ANALYSING FIRM-SPECIFIC AND TYPE-SPECIFIC DETERMINANTS OF ECO-INNOVATION

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Abstract. This paper analyses the main determinants influencing different types of eco-innovations and eco-innovators in Spain. We differentiate between two types of eco-innovations (process vs. product and new-to-the-market (NTM) vs. new-to-the-firm (NTF)) and two different types of eco-innovators (large vs. small and old vs. new firms). Our findings show that new firms are not more eco-innovative and that smaller firms are certainly less eco-innovative. Although the environmental regulation variable is generally a main driver of eco-innovation, there are specific drivers for some eco-innovator and eco-innovation types. This is the case with internal innovation capabilities, which clearly influence small and new firms to eco-innovate, in contrast to large and old firms. Those capabilities are also a driver of NTM eco-innovation versus NTF eco-innovation. Involvement in external knowledge flows and cooperation is also a crucial variable for small firms to eco-innovate and a main driver of NTM versus NTF eco-innovation. Contrary to expectations, there are a few differential drivers for products vs. process eco-innovations. Energy/material cost reductions and environmental regulation influence both eco-innovation types, whereas the demand-pull from the market is absent for both, probably due to a relatively low degree of environmental consciousness and/or willingness to pay for eco-products by its consumers.

Keywords: eco-innovators, determinants, probit model, environmental regulation, internal capabilities.

JEL Classification: O30, Q55.

Introduction

There is a widespread consensus that eco-innovation plays a key role in sustainability transitions. Eco-innovations are innovations with lower environmental impacts, whether the main motivation for their development or deployment is environmental or not (see Carrillo-Hermosilla *et al.* 2010). If eco-innovation is so relevant in this context, then a main issue

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is which are the main determinants (drivers and barriers) for those firms either developing or adopting them (i.e., "eco-innovators") and whether public policy is necessary in order to activate those determinants or remove the barriers.

The literature on firm-level determinants to eco-innovation is abundant (see 1.1). The empirical studies have shown that, when taking the decision to eco-innovate, firms are influenced by a wide array of internal and external factors to the firm, as well as by the characteristics of those eco-innovations (del Río 2009). However, what is missing in the literature is an analysis of how the relevance of those determinants differs for distinct types of eco-innovators and eco-innovations. It is highly likely that the same determinant does not have the same influence on firms with different characteristics (for example, small vs. large eco-innovators). Likewise, drivers might differ for types of different eco-innovations (for example, for process vs. product eco-innovations). If this is so, and policy-makers want to support one specific type of eco-innovation/eco-innovator, then an analysis of those differential determinants is policy-relevant. While the literature on firm-level determinants is wide, the literature on the determinants for different types of eco-innovators and eco-innovations is not, with the possible exception of process vs. product eco-innovations. This paper tries to close this gap.

Therefore, the aim of this paper is to analyse the main determinants influencing eco-innovators in Spain with respect to general innovators with the help of econometric techniques, considering different types of eco-innovations and eco-innovators. In addition, our paper contributes to the literature in other directions. A relatively recent but abundant literature has analysed the determinants to eco-innovations, although generally not in a Southern European context. Furthermore, the analysis of drivers of eco-innovation compared to general innovation has been neglected in the literature, with some exceptions (see 1.1).

Accordingly, the paper is structured as follows. The next section provides a literature review and puts forward the hypotheses. Section 2 describes the data and methods and discusses the main results. The last section concludes.

1. Theoretical framework and research hypotheses

1.1. Links to the existing literature on the determinants to eco-innovation

The literature on the drivers to eco-innovation can be classified in two main groups, i.e., the literature on the general determinants to eco-innovation, which is relatively abundant (Table 1), and the very recent literature on the specific determinants to eco-innovation versus those of general innovation, which is not (Table 2). Many drivers to innovation in general (i.e., for normal innovation) are likely to be shared by eco-innovation. Therefore, policies supporting innovation in general would also lead to eco-innovation. However, eco-innovation has distinctive (additional) features, which are mostly related to the double externality problem and the more relevant role of public policies acting as a main driver[1]. Therefore, policy makers willing to specifically promote eco-innovation should take these differential drivers into account.

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[1] Eco-innovations are generally subject to a double externality (Rennings 2000). In addition to the negative externality of pollution, which leads to an under-provision of eco-innovations, i.e., below the social optimum level, technological change has public good features which discourage their development and deployment. These result from the spillovers in the innovation process, which facilitate imitation, in spite of patent protection (Rennings 2000).

Table 1. Drivers of eco-innovation with firm-level data

Main features		Demirel and Kesidou (2011)	Kesidou and Demirel (2012)	Kammerer (2009)	Mazzanti and Zoboli (2009)	Frondel et al. (2007) End-of-pipe	Frondel et al. (2007) Clean production	Rehfeld et al. (2007)	Rennings et al. (2006)	Wagner (2008)	Wagner (2007) Self-reported env. innov.	Wagner (2007) Env. patents
Explanatory variables	Significant variables	Regulation, Cost-savings, environmental management, productivity	Cost-savings, size, other organizational innovation (apart from EMS), abatement costs	Regulation, internal technological capabilities, size, demand-pull	Regulation, sectoral dummies, demand-pull, cooperation, organizational flatness, influence of trade unions	Regulation, sectoral dummies, environmental management, internal forces	Cost-savings, R&D, size, sectoral dummies, environmental management, internal forces	Regulation, R&D, size, demand-pull, environmental management, age	Regulation, size, demand-pull, environmental management, share of demand from final consumers, image, price as important performance factor	Sectoral dummies, cooperation, environmental management, other organizational innovation (apart from EMAS), environment as competitive factor	Size, sectoral dummies, environmental management, age; influence of trade unions, NGOs, stakeholders	Size, sectoral dummies; influence of trade unions, NGOs, stakeholders quality as management system / ISO9001
	Non-significant variables	Size, sectoral dummies, purchase equipment/ equipment upgrade, CSR	Demand-pull, purchase equipment/ equipment upgrade, CSR	R&D, sectoral dummies.	Subsidies, internal technological capability, size, other organizational innovation (apart from EMS)	Subsidies, cost-savings, R&D, size, competitive pressure from established firms; influence of trade unions, NGOs, stakeholders, image, financial situation	Regulation, subsidies, competitive pressure from established firms; influence of trade unions, NGOs, stakeholders; image, financial situation	Main market internat, environmental variables, quality as management system / ISO9001		Size, age, group (subsidiary), quality as management system / ISO9001	Group (subsidiary), quality as management system / ISO9001 (ISO 2008)	R&D, environmental management, age (subsidiary)
Econometric method (model)		Tobit	Heckman selection	Binary logit	Ordinary least squares (OLS)	Multinomial logit		Binary and multinomial logit	Binary probit	Multivariate probit and logit	Multivariate probit	Negative binomial model, binary probit
Geographical scope		U.K.	U.K.	Germany	Emilia Romagna (Italy)	Seven OECD countries (none South European)		Germany	Germany	Nine European States (none South European)	Germany	Germany
Dependent variable		Three binary dependent var.: investments in end-of-pipe (EOP) integrated cleaner production technologies and env. R&D	Binary. Env. R&D	Binary. Product eco-innovation	Environmental innovation output	Categorical: End-of-pipe, integrated, no new technology		Binary logit: dev. of env. product innovation Multinomial logit: env. product-innovation, env. process innovation, no env. innovation	Binary: Process and product eco-innovations	Binary: green design, implementation of cleaner technology	Binary: green design of a new product, implementation of cleaner technology	Binary probit: whether firms are patenting
Types of data		Survey Data. Government survey of environmental protection expenditure by industry	Survey data (online questionnaire)	Survey data (online questionnaire)	Survey data	Facility-level dataset derived from a cross-country OECD survey		Dataset collected by a telephone survey	Telephone survey data	Survey data	Survey data	
Sample size		289	1566	92	140	3699.		371	1277	849	152	248
Sample segmentation		EOP vs. cleaner technologies	---	Use of different subsamples (by env. impact)	---	---		Process vs. product	Process vs. product	Process vs. product	Process vs. product	---

