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Key business factors for eco-innovation: an overview of recent firm-level empirical studies

Factores empresariales clave para la eco-innovación: una revisión de estudios empíricos recientes a nivel de empresa

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Abstract:

The increasing interest in eco-innovation or environmental innovation as a strategy not only to address the serious global environmental problems but also as a source of competitive advantages for companies and for the emergence of new business areas, leads us to try to identify the different factors that act as determinants of its development and adoption at the micro level. In this paper we integrate the findings from several recent empirical studies according to our own classification of factors derived from the variables used in those analyses. From a conventional perspective we referred to the structural characteristics of firms (size, sector, age), the business logic (cost savings, market expansion) or to its technological competence (R&D, path dependencies, qualification of staff and management, cooperation and participation in networks, etc.). We added another category to refer to organizational or marketing innovations that reflect the existence of a certain environmental strategy within the company. In general, the findings show that factors influencing conventional innovation also work in relation to eco-innovation, in particular those related to cost savings and technological competence. Therefore, along with a stringent environmental regulation (justified because of the specific characteristics of eco-innovation) specific supply and demand side instruments are convenient. Measures to disseminate environmental information amongst all stakeholders can also be very useful to promote environmentally friendly and economically viable products and processes, as well as forms of organization and new business.

Keywords:

Eco-innovation, firm-level determinants, supply side and demand side factors, environmental strategy.

Resumen:

El creciente interés por la eco-innovación o innovación medioambiental como una estrategia no sólo para tratar los problemas medioambientales sino también como una fuente de ventajas competitivas para las empresas y para la emergencia de nuevas áreas de negocio, nos lleva a tratar de identificar los diferentes factores que actúan como determinantes de su desarrollo y adopción a nivel micro. En este artículo integramos los resultados de

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varios estudios empíricos recientes de acuerdo con una clasificación propia de factores derivada de las variables utilizadas en esos análisis. Desde una perspectiva convencional nos referimos a las características estructurales de las empresas (tamaño, sector, edad), a la lógica de negocio (ahorro de costes, ampliación del mercado), y a su competencia tecnológica (actividades de I+D, cualificación del personal y la administración, cooperación y participación en redes,…). Añadimos otra categoría para referirnos a innovaciones de organización y de marketing que reflejan la existencia de una cierta estrategia medioambiental empresarial. En general, los resultados muestran que los factores que influyen en la innovación convencional también afectan a la eco-innovación, destacando los relacionados con el ahorro de costes y la competencia tecnológica. En consecuencia, junto a una regulación medioambiental estricta –justificada en base a las características específicas de la eco-innovación– consideramos útil apoyar los factores de demanda y de oferta con instrumentos específicos. Las medidas para la difusión de información medioambiental entre los actores relevantes pueden también ayudar a promover productos, procesos, nuevas formas de organización y nuevos negocios respetuosos con el medio ambiente y económicamente viables.

Palabras clave:

Eco-innovación, determinantes a nivel empresarial, factores de oferta y demanda, estrategia medioambiental.

1. INTRODUCTION

In recent years, the increasing social and political awareness of the seriousness of environmental problems, coupled with the appreciation of innovation as an engine of economic growth has led to emphasize environmental innovation or more recently eco-innovation as a key strategy that will allow businesses to make economic and environmental goals compatible, and, at the same time but at a higher level, transforming the current pattern of growth of economies towards a more sustainable one.

Neoclassic economics considers environmental policy as a tool to achieve specific environmental goals and this is often assumed as harmful for companies' competitiveness. Nevertheless, in recent years the idea that if environmental policy were correctly designed it could lead to the achievement of competitive advantages for the most dynamic firms, via the promotion of innovation, has been suggested (see Porter and van der Linde, 1995). There is extensive literature on the impact of environmental regulation on innovation and on the effectiveness of different types of policy instruments (command and control vs. market-based instruments). Early studies are typically theoretical modelling (for a very comprehensive review see, for example, Jaffe *et al*, 2003; Requate, 2005) and there are also extensive reviews of empirical studies about the impact of policy instruments on the rate and direction of technological change (see Vollebergh, 2007). The works that analyse the impact of demand and supply factors in eco-innovation are limited but are increasing in numbers. The lack of systematic data on environmental innovation has largely limited its more detailed study. In recent years, government surveys in different European countries started to include questions concerning the environmental impact of innovation. These data and in other cases, some specific surveys carried out *ad hoc* have provided information to build econometric studies. These empirical works constitute the target of our review because, despite their disadvantages (limits related to subjectivity of respondents, low response rates, different forms of measuring eco-innovation and data limited to one moment in time as well as the heterogeneity in modelling) they allow for the characterisation of firms according to a number of variables and taking into account multiple relationships with eco-innovation.

The aim of this paper is to carry out a review of studies that analyse different factors that act as determinants of eco-innovation at the micro level from the perspective of the firm and to integrate them in order to have a more overall understanding. This must be the base to determine which instruments of public policy are the most convenient to promote environmental innovation.

The remainder of the paper is organized as follows: we describe briefly in section 2 the definition and the determinants of eco-innovation. In section 3 we present our methodology and data. We revise, according to our classification, the factors that several recent econometric analyses use as key variables in the study of the determinants of eco-innovation in Section 4. Finally, Section 5 summarises the contributions of this paper and draws some conclusions.

2. DEFINITIONS AND CONCEPTUAL FRAMEWORK

2.1. Definitions of eco-innovation

There is no single definition of eco-innovation. The earliest references to the term began in the mid-90s (probably Fussler and James, 1996) although control pollution innovation, control pollution technologies or environmental innovation were used previously and also refer to similar (technological) issues.

