Does the Eco Management and Audit Scheme foster Innovation in European Firms?

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Abstract

This paper studies whether environmental management systems can spur eco-innovation, analyzing EMAS (Eco Management and Audit Scheme) adoption and patented innovations (at the European Patent Office) at firm level. It uses an original panel database of 30439 European firms belonging to all sectors from 2003 to 2012. An original instrumental variable is implemented to control for potential endogeneity. The analysis reveals that EMAS adoption is conducive to more innovation at the firm level. The results vary across countries and sectors. In particular EMAS is positively related to green patents for medium and low tech manufacturing.

KEYWORDS: Innovation; Environmental Management Systems; Patents; Eco-Management and Audit Scheme.

1. Introduction

Environmental Management Systems (EMSs) are considered a promising type of environmental policy instrument finalized to increase the environmental awareness of firms and to reduce their environmental impact. EMSs are implemented voluntarily by private firms, however worldwide environmental authorities strongly encourage their adoption through subsidies and technical support. The European Commission provided since the 1993 the official European EMS, the Eco Management and Audit Scheme (EMAS), to certify firms adopting well defined eco-management practices.

The number of EMAS registered sites has been constantly increasing over time (about 38% over the last ten years in UE27), as well as the academic effort to explore potential impacts of its implementation at sectoral and at firm level, with particular attention to the impact on innovation (e.g. Wagner, 2007; Wagner, 2009; Gerstlberger et al., 2014; Rennings et al., 2006; Frondel et al., 2008; Horbach, 2008; Ziegler and Nogareda, 2009; Demirel and Kesidou, 2011)[1].

According to the existing literature, several advantages are associated with EMSs implementation: Molina-Azorín et al. (2009) analyze the literature related to the EMS' impact on firms' financial performance, noticing that studies where a positive impact of environment on financial performance is obtained are predominant. Iraldo et al. (2009) show the positive impact of EMSs on environmental performance and on self-reported technical and organizational innovations. Lan et al. (2012) find a positive impact of EMS on human capital. Morrow and Rondinelli (2002) highlight the importance of the reputational effect of EMS implementation as well as the improvements in terms of energy efficiency; Dasgupta et al. (2000) provide empirical evidence that the EMS spurs regulatory compliance.

Dangelico and Pontrandolfo (2015) find that firm's market performance is positively affected by the capabilities to implement environmental actions with a focus on energy and pollution and a firm's image performance is positively affected by the capabilities to implement environmental actions with a focus on materials.

[1] However, in some countries, the growing concern about the long-term profitability of EMSs on competitive markets, the perceived absence of economic returns associated to the costs of EMSs implementation (Morrow and Rondinelli, 2002; Hillary, 2004; Pederesen, 2007; Massoud et al., 2010), caused a slowdown in new registrations and in some cases provoked a drop of certified firms (see also Glachant et al., 2002).

Technological innovation is a key factor for achieving a better environmental performance and for ensuring competitiveness of firms[2], in this respect Colombelli et al (2015) show that eco-innovations make the effects of innovation on firms' growth stronger, in particular for the so called gazelles. However, it is controversial whether the EMSs can spur innovation and, in particular, eco-innovation. The positive correlation between innovation and EMSs often found in the literature could emerge because more innovative firms are also more likely to be certified because there are (unobserved) factors spurring both innovation and EMS adoption.

Existing literature often lacks of longitudinal dimension (e.g. Frondel et al., 2008; Ziegler and Nogareda, 2009) as well as cross country comparison (e.g. Horbach, 2008; Demirel and Kesidou, 2011) and mainly rely on self-assessed innovation and self-reported degree of EMS implementation. Furthermore, the empirical evidence is not conclusive: apparently, the EMS correlates differently with innovation according to specific types of innovation considered (Ziegler and Nogareda, 2009; Frondel et al., 2008) or according to the specific EMS considered.

In order to overcome at least some of the limitations of previous studies, this paper relies on a database of 30439 European firms from 24 different countries, from 2003 to 2012. We consider EMAS as a specific and highly requiring EMS for several reasons: firstly because it is the official European EMS, secondly, because it entails a number of core activities common to all firms and clearly defined, but proportioned to their size, and, finally, because strong empirical evidence on its impact on innovation at firm level over time is scarce.

This paper explores the environmental performance of the companies that can be captured by eco-innovations. We have therefore selected firms' green patents using the WIPO Green Inventory. To overcome data limitations this paper uses also the count of all granted patents at the European Patent Office (EPO) to identify innovation at firm level (Wagner 2007). Patents are a very noisy indicator of innovative activity but however provide comparable measure of innovative outcomes (across time and countries). The results of our investigation reveal that EMAS is effective in fostering innovation at firm level. Also the positive correlation between EMAS and eco-innovation is confirmed. When considering green patents, EMAS shows a positive correlation for medium and low tech

[2] See for instance Costantini and Mazzanti (2012) or Gauthier and Wooldridge (2012).

manufacturing. This evidence is consistent with the high concentration in our sample of innovative firms with EMAS certifications in medium and low tech manufacturing sectors and also with the literature on green systems of innovation. In fact a substantial portion of eco-innovation is incremental and occurs in relatively more traditional sectors like chemicals, ceramic, paper, metallurgy and wood and, finally, environmental innovation is driven by regulation in particular more mature sectors (e.g. Weber and Hemmelskamp, 2005; Cainelli et al. 2012; del Rio et al. 2015). The rest of the paper is organized as follows: Section 2 presents the relevant literature, and develops the relationship between EMAS and innovation. Section 3 describes the data and the methodology. We present our econometric results in Section 4 and Section 5 concludes.

2. Environmental Management Systems and Innovation

The EMS can be defined as "an organizational change within firms based on the adoption of management practices that integrate the environment into production decisions, identifying opportunities for pollution and waste reductions, and implementing plans to make continuous improvements in productions methods and environmental performance" (Khanna and Anton, 2006). EMAS[3] similarly to all EMSs has a core of activities, entailing the publication of a periodical environmental report, the definition of management activities finalized to establish continuous environmental improvements, and the periodical assessment of outcomes, according to the scheme "Plan-Do-Check-Act". EMAS has its own guidelines, and the third party audit allows firms to obtain the certification or its renewals over time.

2.1 Background

A number of empirical studies have attempted to identify the determinants of innovation at the firm level, and whether an EMS could be considered one of them (see

[3] EMAS was drawn by the European Commission with Reg. CEE 1836/93, in the context of the Fifth EU Environment Action Programme 'Towards Sustainability'. EMAS was originally restricted to companies in industrial sectors but since 2001 it has been open to all economic sectors including public ad-ministrations. A second version of EMAS (EMAS II) was adopted by European Commission with Reg. 761/2001, and a further implementation was drawn with Reg. 196/2006. The ultimate revision (EMAS III) has been published in 2009 (Reg. 1221/2009); it subsumes previous regulation, and entered into force on 11 January 2010.