End of Table 1

Main features		Veugelers (2012)	Ziegler and Rennings (2004)	Cleff and Rennings (1999)	Borghesi et al. (2012a)	Cainelli et al. (2012)	Borghesi et al. (2012b)	Triguero et al. (2013)	Inoue et al. (2013)	Cainelli and Mazzanti (2013)
Explanatory variables	Significant variables	Regulation, subsidies, size, sectoral dummies, demand-pull	R&D, size, age (–), environmental variables, quality as management system / ISO9001	Regulation (Mixed evidence), environmental (mixed evidence), size (mixed evidence), share of demand from final consumers, region	Subsidies, internal technological capability, size, sectoral dummies, productivity, internal forces, group (subsidiary), geographic dummy, information from other firms of the group, suppliers, universities, fairies and ind. assoc.	Internal technological capability, sectoral dummies, cooperation, region	Information from other firms, suppliers, conferences, training programs in the firm, membership to a business group, labour productivity, subsidies, firm subject to ETS, EMAS, energy expenditure, geographic dummy, size dummy, industry dummy, R&D programs	Technological capabilities, network, external informacion, energy prices, size, market share, market demand for green products, present regulation, firm belonging to agricultural sector, firm belonging to water supply sector, firm belonging to high-tech	ISO 14001 (ISO 2004) duration, age, size (env. R&D/sales (–)), sales growth (env. R&D/total R&D), market concentration, belonging to Chemical sector (env.R&D/sales (–)), belonging to machinery and instruments (–)	In general: Information by suppliers, by clients, by institutions (only for CO_2 abatement techs (–)), by journals and by industry associations, cooperation activities, investments in training, internal R&D activities, subsidies and geographic dummies
	Non-significant variables	Age	Main market is internat, environmental management, competitive pressure	Cost-savings, sectoral dummies, demand-pull	Regulation, R&D, main market is internat, cooperation, growth of sales	R&D, size, main market is internat, foreign ownership	Information from clients, institutions, universities journals, ind. assoc, R&D, cooperation, information from other firms of the group	Material prices, future regulation, belonging to food services sector, subsidies	Listed firm, head office in foreign country, quality management system, undertaking technical measures, exports, restrictions of manufacturing technology, effects of performance-based standards, input and emissions taxes, sector dummies	Internal information sources, information by competitors, by universities, by public research lab and by conferences, belonging to a group, growth sales
Econometric method (model)		Bivariate probit	Binary probit, and multinomial logit	Multivariate Logit	Probit model	Probit model	Probit model	Trivariate probit	Tobit model	Probit model
Geographical scope		Belgium	Germany	Germany	Italy	Emilia Romagna (Italy)	Italy	27 European countries	Japan	Italy
Dependent variable			Process and product eco-innovation	Six dependent binary variables	Six binary dependent variables	Five binary dependent variables	Two binary dependent variables: adoption of environmental innovation for energy efficiency/for CO_2 abatement	Binary dependent variables. If the firm has introduced a eco-product (1/0), eco-process (1/0) or/and eco-organization innovation (1/0)	Two continuous variables: Environmental R&D/total R&D expenditures and Environmental R&D/sales	Two binary dependent variables: adoption of environmental innovation for energy efficiency/for CO_2 abatement
Types of data		Belgian CIS	Telephone survey data	Survey data	Survey data CIS	Survey data	Survey data CIS	Survey data: Flash Eurobarometer 315	Survey data: Japan part of OECD survey: "Environmental policy tools and firm-level management and practices: an international survey"	Survey Data CIS
Sample size		2893	390	358	6483	555	6483 (1613)	4947	753/754	8161 services firms
Sample segmentation		Firms adopting vs. developing clean technologies	Process vs. product	---	Firms adopting eco-innovations (EI) that produce benefits in the production phase vs. consumption phase	---	ETS industries	Firms adopting eco-innovative product or service to the market, eco-innovative production process or method, eco-innovative organizational innovation	---	By activity service: trade, transport and logistics, information and communication and finance, renting, housing and business services

Source: Own elaboration.

Table 2. Drivers of eco-innovation versus normal innovation with firm-level data

Main Features	Horbach et al. (2013)	Horbach (2008) Probit	Horbach (2008) Multinomial logit	Horbach et al. (2012)	Rave et al. (2011) Probit	Rave et al. (2011) Random-effects probit (New-to market eco-innovations)	De Marchi (2012)
Explanatory variables — Significant variables	Regulation, cost-savings, external sources of knowledge and information, internal information, R&D, size, appropriation (patents), information from institutions, demand-pull (only in Germany not in France)	Subsidies and regulation, cost-savings, internal technological capability, sectoral dummies, other organizational innovation (other than EMAS)	Size, main market is international, other organizational innovation (other than EMAS), path dependency	Regulation, cost-savings, internal technological capability (-), suppliers as source of information, size, cooperation, EMS, other organizational innovation (other than EMS), purchase of equipment / equipment upgrade	Cost-savings (-), size, sectoral dummies, cooperation, EMS	Regulation, cost-savings(-), size, cooperation, EMS, realisation of technology leads	Subsidies, size, sectoral dummies, demand-pull (absence of demand as an obstacle for innovation), main market is international (-), cooperation, purchase of equipment/ equipment upgrade, Presence of established firms as an obstacle for innovation, path dependency, high innovation costs as an obstacle for innovation
Explanatory variables — Non-significant variables	Sectoral dummies, cooperation, competitive pressure from established firms	R&D, size, demand-pull, age, region	Internal technological capability, demand-pull (significant for general innovation), profits, region	Information from sources different than suppliers, R&D, demand-pull, age, region, patents, competition	Demand-pull, age, realisation of technology leads	Subsidies, internal technological capability, demand-pull, age, social pressure	R&D, Belonging to a company group or being a subsidiary: NS
Econometric Method	Probit	Probit	Multinomial logit	Discrete choice probit	Discrete choice : probit	Random-effects probit	Two-part logit model
Geographical scope	France and Germany (2002–2004)	Germany (2001)	Germany (2001)	Germany (2006–2008)	German manufacturing industries (2004–2006)	German manufacturing industries (2004–2009)	Spanish manufacturing firms (2005–2007)
Dependent variable	Binary	Binary	Unordered categorical	Binary	Binary	Binary	Binary
Types of data	Survey Data (CIS)	Survey panel database: Mannheim innovation panel	Survey panel database: Mannheim innovation panel	Survey Data (CIS)	Large scale survey and firm database Amadeus	Large scale survey and firm database Amadeus	Survey data
Sample size	France: 3421 firms, Germany: 1966 firms	1830 observations	1485 Observations	3606 observations	625	1332 (1174 groups)	4613 observations
Sample segmentation	---	---		Two different environmental technology fields:	1. New-to-market/new-to-firm eco- innovation 2. Process/Product 3. Energy/non-energy		---

Source: Own elaboration.

One of the findings of the literature review is that the set of potential explanatory variables for the analysis of the determinants to eco-innovation is large. Indeed, there is no standard method to choose those variables. No single body of literature has succeeded in providing a comprehensive framework for the study of eco-innovation drivers (Diaz-López 2008; Mazzanti, Zoboli 2009). Several theoretical approaches are relevant to guide the selection of explanatory variables, including environmental economics, the systems of innovation perspective and evolutionary economics and the resource-based view (RBV) of the firm. The combination of those approaches suggests that firms are influenced by internal (resources and capabilities) and external factors (e.g., regulation) when taking the decision to eco-innovate (del Río 2009).

Tables 1 and 2 show that, in fact, the list of determinants used in the econometric studies is very large. A few variables are common to most studies. Regulation, size, sectoral dummies and environmental management systems (EMS) are included in at least half of the models. Three particularly relevant variables in those studies which compare drivers to environmental innovation versus normal innovations (Table 2) are cooperation, demand-pull and cost-savings. Other variables have been much less often used. In particular, internal factors to the firm such as resources, capabilities and competences, which are important drivers of innovation performance (see below), have seldom been considered in the empirical literature on eco-innovation, mostly due to the difficulty to include these factors into econometric models, given the unavailability of data.

Public policies play a crucial role in the promotion of eco-innovation and are found to be statistically significant in most studies. They can either be in the form of "sticks" (environmental policies) or "carrots" (i.e., subsidies). The relevance of public policies is related to the aforementioned double externality problem, which is specifically faced by eco-innovation (Rennings 2000; Horbach *et al.* 2013). Thus, eco-innovations are more policy-driven and possibly less market-driven than other innovations (Horbach 2008; Horbach *et al.* 2012).

Regarding *internal innovation capabilities*, in the general innovation theory, firm's technological capabilities are emphasized (see e.g. Baumol 2002; Rosenberg 1974). They comprise the physical and knowledge capital stock of a firm to develop new products and processes. To build up such a capital stock, inputs like R&D investment or further education of the employees are necessary (Horbach 2008). R&D expenditures improve the "knowledge capital" of the firms (affecting innovation) and their "absorptive capacity" of external knowledge (influencing adoption) (Cainelli *et al.* 2012). Horbach *et al.* (2012) argue that, as a relatively new technology field, eco-innovations are characterized by higher innovation intensity. De Marchi (2012) argues that absorptive capacity is more important in contexts such as those faced by eco-innovations, with high market uncertainties and technological turbulences. The firm is likely to have greater innovation capabilities when part of a larger group because it has access to the parent firm's resources and knowledge (de Marchi 2012). For Horbach *et al.* (2013), however, the role of R&D in eco-innovation is not well documented. Finally, the financial situation of the company, its productivity level (Mazzanti, Zoboli 2009) and its growth (Rave *et al.* 2011) is likely to positively affect eco-innovation.

Regarding *cooperation*, the general importance of network relationships for innovation activities has been acknowledged only recently in the specific case of eco-innovation (Ca-

inelli *et al.* 2012). The literature stresses that eco-innovations are more cooperation-intensive than general innovations (Horbach *et al.* 2013; Horbach 2008; Cainelli *et al.* 2012; de Marchi 2012; Rennings, Rammer 2009). Horbach *et al.* (2013) argue that eco-innovation requires more external sources of knowledge and information than innovation in general because eco-innovations are often characterized by relatively new technologies, where more basic research is needed. For Cainelli *et al.* (2012), networking and cooperation with universities becomes essential for achieving more radical and relatively new innovations such as eco-innovation. For de Marchi (2012), eco-innovations require more cooperation than other innovations, given their systemic and complex character. Eco-innovators have to leverage on the competences of external partners to a higher extent than other innovators.

The literature on eco-innovation vs. normal innovation barely supports the *market-pull* for eco-innovation (Horbach *et al.* 2012). Although customer benefits play a key role in product eco-innovations (Kammerer 2009; Horbach *et al.* 2012), eco-friendly products are still expensive (Rehfeld *et al.* 2007; Horbach *et al.* 2012). In countries with low environmental awareness and/or willingness-to-pay for product eco-innovations, a market-pull cannot be expected. According to the Eurobarometer, Spain ranks well below the EU average regarding willingness-to-pay for eco-products (EC 2011: 157). In a recent analysis of environmental management practices (i.e., including eco-innovations) in Spain and Italy, Ormazábal and Sarregi (2014) show a limited impact of "market requirements".

The evidence on cost savings is also rather ambiguous. Only half of the studies including this variable show a positive and statistically significant impact. Several reasons have been proposed to justify the alleged greater relevance of cost savings in eco-innovation. For Horbach *et al.* (2013), the capacity of firms to eco-innovate depends on their ability to combine productive efficiency and product quality with environmental objectives. Environmental regulation may make firms recognize the previously untapped cost-saving potentials of eco-innovations (Rave *et al.* 2011). Notwithstanding, why should cost reductions be a more relevant driver for eco-innovation than for general innovation? In order to be successful, any innovation has to reduce costs or increase the quality of the product, and this is true whether the innovation has an environmental component or not.