The ECODRIVE Project (Sixth Framework Programme of the European Commission) defines eco-innovation restrictively as the area that intersects between environmental innovation (innovation with positive effects on the environment but not profitable from a commercial point of view) and conventional innovation (non-environmental innovation, that has a positive impact in terms of economic profits but fails in relation to the environment). Therefore eco-innovation is specifically that which is able to meet a double gain, to provide a win-win situation. From the perspective of industrial dynamics, Andersen (2008) describes eco-innovations as "innovations which are able to attract green rents on the market" (Andersen, 2008, p. 5). Again, the double gain is emphasized, that is, improving the environment along with the ability to improve business competitiveness.

Based on the definition of innovation of the Oslo Manual (OECD, 2005), the MEI Project (Sixth Framework Programme of the European Commission) suggests: "Eco-innovation is the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives." (Kemp and Pearson, 2007, p. 7). Taking the perspective of the ECODRIVE Project this definition is comparable to environmental innovation.

Most of the studies we reviewed refer to environmental innovation without valuing if it allows a double gain or not. We then use eco-innovation as a synonymous of environmental innovation.

Eco-innovation may refer to products or processes, organizational or institutional changes. Often process eco-innovations are divided into end-of-pipe technologies and production integrated cleaner technologies[1] (see e.g. Rennings, 2000; Frondel *et al*, 2007; Demirel and Kesidou, 2011, for more details). Because of the scope of the studies reviewed, we mainly refer in this paper to process and product eco-innovations.

2.2. Specificities and determinants of eco-innovation

One of the great aims in economic history has been to understand which factors give impulse to technological development. The traditional theory of innovation tends to dis-

[1] End-of-pipeline technologies have the objective of aisle or mitigate pollutant substances after being produced; process-integrated technologies are aimed at decrease the pollution as well as the resources and energy consumption by introducing changes in process and production methods. Product eco-innovations are those that achieve a reduction in the environmental impact through changes in their composition –less harmful substances– or using less energy, generating less residues, etc.

tinguish between technology-push and market-pull factors to explain the development and diffusion of innovations. More recently, evolutionist theories have developed an interactive perspective of the innovative process, in which innovation is not considered a simple response to the stimulus of demand and supply factors, but the importance of innovation systems and the different interactions between the elements of the system in the production and diffusion of new useful knowledge (Lundvall, 1992) are emphasized. Concerning the determinants of conventional innovation an interesting literature review is the one carried out by Cohen (2010). The author analyzes the Schumpeterian hypotheses of the relationships between innovation and size, as well as between innovation and market structure. He also adds some specific industry-level (demand, technological opportunity and appropriability conditions) and firm-level (cash flow, diversification, integration of R&D with other functions, R&D capabilities) determinants.

Before going into the determinants of eco-innovation is useful to understand its specificities. From the neoclassic perspective eco-innovation presents a “double externality” characteristic (Rennings, 2000). Innovation processes generally originate some knowledge spillovers. The appropriability problem implies that different agents can benefit from these spillovers, without the firm that undertakes the initial research and investment effort receives any reward for them. That situation, which is a market failure, is due to the relative simplicity to reproduce knowledge in contrast with the obstacles to its creation. It can mean a disincentive to invest in eco-innovation. On the other hand, if a firm internalises the environmental damages that it causes, this generates a positive social gain, that society does not have to pay for. The agent that makes the investment looking for his own profit is not able to take full advantage of the gains its investment creates. That situation can also drive under-investment from the private sector in environmental issues.

From the double externality problem arises environmental policy as a strong specific determinant of eco-innovation. It is known as the regulatory push/pull effect (Rennings, 2000). The analysis of the importance of this factor is common in the literature that studies the determinants of innovation with environmental characteristics. Porter and van der Linde (1995) maintain that a strict and adequately designed policy can trigger innovation and this, in turn, can offset the costs of compliance with the norm partially or even more than completely. Their hypothesis has a second part, as the authors understand that policy can originate “innovation offsets” that not only allow the lowering of the net cost of complying with the set of environmental norms, but it also can drive a firm to have an absolute advantage over foreign ones not subject to similar norms. Several papers analyze and try to confirm the Porter Hypothesis (see e. g. Lanoie *et al*., 2007; Triebswetter and Wackerbauer, 2008).

According to the evolutionist theory, eco-innovation has a third characteristic, which is the interaction of ecological, social and institutional systems (Rennings, 2000). This is a relevant assumption for those studies dealing with promoting eco-innovation as a general strategy to achieve sustainability goals.

Leaving aside the role of environmental policy, in this paper we take the perspective of the company and focus on demand and supply factors as well as firms’ structural characteristics. We do not think that the development of innovations with a favourable impact on the environment is motivated by substantially different factors of non environmental innovation but there may be some specific aspects that have a greater impact or same factors that have different effects. One must not forget the fact that eco-innovation presents, compared to conventional innovation, an additional characteristics of public good[2], via the improvement of the quality of the environment.

3. RESEARCH METHOD AND DATA

The literature on the determinants (beyond environmental regulation) of eco-innovation is growing. There are an increasing number of empirical analyses that address different questions related to environmental innovation and we believe it is necessary to find common characteristics in order to establish a more overall view. The central aim of this paper is therefore to integrate the factors that act as drivers of eco-innovation and a literature review approach was selected as the research method.

After doing a search in Science Direct and Google Scholars databases using "eco-innovation", "environmental innovation" and "determinants of environmental innovation" as search terms we obtained a considerable number of documents. The literature review consisted of reading and classifying these documents according to topics such as "concepts", "environmental policy and eco-innovation", "strategic policy, eco-innovation and sustainability", "determinants of eco-innovation", etc.

The abstracts of papers included in the topic "determinants of eco-innovation" were read in order to set the sample. The first empirical analyses on the determinants of eco-innovation date from the late 1990s but we selected those from 2006 to 2011 because of better data and indicators. We also analysed their bibliographies with the aim of improving our selection. Finally, 14 studies were included in the sample, using these criteria: (i) the paper studies determinants of eco-innovation (other than regulation); (ii) the analysis is based in an econometric technique.