Table 1). Several papers indeed introduce the EMS as a key explanatory variable of innovation. It is important to point out that most of these papers refers to eco-innovations, and firms' environmental performance. Our paper focuses on both the overall innovation activity of the companies and eco-innovations. In addition the majority of these studies are based on self-assessed data on innovation and do not take into account the magnitude of introduced innovations, because they measure only the presence or not of any innovative behavior.

Demirel and Kesidou (2011) introduce a measure of the innovative effort by using the amount of the environmental investments undertaken by British firms. They investigate the determinants of different types of eco-innovation, such as the end of pipeline pollution control technologies, the integrated cleaner production technologies and the environmental R&D. The paper introduces among the determinants of eco innovation the internal firm level motivations, namely the organizational capabilities of firms, in particular the presence of any EMS. The econometric results show that the EMS is effective in motivating firms to undertake investments in end of pipeline green technologies and in environmental R&D, but it is not effective in increasing R&D expenditure of firms that already perform green R&D. Finally, the variable EMS does not show any effect on the Integrated Cleaner Production technologies related investments.

In some papers a very inclusive definition of organizational changes is considered (e.g. Horbach, 2008 and Frondel et al. 2008) and this introduces wide heterogeneity in the environmental effort declared by firms. Antonioli et al. (2013) study the relationship of complementarity between organizational changes and training[4] on environmental innovations, finding no complementarity when the objective considered is the adoption of EMAS/ISO standards[5]. Rennings et al. (2006) narrow to the EMAS certified firms their analysis, trying to focus on a specific EMS and its characteristics as potential determinants of innovation. The study considers EMAS validated manufacturing German facilities to investigate the impacts of different characteristics of EMAS on technical environmental innovations and economic performance. The main results concern the importance attributed by firms to the learning processes entailed by the certification and the maturity of EMAS (measured as two revalidations obtained) in determining environmental process and products innovation. Similarly, Inoue et al. (2013) find a

[4] High Performance Work Practices (HPWP) and Human Resource Management (HRM).
[5] On ISO and EMS see also Wagner (2003).

positive effect of the maturity of ISO14001 on innovative performance of 1499 Japanese firms in 2003.

2.2 Why EMAS should foster innovation?

This paper asks whether EMAS affects the probability of European firms to innovate and measures innovation with patents. So far, the use of patent data to investigate the relationship between EMSs and innovation is still limited; to our knowledge only Wagner (2007) addresses the issue of the link between EMSs and environmental innovation performing a patent analysis. In addition, EMAS is a specific management process based on the improvement of the environmental performance at firm level, therefore we also deepen the study by considering the correlation between EMAS and eco-innovation narrowing the patent analysis to green patenting activity. The required compliance with the EMAS can be assimilated to the duty to comply with mandatory environmental regulation.

The hypothesis that EMAS can promote, in general, product and process innovations and in particular eco-innovations and green products can be grounded on the capability perspective and the resource-based view of the firm. For example Wagner (2007) shows that EMS facilitate the development of strategic resources, which have a positive effect on innovation capabilities in general, and also on technological environmental innovations. Wernerfelt (1984; 1995) also suggests that EMS adoption fosters the development of strategic resources and competitive advantages, which have a positive influence on firms' innovative capabilities.

In this respect Dangelico et al. (2016) propose an interesting dynamic capability perspective and identify three processes that link EMSs and innovation: external resource integration, internal resource integration and resource building and reconfiguration. External resource integration "includes integration of knowledge on environmental impact of products during customers' use, integration of suppliers' knowledge and competencies on environmental impact of components, materials or production processes, and collaborations with channel members to reduce the environmental impact of products" (p. 3). Internal resource integration includes collaborations between specialized functions of the firm (e.g. R&D, manufacturing, marketing and design) and the integration of sustainability knowledge and competencies in those functions. Finally resource building and reconfiguration includes acquiring new resources (e.g. recruiting, training and R&D), and reconfiguring existing resources (e.g. new environmental divisions, new relationships along the supply chain). Also Marzucchi and Montresor (2017) study the different roles of internal and external knowledge sources on different eco-innovation modes.

Learning and the development of knowledge is a key cumulative process that have a positive impact on future innovative performance (see Baumol, 2002)[6]. Indeed, EMS implementation can result in a new internal source of knowledge, and, at the same time, it can bring externally sourced knowledge, based on cooperation with other certified firms and partners. The complementarity between internal and external knowledge has been widely investigated as a determinant of innovation (Cassiman and Veugelers, 2006; Caloghirou et al., 2004; Arora and Gambardella, 1994).

In addition we assume that processes that link EMSs and innovation may vary according to different sectors and different countries. Technologies may vary substantially in terms of access to external resources, of flexibility to integrate internal resources and, finally, possibility to build and reconfigure resources. Wagner (2009) discusses in depth how county-specific national cultures and regulatory regimes affect the relationship between EMS implementation and process innovations.

The organizational structure of firms can make the introduction of eco-innovations more likely or more difficult, and the adoption of well-designed EMSs can improve innovative performance. A characteristic of EMSs is that they provide permanent incentives for further reductions of the environmental impact. Even though EMAS has been defined a "medium swords" program (Prakash and Potoski, 2005) because it does not sanction shirkers, it nonetheless entails periodical monitoring and annual public disclosure of the environmental performance of adherents. Certified firms have to monitor their activities and improve their performance under several indicators. The persistent gain in efficiency is a challenging achievement, and forces firms to take advantage from the best technologies available on the market, and eventually to develop innovation to provide the improvements stimulated by the EMAS.

[6] Rennings et al. (2006) demonstrate the importance of learning processes by EMSs in developing environmental product innovations (the study though is limited to certified firms and does not provide a comparison with non-certified firms' performance).

2.3 Implications

The implications in terms of public policy are in line with the broad strand of literature - driven by the theoretical framework of the Porter hypothesis – that analyzes the relationship between stringent environmental regulation and innovation (Porter and van der Linde, 1995; Rennings and Rammer, 2011). Jaffe and Palmer (1997) find that increasing the environmental regulatory compliance expenditure influences positively general technical innovation. Similarly, Brunnermeier and Cohen (2003) find that environmental innovation responds to increases in pollution abatement expenditures.

