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by

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Abstract

This paper evaluates the effect of host-country environmental policy stringency on the offshoring of environmental patents for 2000 top world R&D performers. It is shown that a more stringent environmental regulation triggers both the extensive and intensive margin of patent offshoring in the field of environmental technologies. Results are robust to various different specifications, alternative definitions of innovation offshoring and of regulation restrictions, and to the consideration of possible endogeneity of regulation. It is suggested inter alia that R&D subsidies and non-market based regulatory measures are more important than market-based instruments as drivers of cross-border environmental innovation.

Keywords: MNE, environmental policy, patent data

JEL: F10, F23, O33, Q55

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1 Introduction

Technical change and innovation are at the core of strategies aimed at reducing the burden of economic activities on the environment (EEA, 2014). New and more efficient production processes and improved products are crucial to enable a sustainable economic growth where improved welfare is coupled with better environmental quality.

Big companies play a crucial role in the process of technical change and innovation as well as in contributing to environmental pressures. To illustrate, the combination of top 1000 EU companies and top 1000 non-EU companies contributes to more than 90 percent of world business R&D expenditure (Dernis et al, 2015). Most of these R&D performers are multinational enterprises (Unctad 2005, Dachs et al 2014). In terms of environmental impact, about one third of total carbon dioxide emissions in EU28 is released by just 312 large installations and as much as one third of total sulphur oxides (a local pollutant) emissions is released by just 40 large installations (own elaboration on E-PRTR and EEA data for 2012). There is also sparse and largely anecdotal evidence that Multinational (MNEs) play a substantial role the generation and diffusion of green innovation through their R&D facilities both in their home countries and in foreign locations[3].

In this context, the main contribution of this paper is twofold. On the one hand, it provides systematic evidence on the role played by the world's top innovating companies in the development of environmental technologies, as a response to environmental regulation. On the other hand, it sheds some light on how environmental regulation in host countries affects green inventive activities of foreign MNEs active in those countries.

The paper fills a gap in extant empirical literature, that has mostly paid attention to the impact of environmental regulation on innovative activities of domestic firms, with special attention to SMEs, and with a focus on individual national contexts or a few countries. The role of large companies, and of multinational enterprises (MNEs) in particular, has been largely disregarded. This has led to a lack of consideration of how the exposure to multiple local institutional settings may affect green innovation. As we shall see, the few studies taking the latter perspective are either based on case studies or surveys, with relatively low capacity to draw the general picture, or are forced by data limitations to oversimplify the measurement of innovation offshoring and of environmental regulatory measures affecting green technologies. This paper attempts to overcome these drawbacks of previous research by providing systematic evidence on cross-border inventive activities of 2000 top world R&D performers in 35 countries, based on a sample of 37,905 triadic patents. It develops alternative measures of green innovation offshoring, and evaluates the impact of indicators capturing different aspects of environmental regulation - instrumented to account for endogeneity - on both extensive and intensive margins of firms' cross-border invention.

[3] For instance, based on press information Noailly & Ryfisch (2015) documented that the Chinese-based division of General Motors has expanded its involvement in R&D activities relating to battery manufacturing for hybrid and electric vehicles. According to the Ford Sustainability Report (2016) the company's engineers in Europe have been successful in inventing a cutting-edge green technology for the 1.0-l EcoBoost petrol engine. Li et al. (2017) mention different cases of subsidiaries of MNEs that have become essential for promoting the diffusion of green technologies to local firms in China, and Park et al. (2015) illustrate experiences of MNEs greening their regional and global value chain networks.

The paper is organized as follows. Section 2 briefly reviews extant literature and highlights the research gap to be filled in. Section 3 describes the data sources and defines 'offshored' patents, that is our measure of cross-border innovation activities. Section 4 provides some descriptive evidence. Section 5 illustrates the empirical strategy and discusses the results of our econometric analysis. Section 6 concludes.

2 Background literature

The recent literature on the development and diffusion of environmental technologies has stressed the importance of public environmental policies as fundamental drivers of green innovation (Horbach et al, 2012). Public intervention is important as in absence of public policies there will be no incentive for polluting companies to invest in the development and adoption of innovations that reduce a negative externality (i.e. pollution) that has no market value (Jaffe et al, 2005). This idea about the importance of environmental policies to promote environmental innovations dates back to the 1970s (e.g. Ruttan, 1971) and was emphasized by the recent literature about the so-called 'Porter Hypothesis' (Porter and Van Der Linde, 1995). According to Porter and Van Der Linde (1995), environmental regulation triggers innovative responses by companies with the aim of reducing the costs to comply with the regulation itself. Moreover, well designed environmental policies may even lead to overall improvements in the competitiveness of regulated companies as public intervention helps companies to break inefficient routines and signals inefficiencies.[4] Many of the 'successful' case studies described by Porter and Van Der Linde (1995) refer to big established companies that were able to exploit environmental regulations to improve their competitive position by means of organizational or technological innovations.

Despite the core role played by big and established companies in the Porter Hypothesis, most of the empirical analyses based on company-level data focus on small and medium enterprises (see Ambec et al., 2013, and Barbieri et al., 2016 for recent reviews).

One of the reasons why so much attention is devoted to SMEs is that they are usually exposed to well defined environmental regulations enforced in the same jurisdiction and market where these companies operate, hence making it easier to identify a direct impact of such regulation on firm performance.

Generally speaking much of extant research on the impact of institutional pressures on environmental innovation focuses on domestic firms (Berrone et al., 2013; Kawai et al., 2018). However, by focussing on domestic firms, and on SMEs in particular, extant literature largely disregards the fact that big companies, especially MNEs, necessarily deal with a wide variety of contexts characterized by heterogeneous environmental regulations. Being exposed to different institutional contexts, MNEs are responsive to local stakeholder pressures and regulations not only from their home countries, but also from host countries, and are often induced to develop and adapt green technologies in response to such stimuli (Rugman and Verbeke 1998; Peng and Lin, 2008; Tatoglu et al., 2014; Kawai et al., 2018).

[4] There has been an extensive debate over the theoretical foundations and the empirical verification of the Porter Hypothesis. Refer, among others, to Palmer et al (1995), Barbieri et al (2016) and Ambec et al (2013).

Some theoretical and empirical works showed how environmental regulation directed at a specific sector or region may exert its effect on other sectors and region. For example, Greaker (2006) builds a model in which environmental regulation in the polluting sector is complied with by means of abatement technologies developed by an upstream specialized sector. Similarly, Heyes and Kapur (2011) propose a model in which both the specialized supplier and the regulated firm perform R&D to develop the abatement technology with the aim of obtaining a patent over the technology. In sum, the idea is that environmental regulation generates a 'derived demand' for pollution abatement technologies. These technologies could either be developed by regulated firms themselves or developed by specialized suppliers that operate in different sectors and regions from the polluting firm. This market opportunity may induce foreign firms to locate these innovation activities close to the regulated firms to interact directly with them, and to be geographically closer to the environmental authority.