Other interesting conclusions about the studies on eco-innovation can be inferred from Tables 1 and 2. First, the literature has strongly relied on German data. A Southern European perspective has been missing, with some exception, including del Río (2005), del Río *et al.* (2011) and de Marchi (2012) for Spain and Mazzanti and Zoboli (2009) and Cainelli *et al.* (2012) for Italy. Regarding the method, probit models dominate, followed by logit models. Most importantly, very few papers focus on the role of different eco-innovation and eco-innovator types, as analysed in this paper. Some authors pay attention to the different determinants for process and product eco-innovations (Rennings *et al.* 2006; Rehfeld *et al.* 2007). In contrast, the determinants to new-to-the-firm vs. new-to-the-market eco-innovations have seldom been analyzed (Rave *et al.* 2011 is an exception). No paper assesses the differential determinants to eco-innovation in either large or small firms. Finally, as argued in the next subsection, the role of firm age in the propensity to eco-innovate is a recent and unsettled topic.

Therefore, the focus of this paper is on the analysis of the role of different eco-innovation and eco-innovator types (size and age of the firm, and new-to-the-market/new-to-the-firm and products/process eco-innovations). We focus on crucial determinants of eco-innovation (public policies, internal innovation capabilities and cooperation) and also on those for which the influence is not settled (market-pull and cost-savings), using the rest of factors as control variables. The analysis is performed using the eco-innovation vs. normal innovation modality.

1.2. Firm-size and type-specific determinants in eco-innovation. Main hypotheses

1.2.1. Large vs. small firms

Size has generally shown to positively affect the eco-innovative behaviour of firms due to several reasons: a higher public visibility for larger firms and the corresponding pressure from environmental NGOs (Kesidou, Demirel 2012; Kammerer 2009), a higher amount of financial and human resources (Kammerer 2009; Walz 2011; Rave *et al.* 2011), the existence of a systemized R&D department (Kesidou, Demirel 2012), the difficulties of small and medium size firms (SMEs) in facing the complexity of environmental innovations and the investments needed to switch to greener technologies (De Marchi 2012) and economies of scale (Mazzanti, Zoboli 2009).

1.2.2. New versus old firms

Similarly to the discussions in the general innovation literature (see Acemoglu, Cao 2015 for an overview), incremental eco-innovations in traditional industrial sectors might be mainly developed by large established firms or their suppliers (as found by Oltra 2008), whereas disruptive innovation is probably triggered by new entrants who challenge the dominant technological regime (as argued by Bergek *et al.* 2008). For some authors, the newer the firm, the more likely it is to eco-innovate (Walz 2011; UNECE 2011; OECD 2011). However, the influence of firm age on eco-innovation is undetermined in the empirical literature, with some authors showing a non-significant effect (Horbach 2008; Veugelers 2012; Rave *et al.* 2011) and others reporting a weak positive effect (Wagner 2007).

The accumulation of organizational resources and knowledge is good for innovation in general and eco-innovation in particular (Rave *et al.* 2011). Some authors argue that eco-innovation is high, systemic and complex innovation (Andersen 2011; Marchi 2012; Horbach *et al.* 2013). If this so, then, a greater internal innovation capacity and involvement in external knowledge flows and cooperation is required for eco-innovation compared to general innovation. This is even more important for new firms than for existing ones, since the former have not accumulated internal capabilities over the years and need to build relevant knowledge network relationships.

1.2.3. New-to-the-market (NTM) vs. new-to-the-firm (NTF) eco-innovations

Eco-innovations encompass NTM innovations, but also those with a lower degree of novelty, i.e., NTF innovations. The differential determinants of these eco-innovations have not been analysed, with the notable exception of Rave *et al.* (2011). Since the degree of radical-

ity, disruption, complexity and systemicness can be expected to be higher for NTM than for NTF eco-innovations, the amount of funds, internal innovation capabilities and degree of cooperation with external actors required to develop or adopt NTM eco-innovations would also be greater. Indeed, Rave *et al.* (2011) show that NTM eco-innovations typically require more fundamental and often collaborative R&D activities.

If demand-pull factors shape diffusion rather than innovation (Horbach 2008; Horbach *et al.* 2013), then demand-pull would affect more NTF than NTM eco-innovations. NTM eco-innovations can be expected to be more product-oriented, driven by the opportunity to achieve technical leads and introduce new products or replace existing ones, and NTF tend to be more process-oriented, aimed at having greater production flexibility and capacity and lower costs. Compliance with environmental regulation and cost reductions play a more relevant role in the diffusion of known, more incremental firm-level (i.e., NTF) eco-innovations (Rave *et al.* 2011; Frondel *et al.* 2007; del Río 2005; Veugelers 2012).

1.2.4. Process vs. product eco-innovations

The literature suggests that process eco-innovations would be primarily undertaken to reduce energy and resource costs and comply with environmental regulation, whereas product eco-innovations would be driven by demand factors, opportunities in environmental markets and social pressure (Rave *et al.* 2011; Rehfeld *et al.* 2007; Rennings *et al.* 2006; Frondel *et al.* 2007; Veugelers 2012). Integrated environmental protection at the level of the process generally confers little or no additional benefit on the customer and therefore receives comparatively little reward from the market (Cleff, Rennings 1999). On the other hand, Rehfeld *et al.* (2007) and Horbach *et al.* (2013) show that product eco-innovations require greater internal innovation capabilities and external knowledge sources.

Therefore, the following hypotheses are proposed (Table 3).

Table 3. Hypotheses proposed in this paper

Firm size (i) Small firms have more difficulties to eco-innovate, given their lower innovation capabilities and financial resources than larger firms. Thus, whereas environmental regulation would influence both large and small firms, public subsidies and involvement in internal and external information flows are likely to have a greater effect on small firms. **Firm age** (ii) New firms are more eco-innovative than old firms. (iii) Internal innovation capacity and cooperation are more relevant for new firms to eco-innovate compared to old firms. **NTM vs NTF eco-innovations** (iv) Internal innovation capabilities, a sound financial situation, cooperation with external actors and information flows from knowledge institutions are less relevant for NTF than for NTM eco-innovations. (v) NTM eco-innovations are developed or adopted in order to access new markets or new clients in existing markets whereas compliance with environmental regulation and cost-savings are a main driver of NTF compared to NTM eco-innovations. **Product vs. process eco-innovation.** (vi) Product eco-innovations require greater internal innovation capabilities and cooperation. (vii) Process eco-innovations are more driven by environmental regulation and cost-savings, whereas product eco-innovations are driven by the demand-pull from the market.

2. The econometric analysis

2.1. The data

We use annual data from the Spanish Technological Innovation Panel database (PITEC) which, based on the Community Innovation Survey (CIS) methodology, collects information on innovation in Spanish firms[2]. Although PITEC allows us to analyse distinctive features and determinants of eco-innovators versus general innovators, a disadvantage of this database is that it cannot be used as a panel of data (PITEC 2007). This is due to changes in, both, the sample and the questionnaire which prevents, in most cases, comparisons between years (de Marchi 2012). Thus, our study focuses on data provided by the 2009 questionnaire, which covers the period 2007–2009 for some variables. We also include data provided by the 2008 survey in order to use lagged variables as instrumental variables. Therefore, our sample includes manufacturing firms which were present in both the 2008 and 2009 surveys and had no "incidences". A company is considered to have an "incidence" if it has been closed, temporarily closed, merged or absorbed by another firms (actually no longer existing as such), fully split or untraceable. The sample includes 3341 firms which belong to all the industrial sectors (see Table A1 in the Appendix).

For our econometric analysis, the dependent variable is built based on a question introduced by PITEC about how important is reducing environmental impacts as an aim to develop some kind of innovation[3]. A firm is an eco-innovator if it had introduced a process or product innovation with a high positive environmental impact between 2007 and 2009. About 28% of firms in our sample are "highly eco-innovating firms" (948 firms). This is a similar approach to Horbach (2008). The explanatory variables are described in detail in Table A2 in the appendix. Table A3 shows simple correlations between the explanatory variables.

Firms are considered "old" if they were set up before 1990 and "new" otherwise. They are "smaller" if they have less than 100 employees, and "larger" otherwise.

The external drivers of eco-innovation include two policy variables, environmental regulations and public subsidies. Internal determinants include R&D expenditures, firm age, external knowledge acquisition expenditures, firm size, whether it has foreign equity or not, its export capacity, changes in turnover between 2008 and 2009, turnover per employee in 2009, whether the firm has been a patent applicant in 2007–2009 and whether it belongs to a high-technology sector. In addition, we include the importance attached to several factors when firms innovate (increasing the range of products, replacing old products or process, increasing market share, increasing the quality of products, improving production processes, reducing costs), the perceived barriers to innovation (lack of internal or/and

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[2] The 2008 wave of the CIS survey includes an optional one-page set of questions on eco-innovation. Unfortunately, Spain is not one of the countries that included the environmental module.

[3] In PITEC this question is answered with a four-value categorical variable, where the values 1, 2, 3 and 4 stand for "high", "medium", "low" and "non-applicable" importance attached to the reduction of environmental impacts, respectively. We have transformed this categorical variable into a binary variable in which the value of 1 is for companies which attach a high importance to the reduction of environmental impacts and 0 otherwise. This transformation has been made in order to avoid intermediate responses. With intermediate responses (i.e., number 2 above), the importance of the aim of reducing environmental impacts may not be clearly specified (Azofra 1999). This approach is slightly different with respect to other papers using PITEC (see, i.e, De Marchi 2012).

external funds, high innovation costs, lack of qualified staff, lack of information about the new technology, lack of information about new markets, difficulty to find innovation partnerships, existence of a market dominated by established firms, uncertainty on the demand for innovative products, prior innovation in the firm and lack of demand for innovative products) and the importance of different information sources for innovation (knowledge institutions, internal information sources from the company and market players).