Rennings et al. (2006) argue that, even though market-based instruments are generally considered those with the highest innovation efficiency with respect to command and control regulation, standards can be more effective in stimulating environmental innovation in situations characterized by strategic behaviors of firms (i.e., when the impact of one's own activities on other firms are taken into account). Although EMAS is a non-mandatory policy instrument, it is a standard; it entails environmental expenses and can be assimilated to stringent environmental regulations.

Wagner (2009) find that environmental management systems are associated with process innovations, but that this is moderated by country-specific national cultures and regulatory regimes. Indeed, the interaction of EMSs with country location significantly affects environmental product innovations.

Finally, Könnölä and Unruh (2007) question the enthusiastic private and public sector support for EMS implementation: EMS may initially produce improvements in environmental performance, but EMS may also constrain organizational focus to the exploitation of present production systems, rather than exploring for superior innovations that are discontinuous. According to the authors, EMSs can contribute to inertia in the actual production system rather than facilitate the shift toward always more sustainable technologies and systems.

2.4 The reverse causality issue

Some authors have argued that more innovative and technological active firms are more likely to be able to implement the changes associated with the adoption of EMSs. In fact relatively more innovative companies might decide to consolidate their overall position using EMSs. So there is potential reverse causality between EMS and innovation. Frondel et al. (2008) addresses the issue of the relationship between EMSs and environmental innovation performance by modeling a recursive bivariate probit model that allows for 899 German firms' decision on innovation activities and EMSs adoption to be simultaneous. The econometric estimation reports no significant effect of the EMS as a determinant of abatement technological innovations.

Ziegler and Nogareda (2009) discuss why relatively more innovative firms are more likely to adopt EMSs and analyze whether the adoption of an EMS or other environmental assessment activities can be explained by the adoption of any technological environmental innovation implemented. The paper uses a sample of 368 German manufacturing firms and considers both formal and informal management systems. The results show a positive effect of environmental innovation on the adoption of EMSs, but according to the authors this conclusion can be challenged because omitted underlying firm heterogeneity could not be controlled in a cross-sectional framework, i.e. their estimation could be biased by the absence of control for characteristics that affect both the adoption of an EMS and the implementation of technological environmental innovations.

It is difficult to address the issues of reverse causality and unobserved heterogeneity with cross sectional databases that are however very common in this branch of literature. Longitudinal data could partially address the issue For example Horbach (2008) overtakes the difficulties related to the use of cross-sectional data, by relying on two different panel databases[7]. The econometric results of the first analysis confirm a positive role of the environmental management tools in determining the adoption of an environmental innovation in the two previous years. The environmental innovation is self-assessed by firms and it is limited to a binary variable that does not take into account the magnitude of the innovative performance. The paper reports a second analysis using the MIP panel wave 2001, collecting data for 4846 firms in the manufacturing and service sectors. The paper considers any change in the organizational structure (which includes the introduction of EMS, but in a generic sense, e.g. any management system, even informal) and shows a positive effect on innovation measures.

[Table 1 about here]

[7] The establishment panel of the Istitute for Employment Research (IAB) and the Mannheim innovation panel (MIP).

3. Database and methodology

3.1 Database

The analysis is based on a unique database originating from different sources. We started from the Amadeus database with a random sample of 40000 European (EU27) firms. We then merged these 40000 firms with the ones contained in the EMAS Register[8], updated to 2012, in order to identify the certified firms, merging at first tax code and company name information and then checking the complete correspondence with the full address. At the end of 2012 the EMAS Register contained 4502 firms with information on registered sites, number of employees, date of the first registration, NACE code and environmental verifiers responsible for the accreditation. From the EMAS Register we excluded public administrations. We also use data on Environmental Expenditure on GDP from Eurostat[9].

We merged financial data for the whole list of firms from 2003 to 2012 and patent portfolio from the Amadeus database. We have selected the granted patents at the European Patent Office by priority date[10]. In addition to the overall amount of patent we identify green patents using the PATSTAT database merging the applicant name with the name of the firms in the sample. Green patents are identified using the Wipo Green Inventory. The WIPO Green Inventory was created by the IPC Committee of Experts in order to enable searches for patent information relating to so-called Environmentally Sound Technologies as listed by the United Nations Framework Convention on Climate Change (UNFCCC). It includes all the IPC classes that are associated with environment-friendly technologies in a variety of fields. In particular, it includes six technological fields: alternative energy production, transportation, energy conservation, waste management,

[8]The European EMAS Register, provided by the European Commission, is available on line and yearly updated (http://ec.europa.eu/environment/emas/register/). For EMAS diffusion in Italy see also Jirillo et al. (2003).

[9] http://ec.europa.eu/eurostat/data/database.

[10] It corresponds to the first filing worldwide and therefore it is the closest to the invention date. This paper uses granted patents. An alternative strategy could have been to use patent applications that are also a good indicator of companies' innovative effort. The advantage in this case is that the number of patent applications is larger: typically at the EPO approx. 2/3 of the applied patents are granted. The advantage of using granted patents is that they have passed the severe examination procedure at the EPO and therefore there is the certainty of having valid patents. Also this paper does not control directly for the quality of patents (e.g. Squicciarini et al. 2013) since patent quality indicators are not available in the companies' patent portfolio from the Amadeus database.

agriculture/forestry, administrative-regulatory as well as design aspects and nuclear power generation. The Green Inventory represents a valid and commonly used instrument to select green patents, however it also presents some limitations mainly due to the restricted number of classes included.

We obtained a final panel spanning from 2003 to 2012, reporting observations on 30439 European firms. The sample is composed by firms from eight different industries plus a residual category: 1. Infrastructure, 2. Trade 3. General Services, 4. Knowledge Intensive Business services (Kibs), 5. High Tech Manufacturing, 6. Medium Tech Manufacturing, 7. Low Tech Manufacturing, 8. Agriculture and 9. Others. Table 2 shows the sample composition by sector. Table 2 shows also the average number of employees by sector and the average turnover. Table 3 displays the number of firms and the number of firms with the EMAS certification by country. It can be underlined that EMAS certified firms in the sample are mainly in Spain (38.48%) Germany (25.34%) and Italy (12.91%). It can be added that SMEs among EMAS are prevalent (about 53% of small firms and about 30% medium size firms).

[Table 2 about here]

[Table 3 about here]

Table 4 shows that innovative firms represent 10.36% of the sample (firms with at least one granted patent), among them, more than a half is concentrated in the Medium tech and Low tech manufacturing sector. Not surprisingly, the sector in which the percentage of innovators is the highest is the High tech manufacturing sector. Also the highest concentration of innovative firms with EMAS certifications is in medium and low tech manufacturing sectors. A very low percentage of firms have green patents, mainly high tech and low tech firms. This is not necessarily due to the fact that the companies in our sample do not apply for green patents rather the matching procedure based on company names between Amadeus and PATSTAT might lead to an underestimation of the number of patents that can actually be classified as green.