There exists some empirical literature that evaluates the influence of local environmental policies on the development of environmental technologies abroad. Popp (2006) investigates the international innovation and diffusion of air pollution control technologies as a consequence of the introduction of regulation to reduce air emissions of nitrogen oxides and sulphur dioxide in Germany, Japan and the US. His results suggest that environmental regulation triggers patenting in pollution control technologies by domestic inventors while no impact is found on patenting of foreign inventors. The main limitation of this study is that there is no consideration of whether 'domestic' inventors are employed by domestic or foreign companies. In other words, Popp (2006) finds that environmental restrictions in a given market positively impact the propensity to develop green technologies of firms (and individuals) carrying out their inventive activities locally, whereas such restrictions do not have any effect on those carrying out their inventive activity in a foreign country. However, he says nothing about the responsiveness to regulation of foreign based innovators conducting their inventive activities in the local market, as in the case of subsidiaries of foreign firms.

A few studies have shed light on the role of regulatory restrictions among other determinants of green innovation, using MNE subsidiaries as a unit of analysis. They are generally restricted to one or a few countries of origin or destination, and are based on case studies or ad hoc surveys.

Muller (2006) observed that the Mexican subsidiaries of four European MNCs (Scania, Volvo, Mercedes, and Volkswagen) had the freedom to develop and execute proactive environmental strategies aligned with the local institutional contexts. Aguilera-Caracuel, et al. (2012) report that environmental standardization is greater the lower the environmental institutional distance between the MNE home country and the host countries of the subsidiaries. Tatoglu et al. (2014) show that local pressures heavily affected the adoption of voluntary environmental practices by MNE subsidiaries in Turkey. Kawai et al. (2018) conduct a survey on 123 EU and US subsidiaries of Japanese MNEs and find that local regulatory stakeholder pressures affect green innovation by inducing the implementation of formal environmental management systems (EMS) which will eventually facilitate the local adoption and generation of green innovation.

To the best of our knowledge, the only previous study providing systematic evidence on the determinants of cross-border green innovation for a wide range of firms and countries is Noailly and Ryfisch (2015). Using data on inventors' addresses for 1200 MNEs patenting in green technologies over the 2004-2009 period, they find that about 17% of their green patents are filed by inventors that reside outside their home countries. They also observe that the probability of offshoring green inventions increases inter alia with the stringency of environmental regulation. Nevertheless, they adopt a very simplified measure of offshoring, they do not distinguish for different types of regulatory measures, nor do they deal with endogeneity issues. The empirical strategy adopted in this paper will help overcome these limitations.

3 Data sources and variables definition

The main source of data is the COR&DIP database (Edition 2015) developed by the OECD and the IPTS-JRC (Dernis et al, 2015). The COR&DIP database collects information on patent applications and trademarks for years 2010-2012 for the sample of 1000 top EU R&D performers and 1000 top non-EU R&D performers listed in the R&D Scoreboard 2013. The database lists all patent applications to five different patent offices[5] over the period 2010-2012, submitted by headquarters and by all subsidiaries worldwide of top R&D performers. The main advantage of the COR&DIP database with respect to other widely used patent databases is that it evaluates all ownership links (about 500 thousand subsidiaries that belong to top R&D performers) to attribute patents to the headquarter of the company, while in other patent databases (e.g. Patstat, Orbis) applications are assigned to the 'direct' applicants, that may be either a subsidiary or the head of group. COR&DIP allows instead to identify the company headquarters that are the ultimate owner of patents and, combined with patent-level information, to assess whether the nationality of inventors and applicants corresponds to, or differs from, the company's home country. Based on these data, one is enabled to make inference on the extent to which inventive activity occurs across national borders. This is an important feature of the COR&DIP database as the decision of whether to apply for a patent as a group or through a subsidiary cannot be directly observed.[6]

Our work focuses on Triadic Patent Families (TPF), that is patent families that contain applications to the three most important patent offices in the world (EPO, JPO and USPTO). This choice allows to reduce the risk of 'home bias' for patenting strategies of companies (Bacchiocchi and Montobbio, 2010) and is a simple procedure to select only patents with relevant economic value. Companies in our sample applied for a total of 37,905 triadic patent families over the period 2010-2012, accounting for 25.7 percent of total triadic patents applied worldwide in the same period (147,485).

The COR&DIP database also includes data from the R&D scoreboard for top R&D performers for the period 2010-2012. This information refers to R&D expenditure, net sales, number of employees, operating profits, capital investments and main sector of operation.

Additional information on patents was retrieved from the TPF-OECD database (Triadic Patent Families). More specifically, we retrieve detailed IPC (International Patent

[5] European Patent Office (EPO), United States Patent and Trademark Office (USPTO), Japanese Patent Office (JPO), Korean Intellectual Property Office (KIPO) and State Intellectual Property Office of the People's Republic of China (SIPO).

[6] Failing to identify patents applied by subsidiaries is likely to substantially underestimate the patenting activities of big multinationals.

Classification) and CPC (Cooperative Patent Classification) classes and information about the country of residence of applicants and inventors.

The focus of our work is on technologies that contribute to reduce environmental pressures and risks. The use of patents as a proxy of innovation activities is particularly useful as environmental patents can be identified according to their technological features. We follow the taxonomy of IPC and CPC classes in environment-related technology fields developed by the OECD (ENV-TECH Indicator, see Haščič and Migotto, 2015).[7] Out of the 37,905 triadic patent families in our sample, 7.49 percent (2839) refer to environmental technologies, that is a larger share than the world average for the same years (about 5.8 percent).

As a proxy for the stringency of environmental regulation in host countries we use the Environmental Policy Stringency index (EPS) calculated by the OECD (see Botta and Kozluk, 2014). The EPS is a measure that ranges from 0 (not stringent) to 6 (highest stringency) that is comparable across countries. The data refer to 28 OECD countries and 6 BRIICS countries and combines information about 14 different environmental policy tools. The time coverage of the indicator is 1990-2015. The criterion to evaluate the stringency is the degree to which environmental policies put an explicit or implicit price on polluting or environmentally harmful behaviour. An important limitation of this indicator is that the information is available for a small number of high-income and emerging countries, while no information is available for least developed countries. It should be noted, however, that the countries for which we have information about EPS are responsible for the great majority of offshored patents (defined below) of top R&D performers (95.7 percent of total offshored patents, 96.1 percent of environmental offshored patents).

3.1 Definition of 'offshored patents'

Patent data contain detailed information about the residence of applicants and inventors. The COR&DIP database assigns patents to the ultimate owner (i.e. head of the group) of the applicant. This means that each patent in our sample is either owned by the company listed in the R&D scoreboard or by one if its subsidiaries. By looking at the nationality of applicants and/or inventors we can infer whether the patent is ‘offshored’ or not, that is whether or not inventive activities are carried out abroad.[8] Cantwell and Vertova (2004)

[7] The ENV-TECH Indicator refers to the following environment-related technologies: environmental management (air and water pollution abatement, waste management, soil remediation, environmental monitoring), climate change mitigation technologies (renewable energy generation, energy generation from non-fossil fuels, combustion technologies with mitigation potential, nuclear energy, efficiency in electrical power generation, transmission and distribution, enabling technologies in energy sector, other energy conversion or management systems reducing greenhouse gas emissions), capture, storage, sequestration or disposal of greenhouse gases, climate change mitigation technologies related to transportation (road transport, rail transport, air transport, maritime or waterways transport, enabling technologies in transport), climate change mitigation technologies related to buildings.