Our literature review is concept-centric (Webster and Watson, 2002). After completing the reading, we synthesized the literature by discussing each factor identified by the authors. There are different ways of classifying the factors that influence the adoption and development of eco-innovation. For Ashford (2005), three elements are necessary and sufficient within companies for technological change to happen: the desire to change, the opportunity/motivation to change and the capacity to change. These three factors are determined by more basic factors which in turn are interrelated. For example, the attitudes of the directors or the organizational structure itself are behind the desire to change, while the opportunity or motivation to innovate might be determined more typically by technological factors (the existing gap between the technology used by the firm and the availability of advanced technologies in the market or the firm's possibility of developing them) or via demand (normative requirements, costs and cost saving, potential profits, public demand, social and work pressure...). Finally, the capacity to innovate will be determined by the

[2] A public good has two characteristics: nonexclusive, that is to say, no one can be deprived of use or enjoy it; and non-rival, that means that everybody can use it without limiting its availability to others. All innovation presents, because of the use of knowledge, public good characteristics. Additionally, environmental innovation, because of its purpose of improving the environment, enhances its definition as a public good. When a firm reduces its emissions to the atmosphere through the introduction of a filter, this improved air quality is a social good because everyone can benefit from this less polluted air "portion" and nobody can appropriate it.

intentional or casual increase in knowledge and the information on cleaner and safer opportunities, as well as with the increase of the cognitive base of the firm through the training of workers and managers, and ultimately with the business trajectory itself (with regards to its innovation culture, its technological rigidity or flexibility, etc.).

A recent and interesting contribution related to determinants of environmental innovation is the one by Del Río (2009). The author carried out a literature review based in a sample of papers selected from 1985 to 2007, in order to suggest topics for further research. According to his review, factors influencing the engagement of firms with environmental technological change are internal factors (existence of a proactive environmental strategy, technological competence, financial resources, size, ownership, export orientation and sector characteristics) external factors (market and non market pressures, networking and interaction with other actors in the system) and the characteristics of environmental technologies (complexity, compatibility with the existent production processes, life cycle of capital, high initial direct costs of the investment).

Oltra (2008), who suggest to use the evolutionary literature on technological regimes as a relevant framework in order to analyse the various determinants of environmental innovations and the double externality problem in an industrial dynamics context, distinguish three categories of determinants (see Table 1):

Table 1

Determinants of environmental innovation

Regulation and policy determinants	Implementation of environmental policy instruments: economic and regulatory instruments Existence and anticipation of environmental regulations Regulatory design: stringency, flexibility, time frame
Supply side determinants	Cost savings, productivity improvements Organizational innovations: environmental management systems, extended producer responsibility R&D activities Industrial relationships, supply chain pressure, networking activities
Demand side determinants	Environmental consciousness and consumer's preferences for environmentally friendly products. Expected increase in market share or penetration of new market segments

Source: Oltra, 2008, p.7

Our proposition (see Table 2), which is no exhaustive, is related to the factors found in the studies included in the sample (see Appendix A for more details on those analyses). Therefore, the reader must be aware of the fact that other factors can also influence eco-innovation.

Table 2

Factors influencing eco-innovation. Findings from the literature review

Type of determinant		Factor
Conventional factors	Structural characteristics of the firms	Size
		Sector
		Age
	Business logic	Cost savings
		Customer's requirements Customer's benefits Customer's satisfaction Expected demand Export oriented strategy
	Technological competence	R&D activities Path dependencies: innovation in the past, organizational / technological innovation Employees qualifications Cooperation and network activities Industrial relationships
Firm's environmental strategy / management and marketing innovation		Environmental innovation system (ISO, EMAS) Environmental criteria in product planning and development Life cycle assessment activities of own products Waste disposal or take back systems of own products Environmental labelling Market research on green products Informing the customers

3. RESULTS OF THE LITERATURE REVIEW

3.1. Structural characteristics of firms

In this subsection we briefly review some internal characteristics of firms that facilitate their engagement in eco-innovation. The empirical literature reviewed allows discussing the size, the age and the sector. Other important characteristics identified by Del Río (2009) are the ownership of the company, to the extent that being part of a multinational usually involves benefits from major technological competence; and the availability of financial resources or cash flow necessary to invest in environmental technologies.

A. *The size*

One of the most common variables of control in econometric estimations on the determinants of eco-innovation is the measure of the number of employees in a firm. The hypothesis is that a larger firm[3] has greater capacity to implement an environmental innovation strategy due to its greater economic capacity to carry out the necessary investments, more human resources, a clearer internal organization, with the possibility to count on responsible staff or departments specifically orientated to R&D activities[4] and/or related to the environmental impact of its products and/or processes, etc. On the contrary, the small size can constitute a barrier to the extent that small firms usually lack human, technical and financial resources (Del Río, 2009).

The results are not definitive. For Mazzanti and Zoboli (2006) the size is only significant if it relates to the R&D/employee index, and this determines, to a certain degree, the undertaking of R&D but not its results. From another perspective, Wagner (2007) identifies size as a very important determinant of patent with regards to environmental innovation. Kesidou and Demirel (2010) prove that investment in environmental R&D is significantly related to size. Their analysis also suggests a U shape, in that smaller firms and larger ones invest more in this concept than medium sized firms.

On the other hand, in a later study Demirel and Kesidou (2011) identify size as an important determinant related to investments in end of pipe technologies but not significant when they consider investments in integrated technologies or environmental R&D. Meanwhile the estimation by Frondel *et al* (2007) shows a positive influence of size in both cleaner production and end of pipe technologies. Without distinguishing by type, Rennings *et al* (2006) acknowledges a positive influence of size on environmental process innovations.