EMAS certified firms seems to be more innovative with respect to non certified firms, as the percentage of EMAS with at least one patent in their portfolio is 23.7% against 9.6% of innovative firms in the non certified firms group.

[Table 4 about here]

[Table 5 about here]

In our sample, 1082 EMAS firms obtained EMAS certification before 2003, while 810 became EMAS during the period 2003-2012. Table 5 summarizes the number of new registrations per year. The peak of new certifications is between 2006 and 2009.

[Table 6 about here]

3.2 Variables and methodology

The dependent variable $PATENTS_{i,t}$ is the number of granted patents in year t by firm i. Similarly, $GREEN\ PATENTS_{i,t}$ is the number of green patents. The models we estimate are:

$$PATENTS_{i,t} = f(\alpha_i, \tau_t, EMAS_{i,t-1}, Z_{i,t-1}, \varepsilon_{i,t}) \qquad (1)$$

$$GREEN\ PATENTS_{i,t} = f(\alpha_i, \tau_t, EMAS_{i,t-1}, Z_{i,t-1}, \varepsilon_{i,t}) \qquad (2)$$

$EMAS_{i,t-1}$ is the key explanatory variable and $Z_{i,t-1}$ represents a vector of control variables. The independent variables have been chosen for the analysis on the base of prior empirical literature, provided their availability on our database (see for instance Wagner, 2008; Demirel and Kesidou, 2011; Horbach et al., 2008; Frondel et al., 2008). The explanatory variable related to our research question is the dummy $EMAS_{i,t-1}$: it is equal to zero for non certified firms, it is equal to 1 for certified firms, from the year of the accreditation; if the accreditation is obtained before the 2003 it is always equal to 1.

Wagner (2007) argued that a certification dummy is a relatively weak measure for EMS implementation. In addition our data do not include a measure of the degree of implementation; however we assume that in the EMAS case there is a minimum level of implementation irrespective of size and sector of activity, guaranteed by local environmental authorities that support private environmental verifiers in conceding the accreditation. This should ensure comparability of the effort of firms across countries and of the degree of implementation.

The reverse causality issue is discussed in the previous section. This raises the issue of the endogeneity of $EMAS_{i,t-1}$. Some characteristics of firms affecting $EMAS_{i,t-1}$ as well as $PATENTS_{i,t}$ variables are likely to be correlated with unobserved factors relegated into the error term. To deal with these issues, we use panel data, we lag one year the explanatory variable $EMAS_{i,t-1}$, we introduce fixed effects, we control for dynamic country and sector specific trends, and we, finally, use an instrumental variable[11] (see below).

We include several control variables ($Z_{i,t-1}$) such as the number of employees ($EMPLOYEES_{i,t-1}$) and past profits (expressed as share of turnover, $PROFIT_{i,t-1}$) to take in account size and past financial performance of firms. We also introduce the share of GDP devoted by countries each year to the environmental expenditure ($ENV\ EXP_{i,t-1}$), as an attempt to control for country specific effects on innovation. This index should help controlling the trend in new certifications that could be generated by country specific environmental regulation. All these variables are lagged of one year. Other control variables included are *YEAR* dummies, to capture period trend effects, and the interactions between years and country dummies for the major countries in the sample. In addition a dynamic effect of country specific characteristics, such as regulation, domestic market characteristics, intellectual property rules and enforcement, and many others, cannot be excluded therefore we include *COUNTRY**YEAR* interaction term.

Finally a limitation of the analysis is that we do not have information on R&D carried out by companies. However, on one hand, we know from the literature that for SMEs the R&D missing data should be more correctly read as zero R&D expenses, since R&D investments are strictly correlated with size (Brunneimer and Cohen, 2003; Shefer and Frenkel, 2005). On the other hand, we know that the propensity to innovate strongly depends on industries. In high tech sectors the possibilities of technological improvements are higher than in other industries, and this allows for a concentration of high skilled employees and a higher R&D expenditure. We therefore tackle the issue of missing R&D data controlling for the stock of patents at the firm level ($PASTINNO_{i,t-1}$), calculated with

[11] According to Rehfeld et al. (2007), using a lag of the explanatory variable seems of limited effectiveness; they find a high correlation of environmental innovations carried out in the past and planned for the future. Thus there should be high correlation between plans related to past and future environmental innovation and EMSs adoption. However, this is not automatically true for generic innovation that appears to be less correlated with environmental expenditure planned and linked to the implementation of EMSs.

the perpetual inventory method (Greenhalgh and Rogers, 2007)[12]. In addition we control the sectoral level heterogeneous dynamics introducing the SECTOR*YEAR interaction term.

[Table 6 about here]

3.3 Instrumental Variable

With the approach followed so far, the endogeneity issue has not been completely ruled out. We expect the variable $EMAS_{i,t-1}$ to be correlated with the error term of the main regression. To produce a consistent estimation of the $EMAS_{i,t-1}$ coefficient therefore we introduce an instrumental variable. A valid instrument lets us isolate a part of $EMAS_{i,t-1}$ that is uncorrelated with the errors in our main regression, and that part can be used to estimate the effect of a change in EMAS on innovation. We use the variable *VERIFIERS* as instrument: it represents the number of private environmental verifiers per country over the period covered by the panel. This instrumental variable has never been used before to our knowledge and represents an innovative contribution of this study.

The EMAS regulation establishes that in each country there must be private experts or companies charged with public environmental authorities to verify the existence of EMAS requisites to grant the certification. Since they are private consultants, they are interested in proposing their services to firms: they attend a specific training to become verifiers and, after that, they propose to firms their competences, by presenting the advantages to become EMAS certified. Therefore, they foster EMAS adoption and spread the information among local firms. Their presence in European countries has been overall increasing over time, even. At the end of 1998 environmental verifiers were 262; at the end of 2014 they reached the number of 411 operating in European Union. A larger number of environmental verifiers means a greater promotion on the territory of EMAS, a greater availability of opportunities to start the procedure of accreditation and, eventually, a larger number of firms that decide to adopt the certification.

