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Who are the green innovators? An empirical analysis of firm's level factors driving environmental innovation adoption

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Abstract

In recent years, the importance of the environmental agenda for industry has been particularly rising and environmental innovations (EI) are increasingly at the center of policy maker action. Where extant literature has analyzed mainly external factors driving their adoption, in this paper we explore firm-level characteristics that lead to the development of EIs, using data from the community innovation survey (CIS) on Italian manufacturing firms, which, for the first time, address specifically EI. We further contribute to the literature by analyzing firm?s level patterns distinguishing between production-related and product-related EIs.

The econometric estimations suggest that size is positively related to the introduction of any kind of EI. Firms exporting are not more likely to introduce EI, whereas foreign ownership is linked with a greater EI propensity. Our results suggest also that firms that perform R&D activities, acquire machineries or knowledge and carries out training are more likely to be green innovators but that such activities are substitutive. Finally, the analysis suggests that firm?s level characteristics are more important than industry specialization in explaining green innovation propensity and that firm?s level characteristics driving the greening vary consistently among EI types.

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Who are the green innovators? An empirical analysis of firm's level factors driving environmental innovation adoption

Introduction

In recent years, the importance of the environmental agenda for industry has been particularly rising. On the one hand, increasing awareness of consumers of the environmental impact of their consumption choices and their willingness to contribute to the reduction in the ecological footprint create new market opportunities for companies. On the other hand, increasingly restrictive policies and the actions of NGOs and other environmentalist groups that raise attention to firms' polluting behaviors encourage firms to control the effects of their activities on the environment, in order to reduce reputational risks and avoid additional costs.

The attention on environmentally-benign changes of production and consumption systems have gained particular momentum in the current recession crisis, which has led to increasing calls for alternative development paths (Davies & Mullin, 2011). The turn toward a less impacting production model may ensure firms important economic gains by spurring innovations aimed at reducing environmental impacts while providing economic benefits (Nidumolu *et al*, 2009; Florida, 2010). The relationship between innovation and growth has been shown by a consistent amount of theoretical and empirical works; environmental innovation, which is increasingly at the centre of policy action, is the way through which firms may consolidate their competitive advantage by also reducing the ecological footprint. Spanning from studies in environmental economics and innovation economics, the literature on environmental innovations (EIs) has grown considerably in recent years. The majority of the studies in this field have focused so far on the exogenous factors determining their introduction and in particular on the role of environmental policies (e.g., Brunnermeier & Cohen, 2003; Cleff & Rennings, 1999; Porter & Van Der Linde, 1995). Fewer studies have analyzed firms' strategic and managerial factors and technological characteristics, despite recent evidence suggests that they may as important, if not more, that policy stringency in explaining the adoption of EIs (Borghesi *et al.*, 2012; De Marchi, 2012; Horbach, 2008). Therefore, despite the increasing body of literature on EI, knowledge on the characteristics of green innovators and firm-level dynamics that lead to the development of EI is still limited. Furthermore, little is known about the features of firms that introduce such innovations considering for different types of EIs. The introduction of different eco-innovations may have very different technical and managerial implications for firms, as supported also by recent evidence (Borghesi *et al*., 2012; Mazzanti & Zoboli, 2009). Such limitations in the knowledge of green innovators and green innovation dynamics have to be ascribed mainly to the lack of detailed firm level data. For this reason, by now empirical analyses have either focused mainly on the environmental goods and services sectors or have used proxies that have been blamed for under-estimating innovations with environmental benefits (Arundel & Kemp, 2009). In this paper, we overcome this limitation by drawing data from the Italian community innovation survey (5th wave), which, other than information on the firm's innovation strategy and main characteristics, included, for the first time, also a section that specifically addressed EIs, distinguishing between different impacts at the production process and at the product's use level. Focusing on manufacturing firms, in this paper we contribute to the extant literature by proposing an analysis of the innovation strategies and firm's level characteristics that differentiate green innovators from other firms and by analyzing such firm's level patterns according to environmental areas tackled.

Environmental innovations and firm's level factors influencing their adoption

Defining environmental innovations

Despite the increasing interest of policy makers in innovations that lower the impact of firms' activities on the environment, the research on this area is still limited and not systematic. In this setting, we adopt the definition of green, environmental or eco-innovations developed by Kemp & Pearson (2008), that define them as "the production, application or exploitation of a good, service, production, process, organizational structure or management or business method that is novel to the firm or user and which results, throughout its life cycle, in a reduction of environmental risk, pollution and the negative impacts of resource use compared to relevant alternatives". This definition is purposefully very broad, including all the firms' changes which, irrespective of their initial aim, tackle sustainability targets such as the reduction of greenhouse effects, acidification, toxic impacts on ecosystems or on humans, loss of biodiversity and consumption of resources to a higher rate with respect to natural reproduction (Rennings, 2000). Differently from the previous definitions, this one entails also non-technological innovations, including the development of management instruments at the firm level like eco-audits, changes of lifestyles and consumer behaviors and alternative systems of production (Arundel & Kemp, 2009; Rennings, 2000). Technological innovations, the most studied in the empirical literature on eco-innovations, are further differentiated into end-of-pipe or curative – treating emissions once they have been generated and relatively easy to purchase and install – and cleaner or integrated technologies – which reduce impacts rather at the sources and results in higher environmental and economic performances (see del Rio Gonzalez, 2009). As summarized in De Marchi (2012), environmental innovations represent a distinct sub-group of innovations in many respects, which justify the need to study them as an independent object of analysis from other innovations.

Firm's factors and EI adoption

Overall, the empirical literature on EI is still sparse. So far, the majority of the empirical contributions have focused on factors external to the firms as driving force for their introduction, analyzing mainly the impact of environmental regulation and the effectiveness of different environmental policy instruments to foster technological change (see del Rio Gonzalez, 2009) and just to a lower extent to supply and market pull factors, despite recent analysis suggest they may be even more important than regulation to trigger innovation (Horbach, 2008; Horbach *et al.*, 2011; Mazzanti & Zoboli, 2009). Little is known about intra-firms dynamics and on firm's innovation strategies for the development of EI, despite their pivotal role on innovation decisions. In the following, we will concentrate on three firm's factors: size, the international strategies and innovation strategies.