[8] Offshoring of innovation is broadly defined as a firm’s allocation of inventive and/or R&D activities to another country (Castellani et al 2015). Offshoring within the boundaries of multinational enterprises (MNEs) is also referred to as offshore in-house sourcing (OECD 2006) or captive offshoring (Kedia and Mukherjee 2008). Strictly speaking, offshoring implies a total or partial closure of activities at home and their transfer to new or existing foreign affiliates. However, it is widely accepted that offshoring may also include all greenfield and brownfield foreign direct investment (FDI), no matter whether they substitute for activities at home. Offshoring is normally distinguished from international outsourcing which involves independent companies,

employ the country of residence of the first inventor to identify the location of research and invention of patents at the USPTO. Similarly, Dernis et al (2015) suggest comparing the country of residence of the inventor and the country of the headquarter to identify the reliance on 'international' knowledge. It should be noted, however, that the nationality of inventors and applicants is not enough to be sure that the patent was actually 'created' abroad. In Table 1 we summarize the various different cases that may arise.

[Table 1 about here]

For the purpose of this paper, we identify as ‘offshored patents’ the ones belonging to categories 2, 3 and 4 as defined in Table 1. These patents represent, together, 36 percent of triadic patent families in all technological fields of top R&D performers. A large share of these ‘offshored’ patents belongs to category 2 (about 56% of offshored patents, and 20% of total patents recorded), for which there is no doubt about the offshoring status. In fact, this subsample includes patents whose inventors and applicants are resident in countries that differ from the home base of the multinational group they belong to. A tiny share (2 percent of total patents, 6% of offshored patents) belongs to category 3 and 14 percent (39 percent of our sample of ‘offshored’ patents) belong to category 4. Category 3 (all applicants and some of the inventors have the same nationality as the headquarters) and category 4 (some of the applicants and of the inventors have the same nationality of headquarters) may also include co-patenting (as a result of R&D collaboration) between independent companies located in different countries, hence identifying cases that should rather be classified as “outsourcing” rather than “offshoring” (hypotheses D and F), together with 'true' offshored patents which measure the cross-border inventive activities occurring within the boundaries of a MNEs (hypotheses C and E). As we have no explicit information about ownership links between applicants reported in the TPF-OECD database, we cannot distinguish between hypotheses C and D and between hypotheses E and F. This means that categories 3 and 4 may include some patents that are not truly offshored, although they do signal to some extent the internationalisation of inventive activities. We shall run regressions using both the broader and less precise definition of offshored patents which encompasses categories 2, 3 and 4; and the narrower but more precise definition, that identifies offshored patents with category 2 only.

4 Descriptive evidence

Table 2 reports the count of patents offshored (total and environmental) broken down by host country, using the broader definition of offshoring (including categories 2, 3 and 4 described in the previous section).[9] Few countries host the bulk of offshored patents: more than half have as host countries the US, Germany or Japan (55 percent). A similar concentration (57 percent) is found for environmental patents. Overall, the share of offshored environmental patents over the total number of offshored patents is 9 percent, with some important heterogeneity across different host countries. Among the top 20 host countries, Russia is the country hosting the lowest share of environmental patents (3.2 percent) while Spain is the country with the largest share (16.5 percent).

[Table 2 about here]

[9] Descriptive evidence about top companies in terms of offshoring of environmental technologies is reported in Tables A1 and A2 in Annex A.

We now evaluate some descriptive evidence about the aggregate relationship between the 'environmental orientation' of offshored innovation activities and the characteristics of the host country. More specifically, we focus on environmental policy stringency, specialization of the host country in environmental technologies and distance between home and host country.

Figure 1 describes the relationship between the share of environmental patents offshored to the host country over the total number of patents offshored in that country and, respectively, OECD EPS index with reference to 2005-2012 (left panel) and GDP in Purchasing Parity Standard (PPS) per capita (source: World Bank) as a proxy of wealth in the host country per capita (right panel).

[Figure 1 and Table 3 about here]

The figure suggests a positive and strong relationship between the importance of environmental patents over offshored patents both environmental regulatory stringency and GDP per capita. Both these two dimensions, together with many other unobserved factors, are expected to influence the choice to locate innovation activities (or, more specifically, environment-related innovation activities). However, EPS is strongly correlated with GDP per capita as well as with other important structural features of the host countries (Table 3). This means that to identify the role played by environmental regulatory stringency these and other factors need to be accounted for. All these factors may be related both to environmental regulatory stringency and the choice of locating environment-related innovation in a certain country. An example could be the case of countries in which consumers care a lot about the environment and are willing to pay a price premium for environmentally-friendly products. Global firms will have the incentive to locate green innovation activities close enough to these consumers. At the same time, these consumers will also lobby their government to introduce stringent environmental policies. This observation calls for the need to account for the possible endogeneity that derives from the failure to account properly for all possible confounding factors (see Section 5).

When considering the role played by geographical distance, we first notice some difference in the 'average distance' of offshored patents when considering all patents or when focusing on environmental patents. For the former category, the average distance of offshoring is 7899 kilometres, while for offshored environmental patents the average distance is 8051 (1.9 percent higher). As expected, the probability of observing at least one offshoring of innovation (total and environmental) between the home country of company *i* and the host country *j* is a decreasing function of the geographical distance between home and host country (top panel of Figure 2). A less obvious outcome of this descriptive evidence is that firms appear to carry out their cross-border inventive activities farther away in the case of environmental technology than in the case of other technologies. Or, to put it differently, geographic distance is less of a hindering factor in the former case than in the latter. This result might have to do with the fact that many green technologies have applications in a large number of industrial contexts, thus inducing firms to locate R&D facilities in remote markets to exploit their technologies and to explore technological opportunities. On the other hand, institutional distance (proxied by differences in religion between home and host countries) appears to have a nonlinear relation with the probability of innovation offshoring. This is consistent with findings in other studies showing that some degree of institutional diversity does stimulate innovation, but it is generally institutional similarity that favours communication and knowledge sharing in most technological fields (Castellani et al., 2013), and in the case of environmental technologies in particular (Aguilera-Caracuel et al., 2012).

[Figure 2 about here]

5 Drivers of innovation offshoring

The aim of our analysis is to evaluate the drivers of innovation offshoring in the field of environmental technologies, with a specific focus on the role played by environmental regulations. We estimate the following equation on all possible combinations of companies *i* and host country *h*:

$$EnvPat_{ih} = \phi EPS_h^{2005-2012} + X_i'\beta + Y_h'\delta + Z_{ih}'\theta + \varepsilon_{ih} \quad (1)$$

where $EnvPat_{ih}$ is the count of triadic patent families in environmental technologies developed in host country *h* and assigned to company *i*, $EPS_h^{2005-2012}$ is our variable of interest, that is the average stringency of environmental regulation in the host country *h* for the period 2005-2012. By also considering years 2005-2009, prior to the period of observation of our dependent variable (2010-2012), we aim at considering lags in the decision to locate R&D activities in response to changing regulations.[10] X_i is a vector of company-specific characteristics, Y_h is a vector of host county specificities and the vector Z_{ih} refers to variables that are specific to the company – host country pair. We estimate equation (1) on the sample of companies that applied for at least one triadic patent in the years 2010-2012 (either at home or abroad).[11]

[Table 4 about here]

Variables and data sources are described in detail in Table 4. Company-level variable include a series of dummies for the location of the multinational (6 world regions), a dummy for companies in the manufacturing sector, company size (logarithm of number of employees in 2010), R&D intensity (logarithm of the ratio between R&D and net sales in 2010) and a dummy variable for having applied for at least one *environmental* triadic patent in 2010-2012 at home to account for the technological specialization of the company.