The variable *VERIFIERS* is correlated with the decision of firms to implement EMAS, however it is not correlated with the decision to develop or not patentable innovation. It

[12] *PASTINNO i,t-1* is estimated using the perpetual inventory method with a depreciation rate δ=0.10.

can be noticed that the number of verifiers and its trend it's exogenous to country specific innovation policies, since it is not determined by any public incentives or subsidy and it is totally dependent on the voluntary choice of private experts that obtain a specific environmental qualification and try to exploit it on the market. The model estimates the parameters of a IV Poisson regression model in which some of the regressors are endogenous and it is suitable to model a non-negative count outcome[13].

4. Results

Table 6 displays the regression statistics. Table 7 presents the fixed effects Negative Binomial[14] performed on the whole sample as well as the Poisson model with fixed effects. The most important finding is that the variable $EMAS_{i,t-1}$ shows a positive and significant coefficient. This evidence suggests that the EMAS certification is effective in spurring innovation at firm level[15]. The result holds when controlling for *COUNTRY*YEAR* and *SECTOR*YEAR* interaction terms. For these models we calculate the Incidence Rate Ratios. A variation of one unit in the $EMAS_{i,t-1}$ variable, i.e. from 0 to 1 in the case of EMAS, is associated with a patent count increase of 1.299 in the dependent variable for the first regression, an increase of 1.2101 in the count dependent variable in the second estimation and an increase of 1.276 in the third estimation. The control variables have the expected sign: the stock of accumulated knowledge, as well as firms' size, positively influences innovation, while it seems that previous period financial performance does not exert any significant impact. At the same time, we do not find the same significant result when we consider the impact of *EMAS* on *GREENPATENTS,* whereas coefficients of the other control variables are consistent with previous estimations (Table 8). Overall, the estimated coefficients of EMAS on *GREENPATENTS* are positive and with the same

[13] The decision to undertake an environmental certification is a deliberate choice of firms and does not have the characteristics of a randomly assigned variable. It could be that highly productive firms can have enough resources to result into both patents and environmental certifications or relatively more innovative companies might decide to consolidate their overall position using Environmental Management Systems. IF EMAS is non random, there is probably self-selection into EMAS. We have run also a Heckman selection model, to check whether our results are robust to potential selection bias. Some selction bias has been found and the results are in line with the ones presented below, they are not reported but are available from authors upon request.

[14] The Negative Binomial model seems to fit better if compared with the Poisson model, for some reasons. The sample mean is 0.21 whereas the sample variance is 4.32, so there is overdispersion. The test for overdispersion confirms it (coeff. 7.66*** SEs 1.77).

[15] As a further attempt to test the effect of the adoption of EMAS we introduce several lags in the Negative Binomial model. Here we report the coefficients (st. err. in parenthesis): $EMAS_{i,t-2}$: 0,091* (0,021); $EMAS_{i,t-3}$: 0,607* (0 .286) and $EMAS_{i,t-4}$: -0.350 (0.244).

magnitude as the previous estimations even if they cannot be considered statistically different from zero. Our results therefore in this case are affected by the small number of green patents and the small number of green innovators detected in the sample.

[Table 7 about here]

[Table 8 about here]

We replicate the model for countries subsamples and for sector subsamples, in order to analyze possible heterogeneities. Models from 1 to 4 in Table 9 illustrate the results for Italy, France, Germany and Spain. Models 5 and 6 illustrate the results relatively to France and Germany for green patenting activity; other countries such as Italy and Spain show once again a too small number of green innovators to produce some significative results. The positive and significant impact of $EMAS_{i,t-1}$ on innovation is mainly driven by Italy and Germany, while the impact in Spanish and French firms cannot be considered significantly different from zero. These results are worth of further consideration; in particular, the analysis related to such countries can be deepened with the introduction of the national regulatory framework in the model, to better understand the factors that differentiate German and Italian firms with respect to the other European firms.

Table 10 and 11 (models from 7 to 11 and from 12 to 16) show the results for the following sectors: High tech manufacturing, Medium tech manufacturing, Low tech manufacturing, Kibs and Other services. $EMAS_{i,t-1}$ is positive and significant for sectors characterized by low knowledge intensity, while it does not have any impact on firms belonging to high (and medium) technological sectors.

A possible explanation for this can be that EMAS exerts a different impact across sectors and that does not spur innovation "per se", but it is effective in fostering innovation mainly for those sectors in which the R&D expenditure is originally low and not very frequent, while the impact is not significant whenever the sector is characterized by strong R&D activities. Firms with low level of internal R&D could take advantage from EMAS by adding competences and routines to their existent knowledge, as a source of external knowledge with potential complementarity or substitution effects with other sources of knowledge creation. The results are corroborated in Table 11, regarding *GREEN PATENTS*.

[Table 9 about here]

[Table 10 about here]

[Table 11 about here]

We address the issue of endogeneity of *EMAS* estimating the relationship between EMAS and innovation with an original instrumental variable (Table 11). We follow Wooldridge (2010, Ch. 18.5) and estimate the parameters of the regression with the control function estimator method[16]. The estimation confirms the findings of the main model: $EMAS_{i,t-1}$ is significant and positive. In this case the Incidence Rate Ratio for $EMAS_{i,t-1}$ is 1.82. The result is robust to the introduction of the *COUNTRY*YEAR* and *SECTOR*YEAR* interaction terms, even if the magnitude of the coefficient progressively reduces. Similarly, *EMAS* positively affects green patents, but the magnitude of the coefficient is not remarkable.

The model is just-identified, and this does not allow to test over identifying restrictions, however we test the weakness of the instrument that rejects H0 of weak instrument (Wald: chi2(1) = 62.71 , p-value= 0.0000).

[Table 12 about here]

[16] It uses the generalized method of moments (GMM) implemented in the *ivpoisson* command in STATA. The procedure estimates also the ancillary parameter called ρ: the coefficient on the residual variable included to control for the endogeneity of $EMAS_{i,t-1}$; in our estimation ρ =19.45*** (robust s.e. 1.32) providing evidence in favor of the endogeneity of $EMAS_{i,t-1}$.

5. Discussion and conclusions

This paper analyzes the impact of EMAS on patented innovation in European firms. The analysis uses longitudinal data on 30439 European firms over ten years (2003 - 2012).We find evidence that EMAS is positively associated with the number of granted patents; this result is particularly strong in Italy and Germany and in low tech manufacturing sectors and services. We also explore the environmental performance of the companies that can be captured by eco-innovations. We have therefore selected firms' green patents using the WIPO Green Inventory. In this case EMAS certification tends to show a positive correlation with green patents. When considering green patents, EMAS shows a positive correlation for medium and low tech manufacturing.