Similarly to the studies focusing on general innovations – the literature on innovation that do not focus specifically on the environmental one – *size* is considered an important variable to explain the different propensity of firms to introduce EI. The complexity linked with their introduction and the high initial investments that may be needed to switch to greener technologies are considered powerful barriers to the introduction of such innovations at small and medium enterprises (SMEs), which usually do not have the financial and technological resources nor the long-term orientation needed to develop them (del Rio Gonzalez, 2005, 2009). Furthermore, smaller firms may have less incentives to introduce such innovations, given the lower visibility to the general public and therefore the lower scrutiny from consumers, media and NGOs on their social and environmental performance (e.g., Brammer & Millington, 2006). Nonetheless, case study analysis has supported that green product innovation may occur also within small and medium enterprises (SMEs), which may be responsible also for the introduction of cleaner technologies (Noci & Verganti, 1999; Labonne 2006, De Marchi, 2011). Quantitatively empirical analysis have not solved the puzzle yet, since some studies have found a positive relationship between size and EI adoption (e.g. Hemmelskamp, 1999; De Marchi, 2012), while others have found no significant relations (e.g., Horbach, 2008; Horbach et al., 2011).

Firms' *international strategies* may also heavily affect their propensity to introduce environmental innovations. Consumer's awareness, technological availability and regulatory pressures differ from country to country, especially when confronting developing countries and developed ones. Firms that export may have higher incentives than national ones to develop eco-friendly products and processes, particularly those targeting markets characterized by higher consumers' awareness on sustainability issues and where higher standards are diffused. In those markets, customer and institutional pressures on firms to improve the environmental performance of their products and production processes are higher and the adoption of environmental certifications or the compliance with beyond-regulation environmental standards is getting increasingly an entry barrier (Christmann & Taylor, 2001; Jeppesen & Hansen, 2004; Andersen & Skjoett-Larsen, 2009). Furthermore, competing on international markets, being part of an international group, or having FDI – which are often the main channel trough which firms enter global networks – offer to the firm the possibility to learn about the most advanced environmental standards available and about opportunities to deal fruitfully with environmental issues (Cainelli *et al.*, 2011; Ivarsson & Alvstam, 2010a; Jeppesen & Hansen, 2004). Given the larger scale of their operations, multinational corporations may also achieve higher financial benefits from adopting the same standards all over the world and environmental innovations that ensure eco-efficiency or the like, and may be better able to develop EI given the higher pool of capabilities it can leverage on (see e.g., Cainelli *et al.*, 2011). The existence of a positive link between globalization and the diffusion of environmental compliant behaviors and the development of EI is pretty established within the developing countries setting (e.g., Christmann & Taylor, 2001; Jeppesen & Hansen, 2004; Ivarsson & Alvstam, 2010a, 2010b). On the contrary, empirical evidence in the developed countries setting is rather scarce: in some cases, the relationship with the introduction of environmental innovations has been found to be positive just when the firms is embedded within the local context (Cainelli et al., 2011), in others even null or negative (Borghesi et al., 2012; De Marchi, 2012).

To carry out a product that reduces the impact on the environment is a rather complex task, which often requires information and skills distant from the traditional knowledge base of the industry. Companies are often "still inexperienced in dealing creatively with environmental issues" and their "knowledge about environmental impacts is still rudimentary" (Porter & Van Der Linde, 1995, p. 99). For those reasons, the *innovative effort* of the firm is very important in enabling them to realize new products, processes or business models that effectively reduce the ecological footprint. The existing stock of technological competencies of firms, including both human resources and technological equipments, impacts on their ability to develop environmental technologies and assimilate those developed by others. Firm-level analyses support that the internal R&D activity is critical for the development of technical EI, even more critical than for non-environmental innovations (Horbach, 2008; Rennings *et al.*, 2006), at least when it is performed on a continuous basis (De Marchi, 2012). R&D may positively influence green innovations introduction also because it enhances the firm's ability to identify, assimilate and exploit the knowledge coming from external sources, what in the literature is named "absorptive capacity" (Cohen & Levinthal, 1990). The possibility to complement internal resources with competences coming from network partners may be a major driver for the introduction of EI (Andersen, 2002; Mazzanti & Zoboli, 2009; De Marchi, 2012), especially when firms attempt to close their production cycles and enhance recyclability or when eco-innovations requires changes in the raw materials or components used (see Seuring & Müller, 2008). Other than the internal R&D effort of the firm and the cooperation with external partners, other aspects of the innovative strategy of the firms may have a strong impact on their capacity to introduce green products and produces, including the adoption of environmental management systems, the eco-design of the products and the training at personnel and management level, to increase the awareness about the importance to tackle environmental problems and about possible solutions that are already been developed (e.g., Seuring & Müller, 2008; Andersen & Skjoett-Larsen, 2009). The different innovation strategies implemented by firm, however, may depend on the typologies of innovations to be introduces. In a study of German firms, Hemmelskamp (1999) finds evidence to support the hypothesis that environmentally innovative companies have low R&D intensity, which is compensated by the use of external sources of information. This feature, which is stronger especially for product innovations, is seen as evidence of the dominance of end-of-pipe innovations that, being incremental, may require little R&D effort.

Existing research has shown, with differentiated outcomes, that several factors, both within and outside the firm influence its ability to introduce eco-innovations. Very few studies, however, have tried to address the differentiated impact of such factors on different typologies of innovations. The characteristics of the environmental technologies to be introduced – including their complexity, their compatibility with existing production system, their costs structure and their diffusion – may deeply affect the rate and direction of environmental technological change (del Rio Gonzalez, 2009). Cleff & Rennings (1999), for example, suggest that regulations have an impact just on the introduction of process innovations, whereas strategic market goals foster green product introduction. Similarly, the drivers for the introduction of end-of-pipe pollution control technologies are different from those spurring the development of integrated cleaner technologies, with command and control instruments positively affecting the first typology and market-based instruments the second one (Frondel *et al.* 2007; Demirel & Kesidou, 2011). Horbach *et al.* (2011), through the analysis of German CIS data, find a similar heterogeneity, considering a more detailed classification of EI, based on different areas of environmental impacts. The contribution by Cainelli *et al.* (2011) takes this discussion a step further, suggesting that even firm's characteristics and innovation strategies varies with the innovation type, focusing mainly on the role of networking activities.

Against this background, we aim at contributing to the discussion by focusing on the role of firms' level characteristics – focusing mainly on size, the firm's innovation activities and its internationalization strategies – to EI adoption considering for different typologies of EI, based on the main environmental impact they address. Furthermore we aim at understanding if firm's level characteristics may be more important than industry and market's characteristics in explaining EI adoption, which is a research question that has not been addressed yet. Each industry is characterized by a peculiar combination of consumers' awareness, regulation stringency, technological opportunities and market structure characteristics (Del Rio Gonzales, 2009). The degree to which those characteristics affect and bound the firm's EI activities and may explain them, as compared to strategy-related variables is still an open issues.

