firm level data of the 2007 survey of SMEs Observatory[10]. The survey is managed by the Eurobarometer Team of the European Commission, conducted by the Gallup Organization[11]. This survey can be considered a reliable representation of the nation’s economic activity. Previous studies of European SMEs have used this source of data (e.g. Hernández-Cánovas and Koëter-Kant, 2008). The 2007 survey is the most recent on European firms that is freely accessible online and covers both SMEs (1-250 employees) and large firms (+ 250 employees) within the manufacturing and service sectors. Post-stratification weights were used to restore proportions, according to company size and industry sector, for each country. The unweighted sample is made of 909 units for Italy in 2007.

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[10] Data, detailed documentation and descriptive statistics are available at the website of the Observatory of European SMEs http://ec.europa.eu/enterprise/policies/sme/facts-figures-analysis/sme-observatory/index_en.htm

[11] More precisely, the Italian firm were surveyed by Demoskopea in November-December 2006.

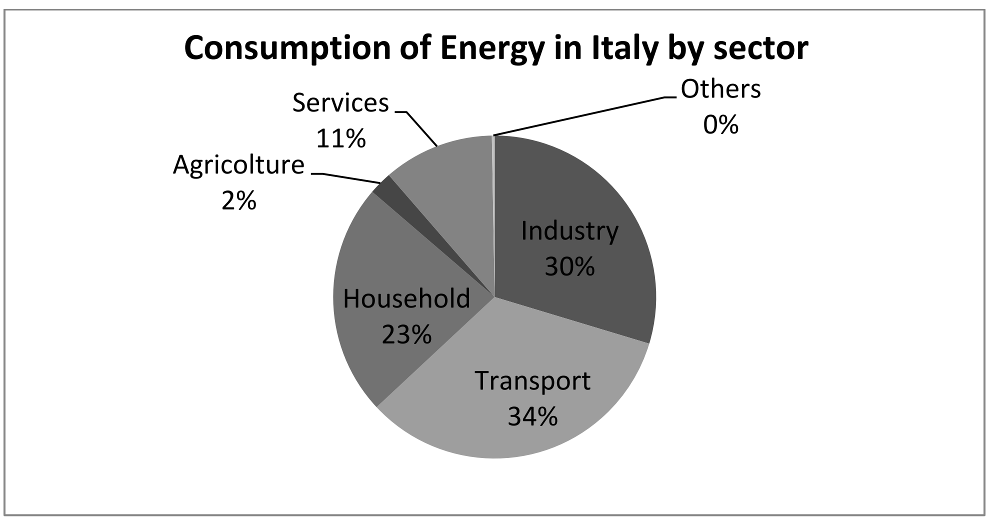
The questionnaire includes questions about the general characteristics of firms, constraints of the business, globalization, competition, innovation, and the labour market. Particularly important for this analysis is Q54: “Does the enterprise use an environmental management system or any other measures to save energy and resources? Possible answers are: “Yes, simple rules or devices to save energy; Yes, complex energy saving systems; No”. Based on this question, firms are screened according their green strategy.

This variable defines the three green strategies that are the treatment. The outcomes of interest are labour productivity and innovation. Labour productivity is proxied as the (natural log) of turnover per employee. Innovation is proxied with a dummy variable that is 1 if the firm introduced into the market new or significantly improved products or services and, if not, zero.

A rich set of covariates is included: economic activity, size, craftsman status, exports, perceived competition and difficulties with funding and with customer demand. The list of variables used in the analysis and some statistics are reported in the annex. To investigate *H4*, the hypothesis that green management benefits more in high energy-consuming sectors. The sample is split between high and low energy consuming sectors and the same analysis is performed on these two groups separately.

The industry and transport sectors absorb more than 60% of energy equivalent in Italy, as shown in Figure 1. Therefore, separated results are presented for high energy consuming sectors (i.e. industry, including construction, and transport) and for low energy consuming sectors (i.e. the other firms).