This study has important implications for business strategy and policy makers. Firms are increasingly required to develop a green innovation strategy. Some authors (e.g. Nash and Ehrenfeld, 2001) have suggested that companies could develop EMSs to hide poor performance and avoid regulatory scrutiny, but will not make the effort required to be innovative. This paper however shows that the adoption of EMSs can improve the overall innovation activity of the firms. According to our conceptual framework, strategy managers adopting EMS should then pay particular attention to three processes: external resource integration, internal resource integration and resource building and reconfiguration. This means for example improving learning processes about materials, products and components and integrating suppliers' knowledge and competencies. Internally managers should foster collaborations between specialized functions of the firm. Finally the adoption of EMSs can be exploited to recruiting, training and reconfiguring existing resources (e.g. new relationships along the supply chain) in order to improve the efficiency and creativity of the organizational structure (see also Marzucchi and Montresor, 2017).

For policy makers this paper suggests that companies, exploring the use of technology in EMSs, select innovations that are patented and could be successful in a competitive environment. This is in contrast with the idea that firms spend their environmental investments in fighting regulation and stalling legislation, rather than in finding real and innovative solutions. This paper shows that EMAS is an effective instrument to raise innovativeness of certified firms while improving their environmental performance. We believe that this positive effect of EMAS justifies environmental authorities' financial and technical support to spur EMAS adoption, as well as certified firms' effort. However, this paper finds that the relation between EMAS and innovation vary according to different sectors and different countries. The results seem to be stronger in those fields (low tech and services) where access to external resources could be easier and there is more flexibility to integrate internal resources and to build and reconfigure resources. EMAS is more convenient for low technological sectors and in some countries, providing support for the hypothesis that some regulatory frameworks are more EMAS and innovation friendly than others, and that some sectors are more suitable to exploit all the advantages of EMAS (Wagner, 2009). This result is valid also for green innovations.

In this period of scarcity of resources to devote to the environment, policymakers should consider to exploit EMAS potentialities adopting strategic improvements of regulation. On the one hand concentrating benefits and subsidies for those sectors in which EMAS is more effective would maximize the returns from firms and environmental authorities' efforts. Additionally, innovation friendly regulations should be enriched with specific provisions for EMSs, as they can be considered innovation friendly as well.

Our results can be improved in many directions. For example the number of granted patents does not capture the all the possible innovations developed by firms and probably underestimate the innovative activity of the certified firms. In addition the dummy *EMASi,t-1* does not provide a measure of the degree of EMAS implementation, thus allowing for some measurement errors. Finally, the explanation that justifies the absence of strong correlation between EMAS and green innovation is still scanty, and a more adequate measure of green innovation is needed.

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TABLES

Table 1. Literature review

Authors	Years	EMS	Source of data	Period of coverage	Country	Data and sectors	Main findings
Demirel and Kesidou	2011	ISO14001	DEFRA survey	2005-2006	UK	289 manufacturing firms	Not conclusive evidence: significant impact of EMS only on specific types of innovation
Ziegler and Nogareda	2009	ISO14001, EMAS	telephone survey	2003	Germany	368 manufacturing firms	Positive effect of environmental innovation on EMS adoption
Horbach	2008	organizational changes	IAB, MIP survey	2001, 2004	Germany	753 firms in environmental sectors and 4846 manufacturing and services firms	Positive effect of organizational changes innovation
Frondel, Horbach and Renning	2008	generic EMS	OECD survey	2003	Germany	899 firms, all sectors	No significant effect of ems on abatement technology innovations
Renning, Ziegler, Ankele, Hoffman	2006	EMAS	telephone survey	2002	Germany	1227 EMAS certified firms	Positive effect of EMAS maturity on environmental innovation
Wagner	2008	EMS and Ecolabel	postal survey	2001	9 EU countries	2095 manufacturing firms	Positive effect of ecolabelling on product innovation,not clear effect of EMS interacted with national regulation indexes on innovation
Wagner	2009	EMSs	postal survey	2001	9 EU countries	2095 manufacturing firms	Positive effect of EMSs moderated by local regulations and culture
Inoue, Arimura, Nakano	2013	ISO14001	OECD survey	2003	Japan	1499 firms of all sectors	Positive effect of ISO 14001 maturity on environmental R&D expenditure

Source: authors' elaboration

Table 2. Sample composition by sector

Sector	Description	N firms	%	Employees (mean)	S.D.	Turnover (mean)	S.D.
Infrastructure	Electricity, gas supply, water supply and waste management, construction, transportation and storage, real estate activities	6223	20,4%	62	145.42	154.11	123.06
Trade	Wholesale and retail trade	7713	25,3%	49	109.39	128.63	204.47
Kibs	Telecommunications, R&D	2423	8%	61	136.34	152.67	188.06
Other services	Accomodation and food services, financial and insurance activities, administrative and support services, PA and defence, education, human health, arts and entertainement	7240	23.7%	173	182.77	177.88	195.68
High tech manufacturing	Aerospace , Pharmaceuticals Computers, office machinery , Electronics-communications Scientific instruments	402	1.3%	185	193.80	154.21	164.62
Medium tech manufacturing	Electrical machinery, Motor vehicles Chemicals, excluding pharmaceuticals, Other transport equipment ,Non-electrical machinery, Coke, refined petroleum products and nuclear fuel, Rubber and plastic products, Non metallic mineral products, Shipbuilding , Basic metals, fabricated metal products	2571	8.6%	213	188.22	124.25	177.12
Low tech manufacturing	Other manufacturing and recycling, Wood, pulp, paper products, printing and publishing , Food, beverages and tobacco, Textile and clothing.	3208	10.6%	158	153.56	166.67	193.92
Agriculture	Agriculture, forestry and fishing Mining and quarring	410	1.3%	50	88.98	77.89	206.60
Others	Households and extraterritorial organizations, residuals (nace unknown)	249	0.8%	65	106.29	172.07	201.81
Total		30439	100%	99	150.43	169.24	196.48

Source: authors' elaboration

Table 3. Sample composition by country

Country	N firms	%	N EMAS	%
AT	916	3.0	43	4.6
BE	592	1.9	16	2.7
CY	23	0.0	23	100
CZ	21	0.0	21	100
DE	8905	29.2	396	4.4
DK	652	2.1	31	4.7
ES	5271	17.4	651	12.3
FR	6038	19.8	66	1.0
GB	1351	4.4	43	3.1
GR	15	0.0	12	0.8
IE	995	3.3	44	4.4
IT	2497	8.2	229	9.1
NL	305	1.0	10	3.2
NO	385	1.3	18	4.6
PL	21	0.0	21	100
PT	2426	7.9	49	2.0
Other countries	26	0.0	24	92
Total	**30439**		**1697**	