The empirical framework

The Italian Community Innovation Survey

In order to analyze the characteristics of firms introducing environmental innovations we draw data from the Italian community innovation survey (CIS), which is carried out every two years by the Italian national statistic institute (ISTAT). CIS surveys – administered by national statistical offices throughout the European Union and other countries and based on the Oslo manual guidelines on innovation – have proved to be a valid and reliable tool to understand innovation dynamics and are widespread in the empirical literature on innovation (see e.g., Laursen & Salter, 2006; Tether & Hipp, 2002). These surveys follow a subjective approach toward innovation, inquiring at firm level the ability to introduce an innovation, rather than an objective one, which focus on individual innovations. CIS data contain information on companies' structural characteristics, R&D strategies and innovative activities over a 3-year period. In this study, we focus on the 5th wave of the CIS survey referring to the years 2006-2008 that, for the first time, includes also specific information on EI, inquiring about the type of innovation introduced, the drivers of their introduction and the implementation of specific actions to monitor and reduce the environmental impacts of the firm's activity[1].

The Italian CIS survey covers innovation activities of enterprises with at least 10 employees active in the manufacturing or service industries: starting from the 19,904 enterprises included in the final sample, we restricting the analysis just on manufacturing firms, being left with 5,677 observations[2]. Data were collected through census survey for firms with more than 249 employees, and through sample survey for the others, based on a stratified random sample based on the economic activities, the size of the firms and its geographical location. The questionnaire was 10-pages long and, for the first time, was web-based[3].

The variables for the analysis

In the literature, different indicators and methodologies have been employed to

[1] The module on eco-innovations has been implemented in all EU27 countries except Denmark, Greece, Spain, Slovenia and United Kingdom.

[2] The manufacturing firms included in the initial database were 6,483, but we were left with 5,677 since the remaining have not responded to the last part of the questionnaire, regarding the introduction of EI. Given that it was not possible to identify any pattern for the non responded firms, we assumed no selection bias for our data.

[3]More information on the Italian CIS can be found at the web site http://www.istat.it/en/archive/35223.

measure quantitatively environmental innovations (Arundel & Kemp, 2009; Kemp, 2010). Environmental patents have been extensively employed as proxies for green innovations (see e.g., Brunnermeier & Cohen, 2003; Nameroff *et al.*, 2004) yet shortcomings similar to those analyzed for general innovations warn against the use of those proxies, which could lead to under- or over-estimate innovation, for example in the case of incremental innovations. Also environmental R&D expenditure has been extensively used as a proxy for EI (see e.g., Jaffe & Palmer, 1996; Mazzanti & Zoboli, 2009), but it is a measure for the input of the innovative activities rather than its output. For the purpose of this study, interested in analyzing firm's level characteristics and innovation activities for green innovation propensity, self-reported data on innovation activities seems the better fit. Previous contributions have addressed such questions using data from the previous waves of the CIS survey and proxying environmental innovation using a question on the impacts of the innovation introduced (Brunnermeier & Cohen, 2003; Horbach, 2008; De Marchi, 2012); the inclusion, in the 5th wave, of specific questions on the topic allows for the first time to assess with more precision who are the firms that introduced environmental innovations. The Italian CIS lists nine types of green innovations, enlisted in .; INN_ENV is a dummy taking on value 1 if a firm reported to have introduced at least one of them, 0 otherwise. In order to assess the differences existing among typologies of innovations, we created also a dummy for each green innovation listed, valuing 1 if the company introduced it and 0 otherwise. The variable INN_ENVBREADTH is instead a count variable, constructed adding up each of the nine dummies for green innovation and taking therefore values from 0 to 9, similarly to what done by Laursen & Salter (2006) to measure how open was the innovation strategy of a firm[4]. Such variable is used as a measure of the breadth of the firm's environmental innovation strategy, and may be interpreted as a proxy of how much the environment concerns are strategic for the firm.

To capture the impact of firm's *size* on its green performances we use the variable LNTURN, measured as the natural logarithm of firm's turnover in 2008. The analysis of the *internationalization* dimension is conducted so to highlight both the impact of foreign competition and of foreign ownership to the propensity of eco-innovate. The variable FOREIGN is a dummy that equals 1 if the firm is part of a group based in a foreign country, and 0 otherwise. In order to separate the impact of foreign ownership from the participation to a group we included in the analysis also the variable GROUP, valuing 1 if

[4] Although it is a relatively simple construct, the variable has a good degree of internal consistency, displaying a Cronbach' s alpha coefficient of 0.88.

the firm is part of a group, being it national or international. The binary variable EXPORT is also included in the analysis, to capture the impact of export activities on environmental propensity. To evaluate the *innovation strategy* of the firm we use a set of variables. R&D is a binary variable valuing 1 if the firm did intra-mural research and development activities during 2006-2008. The dummy TECH_PURCHASE captures if the firm has acquired knowledge or innovations developed by others in the form of i) acquisition of extramural R&D services, ii) purchase of machinery, equipment or software, or iii) acquisition of patents or other knowledge developed by others. The dummy TRAINING indicates if the firms' personnel attended internal or external training with the specific aim at developing or introducing new products or processes. Finally, the variable INN_INTENSITY is used as a proxy to evaluate the importance of innovation activities for the firm and is measured as the ratio between the overall expenditures for innovation activities and the firm's turnover in 2008. Unfortunately, it was not possible to analyze other aspects of the firm innovation strategies, such as cooperation, reliance on external sources of information or the objects of the innovative activities, given that such questions are administered just to firms that declared to introduce product or process innovation, irrespectively from their environmental innovation propensity.

Lastly, we included in the analysis also 11 industry dummies. Table 7, in the Appendix, lists the definition and the descriptive statistics of all the variables used.

Descriptive statistics

Almost half (47.8%) of the Italian manufacturing firms part of the sample has introduced at least one type of EIs during 2006-2008; on average, they introduced 2.0 different types. As emerges from ., innovations with environmental benefits in the production phase are the most diffused (44.7%), with a peak in the innovations aiming at reducing air, water, noise or soil pollution – adopted by 29.4% of the firms – and at recycling the firms waste, water or other materials (28.9%), which are environmental areas that have been particularly targeted by policy regulation. It is worth noting that innovation targeting the reduction of CO_2 emissions are those diffused the least (16.1%), which may be explained with their higher initial costs. Similarly, the low share of firms that substituted traditional materials with eco-friendly ones (16.2%) may be explained by the limited availability of viable alternatives in several industries. Innovations that generate environmental benefits from using the firm's products are also pretty diffused among firms, mainly those reducing pollution and the energy use per unit of output, representing the 26.5% and 24.8% of the overall firms respectively.