Figure 1



Source: "Consumption of energy" -in 2005. Statistics Explained (2013/2/1) http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Consumption_of_energy

4 Results

This section presents the results of the analysis of labour productivity and innovation separately. To investigate the intensity of green management, the analysis compares different intensities of green management. Firstly, any green management is compared vs. no green management, in symbol: “2_1 vs. 0”. Later, comparison is done between management systems and firms without management systems, in symbols: “2 vs. 1_0”. Finally, management systems are compared with simple green rules, in symbols “2 vs. 1”. The analysis is performed once on the full sample and later on high and low energy intensive sectors separately[12]. For each table, to appreciate the importance of considering the sample weight, each estimation is performed twice: once considering the sample weight (i.e. $\text{sw}_i\_w_i$) and once without this consideration (i.e. Cem_w).

4.1 Labour productivity

Table 1 shows that firms implementing any form of green management are not performing any better than firms without green management, in terms of labour productivity. Considering the sample weights, the effect is negative and statistically significant at a level of 10%. However, it should be noted that firms with higher levels of green management do not have poorer performance than other firms, but when compared with firms adopting simple rules, they are outperforming.

Table 1 all sample

Labour productivity	2_1 vs. 0		2 vs. 1_0		2 vs. 1	
	$\text{sw}_i\_w_i$	Cem_w	$\text{sw}_i\_w_i$	Cem_w	$\text{sw}_i\_w_i$	Cem_w
Green effect	-0.273*	-0.220	-0.260	0.0614	0.697**	0.689*
	(0.144)	(0.139)	(0.238)	(0.231)	(0.344)	(0.352)
Observations	351	272	239	137	47	40

Green effect = mean of treated - mean of controls; “2_1 vs. 0”= any green management vs. no green; 2 vs. 1_0 = management system and firms without management system; 2 vs. 1 = management system is compared with simple green rules; $\text{sw}_i\_w_i$ = adjusted sample weights; Cem_w = CEM weights; Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

When splitting the sample, interesting patterns appear. Considering high energy consumption firms, firms with green management systems perform worse than other firms, as shown in Table 2. However, in the low energy consumption sector, there is no statistical difference at a conventional level, as shown in Table 3. The mean labour productivity of firms with high green management levels is lower than the mean of other matched firms only when looking at high energy consumption. Firms with environmental management systems have higher labour productivity only in low energy intensity sectors. However, in the case of high energy consumption, there is no significant difference at a conventional level of statistical significance.

[12] The sum of observation of split samples can be not equal to total observations of the whole sample due to rounding.

Table 2 high energy consumption

Labour productivity	2_1 vs 0		2 vs. 1_0		2 vs. 1	
	$sw_i\_w_i$	Cem_w	$sw_i\_w_i$	Cem_w	$sw_i\_w_i$	Cem_w
Green effect	-0.466*	-0.254	-1.166***	-0.174	-0.397	-0.105
	(0.255)	(0.203)	(0.444)	(0.283)	(0.429)	(0.449)
Observations	78	97	104	75	41	23

Green effect = mean of treated - mean of controls; "2_1 vs. 0"= any green management vs. no green; 2 vs. 1_0 = management system and firms without management system; 2 vs. 1 = management system is compared with simple green rules; $sw_i\_w_i$ = adjusted sample weights; Cem_w = CEM weights; Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 3 low energy consumption

Labour productivity	2_1 vs 0		2 vs. 1_0		2 vs. 1	
	$sw_i\_w_i$	Cem_w	$sw_i\_w_i$	Cem_w	$sw_i\_w_i$	Cem_w
Green effect	-0.180	-0.205	-0.0264	0.256	1.174*	1.350**
	(0.176)	(0.189)	(0.273)	(0.368)	(0.637)	(0.522)
Observations	277	172	142	63	13	19

Green effect = mean of treated - mean of controls; "2_1 vs. 0"= any green management vs. no green; 2 vs. 1_0 = management system and firms without management system; 2 vs. 1 = management system is compared with simple green rules; $sw_i\_w_i$ = adjusted sample weights; Cem_w = CEM weights; Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

4.2 Innovation

As shown in Table 4, firms implementing green management are more likely to be innovative. Firms with high green management are particularly likely to introduce new innovations into the market when compared to firms with only simple green management.