Source: authors' elaboration

Table 4. Innovative firms across sectors

Sector	N. of innovators (a)	% of innovators on total sample	N. of innovators and EMAS (b)	(b)/(a)	N. of green innovators	% of green innovators on total sample
Infrastructure	247	3.9	51	20.6	10	0,00
Trade	364	4.7	32	8.8	33	0,001
Kibs	220	9.0	4	1.8	47	0,001
Other services	283	3.9	8	2.8	16	0,00
High tech manufacturing	226	56	26	0.8	53	0,002
Medium tech manufacturing	1168	45.4	148	12.6	41	0,001
Low tech manufacturing	619	19	111	18	77	0,002
Agriculture	19	4.6	2	10.5	0	0
Others	10	4.0	1	10	1	0,00
Total	3156	10.36	403	12.7	278	0,009

Source: authors' elaboration

Table 5. Registration over time of new EMAS firms

Registration Year	N EMAS	%
2003	40	4.94
2004	90	1.11
2005	50	6.17
2006	150	18.52
2007	110	13.58
2008	140	17.28
2009	70	8.64
2010	60	7.41
2011	60	7.41
2012	40	4.94
Total	810	100

Source: authors' elaboration

Table 6. Summary statistics

Variables and description		Mean	Std. Dev.	Min	Max
Dependent variable					
PATENTS i,t	Number of granted patents per year	0.208	2.098	0	100
GREEN PATENTS i,t	Number of green granted patents per year	0.009	1.940	0	67
Explanatory variable					
EMASi,t-1	Equal to 1 if firm is certified and 0 otherwise	0.035	0.185	0	1
Control variables					
EMPLOYEESi,t-1	Number of employees	76.774	159.777	1	4609
PROFITi,t-1	Share of profit on past revenues	3.97	14.768	-100	100
PAST INNO	Patent stock calculated with perpetual inventory method	0.066	0.632	0	67.98
ENV EXP t-1	Share of GDP devoted to environmental expenditure	0.323	0.135	0.11	1.31
Instrumental Variable					
VERIFIERS	Number of environmental verifiers in the country each year	67.32716	96.04062	0	239
Sectors (dummies)					
Agriculture		0.013	0.114	0	1
Infrastructure		0.22	0.414	0	1
Trade		0.242	0.429	0	1
Kibs		0.075	0.263	0	1
Other services		0.231	0.421	0	1
High tech manufacturing		0.012	0.111	0	1
Medium tech manufacturing		0.077	0.267	0	1
Low tech manufacturing		0.098	0.298	0	1
Others		0.031	0.173	0	1

Source: authors' elaboration

Table 7. Fixed effects negative binomial and Poisson with fixed effects

	Negative Binomial	*Poisson*	*Neg bin*	*Neg bin*
Dep. Variable: PATENTS				
EMAS$_{i,t-1}$	*0.233**	*0.278**	*0.186**	*0.190**
	(0.093)	*(0.111)*	*(0.098)*	*(0.097)*
PASTINNO$_{i,t-1}$	*0.0387****	*0.037****	*0.0381****	*0.0359****
	(0.0014)	*(0.0013)*	*(0.0015)*	*(0.0015)*
EMPLOYEES$_{i,t-1}$	*0.0479****	*0.0481****	*0.0381****	*0.0412****
	(0.0103)	*(0.0108)*	*(0.0106)*	*(0.0108)*
PROFIT$_{i,t-1}$	*0.0108*	*0.006*	*0.0212*	*0.0209*
	(0.0197)	*(0.001)*	*(0.0209)*	*(0.0203)*
ENV EXP $_{t-1}$	*-0.541+*	*0.009*		
	(0.308)	*(0.004)*		
Years dummies	*Y*	*Y*		
Country*Year			*Y*	
Sector*Year				*Y*
Constant	*-0.0832*		*0.306****	*-0.6111*
	(0.161)		*(0.0624)*	*0.5409*
Observations	*183847*	*183847*	*183847*	*183847*
Wald chi2	*1353.95*	*1323.16*	*1345.55*	*1284.37*
Log likelihood	*-8137.9498*	*-8006.1166*	*-8088.8942*	*-7887.1883*
Alpha : 20.05994 Likelihood-ratio test of alpha=0: chibar2 = 9.3e+04 Prob>=chibar2 = 0.000				
Incidence Rate Ratios for EMAS:	1.26	1.32	1.20	1.21

*Standard errors in parentheses + p < 0:10, * p < 0:05, ** p < 0:01, *** p < 0:001*

Table 8. Fixed effects negative binomial and Poisson with fixed effects

	Negative Binomial	*Poisson*	*Neg bin*	*Neg bin*
Dep. Variable: GREEN PATENTS				
EMAS$_{i,t-1}$	*0.244*	*0.253*	*0.279*	*0.302*
	(0.251)	*(0.353)*	*(0.247)*	*(0.252)*
PASTINNO$_{i,t-1}$	*0.001****	*0.014****	*0.001****	*0.001****
	(0.000)	*(0.000)*	*(0.000)*	*(0.000)*
EMPLOYEES$_{i,t-1}$	*0.006****	*0.002***	*0.007****	*0.006****
	(0.000)	*(0.000)*	*(0.000)*	*(0.000)*
PROFIT$_{i,t-1}$	*-0.005*	*-0.002**	*0.002*	*-0.001****
	(0.006)	*(0.000)*	*(0.002)*	*(0.000)*
ENV EXP $_{t-1}$	*-0.217*	*0.187****		
	(0.331)	*(0.002)*		
Years dummies	*Y*	*Y*		
Country*Year			*Y*	
Sector*Year				*Y*
Constant	*-0.038*		*-0.240*	*-0.701****
	(0.165)		*(0.144)*	*(0.160)*
Observations	*183847*	*183847*	*183847*	*183847*
Wald chi2	*1295.20*	*1469.47*	*1345.55*	*1284.37*
Log likelihood	*-20122.277*	*-38688.84*	*-8088.8942*	*-7887.1883*

*Standard errors in parentheses + p < 0:10, * p < 0:05, ** p < 0:01, *** p < 0:001*