For Rave *et al* (2011) eco-innovation is positively associated with firm size when compared to non environmental innovations, when they analyse both self-reported innovations and patent data. This factor is also relatively more associated with eco-patents. On top of this, they find that large firms are more capable of creating continuous eco-innovations.

On the other hand, Frondel *et al*. (2008), when studying the possible existence of a correlation between the adoption of environmental management systems[5] and innovation, reveal that size only affects the adoption of environmental management systems. The capacity of being able to undertake a scheme like this is the major factor that, according to the authors, explains this correlation.

Focusing exclusively on product eco-innovation, Kammerer (2009) finds that the firm's size is positively related to the extension of green characteristics to a wide range of prod-

[3] Rosenberg (1993) cites a fragment of Capital in which Marx argues that large-scale production favours the application of measures to use waste or by-products: "The general requirements for the reemployment of these 'excretions' are: large quantities of such waste, such as are available only in large-scale production, improved machinery whereby materials, formerly useless in their prevailing form, are put into a state fit for new production; scientific progress, particularly chemistry which reveals the useful properties of such waste." (Rosenberg, 1993, p. 57).

[4] Cohen (2010) discusses the Schumpeterian hypothesis of a relationship between firm size and R&D. His review allows him to recognise a monotonic relationship between the two variables, which is roughly related to an advantage derived from the R&D cost spreading of larger firm size. At the same time, this advantage is dependent on the appropriability conditions that usually restrict firms to exploit innovations in their own products; on the limited growth due to innovation and on the market segmentation.

[5] According to the International Standard Organization (ISO) an environmental management system (EMS) is a systematic approach to dealing with the environmental aspects of an organization. It is a 'tool' that enables an organization of any size or type to control the impact of its activities, products or services on the natural environment (http://www.tc207.org/faq.asp?Question=5)

ucts and with a greater degree of novelty. The findings by Horbach (2008) are undefined. When he analyses environmental product innovation in firms from the environmental sector –those that offer environmental goods or services- and also when he compares environmental (products and processes) innovations versus other innovation there is no significant correlation with size. On the other hand, when he compares environmental innovations and other innovations (non environmental) with the no-innovation alternative then there is a positive correlation.

B. *The sector*

Innovation is likely largely determined by the technological opportunities of the specific sector or industrial branch. Del Río (2009) points to the importance of considering the technological maturity of the sector in order to know more about the direction of environmental technological change and its determinants.

The differences between sectors are related to the particular trajectory of the sector –innovative efforts in an industry or complex of industries tend to concentrate in some several problems and the solutions are usually based in a known method–, to the degree of difficulty of learning that specific-sector technologies involve, or even to the different relationships and externalities between actors involved in a given sector.

On the other hand, there are cross-sectoral technologies, as for instance, general purpose technologies, which can be applied to several sectors. Del Río (2009) suggests researching, in that case, if there are common or different factors influencing the adoption of these technologies across sectors.

When talking about environmental issues, is expectable that firms that have a bigger polluting potential tend to develop and/or adopt more innovations that allow them to reduce their environmental impact and probably the associated economic costs. This behaviour may be related to costs saving and / or to external pressure. When analysing the environmental performance of firms we can distinguish sectors that produce final goods or services from those other sectors that produce intermediate goods or services. In the first case environmental pressure usually comes from customers. Therefore the company can develop an environmental strategy to face social pressures (to offer a green image, to improve working conditions, etc.). In relation to sectors that produce goods or services to other sectors, environmental pressure often comes from regulation. Thus, eco-innovation can be motivated by the need for minimising the costs of compliance with a stringent norm.

We may indicate that the studies that were reviewed use the sector as a control variable, so it is not an elaborated analysis. Only Kammerer (2009), who analyzes product eco-innovation in Germany's electrical and electronic appliances sector, distinguishes between different branches of this industry (information and communication technologies, domestic appliances and medical appliances) and arrives to the conclusion that the effects are not significant.

Other studies, in general, come up with expected results. Kesidou and Demirel (2010), who base their study on the average investment in environmental R&D, observe that the most important sectors are the production of energy and water, fuel or coal, oil and nuclear and chemical products. Mazzanti and Zoboli (2006) highlight in their study that sector is more important than size when considering not only the possibility to spend on R&D but also in the adoption of innovative output. The environmentally critical sectors, such as chemical, ceramic and also paper, seem to be more implicated in innovative dynamics. The econometric estimation confirms this observation for the chemical and ceramic sector, although the effects are not too strong.

For Frondel *et al*. (2008) abatement activities[6] (a concept that they use as a proxy for the introduction of eco-innovations) are correlated with a strong environmental impact of a plant's production processes, in that the most pollutant firms seem to innovate and introduce more abatement measures than less polluting firms. Their findings also confirm the existence of differences among industries, a result similar to the one observed by Horbach (2008). "Not surprisingly, there are significant sectoral differences, for example, the chemical industry as an environmentally intensive industry undertakes more innovations with environmental effects" (Horbach, 2008, p. 170). Additionally, this author values the variable "average sales" of new products per employee in a firm's sector as an indicator for sectoral differences due to the divergent life cycle of new products. "The results show that firms belonging to sectors with high average sales of new products are more likely to innovate, be it environmental or other innovations." (Horbach, 2008, p. 172)

From a different perspective, Belin *et al*. (2008) establish a hypothesis according to the evolutionist concept of sectoral technological regime and also according to the environmental pressure of the sector itself. The results of their estimation for German data show a significant impact of the energy intensity in the adoption of eco-innovations. According to the authors, this implies that the more energy intensive firms are the more determined to reduce this consumption. On the other hand, for the French data panel they observe that sectors that carry out larger investments in anti-pollution do not undertake eco-innovations. "This result may be due to the fact that PACE (Pollution Abatement Capital Expenditure) do not measure firms' investments in eco-innovations but in end of pipe technologies and in the adoption of clean technology. So it can be interpreted by saying that in industrial sectors characterized by a high level of anti-pollution investments, firms invest less in ecoinnovative activities." (Belin *et al*. 2009, p. 15).