We consider geographical and cultural differences between the home and potential host country by means of a gravity-like approach.[12] To this purpose, we include the logarithm of distance (in kilometres) between the home and host country, a dummy variable for

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[10] As a robustness check we show that results remain consistent when considering different timing of the environmental policy stringency indicator.

[11] As a robustness check, we also select only those firms that offshored at least one patent, finding very similar results.

[12] The gravity model approach to evaluate the role of environmental policies has generally focused on trade flows rather than on foreign direct investments or innovation offshoring. See, for example, Harris et al (2002), Jug and Mirza (2005) and Costantini and Mazzanti (2012). For more general applications of gravity models to FDI location decisions, including R&D FDIs and innovation offshoring, see Kleinert and Toubal (2010), Dachs and Pyka (2010), Picci (2010) and Castellani et al. (2013).

contiguous home and host countries, a dummy variable for commonality of languages between home and host country, a dummy variable to identify common legal origins and a continuous variable for the similarity in religion between home and host country. All these variables were retrieved from the CEPII Database (http://www.cepii.fr).

Finally, to control for the characteristics of the host country that may be correlated at the same time with environmental policies and the attractiveness (or absence thereof) of the host country for innovation activities. First, we account for the market size and, more generally, the economic conditions of the host country by including the logarithm of total GDP (2005), the logarithm of GDP per capita in PPS in 1995 and the growth rate of GDP per capita in PPS between 1995-2010, all retrieved from the World Development Indicators, World Bank. To account for the possible incentive to localize innovation activities in countries that are specialized in environmental technologies (i.e. asset seeking strategy), we control for specialization of the host country in environmental technologies with the share of environmental patents over total patents (in stock, year 2005) in the host country.

Finally, to account for other unobserved factor that induce a company to locate its innovation activities in country h, we add as a covariate a dummy variable that equals 1 if company i offshored non-environmental patents in country h during the same period. This variable is aimed at providing a synthetic indicator of the unobserved components that induce (or not) company i to locate innovation activities in country h. This variable has the advantage of providing a flexible indirect measure of the likelihood that a company i offshores some kind of innovation activity in country h.

As highlighted above, even accounting for many different control variables may not be enough to identify the impact of environmental regulation. For this reason, we also take an instrumental variable (IV) approach to reduce the endogeneity concerns. Our instrument is the air concentration of particulate matter smaller than 2.5 micron (PM 2.5) in 1995 (data from the World Bank Development Indicators). This is a local pollutant that has negative consequences on people's health. Concentration depends both on local air emissions and geographical characteristics such as, for example, winds. No matter the awareness about environmental quality and the preference for green products, people located in historically heavily polluted areas will lobby their politicians to introduce pollution control measures. If this is the case, the instrument will be positive correlated with the local environmental regulatory stringency but not on the local demand for green products.

In our analysis, we consider both the extensive margin and the intensive margin of innovation offshoring. To evaluate the extensive margin, that is the probability that company i offshores innovation activities in country h, we estimate equation (1) with a probit model, where $EnvPat_{ih}$ equals one when company i has offshored at least one environmental patent in country h. To evaluate the intensive margin, that is the intensity of the innovation offshoring, we consider the count of offshored patent applications of company i. In this case, we estimate equation (1) with a Poisson model to account for the non-negative and count nature of our dependent variable.[13]

[13] When accounting for endogeneity we employ for the extensive and intensive margins, respectively, the maximum likelihood estimator for the probit model with endogenous covariates and the GMM Poisson estimator.

[Table 5 about here]

Baseline estimates are reported in Table 5. In a first specification (columns 1 and 2) the only variable specific to the host country is our measure of environmental regulatory stringency. Environmental regulatory stringency is positive and significant both for the probability of doing environmental patents abroad and for the count of environmental patents abroad. More specifically, one interquartile range of EPS implies a higher probability of doing environmental patents by 0.17 percent (that is an 8.8 percent increase in the average probability) and the count of environmental patents abroad of 39.9 percent. For what concerns other variables, we observe that having offshored at least one non-environmental patent in country *h* is, as expected, a strong predictor of the offshoring of environmental patents. Moreover, doing environmental patents abroad is positively (and significantly) correlated with the size of the company and its R&D intensity. Surprisingly, geographical distance has a positive and significant impact on the offshoring of environmental patents. Even though the existing literature on R&D offshoring emphasizes the relatively small relevance of geographical distance (e.g. Castellani et al, 2013), a positive correlation may hide the fact that some important 'distant' country attracts R&D offshoring for other important (and unaccounted for in this specification) features.

In a second specification (columns 3 and 4) we include all our set of control variables for country *h* but remove the variable that identifies non-green patents offshored in the host country. The 'economic' size of the destination country (GDP) exerts a positive and statistically significant influence on the offshoring of environmental innovation activities. Average wealth in the host country (GDP per capita in Purchasing Power Parity terms) is positive and significant for the extensive margin only while economic growth only influences (positively) the extensive margin. When controlling for host country's characteristics, we observe that the sign of geographical distance turns out to be negative and significant, in line with expectations, as of standard gravity models, while also other measures of geographical and cultural distance play some more relevant role. The estimated impact of environmental policy stringency in the host country on the probability and count of environmental patents abroad is, again, positive and significant but larger in magnitude. One interquartile range of EPS implies a higher probability of doing environmental patents by 0.26 percent (that is a 14.3 percent increase in the average probability) and the count of environmental patents abroad of 14.2 percent.

In column 5 and 6 we use the specification of columns 1 and 2 (that represents the lower bound estimate of the impact of environmental regulation) and instrument environmental regulatory stringency with the concentration of PM 2.5 in year 1995. The instrument is, as expected, positively and strongly correlated with the endogenous variable in the first stage. Results suggest that failing to account for the endogeneity of environmental regulation may lead to a downward bias in the estimated effects, especially so for what concerns the intensive margin. One interquartile range of EPS implies a higher probability of doing environmental patents by 0.31 percent (that is a 17.2 percent increase in the average probability) and the count of environmental patents abroad of 133 percent.

Finally, in column 7 and 8 we include both host-country specific variable and the variable that accounts for the offshoring of non-green innovations in host country *h*. Results suggest again a positive effect of environmental regulatory stringency in the host country. The magnitude of these effect is similar (in terms of marginal effects) to our IV estimates for what concerns the extensive margin but relatively smaller than the IV estimates when considering the intensive margin. One interquartile range of EPS implies a higher probability of doing environmental patents by 0.14 percent (that is a 7.2 percent increase in the average probability) and the count of environmental patents abroad of 22.6 percent. This will be our favourite specification as it represents a lower bound of our estimated effect.

All these results are quite consistent with expectations. Top R&D performers decide to locate (at least part of) their environment-related innovation activities close to the location where these technologies could be deployed profitably due to tight environmental regulations. This means that innovation offshoring is one important channel through which companies react to foreign environmental regulations. The choice to locate in proximity to the regulated possible customers (of the technology) can be motivated inter alia by two sets of reasons. On the one hand, cross-border inventive activities are a direct response to pressures from local authorities imposing stricter environmental regulation; on the other hand, they reflect a more indirect effect though local customers (i.e. regulated companies) who demand for technological solutions in line with the specificities of the 'local' regulation.