. allows also appreciating the different diffusion of green innovations according to the firm's size according to the classification defined by the European Commission, distinguishing among firms with less than 50 employees (SMALL), firms employing more than 50 and less than 250 people (MEDIUM) and firms with 250 employees or more (BIG). In general, big firms are those where green innovators are more numerous: 71% of the big firms introduced at least one typology of green innovations – and on average 3.8 –versus the 55% of medium firms and the 40% of small ones. Such higher incidence is verified for each type of EI considered, but there are interesting differences between classes. For example, the reduction of CO_2 emissions is far more diffused when considering just big firms than what it appears on the overall sample, whereas the substitution of materials is still pretty low, corroborating the explanation of their low diffusion discussed above. Another interesting evidence regards innovations that allow the recyclability of products, which are relatively more important for small firms than for the big ones, within the group of innovations with benefits at the use of firm's products.

Table 1 - Italian environmental innovators by type of environmental innovation (EI) introduced and firm's size

	All	Big	Medium	Small
Introduced any EI	*47.8%*	*71.0%*	*55.0%*	*40.0%*
EI breadth	*2.0*	*3.8*	*2.4*	*1.5*
Introduction of EI with benefits in the production phase	*44.7%*	*68.0%*	*52.0%*	*36.9%*
Reduced material use per unit of output	16.8%	35.6%	20.8%	11.2%
Reduced energy use per unit of output	20.1%	43.9%	25.3%	12.9%
Reduced CO_2 emissions	16.1%	36.9%	18.9%	10.6%
Substitutions of traditional materials with eco-friendly ones	16.2%	29.0%	19.1%	12.3%
Reduction of air, water, noise or soil pollution	29.4%	53.6%	36.5%	21.4%
Recycled materials, waste or water	28.9%	50.5%	32.6%	22.8%
Introduction of EI with benefits at use of firm's products	*38.6%*	*60.0%*	*43.9%*	*31.9%*
Reduced energy use	24.8%	48.9%	29.9%	17.6%
Reduction of air, water, noise or soil pollution	26.5%	48.0%	31.4%	20.1%
Improved after use recycling of products	22.6%	33.4%	24.0%	19.8%
Number of firms	5,677	748	1,403	3,526

In we analyze the distribution of green innovators by industry and the average number of typologies of environmental innovations introduced by firms in each sector. The comparative analysis suggests the existence of strong industry heterogeneities in terms of environmental performance. In general, it seems that firms in low-tech industries, such as textile, leather and furniture, are less likely to introduce environmental innovation, whereas in industries implying more complex technologies EI are more diffused. In particular, in the chemical and pharmaceutical industries and in the plastics the majority of firms (61% and 56.0% respectively) are green innovators, which is not surprising since they are environmentally intense industries. EI with benefits in the production phase are particularly diffused among those firms, with a peak for innovations targeting the reduction of air, water, noise or soil pollution and those improving the recyclability of materials or wastes. EI with benefits at the use of firm's products are also highly diffused, in particularly the reduction of pollution for the chemicals and pharmaceuticals and the reduction of energetic consumptions for plastics. Interestingly, also sectors such as machinery, electrics and informatics, which being most likely business-to-business industry may feel less customer and institutional pressures, are ranking high as incidence of green innovators. In both industries, innovations regarding the reduction of energy consumption at the product use are particularly diffused.

Table 2 - Italian green innovators by industry, ordered by the relative importance of environmental innovators on the industry total

	# of firms	% of green innovators	EI breadth
Chemicals and pharmaceutical	265	61.1%	3.14
Plastics	391	56.0%	2.26
Machinery	582	55.8%	2.53
Electrics and informatics	326	55.5%	2.32
Non metallic minerals	556	54.3%	2.46
Food, drink and tobacco	506	48.4%	2.06
Paper	518	48.1%	2.10
Metals production	631	48.0%	1.89
Wood and furniture	538	45.2%	1.76
Other manufacturing industries	590	38.3%	1.51
Textile and leather	774	33.6%	1.24
Total	5,677	47.8%	2.01

On average, firms that have introduced at least one environmental innovation are bigger than the other firms, as it emerges from Table 3: 19.6% of those firms have more than 250 employees (BIG), versus the 7.3% than the firms that did not introduced any types of environmental innovations, and similar results holds for medium-sized firms. However, the variability within the first group of firms is much bigger than within the second, pointing to the existence of a heterogeneous group of firms that knitted environmental issues to their competitive model. Moreover, environmental innovators are more often part of a group (38.7% vs. 25.4%) and they are more likely to be part of a group whose headquarter is based in a foreign country. More than 70% of green innovators sell at least part of their turnover abroad. Despite this share is much higher than for firms that did not introduced any of the EI listed in the survey the two groups are very similar in terms of number of firms for which foreign countries represents the main destination – 3,8% for environmental innovators and 3,5% for other firms. The CIS survey lists two possible groups of foreign export destinations: i) EU and EFTA countries and ii) all the others. Interestingly, the share of firms for which non-EU countries are the major export destinations is higher for the group of non-environmentally innovative. Also the innovation strategies of the two groups of firms appear to be different. For both, the acquisition of machinery, patents of other forms of external knowledge is the innovation activity that is diffused the most among those considered in this analysis. However, the percentage of firms that claimed to perform R&D activities is almost double for environmental innovators, with nearly half of those firms (43.9%) engaging in such activities at least on a occasional basis. Similar analysis may be held comparing all the other innovative activities considered, namely the purchase of knowledge or innovations developed by others (58.7% vs. 49.3%), and training (37.6% vs. 20.8%). Finally, descriptive statistics analysis suggests that innovation activities are more relevant for environmental innovators than other innovators: they devote 3.2% of their revenues to innovation activities versus the 2.1% of the others.