C. *The age*

A priori, firm age has an ambiguous effect on eco-innovation activities. A company with a wide historical trajectory accumulates, according to the interactive model of technological change, an experience or know-how that favours a fast response to a new opportunity. At the same time, the firm's history can have a completely opposed effect. This occurs when routine dominates the business dynamics creating a barrier to any new opportunities which would mean breaking with a comfortable and stable way of producing throughout

[6] According to OECD pollution abatement refers to technology applied or measure taken to reduce pollution and/ or its impacts on the environment. The most commonly used technologies are scrubbers, noise mufflers, filters, incinerators, waste—water treatment facilities and composting of wastes. (http://stats.oecd.org/glossary/detail.asp?ID=2076). For Frondel *et al* (2008) end-of-pipe technologies and cleaner production technologies constitute the two types of abatement measures, and are referred to changes in production technologies and / or product characteristics to reduce the environmental impact of activities.

the years –what is called a technological lock-in. Wagner (2007) finds a positive association between self-reported environmental innovation and age. Rehfeld *et al*. (2007) reach the conclusion that age has a very strong effect. "Therefore, it seems that there is often a threshold that has to be passed until a firm will undertake environmental product innovations again. When a firm is very young, obviously, everything in this firm is (environmentally) innovative. Subsequently, the (environmental) innovativeness decreases with firm age. However, more mature firms might have developed a broad internal knowledge base, which can lead to the realisation of further environmental product innovations. Furthermore, firms obviously have to develop certain routines of (environmental) innovations to survive the market. Thus, firm age is not an obstacle". (Rehfeld *et al*., 2007, p. 98).

For Rave *et al* (2011) there are different effects. On one hand, age is generally not significant when they compare eco-innovators and non eco-innovators, but in primary sectors younger firms drive the self-reported eco-innovation activities. Their findings also suggest older firms are more capable of giving continuity to eco-innovation.

3.2. **Business logic**

In this subsection we try to identify the factors that a company motivated by profit maximization logic typically considers. We analyze first to what extent cost savings act as a determinant to introduce eco-innovations and then, from another perspective, the firm's interest in increasing the demand for its products.

A. *Cost savings*

Neoclassical theory considers that environmental problems are a source of costs that limit the competitiveness of firms. Innovation related to the mitigation of pollution or other environmental problems is frequently an answer to the obligation, imposed by norms and/or sanctions, of compensating the negative externality that the productive activities cause in terms of social welfare. In that sense, firms that are affected by a specific norm innovate in order to pay less.

Although eco-innovation can mean saving material or energy, or new valued attributes for products, its introduction also involves a cost, as it implies an investment in R&D, in the acquisition of a new technology, in the change of a specific process –given the existence of inter technological complementariness- or in the training of the employees, etc. Therefore, this factor can act as a barrier if it is considered that the change is too costly or the potential profits are not visible in the short term. This would question the Porter's hypothesis according to which environmental innovation will be common given the confluence of firm goals of costs reduction –the authors think explicitly in materials and energy inputs saving- with the social goal of improving the environment (Porter and Van der Linde, 1995).

Papers studied in this review coincide in considering cost reduction a relevant factor, in most cases related to process innovation. Horbach (2008) and Horbach *et al* (2011) find that cost savings especially trigger eco-innovation in comparison with other conventional innovation. In this sense, the two studies highlight the role played by environmental management tools to provide information about opportunities of potential cost reduction. Moreover, Horbach *et al* (2011) distinguish different environmental impacts of eco-innovations and find that for energy-savings process innovations cost savings are the main motivation. In a similar way Belin *et al*. (2009) identify, in their proposal for a European regional pattern of eco-innovation, cost savings as one of the main goals of innovation, in particular the saving of material and energy that cleaner technologies promote. Moreover, these results are clearer for process innovations, a fact that confirms the authors' hypothesis that eco-innovation is more related to processes in comparison to conventional innovation and clearly more related to the analysis of industrial sectors than to service activities. The work by Rave *et al* (2011) notes that self-reported eco-innovations are more often pursued to reduce production costs than conventional innovations. In addition, the reduction of energy and resource costs is the most important driver for the continuity of eco-innovation. This factor also has more influence on process than on product eco-innovations.

Kesidou and Demirel (2010) suggest two different profiles of firms that invest in environmental R&D. Firms with a smaller level of investments are guided mainly by cost savings, the presence of environmental management systems and abatement costs (this last variable acts as a proxy to the stringency of the applicable environmental norm). Firms that have a greater involvement in environmental R&D are also motivated by cost savings and environmental management systems. However, they are not as influenced by abatement costs. For this reason, according to the authors, the normative pressure can be more effective for the firms that are not at the "technological frontier" of environmental investments and not for the most advanced, in which other considerations have more importance. In a later study Demirel and Kesidou (2011) find that the desire of firms to improve their equipment works as a driver of investment in end of pipe and integrated technologies. "This suggests that firms consider the most energy efficient and environmentally friendly technologies when they are renewing existing facilities" (Demirel and Kesidou, 2011, p.1553). In line with their previous study cost savings are significant as a determinant of investment in R&D. "Finally, the results suggest that environmental R&D is not only stimulated by regulation but it is also market driven, mainly motivated by the cost saving potential of the outcomes that arise from environmental R&D" (Demirel and Kesidou, 2011, p.1553). The authors note that the impact of this factor is lower in firms that were already investing in environmental R&D. For Frondel *et al* (2007) cost saving specially drivers investments in process integrated measures.

Frondel *et al*. (2008), assuming the correlation between the adoption of environmental management systems (EMS) and abatement measures conclude that the perceptions of survey respondents are associated negatively with the variable cost savings. For the authors this is due to the fact that businessmen expect the adoption of an EMS to be costly.