2.2. Method

Microeconometric methods (logit, probit and tobit models) are useful tools to analyse the probability that firms eco-innovate and the relative influence of each explanatory variable in this decision. We estimate a dichotomous probit model with endogenous regressors in order to take into account the endogeneity problems. The latent variable is defined as the propensity of a company to develop or adopt eco-innovations. When the latent variable $y^{\star}_{1i}$ exceeds a given threshold, the HEI variable takes the value of 1, 0 otherwise. Therefore, the dichotomous model was specified as (1):

$$y^{\star}_{i} = x'_{i}\beta + \varepsilon_{i}, \quad \varepsilon_{i} \sim N[0,1], \tag{1}$$
$$y_{i} = 1 \, if \, y^{\star}_{i} > 0, \quad y_{i} = 0, \text{ otherwise.}$$

The estimation of such a probit model should take into account the existence of endogeneity problems that may occur if the regressors are correlated with the error term. This is why we estimate a dichotomous probit model with endogenous regressors y_{2i}. Formally (2):

$$y^{\star}_{1i} = y_{2i}\beta + x_{1i}\gamma + u_{i}. \tag{2}$$

$y^{\star}_{1i}$ is a non-observable latent variable representing the probability that an individual (in this case a firm) develops an eco-innovation. Therefore, the following expression results:

$$y_{1i} = \begin{Bmatrix} 0 & y^{\star}_{1i} \leq 0 \\ 1 & y^{\star}_{1i} > 0 \end{Bmatrix}, \tag{3}$$

where y_{1i} corresponds to the dependent variable of the model.

The β parameters are interpreted as marginal effects of the impact of changes in the respective explanatory variable on the probability to eco-innovate (Greene 2008: 772). Subsidies (PUBLICAID) and R&D expenditures (INTERD) are used as instrumental variables in order to correct for the endogeneity of public financing, a common problem in studies of innovation at the firm level (Almus, Czarnitzki (2003), among others).

2.3. Main results

Table 4 provides the results of the estimations for different types of eco-innovators and eco-innovations. Only the main final estimations are reported[4]. They are robust to different types of specifications, i.e., only minor changes in either the sign, magnitude or statistical significance of the estimations occur when we remove one variable from the estimations.

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[4] Table A4 in the appendix includes the coefficients of the probit model with endogenous regressors.

Table 4. Results of the estimations (average marginal effects of the probit model with endogenous regressors)

	Size		Age		Process/product		NTF/NTM	
	small <100	big ≥100	old <1990	new ≥1990	process	product	NTF	NTM
Publicaid	0.0634**	–0.0128	0.0539*	–0.0105	0.0677	0.0035	0.0473	0.0376
	(0.031)	(0.042)	(0.028)	(0.047)	(0.058)	(0.048)	(0.043)	(0.056)
Interd	0.0006	0.0006	0.0003	0.0012**	0.0019***	0.0018**	-0.0001	0.0015*
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)
Extknow	–0.0014	0.0016	0.0005	0.0017	Omitted	0.0034**	0.0007	0.0020
	(0.002)	(0.002)	(0.001)	(0.002)		(0.001)	(0.001)	(0.002)
International	–0.0368	0.0426	–0.0166	–0.0631**	–0.0071	–0.0499	–0.0435	–0.0415
	(0.023)	(0.039)	(0.027)	(0.030)	(0.047)	(0.041)	(0.030)	(0.049)
Techopport	–0.0376**	–0.0131	–0.0163	–0.0491**	–0.0542*	–0.04744*	–0.0339*	–0.0142
	(0.016)	(0.021)	(0.015)	(0.022)	(0.032)	(0.028)	(0.020)	(0.30)
Age	0.0003	–0.0000	0.0004	0.0014	0.0005	–0.0000	–0.0002	0.0000
	(0.000)	(0.000)	(0.000)	(0.003)	(0.001)	(0.001)	(0.000)	(0.001)
Pat	–0.0374*	–0.0020	–0.0340*	–0.0113	–0.0635	–0.0305	0.0247	–0.0394
	(0.022)	(0.026)	(0.020)	(0.028)	(0.069)	(0.034)	(0.030)	(0.033)
Roemployee	0.0045	0.0453***	0.0191**	0.0055	0.0025	–0.0432	0.0074	0.0500**
	(0.005)	(0.014)	(0.009)	(0.007)	(0.006)	(0.037)	(0.010)	(0.021)
Owner	0.0617**	0.0219	0.0348*	0.0697**	0.0461	0.0953***	0.0048	0.0566
	(0.026)	(0.022)	(0.018)	(0.028)	(0.041)	(0.034)	(0.025)	(0.037)
Turnvar	0.0001	–0.0003	–0.0002	0.0000	0.0001	0.0001	0.0004	0.0000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
Widerange	–0.0082	0.020	0.0107	–0.0222	0.0062	–0.0033	–0.0309	0.0699**
	(0.017)	(0.023)	(0.016)	(0.024)	(0.039)	(0.029)	(0.021)	(0.033)
Replace	0.0286*	0.0576***	0.0279*	0.0704***	0.0388	0.0058	0.0340	0.0538*
	(0.017)	(0.022)	(0.017)	(0.023)	(0.040)	(0.027)	(0.022)	(0.031)
Market	0.0266	–0.0193	0.0143	0.0116	–0.0033	0.0005	0.0179	0.0178
	(0.018)	(0.023)	(0.017)	(0.027)	(0.040)	(0.033)	(0.023)	(0.035)
Pquality	0.0126	0.0476**	0.0245	0.0297	–0.0140	0.0190	0.0039	0.0324
	(0.017)	(0.023)	(0.017)	(0.025)	(0.039)	(0.030)	(0.022)	(0.033)
Processes	0.0298*	0.0482**	0.0486***	0.0048	–0.0463	0.0388	0.0569**	0.0483
	(0.017)	(0.024)	(0.017)	(0.025)	(0.036)	(0.033)	(0.022)	(0.033)
Regulation	0.3197***	0.3414***	0.3340***	0.3172***	0.3352***	0.2825***	0.3431***	0.3378***
	(0.011)	(0.014)	(0.010)	(0.018)	(0.025)	(0.019)	(0.013)	(0.021)
Savings	0.0831***	0.1307***	0.0876***	0.01287***	0.1807***	0.1124***	0.0768***	0.0556*
	(0.017)	(0.022)	(0.017)	(0.023)	(0.033)	(0.033)	(0.022)	(0.033)
Size	–0.0004	0.0001***	0.0001***	0.0000	0.0001**	0.0000	0.0000	0.0000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
				Cooperation				
2	0.0145	0.0430	0.0017	0.0897***	0.1228**	0.0849*	0.0430	0.0014
	(0.025)	(0.033)	(0.024)	(0.033)	(0.052)	(0.049)	(0.031)	(0.046)
3	0.0007	0.0194	0.0029	0.0423	0.0255	0.0504	0.0210	–0.0128
	(0.020)	(0.026)	(0.019)	(0.031)	(0.040)	(0.035)	(0.027)	(0.038)
Nofun	0.0144	0.0415*	0.0122	0.0414*	–0.0391	0.0342	0.0476**	0.0195
	(0.017)	(0.023)	(0.017)	(0.024)	(0.037)	(0.030)	(0.023)	(0.034)

End of Table 4

	Size		Age		Process/product		NTF/NTM	
	small <100	big ≥100	old <1990	new ≥1990	process	product	NTF	NTM
Highivcost	−0.0238 (0.018)	0.0010 (0.025)	−0.0219 (0.018)	0.054 (0.025)	0.0372 (0.041)	0.0202 (0.032)	−0.0128 (0.024)	0.0199 (0.034)
Nostaff	−0.0593** (0.026)	−0.0120 (0.043)	−0.0454 (0.029)	−0.0461 (0.037)	−0.0014 (0.063)	−0.0633 (0.043)	−0.0640* (0.037)	−0.0100 (0.064)
Notecinfo	0.0444 (0.031)	0.0351 (0.047)	0.0477 (0.033)	0.0543 (0.043)	0.0583 (0.078)	0.1296*** (0.048)	0.0938** (0.040)	0.0535 (0.074)
Nomarketinfo	−0.0229 (0.027)	−0.034 (0.050)	−0.0549* (0.030)	0.0004 (0.038)	−0.0409 (0.062)	−0.0207 (0.047)	−0.0526 (0.037)	−0.0758 (0.058)
Nopartner	−0.0532** (0.026)	−0.0011 (0.040)	−0.0382 (0.027)	−0.0576 (0.038)	−0.1725*** (0.066)	0.0002 (0.044)	−0.0255 (0.034)	−0.0271 (0.055)
Estfirms	0.0357* (0.019)	−0.0062 (0.028)	0.0208 (0.020)	0.0262 (0.028)	0.0923** (0.042)	−0.0214 (0.033)	−0.0230 (0.025)	0.0544 (0.039)
Uncertd	−0.004 (0.018)	−0.033 (0.026)	−0.0036 (0.018)	−0.013 (0.026)	−0.0720* (0.042)	0.0105 (0.031)	−0.0013 (0.022)	0.0109 (0.036)
Pastiv	0.0242 (0.053)	−0.074 (0.083)	−0.0463 (0.063)	0.0622 (0.073)	−0.0290 (0.095)	Omitted	−0.0125 (0.072)	0.1193 (0.083)
Nodemand	0.0159 (0.051)	−0.1163 (0.097)	0.0380 (0.058)	−0.1724* (0.099)	0.1049 (0.064)	−0.0171 (0.085)	−0.0693 (0.069)	Omitted
Interinfo	0.0349** (0.017)	0.0016 (0.023)	0.0414** (0.016)	−0.0268 (0.024)	0.0608* (0.037)	0.0283 (0.028)	−0.0031 (0.021)	−0.0211 (0.032)
Instinfo	0.054*** (0.019)	0.0223 (0.024)	0.0492*** (0.018)	0.0264 (0.027)	−0.0389 (0.044)	0.0567* (0.033)	0.0207 (0.024)	0.0536* (0.034)
Marketinfo	0.0102 (0.015)	−0.0130 (0.020)	0.0006 (0.015)	0.0030 (0.021)	0.0162 (0.034)	−0.0020 (0.025)	−0.0104 (0.019)	0.0133 (0.029)
Otherinfo	0.0082 (0.019)	0.0131 (0.027)	0.0109 (0.019)	0.0182 (0.028)	0.1464*** (0.046)	−0.0242 (0.035)	0.0029 (0.024)	−0.0449 (0.038)
Obs	2097	1244	2236	1105	422	537	1133	608

Note: (*) significant at the 10% level of significance; (**) significant at the 5% level of significance; (***) significant at the 1% level of significance.