Table 9. Negative Binomial FE Country subsamples

	(1) IT	(2) FR	(3) DE	(4) ES	(5) FR	(6) DE
	Dep variable: PATENTS				Dep variable: GREEN PATENTS	
$EMAS_{i,t-1}$	0.243*	0.0900	0.707***	0.0765	-0.141	0.247
	(0.463)	(0.669)	(0.188)	(0.209)	(0.761)	(0.252)
$PASTINNO_{i,t-1}$	0.0490***	0.0296*	0.0386***	0.0271***	0.007*	0.001***
	(0.00890)	(0.0122)	(0.00164)	(0.00664)	(0.001)	(0.000)
$EMPLOYEES_{i,t-1}$	0.0551	0.136	0.0324**	0.0590	0.004***	0.005***
	(0.0476)	(0.115)	(0.0115)	(0.0365)	(0.000)	(0.000)
$PROFIT_{i,t-1}$	0.0117	0.0109	-0.000117	0.00842	0.007	-0.009***
	(0.00722)	(0.0113)	(0.00235)	(0.00721)	(0.007)	(0.000)
ENV EXP $_{t-1}$	-0.8316	5.466	2.123***	2.631	0.004*	0.392***
	(0.9282)	(4.295)	(1.961)	(2.516)	(0.001)	(0.021)
Year dummies	Y	Y	Y	Y	Y	Y
Constant	5.805	-7.012	-10.69***	-6.892	-0.182***	-0.205***
	(7.266)	(5.023)	(1.013)	(6.447)	(0.035)	(0.018)
Observations	24970	60380	89050	52710	60380	89050
Wald chi2	60,46	30,82	1211,64	38,94	30,82	32.89
Log likelihood	-496.25846	-233.71496	-6691.572	-650.07903	-233.71496	-832.92911

*Standard errors in parentheses + p < 0:10, * p < 0:05, ** p < 0:01, *** p < 0:001*

Table 10. Fixed Effects Negative Binomial, Sectors subsamples

	(7) *high tech*	*(8)* *medium tech*	*(9)* *low tech*	*(10)* *kibs*	*(11)* *other serv*
PATENTS $_t$					
EMAS$_{i,t-1}$	*0.0164*	*0.0259*	*1.172****	*-1.005*	*2.187 ***
	(0.308)	*(0.155)*	*(0.301)*	*(0.672)*	*(0.7192)*
PASTINNO$_{i,t-1}$	*0.0487****	*0.0414****	*0.0430****	*0.0350****	*0.0319****
	(0.00568)	*(0.00235)*	*(0.00412)*	*(0.00572)*	*(0.00375)*
EMPLOYEES$_{i,t-1}$	*0.00539*	*0.00108*	*0.109****	*-0.0108*	*0.0505**
	(0.0313)	*(0.0183)*	*(0.0264)*	*(0.0416)*	*(0.0237)*
PROFIT$_{i,t-1}$	*-0.000487*	*0.00847**	*0.00100*	*0.00150*	*-0.00384*
	(0.00569)	*(0.00413)*	*(0.00608)*	*(0.00652)*	*(0.00354)*
ENV EXP $_{t-1}$	*-2.822+*	*-0.774*	*0.118*	*-21.18*	*-4.548*
	(1.589)	*(0.750)*	*(1.813)*	*(18.06)*	*(3.023)*
Country*Years	*Y*	*Y*	*Y*	*Y*	*Y*
Constant	*1.923**	*0.801**	*0.111*	*11.68*	*2.710+*
	(0.865)	*(0.392)*	*(0.944)*	*(9.399)*	*(1.597)*
Observations	*960*	*19260*	*15550*	*1695*	*22960*
Wald chi2	*170,57*	*551,16*	*261,96*	*117,89*	*187,50*
Log likelihood	*-778.56761*	*-3034.7504*	*-1328.7994*	*-512.72605*	*-877.60243*

*Standard errors in parentheses + p < 0:10, * p < 0:05, ** p < 0:01, *** p < 0:001*

Table 11. Fixed Effects Negative Binomial, Sectors subsamples

	(12) *high tech*	*(13)* *medium tech*	*(14)* *low tech*	*(15)* *kibs*	*(16)* *other serv*
GREEN PATENTS t					
EMAS $_{i,t-1}$	*0.237*	*0.114**	*0.142**	*-0.250*	*-0.034*
	(0.281)	*(0.044)*	*(0.056)*	*(0.380)*	*(0.175)*
PASTINNO $_{i,t-1}$	*0. 002****	*0.001***	*0.003*	*0.003****	*-0.004**
	(0.000)	*(0.000)*	*(0.005)*	*(0.000)*	*(0.002)*
EMPLOYEES $_{i,t-1}$	*0.005****	*0.005***	*0.006**	*0.004****	*0.005****
	(0.000)	*(0.002)*	*(0.003)*	*0.001*	*(0.000)*
PROFIT $_{i,t-1}$	*-0.001*	*-0.013**	*-0.005*	*-0.001*	*-0.007*
	(0.002)	*(0.006)*	*(0.006)*	*(0.004)*	*(0.006)*
ENV EXP $_{t-1}$	*1.955****	*0.235**	*0.233*	*1.116****	*0.087****
	(0.520)	*(0.128)*	*(0.142)*	*(0.007)*	*(0.002)*
Country*Years	*Y*	*Y*	*Y*	*Y*	*Y*
Constant	*-1.543****	*0.398*	*-1.268*	*-0.733****	*-0.436****
	(0.258)	*(0.631)*	*(0.699)*	*(0.039)*	*(0.120)*
Observations	*960*	*19260*	*15550*	*1695*	*22960*
Wald chi2	*548.05*	*85.12*	*110.77*	*439.17*	*37.36*
Log likelihood	*-7555.5581*	*-1558.5944*	*-1013.1033*	*-2989.9824*	*-359.53396*

*Standard errors in parentheses + p < 0:10, * p < 0:05, ** p < 0:01, *** p < 0:001*

Table 12. Instrumental Variable Poisson estimates

	First stage	*Second stage*	*Second stage GREEN PATENTS*
EMPLOYEES*i,t-1*	*0.000****	*0.003****	*0.001****
	(0.000)	*(0.000)*	*(0.000)*
PROFIT*i,t-1*	*0.006***	*0.016***	*0.017****
	(0.000)	*(0.005)*	*(0.000)*
PASTINNO*i,t-1*	*0.002****	*0.837****	*0.004****
	(0.001)	*0.066*	*(0.000)*
VERIFIERS*t-1*	*0.401****		
	(0.002)		
EMAS*i,t-1*		*0.607****	*0.001****
		(0.050)	*(0.000)*
Years dummies	*Y*	*Y*	*Y*
Country dummies	*Y*	*Y*	*Y*
Constant	*0.091****	*0.683****	*-0.234****
	(0.003)	*(0.037)*	*(0.001)*
R-squared	0.4048		
LR chi2		1650.33	

*Standard errors in parentheses + p < 0:10, * p < 0:05, ** p < 0:01, *** p < 0:00*