B. *Demand factors*

A typical firm is motivated by the expectations of increasing its turnover; therefore, when making relevant decisions on which investments to carry out and at which level, the firm takes into account market sensitivity to its products. For instance, Horbach (2008) measures the demand factor in two ways, as expected future demand, which matters for the realization of environmental product innovation, and as expected increase of the level of employment –used as a proxy for turnover expectations- that is more important to other innovators than for environmental innovators. For Rave *et al* (2011) eco-innovations for the electrical and optical equipment sectors are relatively more pursued to secure market shares or to create new markets and this also stimulates the continuity of innovations. From their estimation, the opportunity to create new markets is a more important determinant of eco-patenting in relation to self-reported eco-innovations.

Nowadays there is a fashionable tendency for offering an ecological, green image, respectful with the environment. This has promoted an increasing interest in corporative social responsibility (CSR), in the implementation of environmental management and audit schemes and in the marketing of the green attributes of products. Public administrations[7] are themselves implementing green public procurement and integrated product policies which try to affect the valuation of products that have a green differential characteristic. Kesidou and Demirel (2010) try to contrast how factors, such as the adoption of policies of corporative social responsibility and the customers' demand affect the firm decision of investing in environmental R&D as well as the subsequent level of investments. From their findings, the authors interpret that whilst these types of factors initially have the virtue of encouraging innovation in firms, they do not stimulate further innovations and it is probable that they do not increase investment. "While demand factors such as CSR and customer requirements are important initiators of eco-innovations, the presence of organizational capabilities and environmental regulations are the key factors that boost the level of eco-innovations." (Kesidou and Demirel, 2010, p. 18).

Other works highlight the importance of this factor related to product eco-innovation. Horbach *et al* (2011) find that demand is quantitatively important for all analysed areas regarding to product (energy consumption, emission reductions of air, water, soil and noise, and recycling) but especially for energy consumption because of a specific regulation pull effect. Kammerer (2009) assumes that "green" can be a form of differentiation, generating a competitive advantage. On the other hand, he acknowledges that it can involve certain commercialization difficulties, because of consumers' adversity to pay bigger prices for attributes that they do not value completely yet. Then, he tries to point out that if the firm is able to transfer part of the public benefit –the lesser impact on the environment- to the customer, that is, if the firm is able to make the consumer perceive that the characteristics of the product can provide a direct benefit –such as costs and energy savings, better quality, etc.-, allowing him to appropriate of a part of the added value, then, it is more probable that the firm carries out environmental innovations. According to his econometric estimation, the greater potential of customer benefit a firm attributes to an environmental matter, the greater the chance that it carries out the improvement and that it extends this to a larger range of products. Moreover, this factor significantly affects the possibility that a firm develops innovations for the market. Kammerer derives the following conclusions: "Thus, a further fruitful area for regulators is the creation of market conditions that transform the environmental quality of products into a direct benefit for customers. This could mean taxes on resources and emissions but also differentiated rights of use in dependence of products'

[7] See e. g. European Comission DG Environment http://ec.europa.eu/environment/gpp/index_en.htm and http://ec.europa.eu/environment/ipp/

environmental performance." (Kammerer, 2009, p. 2293). Similarly, Rehfeld *et al*. (2007) consider that customer satisfaction is an important factor to obtain a competitive advantage in the main sales market, because of the higher price of eco-innovative products compared to conventional ones. They confirm that the effect is especially important for environmental product innovations. On the contrary, Rave *et al* (2011) find an insignificant influence of customer demand and social pressure on product eco-innovation.

The last factor analyzed among the variables of demand is the firm's sales market in question. The assumption is that a company orientated to the international market is submitted to a greater competitive pressure and therefore, is more likely to carry out some type of eco-innovation. Rehfeld *et al*. (2008) analyze a firm's exporting activity as a proxy to its market orientation but concludes that it is not a relevant factor for product eco-innovations. "It seems that most environmentally friendly products are still marketed on regional or national niche rather than on global markets." (Rehfeld *et al*., 2007, p. 98). On the contrary, Horbach (2008), who relates the sector variable to the exporting activity, comes to a different result. According to his findings, sectors such as machinery (electrical) or engine vehicles, which maintain high shares of export and which are strongly exposed to international competition, compared to others such as agriculture, mining and energy, are more prone to innovate.

3.3. **Technological competence**

In this section we refer to the accumulation of knowledge capital necessary to develop and / or adopt new products and processes. Investment in R&D is one of the main conditions to obtain new knowledge and to develop innovations. Besides codified knowledge and general information we also must take into account the combination of different skills and knowledge bases within firm that conform which are called tacit knowledge and routines. In that sense, a qualified staff is essential in order to the adoption of an innovation fits in the firm's productive process or even to be able to introduce some improvements according to staff's suggestions. Furthermore, the existence of industrial relationships among the main actors of the production chain, or the participation in networks and the collaboration with research institutes also contribute to a greater innovative dynamism within firms.

In relation to environmental innovation, one of the most interesting works in this category is the one that Mazzanti and Zoboli (2006) carry out through two surveys of firms in an Italian industrial district. They suggest this list of drivers for innovation:

- Firm participation in groups and network activities
- Industrial relations "orientated to innovation" and less hierarchical organizations
- Environmental costs (related to policy)
- R&D
- Voluntary programs of environmental audit

The particular interest of this study lies in the characterization of the studied sample itself, because it shows the double externality characteristic of eco-innovations. The harmful effects on the environment of high density industrial concentration can be compensated with a bigger propensity to innovate by the district's firms, which exploiting the network relationships and the spillovers of knowledge due to the proximity and internal sources, can dynamically increase the environmental efficiency of that productive area.