Concerning *size*, some determinants to eco-innovate are common to both types of firms, suggesting the relevance of energy and material cost savings due to innovation and environmental regulation. However, clear differences can be observed.

Some features and determinants are specific to small firms. First, the firms are more influenced by internal and external information flows when eco-innovating (INTERINFO AND INSTINFO). The difficulty to find innovation partnerships (NOPARTNER) and lack of qualified staff as a barrier to innovation (NOSTAFF) are an obstacle to eco-innovate for small firms, but not for large firms. Small firms belonging to private companies with foreign equity are more likely to eco-innovate (OWNER). They benefit from the innovation capabilities, financial resources and information flowing from the parent company. These results suggest that lack of internal innovation capabilities and involvement in knowledge networks are a main barrier to eco-innovate by these firms.

On the other hand, our results show that in contrast to what it is generally argued about the lack of financial capability of small firms being a barrier to eco-innovation, neither lack of internal and external funding (NOFUN) nor a poor financial situation (ROEMPLOY-EE) are barriers to eco-innovate for small firms with respect to normal innovation. The positive sign and statistical significance of public subsidies (PUBLICAID) suggest that, in fact, public funds (which are not specifically provided to eco-innovate) are being effective for small firms to eco-innovate. In other words, firms may not perceive those financial barriers due to the availability of those funds. Overall, these results allow us to (partly) reject hypothesis (i).

Regarding *firm age*, new ones are not more eco-innovative than older ones, as shown by the lack of significance of AGE as a regressor. Therefore, hypothesis (ii) can be rejected. This finding is against the common statement that new firms are necessarily more eco-innovative (see section 1.2) when the empirical literature is not conclusive in this regard (see Tables 1 and 2).

Knowledge capital accumulated by the firm though R&D (INTERD) or knowledge flows from the parent company (OWNER) or as a result of cooperation (COOPERATION) are a main driver for new firms to eco-innovate, in contrast to older firms. Thus, internal innovation capacity and cooperation are more relevant for new firms to eco-innovate compared to old firms, i.e., hypothesis (iii) can not be rejected.

A few determinants are a common driver to both NTF vs. NTM eco-innovations: environmental regulation (REGULATION) and unitary material and energy cost savings (SAVINGS). However, in contrast to NTF eco-innovations, the innovation objective "wider product lines" (WIDERANGE) is a main driver of NTM eco-innovations, i.e., these eco-innovations tend to increase the types of products being offered by the firm. However, compared to normal innovation, eco-innovation is not regarded as a way to access new consumers in existing or new markets, i.e. a demand-pull from the market is not perceived and is not a driver neither for NTF nor NTM eco-innovation. Thus, hypothesis (v) can be rejected.

Since NTM eco-innovations can be regarded as more radical, complex, systemic or disruptive than NTF eco-innovation, the features and determinants should be different for both eco-innovations types. We could expect that NTM eco-innovations would require greater internal and external innovation capabilities. Our results show that NTF eco-innovations do not require high internal innovation capabilities and knowledge flows from external sources with respect to general NTF innovation (i.e., lack of significance of INTERD, COOPERATION and INSTINFO). In contrast, internal innovation capabilities (INTERD), external knowledge sources (INSTINFO) and a sound financial situation (ROEMPLOYEE) are relevant drivers for NTM eco-innovations. This confirms hypothesis (iv).

Finally, the results show that there are a few differential drivers of product and process eco-innovations. Both eco-innovation types are positively affected by internal R&D investments (INTERD) and cooperation (COOPERATION). External knowledge flows from knowledge institutions (INSTINFO) are relevant only for product eco-innovations, whereas knowledge flows internal to the firm (INTERINFO) are a driver of process eco-innovations. This suggests that product eco-innovations do not require greater internal innovation capabilities and cooperation, i.e., hypothesis (vi) should be rejected.

Contrary to expectations, energy/material cost reductions (SAVINGS) and environmental regulation (REGULATION) influence both product and process eco-innovations. The demand-pull from the market is absent for product (and also for process) eco-innovations, i.e., hypothesis (vii) should be rejected. Thus, eco-innovations are not regarded as a way to penetrate new markets or increase quotas in existing markets. This lack of a demand-pull from the market could be attributed to the special features of Spain regarding the willingness to pay for eco-products and consciousness of its consumers. Although the environmental consciousness of consumers is an important characteristic of demand for product eco-innovations (see section 1), the relatively low willingness-to-pay of Spanish consumers for eco-friendly products (as shown by EC 2011: 157) may explain the lack of statistical significance of the demand-pull variable. This result is in line with previous research on drivers to eco-innovation or corporate environmental performance in Spain (see del Río 2005; del Río *et al.* 2015; Cabezudo *et al.* 2000; Aragón Correa 1998). See Peñasco and del Río (2013) for a review of studies on the determinants to eco-innovation in Spanish firms.

Table 5 summarizes the above discussion.

Table 5. Rejection of hypotheses

Hypothesis	Rejection
Size	
(i) Public subsidies and involvement in internal and external information flows have a greater effect on small firms.	Partly
Age	
(ii) New firms are more eco-innovative.	Yes
(iii) Internal innovation capacity and cooperation are more relevant for new firms.	No
NTM/NTF	
(iv) Internal innovation capabilities, a sound financial situation and information flows from knowledge institutions are less relevant for NTF eco-innovations.	No
(v) NTM eco-innovations are deployed to access new markets or new clients in existing markets, whereas compliance with environment regulation and cost-savings are a main driver of NTF eco-innovations.	Yes
Product/process	
(vi) Product eco-innovations require greater internal innovation capabilities and cooperation.	Yes
(vii) Process eco-innovations are more driven by environmental regulation and cost-savings, whereas product eco-innovations are driven by the market-pull.	Yes

Conclusions

This paper has analysed the main determinants influencing eco-innovators versus non-eco-innovators in Spain, considering different eco-innovation and eco-innovator types.

The environmental regulation variable is a main driver for all eco-innovation and eco-innovator types, whereas another public policy, i.e., grants, are only a driver for small and old eco-innovators, and do not seem to encourage any eco-innovation type.

Other drivers are particularly relevant for certain eco-innovation or eco-innovator types. Our results suggest that this is the case of internal innovation capabilities, involvement in external knowledge flows and cooperation which are important for given eco-innovator/eco-innovation types. Internal innovation capabilities clearly influence small and new firms to eco-innovate, vs. large and old firms. Those capabilities are also a driver of NTM with respect to NTF eco-innovation. Involvement in external knowledge flows and cooperation is a crucial variable for small firms to eco-innovate and a driver for NTM eco-innovation.

Unexpectedly, there are a few differential drivers for product vs. process eco-innovation. Energy/material cost reductions and environmental regulation influence both eco-innovation types, whereas the demand-pull from the market is absent for both. The lack of a demand-pull from the market is attributed to the special features of Spain regarding the willingness to pay for eco-products and consciousness of its consumers. Also unexpectedly, product eco-innovations do not require greater internal innovation capabilities than process eco-innovations. External knowledge flows from knowledge institutions are relevant only for product eco-innovations, whereas knowledge flows internal to the firm are a driver of process eco-innovations.

Overall, these results suggest that a combination of environmental regulation and targeted policy instruments is likely to be effective to trigger eco-innovation, by addressing the different drivers for distinct eco-innovation and eco-innovator types. In general, public policies enhancing internal innovation capabilities, cooperation and knowledge flows are highly effective in influencing most eco-innovation/eco-innovator types. This could be done by providing firm-level support to upgrade the skills of companies. Encouraging networking, i.e., promoting public-private collaboration (through public-private partnerships in R&D and innovation) and cooperation between firms and knowledge institutions (i.e., universities and research centres) triggers some eco-innovation and eco-innovator types directly (by providing the required knowledge) but also indirectly (by enhancing the internal capabilities of firms). According to our results, these instruments would be particularly effective to encourage small and new firms to eco-innovate and NTM eco-innovation. In contrast to environmental regulation, grants specifically targeted at eco-innovation do not seem to be justified, except only to induce small and old firms to eco-innovate. The significance of the cost-savings variable for all eco-innovator and eco-innovation types suggests that instruments which make firms aware of cost-saving eco-innovation opportunities (for example, through the creation of clearinghouses) would be particularly effective in this context, especially for SMEs. Indeed, the fact that SMEs are much less eco-innovative than larger firms might be related to lack of information on the existence of cost-saving eco-innovations (del Río *et al.* 2015), as shown in the past by del Río (2005).

Our results suggest that, if the aim is to support specific eco-innovation or eco-innovator types, some instruments could be quite effective. This specific targeting of instruments has in the past been justified for small and new firms and for NTM eco-innovations. If, as suggested by our results, it is true that small firms have more difficulties to eco-innovate than their larger counterparts (Kammerer 2009), then environmental regulation, grants, information campaigns on cost savings, and facilitating the integration of small firms in external knowledge flows would be appropriate instruments. If NTM are more radical than NTF eco-innovations and, thus, bring potentially higher environmental benefits (OECD

2009; Tukker, Butler 2007; Smith *et al.* 2005), then they should be supported with environmental regulation, encouraging the accumulation of internal innovation capabilities in firms and supporting integration in external knowledge flows, whereas providing information on cost savings and giving grants would be clearly much less effective. In contrast, according to our analysis, it is not clear that differential support should be provided for process vs. product eco-innovation, given that there are few differential barriers for each eco-innovation type. Finally, our results suggest that, contrary to the claims of some authors, but in line with previous econometric research (see 1.1), new firms are not more eco-innovative than old ones. If it is the aim of policy-makers to encourage eco-innovations in new firms, then environmental regulation, support for internal innovation capabilities, information on cost savings and supporting cooperation would be suitable instruments in this regard, whereas environmental regulation, grants, up-front costs savings and facilitating the integration of firms in external knowledge flows are more appropriate to encourage eco-innovation in incumbent firms.