Table 4 innovation all sample

Innovation	2_1 vs 0		2 vs. 1_0		2 vs. 1	
	$sw_i\_w_i$	Cem_w	$sw_i\_w_i$	Cem_w	$sw_i\_w_i$	Cem_w
Green effect	0.248***	-0.0381	0.255**	0.198**	0.394***	0.362***
	(0.0355)	(0.0510)	(0.102)	(0.1000)	(0.0884)	(0.118)
Observations	1,122	411	292	165	78	49

Green effect = mean of treated - mean of controls; "2_1 vs. 0"= any green management vs. no green; 2 vs. 1_0 = management system and firms without management system; 2 vs. 1 = management system is compared with simple green rules; $sw_i\_w_i$ = adjusted sample weights; Cem_w = CEM weights; Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 5 shows that high energy performing firms with any green management systems are not likely to be more innovative than other matched control firms. Similar patterns appear when comparing firms with green management systems and other firms.

However, as shown in Table 6, low energy intensive firms with green management are outperforming other matched firms with no green management. Firms with green management systems are performing better than other firms, and better than firms with simple green management systems, as shown in Table 6.

Table 5 innovation high energy consumption

	2_1 vs 0		2 vs. 1_0		2 vs. 1	
Innovation	$sw_i\_w_i$	Cem_w	$sw_i\_w_i$	Cem_w	$sw_i\_w_i$	Cem_w
Green effect	-0.0692	-0.0714	0.0844	0.0671	0.310**	0.216
	(0.0971)	(0.0866)	(0.172)	(0.142)	(0.132)	(0.179)
Observations	118	136	130	88	46	26

Green effect = mean of treated - mean of controls; “2_1 vs. 0”= any green management vs. no green; 2 vs. 1_0 = management system and firms without management system; 2 vs. 1 = management system is compared with simple green rules; $sw_i\_w_i$ = adjusted sample weights; Cem_w = CEM weights; Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 6 innovation low energy consumption

	2_1 vs 0		2 vs. 1_0		2 vs. 1	
Innovation	$sw_i\_w_i$	Cem_w	$sw_i\_w_i$	Cem_w	$sw_i\_w_i$	Cem_w
Green effect	0.296***	-0.0173	0.359***	0.338**	0.472***	0.481***
	(0.0374)	(0.0634)	(0.126)	(0.140)	(0.120)	(0.165)
Observations	1,086	274	170	78	35	23

Green effect = mean of treated - mean of controls; “2_1 vs. 0”= any green management vs. no green; 2 vs. 1_0 = management system and firms without management system; 2 vs. 1 = management system is compared with simple green rules; $sw_i\_w_i$ = adjusted sample weights; Cem_w = CEM weights; Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

5 Conclusions and final remarks

Adopting the Coarsened Exact Matching model adjusted for survey data, this research has investigated the impact of green management systems on business performance. Labour productivity and innovation are the performances investigated.

The hypothesis that firms with any green management systems would outperform firms without green management (H1a) is rejected at a conventional level of statistical significance. The hypothesis that firms with environmental systems would outperform firms with lower intensity of green management (H2a) cannot be rejected. However, analysing only firms with high energy consumption, (H2a) this hypothesis is rejected.

The hypothesis that firms with environmental systems outperform firms with simple rules (H3a) cannot be rejected. Considering innovation, the hypothesis that firm with any green management have higher innovation propensity that firms without green management (H1b) cannot be rejected at a conventional statistical level. However, high energy consumption firms with environmental systems are not statistically different to their controls. The hypothesis that firms with environmental systems have higher innovation compared firstly with firms with lower intensity of green management (H2b) and then with firms with simple rules (H3b) cannot be rejected. The hypothesis that the benefits of green management are higher in firms in energy-consuming sectors than in firms of other sectors, at any green management level, (H4) is rejected. It appears that firms with green management have lower performance than other firms and this difference is statistically significant.

Reading these results together, three main considerations can be noted. Firstly, results suggest that firms with green management are not performing any better than their peers. This fact is not supportive of the Porter hypothesis. Moreover, as they are performing better in terms of innovation than in terms of turnover, the analysis shows that they face some difficulties in translating higher product innovations into higher turnover. However, firms with environmental systems are generally performing significantly better than their peers with simple environmental rules. These results clearly suggest that environmental issues require comprehensive and integrated management. Indeed, when firms implement environmental management systems, they are not performing worse than other firms. It is possible that the better performance of firms with environmental management systems is the combined effect of better management and of the signalling effect of the certificate.