[Table 6 about here]

In Table 6 we perform a series of robustness checks. In columns 1 and 2 we keep only those companies that offshored at least one patent (either environmental or non-environmental) in at least one foreign country. This reduces the heterogeneity across companies to the ones that already self-select into innovation offshoring. Results are very similar in magnitude and statistical significance to the ones in columns 7 and 8 of Table 5. In column 3, 4 and 5 of Table 6 we repeat our estimation on the intensive margin by means of three different estimators. The negative binomial estimator (column 3) accounts for the possibility of overdispersion, i.e. a variance greater than the mean. In case of overdispersion, the poisson regression remains consistent but standard errors turn out to be biased. The zero inflated poisson estimator (column 4) accounts for the presence of excess of zeros. Finally, the zero-inflated negative binomial estimator (column 5) accounts for both excess zeros and overdispersion. All results tend to confirm our baseline estimates in terms of magnitude and statistical significance.

[Table 7 about here]

Another reason of concern about our baseline estimates may refer to the timing of environmental policy that is relevant to motivate a company to locate its environment-related innovation activities in a specific country. On the one hand, companies may want to serve the market for technologies in the host country to comply with existing and 'stable' regulations. On the other hand, companies also consider the current regulatory framework as well as expected and forecasted changes in regulations. In our baseline estimate we consider average EPS between 2005 and 2012, thus accounting both for stable policies in force since many years and for newly adopted policy tools that are contemporary to the patent application. As we cannot exploit the panel dimension of our patent data in any meaningful way (given the short time span of detailed patent data presently available), we evaluate the robustness of our results to different possible lag structure between environmental policy stringency and patent offshoring decisions. The correlation matrix across countries of our EPS indicator measured in different time frames (and thus the persistence) is overall very large, ranging from a minimum of 0.6065 (EPS

1995 2012 vs EPS 2000-2012) to a maximum of 0.9867 (EPS 1995-2000 vs EPS 2010-2012). Results for the different lags are reported in Table 7. Column 4 is our favourite estimate wherein EPS index is introduced with reference to the standard time span (2005-2012). Overall, results are confirmed in sign, significance and magnitude across all different lags of EPS. Interestingly, the magnitude of the estimated coefficient is largest when considering the whole period 1995-2012.

[Table 8 about here]

Finally, we unpack the EPS indicator into its various components. Environmental regulation refers to a large variety of environmental domains and adopts many different approaches. There exists an extensive literature that evaluates the induced innovation effect of different environmental policy design (refer to Requate and Unold, 2003, Requate, 2005 and Jaffe et al, 2002 for reviews). Two broad categories of policies are usually identified: market-based and non-market based instruments. More specifically, non-market based instruments often focus on the requirement to adopt a specific technology (e.g. the catalytic converter), thus stimulating the diffusion of a more environmental efficient technology (that is enforced by law) but limiting freedom to explore different and unknown (innovative) technological solutions to the environmental problem. Market-based instruments, on the other hand, do not mandate the use of specific technologies leaving the choice of the most efficient one to regulated entities and reward over-compliance. Moreover, specific measures are directed at stimulating innovation activities for the development of green technologies by means of R&D subsidies. In column 1 of Table 8 we include three distinct measures for market-based measures (environmental taxes, trading schemes, feed-in tariffs), non-market based instruments (standards and emission limits, often defined command-and-control) and R&D subsidies. All the three measures contribute positively to the location choice of offshored patents even though none of the coefficients turn out to be statistically different from zero. In columns 2 to 4 we include each measure separately to gain some understanding about the relative importance of each dimension of environmental regulation. Contrary to expectations, market-based measures exert no significant effect on green innovation offshoring, while both non-market based instruments and R&D subsidies significantly influence green innovation offshoring. While the result for environment-related R&D subsidies was expected, as they contribute to cover the upfront cost of innovating in the host country, the prevalence of non-market based over market based policies deserves more attention. A possible explanation is that market based instruments may be induce (even substantial) efficiency improvements within existing mature technological domains that do not require specialized foreign knowledge. On the contrary, environmental standard (non-market based measures) introduced in laggard countries may induce global firms to adapt to the local standard their environmental technologies that were developed to deal with similar standards in early mover countries.

6 Conclusions

This paper evaluates the role of host-country environmental policy stringency on the decision of top R&D performers to locate their environmental innovation activities. Results based on triadic patent families suggest that top R&D performers are more likely to offshore environment-related innovation activities in host countries characterized by stringent environmental policies. This reflects the multinational nature of most of these large R&D performers, which are exposed to multiple institutional settings and pressures, stimulating them to develop green innovation. Non-market based regulatory measures and R&D subsidies appear to have a remarkable impact in this respect, whereas market based types of measures do not seem to have any significant effect. Results are robust to different specifications of the econometric model and to different assumptions about the lag structure between environmental policy and innovation. Our results shed a new light both on the impact of environmental regulation in affecting inventive activities of large firms; and on the specific role played by MNEs as key actors absorbing stimuli to innovate from a variety of national (and regional) contexts.

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Tables and figures

Table 1 – Identification of offshored patents

<table>
<tr><th>Information in the patent database</th><th>Description</th><th>Status</th></tr>
<tr><td>1. All applicants and inventors have the same nationality of the group headquarters (64 percent of patents)</td><td>A. The patent is not offshored</td><td>Not offshoring</td></tr>
<tr><td>2. None of the applicants have the same nationality of the group headquarters (20 percent of patents)</td><td>B. The patent is offshored</td><td>Offshoring</td></tr>
<tr><td rowspan="2">3. All applicants have the same nationality of the group headquarters and none of the inventors have the same nationality of the group headquarters (2 percent of patents)</td><td>C. The innovation is developed by a subsidiary abroad but for reasons internal to the company the application is done by the group headquarters</td><td>Offshoring</td></tr>
<tr><td>D. The innovation is developed in the country of the group headquarters by a team of inventors that reside in different countries</td><td>Not offshoring</td></tr>
<tr><td rowspan="2">4. Some of the applicants and of the inventors are not of the same nationality of the group headquarters (14 percent of patents)</td><td>E. The innovation is the result of a collaboration between the group headquarters and a foreign company that belongs to the same group</td><td>Offshoring</td></tr>
<tr><td>F. The innovation is the result of a collaboration between the group headquarters and a foreign company that does not belong to the same group</td><td>Not offshoring (outsourcing)</td></tr>
</table>

Table 2 – Patents by host country

Host country	Patents received as host (total)	Patents received as host (environmental)	Share of hosted env patents of total hosted patents
US	5,293	518	0.0979
DE	2,095	183	0.0874
JP	1,237	111	0.0897
UK	1,205	128	0.1062
FR	806	92	0.1141
CN	783	48	0.0613
KR	643	44	0.0684
CH	523	58	0.1109
CA	490	28	0.0571
BE	391	41	0.1049
IN	357	22	0.0616
NL	345	23	0.0667
IT	315	35	0.1111
SE	267	20	0.0749
AT	226	25	0.1106
AU	131	6	0.0458
FI	89	9	0.1011
DK	88	9	0.1023
ES	85	14	0.1647
RU	63	2	0.0317
IE	62	4	0.0645
BR	55	1	0.0182
NO	49	8	0.1633
PL	31	3	0.0968
HU	25	1	0.0400
CZ	17	2	0.1176
TR	15	0	0.0000
ZA	13	0	0.0000
SK	7	2	0.2857
PT	5	0	0.0000
GR	4	0	0.0000
SI	4	0	0.0000
ID	3	0	0.0000
Total	15,722	1,437	0.0914