We highlight some interesting data that the authors obtain from primary observation:

- 79% of the firms adopted innovations related to the environment in at least one of the four areas consulted (emissions, wastes and management, inputs of material, sources of energy) but only 10% in all of them.
- Less than 2% of the sample has patents related to the environment; therefore, this is not a good indicator of the eco-innovation output.
- With regards to the environmental issue cooperation between firms through networks is remarkable: 28% material input and 41% reduction of emissions. The percentage of firms that develop innovation activities by themselves is very high if it is related to inputs of material, 62% and goes down for the reduction of emissions, 34%. However, there is not much cooperation with Universities and research centres. "We see that the role played by networking dynamics, which is crucial in industrial district areas, is relevant, as expected, also for environmental issues." (Mazzanti and Zoboli, 2006, p. 11)
- In relation with innovation inputs, 61 firms present positive R&D related to the environmental issues and other 72 positive capital investments.

From a bivariate analysis the study also finds that the innovation dynamics, on the technological side as in the technical-organizational one, are as a rule highly correlated "perhaps because environmental innovations are pursued by a limited number of innovative firms, which are more committed on all environmental grounds" (Mazzanti and Zoboli, 2006, p. 13).

According to their econometric analysis being member of a group and developing network activities –represented in the study as the driving force behind "economies of scale"-, are greater than the influence of the size factor, both in the promotion of R&D and in the result. Moreover, R&D shows up as one of the primary drivers of most innovation outputs. When analyzing which factors influence the possibility to carry out investments in R&D related to environmental innovation, they highlight the network activities with other firms and research institutes. According to the authors, this suggests a certain causal relationship: networks/cooperation → R&D → innovations. "Our investigation suggests that networking relationships aimed at building up social capital, instrumental to creating and introducing innovations, and "membership" to a district or a group, are factors as important, if not more, than a firm's structural characteristics. It is worth noting that a three-factor link might emerge: networking "investments" and research-oriented relationships are possibly influencing (and theoretically being complementary to) R&D/environmental investments. Then, and consequently, R&D is one of the inputs driving the adoption of innovative output." (Mazzanti and Zoboli, 2006, p. 21).

In regards to cooperation Horbach *et al* (2011) also confirm that eco-innovators are more likely to cooperate with other firms than other innovators. Rave *et al* (2011) find that eco-innovations for the market are more stimulated by major technological advancements, network activities –which include cooperation with universities- than those innovations only new to the firm. In addition, according to the study by Horbach *et al* (2011), self-commitment –a factor which is understood as a hybrid form of regulation and market push-, is an important determinant of process and product eco-innovations –especially for recycling.

The importance of investment in R&D as a determinant of eco-innovation is also confirmed by Frondel *et al* (2007) especially for cleaner technologies, and Horbach (2008). The latter confirms the influence of the firm's trajectory throughout time, what is termed existence of path dependencies: "General and environmental innovative firms in the past are also more likely to innovate in the present." (Horbach, 2008, p. 172). The study also points out that the high qualification of the employees in environmental firms –as an indicator of technological competence-, promotes the introduction of environmental product innovations.

On the contrary, various authors obtain some weaker findings (see e.g. Rehfeld *et al*., 2007 or Kammerer, 2009). Kammerer, who uses R&D as a proxy for a firm's innovative capacity, does not obtain significant results with regard to the possibility of introducing product eco-innovations, and he does not find relation with the extent or with the degree of novelty of them either. The author attributes this result to operational differences in the variable. While Kammerer uses the share of employees in R&D, other studies measure whether the firm carries out activities of R&D or not. "Another explanation could be that the impact of R&D activities on environmental product innovation is sector specific and not very relevant for the electrical and electronic appliances industry". (Kammerer, 2009, p. 2292)

3.4. **Environmental strategy / management and marketing innovations**

We put together in this category a series of measures that constitute, themselves, organizational or marketing innovations and which we identify as indicative of the existence of an environmental strategy within the company. We would expect these measures to influence the development and/or adoption of another type of eco-innovation.

One of the most common measures analyzed are the environmental management systems in accordance with the international norm ISO 14001 or the European Eco-Management and Audit Scheme (EMAS). These programs entail a series of practices related to the integration of environmental concerns with production decisions, the adoption of practices and methods of improvement, which involve a certain self-regulation by the company. Apart from this, they also mean the compliance with some environmental controls as well as the evaluation and registered report of the fulfilment with the program. There is a great debate on whether these types of flexible policy instruments are truly effective in achieving environmental goals. Some authors consider EMS as "a vital supplement to mandatory environmental policies based on regulation and legislation." (Frondel *et al*., 2008, p. 154).

In several studies the relationship between the implementation of an EMS and the development and adoption of eco-innovations is associated with the generation of information that allows firms to initiate environmental research and learning processes with regards to the possibilities of improving processes and products. In turn, this is determined by a firm's environmental commitment (Horbach, 2008; Wagner, 2008) or to its strength in environmental issues (Kesidou and Demirel, 2010). "Environmental management tools help to reduce the information deficits to detect cost saving potentials (specifically material and energy savings) that are also an important driving force of environmental innovation following our econometric analysis. In fact, these results seem to be very important for the design of a joint research and environmental policy: an environmentally oriented research policy not only has to regard traditional instruments like the improvement of the technological capabilities of a firm but also the coordination with soft environmental policy instruments like the introduction of environmental management systems." (Horbach, 2008, p. 172).

According to Rave *et al* (2011) the EMS is positively related to eco-innovation when compared to conventional innovation; it leads to more continuous eco-innovation activities and acts as a relatively important determinant of eco-innovations only new to the firm. With regard to types of innovation, they find a positive association with process eco-innovations and a negative association with product eco-innovation. Most of the studies find a positive relationship between EMS and process innovation but no effect on product innovation (e.g., Rennings et al, 2006; Wagner, 2007; Horbach et al, 2011).