Secondly, it can be seen that high energy consumption firms with environmental management systems have surprisingly poorer performance than others. This fact is not supportive of the Porter hypothesis. As there is no difference between high and low green management systems in high energy consumption sectors, this unexpected pattern is particularly challenging. A possible explanation is that, in this sector, environmental legislation is severe and additional attention to green issues is not paying off. In other words, if the level of environmental legislation is high, or if there are more difficulties in becoming environmental friendly (e.g. cutting emissions of a factory below legal requirements), there is not much space for easy improvements and green management requires too much effort. The fact that there is no difference in terms of innovation between green and not green firms in high energy consumption sectors suggests that there are not many opportunities for improvements. This represents further support for this explanation.

Thirdly, and contrary to expectations, environmentally friendly firms are performing better in low energy consumption sectors than in high energy consuming sectors. Considering that it is easier to save paper in an office than it is to cut emissions from a factory, a possible explanation is that green management is easer in the first sector than in the second. Further research targeting this issue is advisable.

It should be emphasized that these results are preliminary but, if confirmed, they question the financial impact of green management. Further research implementing time series data sets is advisable. It is necessary to understand how green commitment can show its benefits in the long run. The use of the panel dataset permits the exploration in detail of how different green management influences dynamic innovation and financial performance over time. In this research, labour productivity was proxied with turnover per employee, due to data availability. However, alternative measurements of productivity, including operation costs and value added, can shed better light on the phenomenon. Detangling the signalling effect of the certification - "the green label"- and the high "green strategy" can be relevant for management decisions.

The final remark is that, if green strategies are not paying off and they are not self-sustaining, firms in pure capitalistic settings will not be eager to pursue environmentally friendly operations. For this reason, if there are no gains in being environmentally friendly, and the costs of "unfriendly" operations are not internalized, the results of this research call for new tools to push firms toward more environmentally friendly operations.

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Annex

Variables

	Treatment Environmental management system				
	Yes, simple rules	Yes, complex systems	No	Total observations	Weighted Total of Sample size
Covariates					
reg_nace					
D. Manufacturing	27	7	81	115	182
F. Construction	11	2	88	101	118
G. Wholesale and retail	56	16	200	272	217
H. Hotels and restaurants	16	0	39	55	57
I. Transport, storage and communication	13	0	19	32	40
J. Financial intermediation	3	1	32	37	39
K. Real estate, renting and business activities	41	5	144	190	168
N. Health and social work	9	4	29	41	35
O. Other community, social and personal service	12	0	39	52	34
Total	188	37	670	895	890
reg_size					
1 - 9	174	30	617	822	642
10-49	10	4	19	33	102
50-249	3	2	34	39	117
250+	1	0	0	1	29
Total	188	37	670	895	890
Q10 Crafts sector					
Craftsman	73	10	177	260	215
No craftsman	114	26	490	630	670
Total	186	37	667	890	885
Exports Catq31_alleuro yes if q31_alleuro (exports 2005) > 0					
Yes	147	27	551	726	685
NO	16	2	40	58	94
Total	163	29	591	783	779
q41 Competition					
Increase	10	0	13	23	20
Unchanged	44	19	202	265	280
Increased	131	16	439	586	570
Total	184	35	655	874	870
q21_a					

Limited access to Finance					
Yes	54	7	161	221	199
No	130	28	488	645	666
No such constraint	3	2	18	23	19
Total	186	37	667	890	884
q21_i Problems with the purchasing power of customers					
Yes	112	14	356	481	432
No	74	23	297	394	441
No such constraint	2	0	13	15	12
Total	188	37	666	890	885

Outcomes					
catq51- Innovation Innovator if q51 > 0 (q51 percentage of turnover coming from new or significantly improved products or services)					
	Treatment Environmental management system				
	Yes, simple rules	Yes, complex systems	No	Total observations	Weighted Total of Sample size
No Innovator	87	15	308	410	417
Innovator	62	12	197	271	256
Total	150	27	505	682	673
Prod - Labour productivity Ln (q7_alleuro/q3) q7_alleuro = turnover 2005 q3 = employees 2005					
	Treatment Environmental management system				
	Yes, simple rules	Yes, complex systems	No		
Mean	11.45298	11.51661	11.94218		
Std. Err.	.1477999	.300107	.0940982		