Table 3 - Descriptive statistics of the main regressors, for firms that introduced any environmental innovation and the others

	Environmental innovators		**Others**	
	Mean	**Std. Dev.**	**Mean**	**Std. Dev.**
LNTURN	2.37	1.90	1.47	1.65
BIG	19.6%	39.7%	7.3%	26.1%
MEDIUM	28.4%	45.1%	21.3%	41.0%
SMALL	52.0%	50.0%	71.4%	45.2%
GROUP	38.7%	48.7%	25.4%	43.5%
FOREIGN	13.0%	33.6%	5.9%	23.5%
EXPORT	70.2%	45.7%	57.0%	49.5%
R&D	43.9%	49.6%	24.6%	43.1%
TECH PURCHASE	58.7%	49.3%	38.4%	48.6%
TRAINING	37.6%	48.4%	20.8%	40.6%
INN INTENSITY	3.2%	6.6%	2.1%	5.8%
# of firms	2,715		2,692	

Statistical methods and main results

To investigate the impact of size and of firms’ internationalization and innovation strategies on EI propensity we implemented a logit regression, given that our dependent variables are binary. This specification identifies the impact of the measures described above on the probability to introduce an EI with respect to not introduce it. Logit regressions, like other types of multiple regressions, are sensitive to high correlation among the independent variables: tests for multicollinearity suggest no problem in this respect. All the models presented in the following tables passed also the Pearson goodness-of-fit test and the link test for model specification and classifies correctly from a minimum of 63.1% to a maximum of 83.9% cases, using a cut-off point of 50% for the predicted probability.

reports the results of the regression when considering INN_ENV as the dependent variable: column I reports the main model and column II a model including interactions variables among regressors measuring the innovation strategy. In column III we report the results of a poisson regression measuring the impact of the regressors considered on the count variable INN_ENVBREADTH.

We find strong evidence that bigger firms are more likely to introduce environmental innovations: the coefficient of the variable LNTURN, in fact, is always highly significant and positive. This result holds also if we use dummies based on the number of people employed in 2008 as an alternative measure of size. According to our econometric estimation, firms that are part of a group are more likely to be green innovators just if the group is a multinational, having its main headquarters abroad. Actually, the coefficient of GROUP is never significant, whereas that of FOREIGN is significant at the 5% level. Selling in international markets (EXPORT) is, instead, not significant in explaining the introduction of EIs. Interestingly, this results holds also when using different specifications for export activities of firms, considering for the destinations – focusing just on export to EU or EFTA countries, where environmental standards and regulations are amongst the highest worldwide – and for the relevance of export on the overall turnover – focusing just on firms that realized the majority of their turnover in international markets.

The econometric analysis supports that the innovative activities considered in the analysis trigger EIs adoption, but that they are not complementary. The coefficients for R&D and TECH_PURCHASE are positive and significant at the 1% level, and also that of TRAINING, which however is significant just at the 5% level and has a smaller coefficient. In column II, the variable R&D_TECH PURCHASE indicates if firms perform R&D activities in-house and have bought external knowledge or equipment and R&D_TRAINING if it performed R&D and training. The negative sign of such variables, which however is significant just in the case of R&D_TECH PURCHASE, suggests the existence of a substitution effect between those innovative activities in the effort of developing EIs. Finally, innovation intensity (INN INTENSITY) is just weakly significant, signifying that the amount of resources devoted to innovation is not important in explaining firm's eco-friendly performance. It is worth saying that this variable become highly significant when it comes to explain the propensity to introduce more than one typology of environmental innovations, as emerges from the poisson regression reported in column III; the more the company invest in innovation activities the more it will be able to introduce innovations with several environmental benefits, therefore adopting an holistic approach to the reduction of its environmental footprint.

The analysis suggests also homogeneity in firms' environmental performance across sectors, suggesting that firm's strategies may matter more than industry characteristics such as differences in the availability of eco-friendly technological alternatives and environmental policy stringency. In , so as in the followings, the reference dummy is CHEMICALS, the industry that displays the highest incidence of environmental innovators: significance levels and coefficients are hence to be interpreted relatively to the environmental propensity in this industry. The analysis suggests that the only industry that significantly under-perform with respect to the chemical and pharmaceutical ones is textile and leather (TEXTILE), which confirms what emerged from descriptive statistics' analysis (see). Interestingly, the wood and furniture (WOODFURN) or other manufacturing industries (OTHER), which were also industries with low share of firms that introduced at least one type of EIs, do not seem to be less likely to introduce at least one type of environmental innovations. OTHER, however, became negatively significant when considering as a dependent variable INN_ENVBREADTH (column III), and so does MACHINERY, suggesting that firms specialized in those industries may be less prone than chemical producers to become "heavy" environmental innovators.

Table 4 - Logit (columns I and II) and poisson (column III) regressions, explaining the propensity to introduce environmental innovations among Italian manufacturing firms.

	(I) INN_ENV		(II) INN_ENV		(III) INN_ENVBREADTH	
	Coef.	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**
LNTURN	0.175***	(0.023)	0.173***	(0.023)	0.143***	(0.013)
GROUP	0.035	(0.080)	0.049	(0.080)	-0.003	(0.045)
FOREIGN	0.272**	(0.114)	0.272**	(0.114)	0.101**	(0.050)
EXPORT	0.081	(0.067)	0.070	(0.067)	0.000	(0.043)
R&D	0.272***	(0.073)	0.567***	(0.115)	0.242***	(0.042)
TECH PURCHASE	0.390***	(0.070)	0.488***	(0.087)	0.237***	(0.043)
R&D_TECH PURCHASE			-0.366**	(0.145)		
TRAINING	0.177**	(0.076)	0.263**	(0.113)	0.141***	(0.040)
R&D_TRAINING			-0.152	(0.152)		
INN INTENSITY	1.019*	(0.556)	0.915*	(0.540)	0.856***	(0.243)
FOOD	-0.067	(0.165)	-0.066	(0.165)	-0.073	(0.081)
TEXTILE	-0.498***	(0.160)	-0.491***	(0.160)	-0.402***	(0.088)
WOODFURN	-0.007	(0.167)	0.003	(0.167)	-0.064	(0.086)
PAPERPRINT	0.116	(0.167)	0.117	(0.166)	0.116	(0.084)
PLASTICS	0.218	(0.173)	0.228	(0.173)	0.019	(0.083)
NONMETMINER	0.129	(0.163)	0.136	(0.163)	0.056	(0.076)
BASICMETAL	0.097	(0.162)	0.092	(0.162)	-0.003	(0.081)
ELECTRICAL	-0.012	(0.179)	-0.010	(0.178)	-0.131	(0.085)
MACHINERY	-0.074	(0.161)	-0.067	(0.161)	-0.122*	(0.074)
OTHER	-0.256	(0.165)	-0.255	(0.165)	-0.171*	(0.090)
Constant	-0.808***	(0.150)	-0.851***	(0.150)	0.129*	(0.076)
Observations	5,677		5,677		5,677	
Pseudo R-squared	0.0723		0.0737		0.0959	
ll	-3646		-3640		-13156	

*Robust standard errors in parenthesis. *** p<0.01, ** p<0.05, * p<0.1*

In the following, results of logit regressions explaining the propensity to introduce each of the nine EI types listed in the Italian CIS are reported: Table 5 focuses on innovations with environmental benefits at the firm's level while Table 6 on innovations with environmental benefits at the use of the firm's products. The most interesting evidence emerging from the comparative analysis regards the high heterogeneity in the firm's environmentally innovative propensity, according to the different environmental areas targeted. This result suggests that firm's characteristics that drive their introduction may differ according to their environmental targets, which justify the need to analyze them separately.