Figure 1 – Relationships between host-country features and share of (hosted) environmental patents over total (hosted) patents - countries that host 50 or more patents

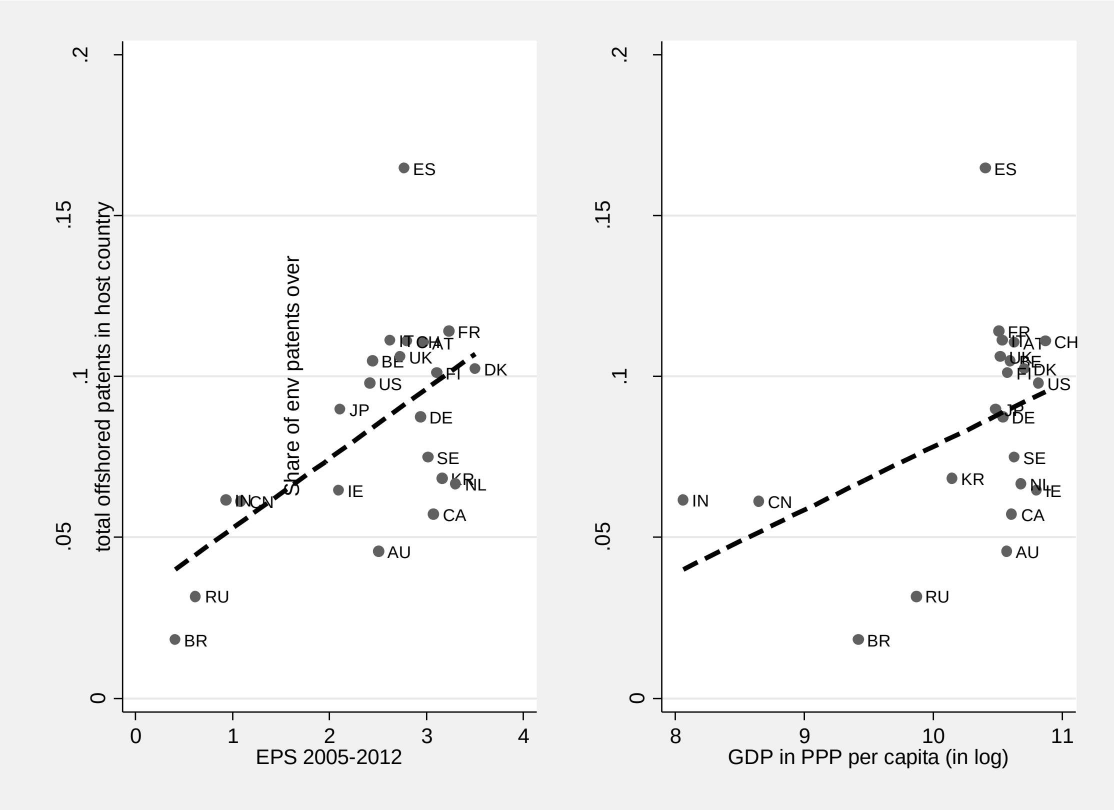

Table 3 – Correlation between country-level features

	EPS 2005-2012	Total GDP (in log, 2005)	GDP in PPS per capita (in log, 1995)	Growth in GDP per capita PPS (1995-2010)	Share of environmental patents in total patent stock
EPS 2005-2012	1				
Total GDP (in log, 2005)	-0.297	1			
GDP in PPS per capita (in log, 1995)	0.7492	-0.3145	1		
Growth in GDP per capita PPS (1995-2010)	-0.426	0.1972	-0.7685	1	
Share of environmental patents in total patent stock	-0.3922	0.0637	-0.3199	0.0032	1

Figure 2 – Relationship between log(distance) and similarity of religion and the probability of hosting patents