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APPENDIX

Description of variables

Table A1. Number of firms per activity branch in the sample

Code	Activity branch	CNAE-2009	Firms
0001	mining and extractive industries	05, 06, 07, 08, 09	18
0002	oil industry	19	2
0003	food, beverages and tobacco	10, 11, 12	418
0004	textile	13	112
0005	manufacturing wearing apparel	14	39
0006	leather and footwear	15	25
0007	wood and corck	16	46
0008	pulp, paper and cardboard	17	57
0009	printing	18	34
0010	chemical industry	20	430
0011	pharmaceutical industry	21	134
0012	rubber and plastic products	22	204
0013	non-metallic mineral products	23	151
0014	basic metals	24	104
0015	metal processing	25	297
0016	manuf. of TIC, medical and precision	26	227
0017	electrical machinery and equipment	27	195
0018	other machinery and equipment	28	447

End of Table A1

Code	Activity branch	CNAE-2009	Firms
0019	motor vehicles	29	171
0020	ship building	301	14
0021	aircraft and spacecraft	303	14
0022	other transport equipment	30	(exc. 301, 303)20
0023	furniture	31	96
0024	other manufacturing activities	32	86
TOTAL			3341

Table A2. Summary statistics and description of the variables used in the estimations

Code	Description of variables	Values	Mean	Std. Deviation
HEI	Dependent: Environmental Innovators	1 High importance of reducing environmental impact 0 Otherwise	0.284	0.451
AGE	Time since company foundation	Years	30.354	20.223
SIZE	Employees	Number of employees	193.524	528.717
INTERNATIONAL	Product sales in domestic or international markets	1 International markets 0 Only national market	0.879	0.326
INTERD	Internal R&D expenditures (as % of innovation expenditures)	%	65.951	35.514
Barriers to innovation				
NOFUN	Lack of internal or/and external funds as a barrier to innovation	1 High importance 0 Otherwise	0.446	0.497
HIGHIVCOST	High innovation costs as a barrier to innovation	1 High importance 0 Otherwise	0.347	0.476
NOSTAFF	Lack of qualified staff as a barrier to innovation	1 High importance 0 Otherwise	0.098	0.297
NOTECINFO	Lack of information about new technology	1 High importance 0 Otherwise	0.080	0.271
NOMARKINFO	Lack of information about new markets	1 High importance 0 Otherwise	0.091	0.287
NOPARTNER	Difficulty to find innovation partnerships	1 High importance 0 Otherwise	0.099	0.299
ESTFIRMS	Existence of a market dominated by established firms	1 High importance 0 Otherwise	0.205	0.404
UNCERTD	Uncertainty on the demand for innovative products	1 High importance 0 Otherwise	0.274	0.446
PASTIV	Prior innovation in the firm	1 High importance 0 Otherwise	0.021	0.144
NODEMAND	Lack of demand for innovative products	1 High importance 0 Otherwise	0.025	0.157
Aim of innovation				
WIDERANGE	Increasing the range of products	1 High importance 0 Otherwise	0.528	0.499

End of Table A2

Code	Description of variables	Values	Mean	Std. Deviation
REPLACE	Replacing old products or process	1 High importance 0 Otherwise	0.351	0.477
MARKET	Increasing market share by different means	1 High importance 0 Otherwise	0.528	0.499
PQUALITY	Increasing the quality of products	1 High importance 0 Otherwise	0.525	0.499
PROCESSES	Improving production processes	1 High importance 0 Otherwise	0.424	0.494
SAVINGS	Reducing feedstock and/or energy and or labour costs per unit output	1 High importance 0 Otherwise	0.363	0.481
	Information sources for innovation			
INSTINFO	Importance of knowledge institutions	1 High importance 0 Otherwise	0.226	0.418
INTERINFO	Importance of internal information sources from the company	1 High importance 0 Otherwise	0.654	0.476
MARKETINFO	Importance of market players information	1 High importance 0 Otherwise	0.467	0.499
OTHERINFO	Importance of other information sources	1 High importance 0 Otherwise	0.174	0.379
	Other variables			
PUBLICAID	Public subsidies received from local, regional or central governments or from the EU.	1 The firm has received subsidies 0 The firm has not received subsidies	0.476	0.499
EXTKNOW	External knowledge acquisition expenditures (as a percentage of innovation expenditures)	%	0.618	6.240
TECHOPPORT	The firm belongs to a high-technology sector.	1 Yes 0 No	0.516	0.500
PAT	Patent applications (2007–2009)	1 Patent applicant firm 0 No patent applicant firm	0.173	0.379
ROEMPLOYEE	Company turnover/number of employees	€/employee	228297.4	377749.5
OWNER	Company type	1 private company without foreign equity 2 private company with foreign equity	1.195	0.396
TURNVAR	Turnover change 2008–2009	%	–12.364	58.273
REGULATION	Importance of compliance with environmental, health and safety regulations as an aim of innovation	1 High 0 Otherwise	0.349	0.477
COOPERATION	Participation in innovation cooperation	1 Non-cooperative company 2 Cooperative company between 2006–2008 or between 2007–2009 3 Cooperative company between 2006–2009	1.777	0.898

Note: All variables refer to 2009, unless stated otherwise.