Innovations with environmental benefits at the firm level

As far as size is concerned, there is no difference from the analysis reported in Model (I) as far as significance is concerned. However, we note that the magnitude of the coefficients of the variable SIZE is higher for typical end-of-pipe oriented technologies, namely innovations aiming at reducing CO_2 emissions (column 3) and other air, soil or noise pollution (column 5). A similar consideration holds for energy-efficiency EI (column 2), a type of innovation where it is possible to achieve higher gains at the increase of the scale of production.

Interestingly, foreign ownership is significant just for innovations aiming at reducing the use of materials (column 1) and CO_2 emissions (column 3), which in our eyes may be explained with the complexity linked with the introduction of those innovations. To reduce the use of materials per unit of outputs, in fact, require a strong eco-design effort, which may benefit from the capabilities present in other firms part of the group and the knowledge developed within other geographical settings. Similarly, the reduction of air emissions may require re-thinking the production process, which is a costly and complex activity that may well benefit from the knowledge developed within the group and that may be better amortize when applied in several subsidiaries.

As far as the innovation activities are concerned, firms that perform R&D activities are more likely to introduce all types of production-related innovation, except those aiming at recycling materials, waste or water (column 6). The impact of R&D on innovation propensity is particularly high for innovation aiming at reducing the use of materials (column 1) or substitute traditional with eco-friendly ones (column 4), which may be explained with the fact that they are innovations where design and planning play a significant role. Also TRAINING confirms to be an important driver of EI adoption, with the exception of material-efficiency innovations (column 1). The coefficient for the variable TECH PURCHASE is significant and positive in all models, with a peak for energy efficiency innovations (column 2). The analysis of the innovation intensity of the firm (INN_INTENSITY) is particularly interesting and suggests that the relative amount of resources allocated by firms to innovation activities may be relevant in explaining their capability to introduce just some types of green innovations. Both the magnitude and the significance of its coefficient varies accordingly to the type of EI considered, having the lowest influence on innovations targeting the substitution of traditional materials (column 4) and even no impact on innovations aiming at recycle waste or other materials (column 6), and the highest influence on innovations targeting energy-efficiency (column 2). Such variability suggests that just in some cases.

Table 5 - Logit regression, explaining the propensity to introduce innovations with environmental benefits at the firm's level

	(1)	(2)	(3)	(4)	(5)	(6)
	MAT-EFF	**EN-EFF**	**CO2**	**MATERIALS**	**POLLUTION**	**RECYCLE**
LNTURN	0.167***	0.237***	0.282***	0.181***	0.237***	0.192***
	(0.030)	(0.028)	(0.030)	(0.029)	(0.025)	(0.024)
GROUP	0.173*	-	-	-	-	-
	(0.102)					
FOREIGN	-	-	0.312**	-	-	-
			(0.126)			
EXPORT	-	-	-	-	-	-
R&D	0.670***	0.460***	0.169*	0.507***	0.328***	-
	(0.094)	(0.088)	(0.094)	(0.095)	(0.078)	
TECH PURCHASE	0.354***	0.453***	0.322***	0.377***	0.283***	0.293***
	(0.098)	(0.092)	(0.098)	(0.096)	(0.078)	(0.077)
TRAINING	-	0.211**	0.310***	0.162*	0.269***	0.276***
		(0.089)	(0.096)	(0.095)	(0.080)	(0.080)
INN_INTENSITY	1.369**	1.608***	1.162**	1.098*	1.380**	-
	(0.562)	(0.566)	(0.559)	(0.561)	(0.541)	
FOOD	-0.423**	-	-	-0.344*	-	-
	(0.201)			(0.209)		
TEXTILE	-0.547***	-0.644***	-0.587***	-	-0.805***	-0.388**
	(0.199)	(0.186)	(0.200)		(0.171)	(0.167)
WOODFURN	-	-	-	-	-	-
PAPERPRINT	0.342*	-	-	0.626***	-	0.369**
	(0.194)			(0.197)		(0.169)
PLASTICS	-	-	-	-	-	-
NONMETMINER	-	-	-	-	-	-
BASICMETAL	-	-	-	-	-	-
ELECTRICAL	-	-	-	-	-0.785***	-
					(0.187)	
MACHINERY	-	-	-0.377**	-	-0.338**	-
			(0.184)		(0.163)	
OTHER	-0.438**	-0.384**	-	-	-0.542***	-
	(0.209)	(0.193)			(0.177)	
Constant	-2.437***	-2.437***	-2.423***	-2.449***	-1.518***	-1.565***
	(0.179)	(0.165)	(0.178)	(0.186)	(0.155)	(0.154)
Observations	5,677	5,677	5,677	5,677	5,677	5,677
Pseudo R-squared	0.0948	0.115	0.0861	0.0649	0.0918	0.0621
ll	-2324	-2518	-2291	-2350	-3122	-3200

*Only coefficient and S.E. that were significant at least at the 10% level are reported, for the sake of clarity. Robust standard errors in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.*

Innovations with environmental benefits at the product's use level

Table 6 reports evidence for innovations that produce environmental benefits at the consumption phase, so when firm's products are used by clients rather than when they are produced by the company, which was the case in previous paragraph. The Italian CIS survey lists just three typologies of such innovations, namely the reduction of product energy usage (PROD-EFF), the reduction of products' pollution and emissions (PROD-POLL) and the improvement of the recyclability of products (PROD-RECYCLE). As seen for production-related innovations, size is positive and significant in explaining all the typologies of EIs analyzed. However, the magnitude of the coefficient for the variable LNTURN is much lower when considering innovations aiming at improving the recyclability of products at their end of life (column 9), much lower also than for any innovation producing benefits at production phase. Innovations aimed at reducing end-of-life impacts and at closing the cycle by ensuring the recyclability of the product very often requires an high level of cooperation with suppliers and consumers (see e.g., Andersen, 2002; Seuring & Müller, 2008; De Marchi, 2011). Such relational characteristics may offset the need of high internal resources for the development of this innovation, which is instead higher to develop innovations aiming at reducing emissions (columns 3, 5 and 8) or increasing energy efficiency (columns 2 and 7). This consideration is consistent also with the lower magnitude of the coefficients for the variable R&D and the greatest for the variable TRAINING, since often training activities are enacted by supply chain partners (see e.g. Ivarsson & Alvstam 2010 a,b; De Marchi 2011). In general, product-related EIs are very similar in terms of innovation strategies: the sign and the significance of all the variables considered are consistent with what emerged in the main model (column I), with innovations aiming at improving the energy efficiency of the products (column 7) and, to a lower extent, those reducing its pollution (column 8), displaying the larger coefficients.