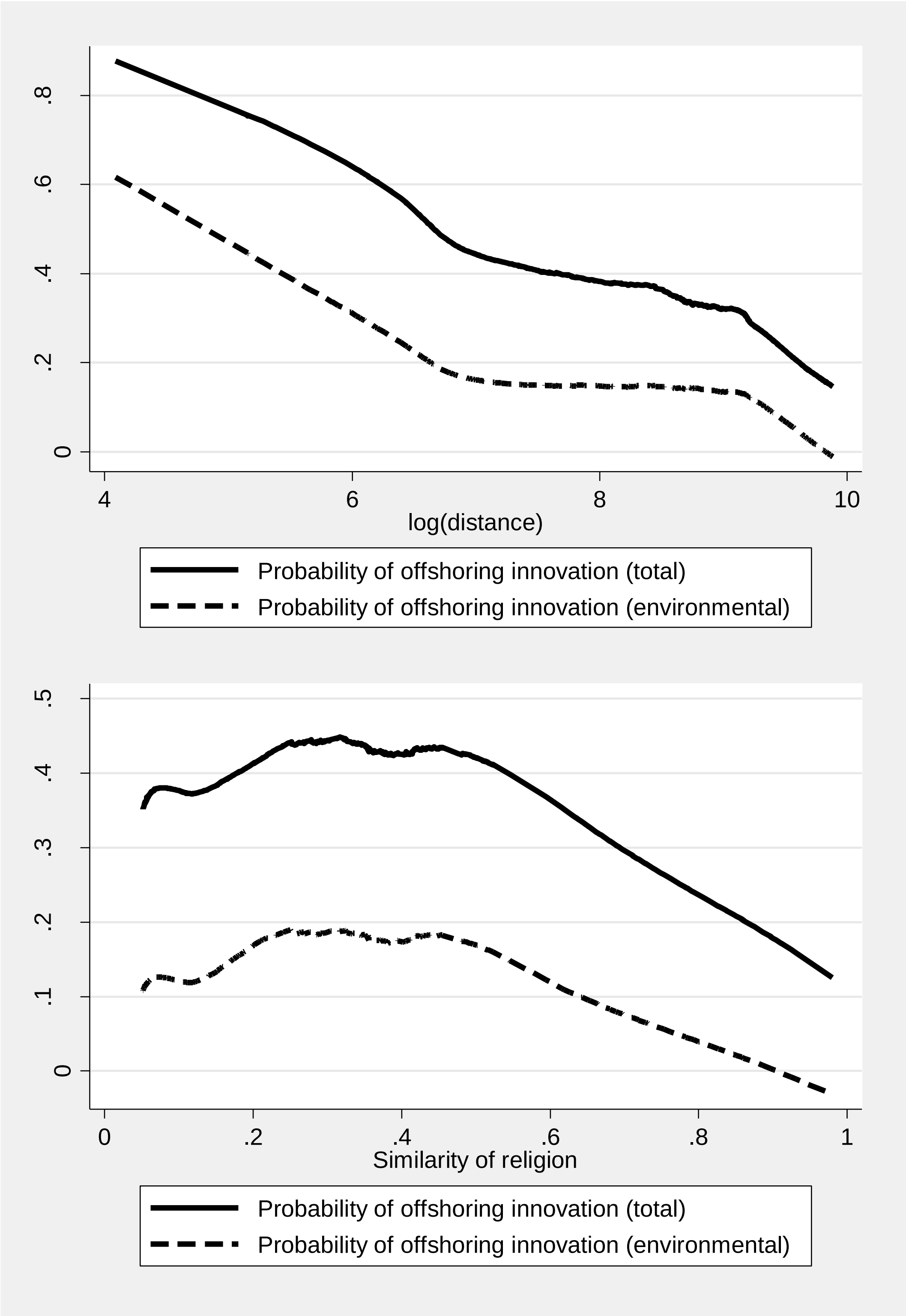

Table 4 – Definition and sources of variables

Variable name	Description	Source
Environmental patents in country *h*	Number of environmental patents of firm *i* offshored in country *h*	COR-DIP database (OECD) and TPF database (OECD)
log(distance)	Distance (in logarithm) between the country in which the headquarter of firm *i* is located and country *h*	GeoDist, CEPII
Contiguity	The country in which the headquarter of firm *i* is located is contiguous to country *h*	GeoDist, CEPII
Common language	The country in which the headquarter of firm *i* has the same language of country *h*	GeoDist, CEPII
Colonial ties	The country in which the headquarter of firm *i* is located is had a colonial tie with country *h*	GeoDist, CEPII
Common religion	The country in which the headquarter of firm *i* has the same religion of country *h*	GeoDist, CEPII
Common legal origins	The country in which the headquarter of firm *i* has the same legal origin of country *h*	GeoDist, CEPII
log(R&D/sales)	R&D expenditure intensity of sale (year 2010, in logarithm)	R&D Scoreboard
log(employment)	Total employment (year 2010, in logarithm)	R&D Scoreboard
Green patents at home (dummy)	Firm *i* applied for at least 1 environmental patent in the home country	COR-DIP database (OECD), TPF database (OECD)
EPS 2005-2012 at home	Environmental Policy Stringency index (average 2005-2012) in the home country	EPS-OECD
Non-green patents in country *h* (dummy)	Firm *i* offshored at least one non-environmental patent in country *h*	COR-DIP database (OECD), TPF database (OECD)
EPS 2005-2012 in country *h*	Environmental Policy Stringency index (average 2005-2012) in the host country	EPS-OECD
log(GDP in country *h*)	GDP level in the host country (2005, in logarithm)	World Bank Development Indicators
log(GDP per capita in PPP in country *h*)	GDP per capita in purchasing power parity in the host country (2005, in logarithm)	World Bank Development Indicators
Growth in GDP per capita PPS (1995-2010)	Growth 1995-2010 of GDP per capita in purchasing power parity in the host country	World Bank Development Indicators
Share of environmental patents in total patent stock in country *h*	Ratio between environmental and total patent stock in 2005. The patent stock has been computed with the perpetual inventory method, with 20 percent depreciation rate. Triadic patents, sorted by priority date, were assigned to the inventor's country of residence.	TPF database (OECD)

Table 5 – Determinants of offshored environmental patents – Baseline estimates

Dep var: Environmental patents in country *h*	(1) Probability	(2) Count	(3) Probability	(4) Count	(5) Probability	(6) Count	(7) Probability	(8) Count
EPS 2005-2012 in country *h*	0.200***	0.168***	0.229***	0.472***	0.224***	0.603***	0.188***	0.267**
	(0.0276)	(0.0517)	(0.0414)	(0.129)	(0.0701)	(0.177)	(0.0436)	(0.130)
Non-green patents in country *h*	1.160***	3.107***			1.152***	3.005***	0.782***	1.971***
(dummy)	(0.0443)	(0.131)			(0.0464)	(0.131)	(0.0497)	(0.138)
Company in manufacturing sector	0.169**	0.831***	0.281***	0.968***	0.170**	0.843***	0.215***	0.820***
	(0.0788)	(0.204)	(0.0820)	(0.207)	(0.0787)	(0.203)	(0.0826)	(0.202)
log(distance)	0.104***	0.407***	-0.0820**	-0.267***	0.110***	0.464***	-0.0490	-0.170**
	(0.0347)	(0.0824)	(0.0333)	(0.0835)	(0.0386)	(0.0903)	(0.0351)	(0.0851)
Contiguity	0.251**	0.886***	0.0318	0.212	0.252**	0.829**	0.0533	0.333
	(0.104)	(0.328)	(0.101)	(0.325)	(0.104)	(0.330)	(0.106)	(0.320)
Common language	0.209**	0.430*	0.254***	0.596**	0.213**	0.494*	0.216**	0.449*
	(0.0865)	(0.255)	(0.0867)	(0.286)	(0.0870)	(0.256)	(0.0898)	(0.272)
Colonial ties	0.205**	0.252	-0.0914	-0.466*	0.196**	0.130	-0.0909	-0.485**
	(0.0805)	(0.224)	(0.0781)	(0.244)	(0.0832)	(0.226)	(0.0836)	(0.241)
Common religion	-0.654***	0.445	-0.509**	-0.161	-0.691***	-0.0192	-0.517**	0.156
	(0.189)	(0.683)	(0.199)	(0.800)	(0.199)	(0.802)	(0.203)	(0.828)
Common legal origins	0.00420	-0.0999	0.170***	0.431***	0.00547	-0.0699	0.129**	0.332**
	(0.0504)	(0.132)	(0.0561)	(0.155)	(0.0505)	(0.135)	(0.0570)	(0.149)
log(R&D/sales)	0.0820***	0.297***	0.153***	0.413***	0.0823***	0.292***	0.115***	0.350***
	(0.0202)	(0.0620)	(0.0193)	(0.0519)	(0.0202)	(0.0631)	(0.0206)	(0.0569)
log(employment)	0.110***	0.291***	0.238***	0.586***	0.111***	0.295***	0.162***	0.415***
	(0.0149)	(0.0407)	(0.0155)	(0.0347)	(0.0148)	(0.0411)	(0.0162)	(0.0374)
Green patents at home (dummy)	0.670***	1.083***	0.817***	1.428***	0.671***	1.077***	0.764***	1.222***
	(0.0439)	(0.162)	(0.0454)	(0.150)	(0.0439)	(0.162)	(0.0476)	(0.148)
log(GDP in country *h*)			0.471***	1.161***			0.346***	0.839***
			(0.0198)	(0.0601)			(0.0210)	(0.0582)
log(GDP pc in PPS in country *h*)			0.509***	1.014***			0.385***	0.780**
[year 1995]			(0.112)	(0.338)			(0.106)	(0.312)
Growth rate of GDP pc in PPS			0.496**	0.643			0.418*	0.562
[1995-2010]			(0.231)	(0.693)			(0.223)	(0.656)
Share of environmental patents in			-1.008*	-2.604			-1.033*	-4.277
total patent stock in country *h [2005]*			(0.550)	(2.035)			(0.589)	(2.672)
Estimator	Probit	Poisson	Probit	Poisson	IV-Probit	IV-Poisson	Probit	Poisson
N	32080	32080	32080	32080	32080	32080	32080	32080

Robust standard errors in parenthesis. * p<0.1, ** p<0.05, *** p<0.01. Other control variables: world region dummies for the company. Instrumental variable (columns 5 and 6): PM 2.5 concentration in the atmosphere in 1995. z-stat of excluded instrument in the first stage: -136.34.