Table A3. Correlation matrix

	PUBLICAID	INTERD	EXTKNOW	INTERNATIONAL	TECHOPPORT	AGE	PAT	ROEMPLOYEE	OWNER	TURNVAR	WIDERANGE	REPLACE	MARKET	PQUALITY	PROCESSES	REGULATION	SAVINGS	SIZE	COOPERATION	NOINEXFUN	HIGHIVCOST	NOSTAFF	NOTECINFO	NOMARKETINFO	NOPARTNER	ESTFIRMS	UNCERTS	PASTIV	NODEMAND	INTERINFO	INSTINFO	MARKETINFO	OTHERINFO
PUBLICAID	1.000																																
INTERD	0.046 (0.339)	1.000																															
EXTKNOW	-0.011 (0.339)	-0.106 (0.000)	1.000																														
INTERNATIONAL	0.076 (0.000)	0.043 (0.014)	0.016 (0.353)	1.0000																													
TECHOPPORT	0.034 (0.175)	0.127 (0.000)	-0.024 (0.170)	0.052 (0.003)	1.000																												
AGE	0.028 (0.102)	-0.010 (0.583)	0.027 (0.123)	0.118 (0.000)	-0.059 (0.001)	1.000																											
PAT	0.115 (0.000)	0.060 (0.001)	0.006 (0.742)	0.070 (0.000)	0.091 (0.000)	0.020 (0.251)	1.000																										
ROEMPLOYEE	0.060 (0.001)	-0.021 (0.223)	0.026 (0.140)	0.072 (0.000)	-0.059 (0.001)	0.045 (0.009)	0.030 (0.080)	1.000																									
OWNER	-0.032 (0.069)	-0.013 (0.465)	0.036 (0.035)	0.111 (0.000)	0.030 (0.001)	0.092 (0.000)	0.034 (0.053)	0.118 (0.000)	1.000																								
TURNVAR	0.050 (0.004)	-0.007 (0.706)	-0.022 (0.207)	0.049 (0.005)	0.069 (0.688)	-0.039 (0.026)	0.038 (0.028)	0.019 (0.281)	0.020 (0.099)	1.000																							
WIDERANGE	0.082 (0.000)	0.106 (0.000)	0.049 (0.005)	0.069 (0.000)	0.105 (0.000)	-0.024 (0.017)	0.053 (0.002)	0.019 (0.266)	0.020 (0.010)	0.010 (0.567)	1.000																						
REPLACE	0.028 (0.107)	0.024 (0.170)	0.054 (0.009)	0.061 (0.000)	0.057 (0.001)	0.035 (0.046)	0.052 (0.003)	-0.008 (0.635)	-0.045 (0.010)	-0.026 (0.133)	0.259 (0.000)	1.000																					
MARKET	0.110 (0.000)	0.086 (0.000)	-0.042 (0.014)	0.048 (0.000)	0.117 (0.000)	-0.010 (0.555)	0.075 (0.000)	0.095 (0.000)	0.020 (0.247)	0.051 (0.003)	0.259 (0.000)	0.258 (0.000)	1.000																				
PQUALITY	0.052 (0.003)	0.043 (0.013)	-0.012 (0.475)	0.020 (0.239)	0.012 (0.492)	-0.020 (0.242)	0.038 (0.028)	-0.007 (0.674)	0.079 (0.000)	0.061 (0.001)	0.292 (0.000)	0.292 (0.000)	0.402 (0.000)	1.000																			
PROCESSES	0.070 (0.000)	0.054 (0.002)	0.021 (0.218)	0.047 (0.475)	0.045 (0.033)	-0.047 (0.423)	0.014 (0.423)	-0.014 (0.405)	0.014 (0.423)	0.031 (0.078)	0.138 (0.000)	0.205 (0.000)	0.222 (0.000)	0.255 (0.000)	1.000																		
REGULATION	0.029 (0.090)	0.011 (0.542)	-0.003 (0.860)	0.046 (0.019)	0.102 (0.000)	-0.039 (0.670)	0.028 (0.110)	0.021 (0.216)	0.021 (0.099)	-0.009 (0.622)	0.155 (0.000)	0.169 (0.000)	0.242 (0.000)	0.285 (0.000)	0.266 (0.000)	1.000																	
SAVINGS	0.073 (0.000)	-0.002 (0.892)	0.011 (0.546)	-0.007 (0.693)	0.062 (0.004)	0.035 (0.002)	0.053 (0.002)	0.019 (0.026)	0.044 (0.010)	0.044 (0.248)	0.044 (0.004)	0.247 (0.000)	0.209 (0.000)	0.258 (0.000)	0.085 (0.000)	0.266 (0.000)	1.000																
SIZE	0.106 (0.000)	-0.057 (0.001)	0.160 (0.000)	0.064 (0.000)	0.023 (0.178)	0.184 (0.000)	0.117 (0.000)	0.040 (0.043)	-0.078 (0.000)	0.064 (0.000)	0.064 (0.000)	0.043 (0.013)	0.109 (0.000)	0.031 (0.074)	0.092 (0.187)	0.071 (0.000)	0.084 (0.000)	1.000															
COOPERATION	0.352 (0.000)	-0.028 (0.103)	0.011 (0.537)	0.075 (0.000)	0.023 (0.178)	-0.003 (0.938)	0.001 (0.938)	-0.035 (0.043)	-0.084 (0.000)	0.051 (0.003)	0.031 (0.035)	0.028 (0.103)	0.016 (0.346)	0.034 (0.051)	0.102 (0.000)	0.052 (0.003)	0.092 (0.000)	0.125 (0.000)	1.000														
NOINEXFUN	-0.003 (0.845)	0.040 (0.023)	-0.049 (0.004)	-0.041 (0.019)	0.037 (0.033)	-0.029 (0.127)	0.028 (0.857)	-0.035 (0.043)	-0.050 (0.179)	0.040 (0.020)	0.036 (0.036)	0.045 (0.000)	0.109 (0.000)	0.047 (0.051)	0.031 (0.078)	0.052 (0.003)	0.060 (0.001)	-0.083 (0.000)	-0.026 (0.127)	1.000													
HIGHIVCOST	0.001 (0.959)	-0.003 (0.875)	-0.022 (0.203)	0.037 (0.033)	0.062 (0.004)	-0.007 (0.696)	0.005 (0.776)	-0.061 (0.010)	-0.079 (0.099)	0.033 (0.020)	0.036 (0.036)	0.045 (0.004)	0.009 (0.616)	0.040 (0.080)	0.006 (0.732)	0.018 (0.303)	0.060 (0.001)	-0.088 (0.000)	-0.059 (0.001)	0.443 (0.000)	1.000												
NOSTAFF	0.027 (0.118)	0.015 (0.385)	-0.019 (0.275)	0.011 (0.511)	0.023 (0.190)	-0.019 (0.696)	-0.010 (0.201)	-0.029 (0.026)	-0.080 (0.000)	0.037 (0.055)	0.065 (0.000)	0.054 (0.004)	0.064 (0.000)	0.022 (0.080)	0.023 (0.187)	0.018 (0.303)	0.030 (0.035)	-0.055 (0.001)	-0.008 (0.658)	0.094 (0.000)	0.105 (0.000)	1.000											
NOTECINFO	0.024 (0.164)	0.017 (0.330)	-0.020 (0.250)	0.045 (0.011)	0.054 (0.190)	-0.015 (0.731)	-0.004 (0.797)	-0.035 (0.043)	-0.087 (0.380)	0.064 (0.034)	0.065 (0.000)	0.025 (0.157)	0.037 (0.033)	0.027 (0.209)	0.025 (0.151)	0.026 (0.007)	0.031 (0.001)	-0.065 (0.001)	0.006 (0.710)	0.086 (0.000)	0.108 (0.000)	0.409 (0.000)	1.000										
NOMARKETINFO	0.016 (0.358)	-0.009 (0.623)	0.003 (0.852)	-0.018 (0.291)	0.023 (0.178)	-0.018 (0.291)	0.001 (0.938)	0.040 (0.043)	-0.084 (0.000)	0.037 (0.034)	0.065 (0.000)	0.025 (0.157)	0.067 (0.000)	0.025 (0.150)	0.005 (0.770)	0.010 (0.583)	0.015 (0.375)	-0.042 (0.016)	0.016 (0.366)	0.128 (0.000)	0.118 (0.000)	0.247 (0.000)	0.431 (0.000)	1.000									
NOPARTNER	0.030 (0.081)	-0.014 (0.411)	-0.013 (0.445)	0.046 (0.019)	0.007 (0.693)	-0.029 (0.693)	0.028 (0.857)	-0.045 (0.010)	-0.050 (0.099)	0.040 (0.020)	0.036 (0.036)	0.050 (0.000)	0.044 (0.283)	0.030 (0.309)	0.002 (0.898)	0.043 (0.014)	0.018 (0.303)	-0.049 (0.005)	0.016 (0.370)	0.179 (0.000)	0.153 (0.000)	0.194 (0.000)	0.228 (0.000)	0.223 (0.000)	1.000								
ESTFIRMS	0.023 (0.187)	0.015 (0.389)	0.002 (0.927)	0.010 (0.571)	0.102 (0.033)	-0.019 (0.679)	-0.010 (0.679)	-0.029 (0.026)	-0.080 (0.380)	0.033 (0.055)	0.078 (0.000)	0.037 (0.035)	0.068 (0.000)	0.030 (0.080)	0.072 (0.000)	0.091 (0.000)	0.061 (0.000)	-0.046 (0.008)	-0.008 (0.652)	0.161 (0.000)	0.200 (0.000)	0.107 (0.000)	0.137 (0.000)	0.157 (0.005)	0.183 (0.000)	1.000							
UNCERTS	0.011 (0.509)	0.017 (0.342)	0.011 (0.546)	0.017 (0.279)	0.023 (0.035)	-0.015 (0.300)	-0.010 (0.611)	-0.003 (0.380)	-0.087 (0.246)	0.037 (0.034)	0.065 (0.000)	0.025 (0.389)	0.063 (0.000)	0.022 (0.209)	0.053 (0.187)	0.047 (0.007)	0.030 (0.010)	-0.027 (0.117)	-0.000 (0.984)	0.194 (0.000)	0.194 (0.000)	0.094 (0.000)	0.072 (0.011)	0.213 (0.198)	0.184 (0.017)	0.330 (0.012)	1.000						
PASTIV	-0.017 (0.321)	-0.030 (0.080)	0.009 (0.603)	-0.015 (0.389)	0.010 (0.555)	-0.015 (0.731)	-0.007 (0.679)	-0.007 (0.625)	0.017 (0.389)	0.020 (0.246)	-0.008 (0.644)	0.025 (0.389)	0.037 (0.033)	-0.030 (0.077)	0.025 (0.310)	0.010 (0.734)	0.015 (0.444)	-0.022 (0.212)	-0.012 (0.488)	0.010 (0.570)	0.019 (0.273)	0.056 (0.011)	0.072 (0.067)	0.062 (0.163)	0.041 (0.095)	0.043 (0.012)	0.045 (0.010)	1.000					
NODEMAND	-0.048 (0.005)	-0.041 (0.017)	-0.013 (0.833)	0.004 (0.833)	0.007 (0.693)	0.004 (0.693)	0.028 (0.852)	-0.017 (0.322)	-0.012 (0.477)	-0.018 (0.302)	-0.042 (0.016)	-0.011 (0.509)	-0.019 (0.547)	-0.018 (0.309)	0.007 (0.669)	-0.023 (0.194)	-0.003 (0.849)	-0.065 (0.117)	-0.038 (0.027)	0.023 (0.176)	0.050 (0.004)	0.049 (0.005)	0.051 (0.033)	0.048 (0.005)	0.029 (0.095)	0.059 (0.001)	0.080 (0.007)	0.411 (0.000)	1.000				
INTERINFO	0.047 (0.006)	0.099 (0.000)	0.002 (0.927)	0.074 (0.000)	0.065 (0.693)	0.007 (0.693)	0.028 (0.234)	0.021 (0.234)	0.047 (0.007)	0.022 (0.198)	0.193 (0.000)	0.050 (0.000)	-0.034 (0.051)	-0.018 (0.000)	0.166 (0.000)	0.128 (0.000)	0.141 (0.000)	-0.042 (0.212)	-0.038 (0.413)	0.014 (0.413)	0.004 (0.797)	0.026 (0.137)	-0.002 (0.897)	-0.022 (0.198)	-0.013 (0.457)	0.003 (0.356)	-0.008 (0.387)	-0.015 (0.387)	-0.046 (0.007)	1.000			
INSTINFO	0.205 (0.000)	-0.025 (0.157)	0.011 (0.546)	0.072 (0.000)	-0.050 (0.000)	0.020 (0.693)	0.072 (0.337)	0.031 (0.077)	-0.031 (0.389)	0.009 (0.611)	0.078 (0.000)	0.025 (0.035)	0.115 (0.000)	0.102 (0.080)	0.065 (0.000)	0.065 (0.000)	0.077 (0.000)	0.036 (0.035)	0.259 (0.286)	0.038 (0.030)	0.037 (0.035)	0.022 (0.210)	0.037 (0.035)	0.039 (0.163)	0.033 (0.052)	0.034 (0.052)	0.018 (0.300)	0.008 (0.661)	-0.030 (0.082)	0.025 (0.143)	1.000		
MARKETINFO	0.021 (0.221)	-0.002 (0.924)	-0.002 (0.910)	0.001 (0.924)	0.054 (0.002)	0.006 (0.731)	0.061 (0.337)	-0.009 (0.625)	0.015 (0.389)	0.020 (0.246)	-0.008 (0.644)	0.106 (0.000)	0.160 (0.000)	0.103 (0.000)	0.116 (0.000)	0.143 (0.000)	0.109 (0.000)	-0.003 (0.851)	0.068 (0.000)	0.062 (0.000)	0.032 (0.065)	0.0149 (0.273)	0.026 (0.141)	0.067 (0.000)	0.030 (0.086)	-0.000 (0.997)	0.073 (0.000)	0.004 (0.836)	-0.009 (0.606)	0.058 (0.000)	0.148 (0.000)	1.000	
OTHERINFO	0.066 (0.000)	0.035 (0.043)	-0.002 (0.910)	0.015 (0.381)	0.054 (0.002)	0.015 (0.375)	0.061 (0.337)	-0.006 (0.728)	-0.028 (0.102)	-0.006 (0.734)	0.135 (0.000)	0.106 (0.000)	0.160 (0.000)	0.103 (0.000)	0.116 (0.000)	0.143 (0.000)	0.109 (0.000)	-0.003 (0.851)	0.068 (0.000)	0.062 (0.000)	0.032 (0.065)	0.0149 (0.273)	0.026 (0.141)	0.067 (0.000)	0.030 (0.086)	0.066 (0.000)	0.073 (0.000)	0.004 (0.836)	-0.009 (0.606)	0.058 (0.000)	0.148 (0.000)	-0.004 (0.822)	1.000