Table 6 - Logit regression, explaining the propensity to introduce different types of innovations with environmental benefits at the use of firm's products

	(7) PROD-EFF	(8) PROD-POLL	(9) PROD-RECYCLE
LNTURN	0.262***	0.234***	0.096***
	(0.026)	(0.025)	(0.026)
GROUP	-	-	-
FOREIGN	0.247**	-	-
	(0.115)		
EXPORT	-	-	-
R&D	0.289***	0.304***	0.232***
	(0.081)	(0.080)	(0.085)
TECH PURCHASE	0.283***	0.245***	0.220***
	(0.083)	(0.079)	(0.083)
TRAINING	0.188**	0.187**	0.203**
	(0.084)	(0.082)	(0.085)
INN_INTENSITY	1.383**	1.212**	1.116**
	(0.540)	(0.522)	(0.518)
FOOD	-	-0.368**	-
		(0.171)	
TEXTILE	-0.405**	-0.799***	-0.464**
	(0.174)	(0.171)	(0.184)
WOODFURN	-	-	-
PAPERPRINT	-	-	-
PLASTICS	-	-0.337*	-
		(0.179)	
NONMETMINER	-	-	-
BASICMETAL	-	-	-
ELECTRICAL	-	-0.467**	-
		(0.184)	
MACHINERY	-	-	-
OTHER	-	-0.286*	-
		(0.172)	
Constant	-2.075***	-1.521***	-1.713***
	(0.157)	(0.152)	(0.166)
Observations	5,677	5,677	5,677
Pseudo R-squared	0.0866	0.0709	0.0322
ll	-2902	-3052	-2939

*Only coefficient and S.E. that were significant at least at the 10% level are reported, for the sake of clarity. Robust standard errors in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.*

If the analysis reported in suggested a pretty homogenous propensity to introduce environmental innovations across industries, regressions considering for different EIs types (Tables 5 and 6) report a more differentiated picture. In general, the reduction of pollution during the production process (column 5) or at the product use (column 8) and, to a lower extent, material efficiency (column 1) are the areas where the greatest difference in the green innovation propensity across sectors is concentrated. Overall, it seems not possible to see any common pattern among industries sharing the same technological levels, according to the EU classification of high-technology industries[5]. Rather, according to the logit regressions reported in Tables 5 and 6, firms specialized in the wood and furniture industries (WOODFURN), in the non metallic minerals (NONMETMINER) and in basic metals production (BASICMETAL) have the same probability of chemical firms to introduce all the types of environmental innovations considered. PLASTICS differs from the chemicals just for the introduction of one type of EI, the reduction of pollution at the product's use. On the contrary, TEXTILE is consistently negatively related to the introduction of all environmental innovations considered, except for the substitutions of traditional materials with less harmful ones (column 4), which is not surprising since in this industry this practice is getting quite diffused. Finally, the paper and printing industries (PAPERPRINT) are the only ones that display an higher environmental innovation propensity than the chemicals, at least for innovations linked with the materials used, namely material efficiency (column 1), substitution of materials with eco-friendly ones (column 4) and the recycling of materials, waste and water (column 6). To use recycled paper is getting quite common in the industry and so are other practices like the use of paper pulp coming from responsible managed forests or use of less impacting inks, which is the result of a combination of high consumers' awareness, stringent policies regulating, and the availability of eco-friendly technological alternatives (see e.g., Andersen, 1999).

Discussion and conclusion

The more sustainable production and consumption systems are advocated as a possible solution to escape from the current economic crisis while improving living conditions, the more it is important to understand how such changes may occur within firms and therefore which dynamics lead to environmental innovation adoption. Where the extant empirical contributions on the topic have analyzed mainly external drivers, regulation and demand pull factors above all, spurring firms to develop green products or processes, this paper provides an analysis of the relations between firm-level

[5] According to the aggregation of the manufacturing industry according to technological intensity used by Eurostat, CHEMICALS, ELECTRICAL and MACHINERY are high or medium-high technology industries; PLASTICS, NONMETMINER and BASICMETAL are industries characterized by med-low levels of technology and the remaining (FOOD, TEXTILE, WOOFURN, PAPERPRINT and OTHER) are low-tech industries.

characteristics and greening propensity, focusing mainly on the role of size and of the firms' internationalization and innovation strategies. Using data from a unique dataset on innovation that for the first time inquires also specifically about firms' environmental innovative performance – the 5th wave of the Italian community innovation survey (CIS) – we contribute to the literature also by investigating the impact of such factors on the propensity to introduce different typologies of environmental innovations (EIs), which up to now is a rather unexplored issue in the literature, distinguishing among production- and product-related EIs.

The analysis suggests that size positively affects eco-innovation propensity of manufacturing firm. Given the high complexity and the initial costs in which firms incur to introduce green innovations, the firm's stock of financial, human and technological resources may crucially contribute to its ability to successfully introduce them. Interestingly, the impact of size is much lower when considering innovations aimed at improving the products' recyclability and closing firms' production cycles, whose development requires a close cooperation with supply chain partner that may offset for the firms' lack of resources (Andersen, 1999; Seuring & Müller, 2008).

Evidence of the impact of the firms' international strategy on its propensity to introduce product, process, organizational or marketing innovations that lower the impacts on the environment is mixed. Firms owned by a foreign multinational are more likely to become green innovators, at least for innovations aiming at reducing CO_2 emissions and reduce the energy needed at the product use. The possibility to access the knowledge developed in other geographical areas and to pool resources with the other members of the group increase the capability of firms to learn how to deal fruitfully with environmental issues. Furthermore, the more the units in which the innovation can be applied, the greater the incentives to bear the effort to develop it. On the contrary, serving an international market does not increase significantly the probability that a firm will introduce any type of green innovations, even when exporting to countries where environmental awareness is high. This evidence may be explained with the fact that, since in Italy environmental regulation and consumers' awareness are in line with those present in other advanced economies – especially within the EU, where environmental regulation is rather homogeneous – export activities do not provide firms with additionally incentives than those they face in the internal market to introduce EIs. Furthermore, as suggested in De Marchi (2012, p. 621), local market opportunities open up for firms as the absence of uniquely recognized standards defining green features and the difficulties to detect environmental characteristics at the product's use add to the importance of trust, reputation and direct communication efforts, which may be better acquired through proximity to the final market.