Table 6 – Robustness checks: alternative samples and estimators

Dep var: environmental patents in country *h*	(1) Probability (companies with at least 1 offshored patent)	(2) Count (companies with at least 1 offshored patent)	(3) Count	(4) Count	(5) Count
EPS 2005-2012 in country *h*	0.193***	0.280**	0.401***	0.261**	0.382***
	(0.0441)	(0.130)	(0.120)	(0.125)	(0.112)
Non-green patents in country *h* (dummy)	0.701***	1.774***	1.980***	0.919***	1.057***
	(0.0505)	(0.135)	(0.128)	(0.276)	(0.256)
Company in manufacturing sector	0.203**	0.787***	0.638***	0.724***	0.684***
	(0.0840)	(0.202)	(0.209)	(0.203)	(0.224)
log(distance)	-0.0489	-0.167**	-0.124	-0.280*	0.0510
	(0.0354)	(0.0849)	(0.0926)	(0.151)	(0.278)
Contiguity	0.0656	0.346	0.0435	0.236	0.508
	(0.108)	(0.318)	(0.297)	(0.484)	(1.294)
Common language	0.212**	0.431	0.572***	0.373	0.380
	(0.0912)	(0.272)	(0.215)	(0.350)	(0.664)
Colonial ties	-0.0987	-0.486**	-0.250	-0.466	-0.286
	(0.0852)	(0.240)	(0.253)	(0.362)	(0.692)
Common religion	-0.499**	0.168	0.0241	2.425**	3.150***
	(0.207)	(0.826)	(0.699)	(0.989)	(0.998)
Common legal origins	0.139**	0.340**	0.413***	0.563***	0.661***
	(0.0578)	(0.149)	(0.152)	(0.174)	(0.219)
log(R&D/sales)	0.125***	0.370***	0.240***	0.165**	0.233***
	(0.0240)	(0.0647)	(0.0529)	(0.0645)	(0.0561)
log(employment)	0.138***	0.384***	0.386***	0.346***	0.389***
	(0.0170)	(0.0378)	(0.0369)	(0.0377)	(0.0349)
Green patents at home (dummy)	0.767***	1.218***	1.574***	0.931***	1.610***
	(0.0500)	(0.147)	(0.106)	(0.174)	(0.112)
log(GDP in country *h*)	0.361***	0.849***	0.828***	0.766***	0.838***
	(0.0217)	(0.0589)	(0.0489)	(0.0558)	(0.0469)
log(GDP pc in PPS in country *h*) *[year 1995]*	0.401***	0.780**	0.763***	0.585**	0.820***
	(0.108)	(0.312)	(0.249)	(0.256)	(0.247)
Growth rate of GDP pc in PPS *[1995-2010]*	0.431*	0.562	0.818	0.288	0.937*
	(0.226)	(0.655)	(0.563)	(0.608)	(0.552)
Share of environmental patents in total patent stock in country *h [2005]*	-1.042*	-4.221	-3.861**	-3.933**	-3.363**
	(0.588)	(2.604)	(1.804)	(1.856)	(1.531)
		Inflation			
Non-green patents in country *h* (dummy)				-1.466***	-2.328***
				(0.292)	(0.663)
log(distance)				-0.0656	0.404
				(0.149)	(0.703)
Contiguity				-0.279	0.506
				(0.420)	(2.452)
Common language				0.0887	-0.127
				(0.335)	(1.176)
Colonial ties				-0.0698	-0.104
				(0.376)	(1.475)
Common religion				3.661***	7.603***
				(0.728)	(1.436)
Common legal origins				0.258	0.572
				(0.205)	(0.411)
Alpha	-	-	4.732***	-	2.726***
Estimator	Probit	Poisson	Negative binomial	Zero inflated poisson	Zero inflated negative binomial
N	24197	24197	32080	32080	32080

Robust standard errors in parenthesis. * p<0.1, ** p<0.05, *** p<0.01. Other control variables: sector dummies.

Table 7 – Robustness checks: different timing of environmental regulatory stringency

Dep var: environmental patents in country *h*	(1)	(2)	(3)	(4)	(5)
EPS 1995-2005 in country h	0.454***				
	(0.161)				
EPS 1995-2012 in country h		0.559***			
		(0.194)			
EPS 2000-2012 in country h			0.449***		
			(0.171)		
EPS 2005-2012 in country h				0.267**	
				(0.130)	
EPS 2010-2012 in country h					0.308**
					(0.125)
N	31079	32080	32080	32080	32080

Poisson estimator. Robust standard errors in parenthesis. * p<0.1, ** p<0.05, *** p<0.01. Additional control variables: Non-green patents in country h (dummy), Company in manufacturing sector, log(distance), Contiguity, Common language, Colonial ties, Common religion, Common legal origins, log(R&D/sales), log(employment), Green patents at home (dummy), log(GDP in country h), log(GDP pc in PPS in country h) [year 1995], Growth rate of GDP pc in PPS [1995-2010], Share of environmental patents in total patent stock in country h [2005]

Table 8 – Robustness checks: different components of environmental regulatory stringency

Dep var: environmental patents in country *h*	(1)	(2)	(3)	(4)
Market-based EPS 2005-2012	0.120	0.121		
	(0.197)	(0.109)		
Non-market-based EPS 2005-2012	0.0565		0.277**	
	(0.271)		(0.122)	
R&D subsidies 2005-2012	0.188			0.203**
	(0.189)			(0.0896)
N	31079	32080	32080	32080

Poisson estimator. Robust standard errors in parenthesis. * p<0.1, ** p<0.05, *** p<0.01. Additional control variables: Non-green patents in country h (dummy), Company in manufacturing sector, log(distance), Contiguity, Common language, Colonial ties, Common religion, Common legal origins, log(R&D/sales), log(employment), Green patents at home (dummy), log(GDP in country h), log(GDP pc in PPS in country h) [year 1995], Growth rate of GDP pc in PPS [1995-2010], Share of environmental patents in total patent stock in country h [2005]

Appendix A – Top company in terms of environmental innovation offshoring

Table A1 – Top 10 companies in terms of offshoring of environmental patents

Company name	Country	NACE rev 2	R&D in 2010 (mln $)	Net sales (mln $)	Total offshored patents	Of which environmental patents
NOVARTIS	CH	2120	6422	38369	134	44
ROCHE	CH	2120	7483	39255	243	42
GENERAL ELECTRIC	US	2811	3131	112000	578	38
NITTO DENKO	JP	2059	192	5592	93	33
COVIDIEN	IE	3250	339	7904	254	33
SOLVAY	BE	2120	189	5959	135	32
PHILIPS	NL	2751	1697	22287	605	32
DENSO	JP	2932	2057	27422	104	32
WIPRO	IN	6209	23	4295	52	31
BASF	DE	2059	1507	63873	172	30

Table A2 – Top 10 companies in terms of share of environmental offshored patents over total offshored patents (with at least 10 offshored patents)

Company name	Country	NACE rev 2	R&D in 2010 (mln $)	Net sales (mln $)	Total offshored patents	Of which environmental patents	Share of offshored env patents over total offshored patents
VERTEX PHARMACEUTICALS	US	2120	409	109	10	8	0.800
KOITO MANUFACTURING	JP	2931	150	3757	12	9	0.750
ABBOTT LABORATORIES	US	2120	2823	26654	20	12	0.600
WIPRO	IN	6209	23	4295	52	31	0.596
PIRAMAL ENTERPRISES	IN	2120	10	225	14	8	0.571
SAMSUNG DISPLAY	KR	2611	664	15389	39	22	0.564
AISAN	JP	2932	64	1321	14	7	0.500
HENKEL	DE	2041	393	15092	56	28	0.500
TAKEDA PHARMACEUTICAL	JP	2120	2530	12430	25	12	0.480
GRUNENTHAL	DE	2042	207	881	13	6	0.462