Table A4. Coefficient results of the probit model with instrumental variables

	Size		Age		Process/product		NTF/NTM	
	small <100	big ≥100	old <1990	new ≥1990	process	product	NTF	NTM
Publicaid	0.3005**	−0.0571	0.2528*	−0.0476	0.3544	0.0211	0.2504	0.1672
	(0.143)	(0.186)	(0.133)	(0.213)	(0.296)	(0.290)	(0.225)	(0.246)
Interd	0.0030	0.0027	0.0013	0.0056**	0.0098***	0.0109**	−0.0006	0.0065**
	(0.002)	(0.002)	(0.002)	(0.003)	(0.004)	(0.004)	(0.002)	(0.003)
Extknow	−0.0066	0.0072	0.0025	0.0075	Omitted	0.0203**	0.0035	0.0090
	(0.008)	(0.007)	(0.006)	(0.007)		(0.009)	(0.006)	(0.008)
International	−0.1742	−0.1990	−0.0780	−0.2848**	−0.0374	−0.3011	−0.2299	−0.1845
	(0.107)	(0.174)	(0.125)	(0.134)	(0.246)	(0.249)	(0.156)	(0.219)
Techopport	−0.1779**	−0.0584	−0.0764	−0.2217**	−0.2836*	−0.2865*	−0.1793*	−0.0629
	(0.076)	(0.095)	(0.071)	(0.101)	(0.166)	(0.170)	(0.105)	(0.132)
Age	0.0015	−0.0001	0.0017	0.0064	0.0027	−0.0002	−0.0008	0.0001
	(0.002)	(0.002)	(0.002)	(0.011)	(0.004)	(0.004)	(0.003)	(0.003)
Pat	−0.1773*	−0.0090	−0.1593*	−0.0510	−0.3323	−0.1841	0.1306	−0.1748
	(0.106)	(0.118)	(0.094)	(0.128)	(0.361)	(0.208)	(0.157)	(0.148)
Roemployee	0.0212	0.2017***	0.0895**	0.0250	0.0130	−0.2607	0.0392	0.2223**
	(0.023)	(0.064)	(0.041)	(0.030)	(0.030)	(0.223)	(0.051)	(0.097)
Owner	0.2921**	0.0977	0.1632*	0.3147**	0.2410	0.5755***	0.0256	0.2516
	(0.124)	(0.099)	(0.085)	(0.125)	(0.214)	(0.210)	(0.135)	(0.167)
Turnvar	0.0003	−0.0012	−0.0008	−0.0000	0.0006	0.0009	0.0019	−0.0000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.004)	(0.001)	(0.001)	(0.001)
Widerange	−0.0387	0.0898	0.0501	−0.1001	0.0326	−0.0202	−0.1637	0.3104**
	(0.081)	(0.101)	(0.077)	(0.109)	(0.204)	(0.176)	(0.113)	(0.151)
Replace	0.1353*	0.2565***	0.1311*	0.3176***	0.2029	0.035	0.1796	0.2388*
	(0.080)	(0.099)	(0.078)	(0.104)	(0.208)	(0.166)	(0.114)	(0.138)
Market	0.1258	−0.0860	0.0670	0.0525	−0.175	0.0031	0.0949	0.789
	(0.085)	(0.105)	(0.079)	(0.120)	(0.208)	(0.199)	(0.120)	(0.153)
Pquality	0.0595	0.2118**	0.1149	0.1342	−0.0731	0.1147	0.0208	0.1439
	(0.082)	(0.102)	(0.078)	(0.112)	(0.202)	(0.184)	(0.118)	(0.146)
Processes	0.1413*	0.2147**	0.2280***	0.0215	−0.2421	0.2346	0.3008**	0.2146
	(0.081)	(0.105)	(0.078)	(0.111)	(0.192)	(0.198)	(0.118)	(0.145)
Regulation	1.5144***	1.5202***	1.5670***	1.4315***	1.7540***	1.7060***	1.8148***	1.5008***
	(0.075)	(0.096)	(0.071)	(0.107)	(0.198)	(0.155)	(0.110)	(0.139)
Savings	0.3937***	0.5820***	0.4108***	0.5809***	0.9452***	0.6787***	0.4061***	0.2469*
	(0.083)	(0.102)	(0.080)	(0.108)	(0.193)	(0.201)	(0.119)	(0.147)
Size	−0.0019	0.0002***	0.0003***	0.0000	0.0006**	0.0001	0.0001	0.0001
	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Cooperation								
2	0.0680	0.1894	0.0081	0.3938***	0.6047**	0.4867*	0.2233	0.0060
	(0.117)	(0.142)	(0.112)	(0.141)	(0.251)	(0.264)	(0.157)	(0.203)
3	0.0032	0.0867	0.0135	0.1929	0.136	0.3025	0.1112	−0.0570
	(0.096)	(0.116)	(0.088)	(0.139)	(0.216)	(0.204)	(0.142)	(0.172)

	Size		Age		Process/product		NTF/NTM	
	small <100	big ≥100	old <1990	new ≥1990	process	product	NTF	NTM
Nofun	0.0680 (0.080)	0.1850* (0.103)	0.0574 (0.079)	0.1868* (0.107)	−0.2048 (0.193)	0.2065 (0.178)	0.252** (0.120)	0.0867 (0.146)
Highivcost	−0.1129 (0.083)	0.0043 (0.113)	−0.1027 (0.084)	0.0244 (0.113)	0.195 (0.215)	0.1222 (0.196)	−0.0675 (0.124)	0.0885 (0.152)
Nostaff	−0.2807** (0.124)	−0.0533 (0.192)	−0.2129 (0.138)	−0.2081 (0.165)	−0.0071 (0.330)	−0.3823 (0.259)	−0.3387* (0.198)	−0.446 (0.285)
Notecinfo	0.2103 (0.145)	0.1564 (0.211)	0.2238 (0.156)	0.2450 (0.195)	0.3048 (0.406)	0.7825*** (0.289)	0.4961** (0.215)	0.2375 (0.328)
Nomarketinfo	−0.1083 (0.127)	−0.1523 (0.221)	−0.2577* (0.142)	0.0016 (0.173)	−0.2138 (0.322)	−0.1250 (0.281)	−0.2783 (0.197)	−0.3365 (0.258)
Nopartner	−0.2521** (0.123)	−0.0048 (0.177)	−0.1790 (0.124)	−0.2598 (0.172)	−0.9024** (0.357)	0.0011 (0.265)	−0.1349 (0.179)	−0.1203 (0.247)
Estfirms	0.1692* (0.092)	−0.0275 (0.126)	0.0976 (0.092)	0.1182 (0.126)	0.4831** (0.222)	−0.1293 (0.198)	−0.1217 (0.132)	0.2416 (0.176)
Uncertd	−0.190 (0.084)	−0.1451 (0.114)	−0.0170 (0.083)	−0.0600 (0.119)	−0.3767* (0.218)	0.0635 (0.189)	−0.0068 (0.119)	0.0483 (0.160)
Pastiv	0.1145 (0.253)	−0.3298 (0.371)	−0.2172 (0.293)	0.2810 (0.328)	−0.1516 (0.499)	Omitted	−0.0663 (0.381)	0.5300 (0.373)
Nodemand	0.0752 (0.241)	−0.5178 (0.434)	0.1782 (0.272)	−0.7781* (0.447)	0.5486 (0.340)	−0.1034 (0.513)	−0.3666 (0.366)	omitted
Interinfo	0.1652** (0.079)	0.0070 (0.103)	0.1944** (0.076)	−0.1209 (0.109)	0.3179* (0.192)	0.1712 (0.166)	−0.0167 (0.113)	−0.0939 (0.143)
Instinfo	0.2554*** (0.091)	0.0993 (0.108)	0.2309*** (0.085)	0.1193 (0.121)	−0.2033 (0.234)	0.3424* (0.199)	0.1097 (0.128)	0.2380 (0.154)
Marketinfo	0.0483 (0.071)	−0.0578 (0.089)	0.0029 (0.069)	0.0133 (0.095)	0.0848 (0.178)	−0.0122 (0.154)	−0.0551 (0.101)	0.0592 (0.129)
Otherinfo	0.0387 (0.092)	0.0583 (0.121)	0.0510 (0.090)	0.0823 (0.126)	0.766*** (0.253)	−0.1464 (0.212)	0.01524 (0.127)	−0.1995 (0.171)
Cons	−2.2373*** (0.2173)	−2.0578*** (0.266)	−2.3465*** (0.207)	−2.2516*** (0.297)	−3.0395*** (0.508)	−3.3794*** (0.567)	−1.6707*** (0.2692)	−2.5605*** (0.376)
Wald	$\chi^2(34) =$ 670.93 (0.000)	$\chi^2(34) =$ 483.75 (0.000)	$\chi^2(34) =$ 803.66 (0.000)	$\chi^2(34) =$ 386.43 (0.000)	$\chi^2(33) =$ 167.31 (0.000)	$\chi^2(33) =$ 209.29 (0.000)	$\chi^2(34) =$ 433.80 (0.000)	$\chi^2(33) =$ 206.02 (0.000)
Wald test exogeneity	$\chi^2(2) =$ 5.14 (0.077)	$\chi^2(2) =$ 3.61 (0.164)	$\chi^2(2) =$ 4.15(0.126)	$\chi^2(2) =$ 2.67(0.263)	$\chi^2(2) =$ 3.61 (0.165)	$\chi^2(2) =$ 1.04 (0.593)	$\chi^2(2) =$ 0.77 (0.682)	$\chi^2(2) =$ 6.80 (0.033)
Obs	2097	1244	2236	1105	422	537	1133	608

Note: (*) significant at the 10% level of significance; (**) significant at the 5% level of significance; (***) significant at the 1% level of significance.

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