As far as the innovation strategy is concerned, we find strong evidence that environmental innovators are more likely than non-environmental innovators to perform R&D activities, especially when it comes to introduce innovations in which eco-design and planning plays a significant role. Furthermore, they are also more likely to acquire knowledge or innovations developed by external agents, mainly in the form of purchase of machinery, equipment or software. Those two activities, however, are substitutive rather than complementary in the effort to introduce innovations entailing a reduction of environmental impacts with respect to existing alternatives, which may be explained with the fact that eco-friendly technologies are not always readily available on the market. Where green alternatives exist and are well developed it may be more convenient for firm to acquire them on the market; in the other cases the introduction of environmental innovations cannot prescind from a strong internal research and development effort. Also training of the personnel is positively related to environmental innovations, confirming the importance of firm's capabilities and knowledge base to explain its ability to address successfully environmental problems. Our analysis suggests that the amount of resources devoted to innovation is just weakly significant in explaining the probability of a firm to become a green innovator, but it becomes pivotal when it comes to introduce more than one type of EIs at once. Firms for which sustainability is strategic and that adopt a holistic approach in addressing the environmental impacts of their production process and products are those that invest more resources in innovation activities. If it may be relatively easy to introduce one type of green innovation, to become a fully green company requires much more effort on the firm's side.

Finally, the analysis suggests that firm's level characteristics are more important than industry specialization – which captures the peculiar availability of environmental technological alternatives, level of regulatory stringency and the role of consumers in spurring the greening that characterize each industry – in explaining green innovation propensity. When considering the impact of size and of firms' strategies, just the textile and leather industry is differing significantly from the others in explaining the propensity of Italian manufacturing firms to introduce innovations that reduce at least one area of environmental impacts, which suggests a high heterogeneity in firm's green performance even within the same industries. A higher difference in industry eco-innovation propensity emerges when focusing on EIS reducing pollution at the production or product use levels or aiming at improving efficiency in the use of materials per unit output.

In line with results emerging in recent contributions (e.g., Cainelli et al. 2011, Horbach et al. 2011) our analysis supports the importance to analyze determinants of environmental innovations distinguishing among types, based on the main environmental impact they address. The magnitude and even the significance of the variables analyzed varies appreciably according to the typology considered, confirming that the specific characteristics of the green innovation to be introduced, including its complexity, compatibility with existing production system and cost structure, may affect the rate and direction of environmental technological change (del Rio Gonzalez, 2009).

The paper provides original results on firm's level characteristics affecting environmental innovation propensity. Further research should be performed, on the one hand, to compare such results with those emerging in other countries, enabling to understand if any of those results are driven by specific country characteristics, on the other hand, to inquire the impact of the variables considered while controlling for the impact of other aspects of the firm's innovation strategies, like the cooperation with supply chain partners or the objects of innovative activities that recent studies suggest as other important determinants (Horbach *et al.*, 2011; De Marchi, 2012). Qualitative case studies could complete the framework emerging from this quantitative analysis, enabling to better understand the phenomena considered.

Appendix

Table 7 - The variables used for the analysis

Name	Description	Mean	S.D.
INN_ENV	Introduced any innovation with positive environmental effects – 1 yes, 0 no	47.8%	50.0%
INN_ENV BREADTH	Total number of innovations with positive environmental effects introduced – 0, 9	2.01	2.66
Introduced innovation that have environmental benefits – 1 yes, 0 no			
MAT_EFF	Reduced material use per unit of output	16.8%	37.4%
EN_EFF	Reduced energy use per unit of output	20.1%	40.1%
CO2	Reduced CO_2 emissions	16.1%	36.8%
MATERIALS	Substitutions of traditional materials with eco-friendly ones	16.2%	36.8%
POLLUTION	Reduction of air, water, noise or soil pollution	29.4%	45.6%
RECYCLE	Recycled materials, waste or water	28.9%	45.3%
PROD-EFF	Reduced energy use at product	24.8%	43.2%
PROD-POLL	Reduction of air, water, noise or soil pollution of product	26.5%	44.2%
PROD-RECYCLE	Improved after use recycling of products	22.6%	41.9%
GROUP	Belongs to a group – 1 yes, 0 no	29.8%	45.7%
FOREIGN	Belongs to a foreign group – 1 yes, 0 no	8.6%	28.0%
EXPORT	Turnover in foreign markets – 1 yes, 0 no	60.9%	48.8%
LNTURN	Natural logarithm of turnover (2008)	1.81	1.81
R&D	Engagement in in-house R&D activities – 1 yes, 0 no	30.5%	46.1%
TECH PURCHASE	Purchase of external knowledge and technology (equipment, R&D or other technology) – 1 yes, 0 no	43.8%	49.6%
R&D_TECH PURCHASE	Engagement in in-house R&D activities (R&D) and purchase of external knowledge and technology (TECH PURCHASE) – 1 yes, 0 no	23.6%	42.5%
TRAINING	Training activities – 1 yes, 0 no	25.9%	43.8%
R&D_TRAINING	Engagement in in-house R&D activities (R&D) and training (TRAINING) – 1 yes, 0 no	17.5%	38.0%
INN INTENSITY	Percentage of total innovation expenses on firm's turnover	2.4%	6.0%
Industry dummies – 1 yes, 0 no			
FOOD	Food, drink and tobacco	8.9%	28.4%
TEXTILE	Textile and leather	14.0%	34.7%
WOODFURN	Wood and furniture	9.6%	29.5%
PAPERPRINT	Paper	9.3%	29.1%
CHEMICALS	Chemicals and pharmaceutical	4.3%	20.4%
PLASTICS	Plastics	6.9%	25.3%
NONMETMINER	Non metallic minerals	9.7%	29.6%
BASICMETAL	Metals production	11.4%	31.7%
ELECTRICAL	Electrics and informatics	5.5%	22.8%
MACHINERY	Machinery	9.9%	29.9%
OTHER	Other manufacturing industries	10.6%	30.7%

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