Sometimes, the relationship between EMS and innovation depends on how the implementation of EMS is measured. For instance, Wagner (2007) builds an index to control the level of implementation of EMS in opposition to certification because of the opportunistic behaviour and institutional problems that it can generate. We also can highlight the study by Rennings et al (2006) which focuses on the influence of the different characteristics of EMAS, such as the maturity of the scheme, its organizational scope –strong participation of general management, distribution and R&D department in further development of EMAS- and its strategic importance. All these characteristics are found to be important determinants of environmental process innovations and not related to product eco-innovations. Nevertheless, according to their estimation, learning processes triggered by EMS have a positive influence on environmental product innovations.

Frondel *et al* (2007) and Demirel and Kesidou (2011) distinguish the influence of the EMS depending on the type of process eco-innovation. While the former acknowledges the positive influence of general management systems and that specific environmental management tools tend to favour clean production, Demirel and Kesidou consider it is an important driver for investment in environmental R&D and end of pipe technologies, whereas it has no effect in integrated technologies. "A plausible explanation of this finding is related to the innovative heterogeneity of firms where the least innovative firms benefit from having an organizational environmental structure to support them with the minimum compliance requirements through end of pipeline while the most innovative firms use EMS as an innovation platform to build upon for environmental R&D." (Demirel and Kesidou, 2011, p.1554).

Other studies grant these schemes relative importance in the promotion of eco-innovation (or minor importance, as Rehfeld *et al*, 2007). Although Mazzanti and Zoboli (2006) found a positive relationship between innovation outputs and voluntary audit schemes, they still conclude that the innovative content of these programs is related to the fact that only a limited number of innovative firms really exploit them. According to the study by Frondel *et al* (2008) the most important reasons to introduce an audit program are the desire to improve corporate image, to save in the management of waste and the use of resources as well as to increase the efforts in complying with norms. The study does not find association between abatement activities and the adoption of EMS. Therefore, they conclude that the adoption of EMS does not seem to stimulate innovation and abatement measures. "(...) [it] appears to be particularly plausible in the absence of sanctions on lack of improvement (Frondel *et al*., 2008, p. 158)".

Finally, to close this category, we identify the impact of some organizational and marketing measures in eco-innovation –primarily product eco-innovation-, such as the consideration of environmental criteria in product planning and development, life cycle assessment activities of products, waste disposal or take-back systems of own products, eco-labelling, provision of information, benchmarking, and so on. These are identified by Kammerer (2009) as firms' green capabilities and he proves that as a whole, these skills positively influence the accomplishment of eco-innovations, extension of eco-innovation to a wide range of products as well as the possibility to offer a greater degree of novelty. Rehfeld *et al* (2007) also recognise the importance of measures related to waste disposal or take-back systems. "Thus, if a manufacturer has a continued interest in his product, even after its useful phase, environmentally friendly product innovations such as recycling are far more probable." (Rehfeld *et al*, 2007, p. 98).

In a similar way, Wagner (2008) argues that these measures provide an additional positive effect in a firm's propensity to develop an eco-innovation. The author identifies the following causal relations:

- The market research on green products leads to a better understanding of the demand for product innovations with environmental characteristics; or it also enables firms to identify environmentally orientated consumer segments. It also triggers an increase in process innovation, which could be related to the new products requirements.
- The experience with eco-labelling can result in better knowledge about the product benefits, acting as an incentive for the firm to develop new eco-products as well as favouring internal training.
- Giving information to consumers can induce additional demand if there is an environmentally orientated segment of consumers, acting also as an incentive so that a firm carries out a product eco-innovation.

Although all these studies consider the influence in product innovation, Rennings *et al* (2006) also find that the explicit consideration of environmental aspects in product development has a positive influence on environmental process innovations.

4. CONCLUSIONS

The singularity of eco-innovation with regard to conventional innovation resides in its favourable effect on the environment, which improves social well being. The concept tries to highlight the compatibility between two traditionally opposed goals such as the improvement of business competitiveness and the environmental care.

There is an increasing body of empirical literature on the factors that influences eco-innovation. A number of studies have contrasted the importance that, because of the double externality that characterizes eco-innovation, environmental policy instruments have to promote the development and diffusion of this kind of innovation. In this paper we have tried to integrate the findings of several econometric analyses on those other factors that depend on the characteristics and impulses of the firms themselves and on demand side issues. This effort involves certain risks as findings of different studies are difficult to compare because they use several methodological approaches and take different assumptions as starting points. Nevertheless, this paper can be understood as an overall picture.

As a synthesis, we highlight the main results of this review:

- In relation to structural characteristics, the industrial sector constitutes a relevant factor as a determinant for the introduction of eco-innovations, usually related to the most polluting character of the activity as well as the intensive use of energy and materials. Most of the studies point to a certain influence of size on eco-innovation.
- Eco-innovation is not contrary to business logic. Cost savings constitute one of the main criteria to take decisions on investments on eco-innovations. In that sense, the lack of knowledge about the potential of technologies, material and energy savings, etc. can act as a barrier to their application due to the lack of immediate visible results.
- In relation to products, taking into account customers desires and expectations can be crucial to give the producers a strong incentive to expand their markets through eco-innovations.
- As with conventional innovation, technological capabilities are a very relevant factor. There are some authors that hold that eco-innovation depends more on external knowledge sources due to its superior dependence on basic research, than conventional innovation (Belin *et al*., 2009). Based on the literature review the importance of relations and cooperation with external actors is also clear.
- There is a series of organizational and marketing innovations that also constitute a factor that triggers other types of eco-innovations. Although there is mixed evidence on the real impact of environmental management systems it seems that these flexible tools can help to provide some minimal information on the activities impact and to induce an environmental strategy within firms, which in turn favours the development and / or adoption of eco-innovation.
- Other managerial measures, such as take back activities of products, life cycle assessment of own products and eco-labelling are specifically aimed to improve products, so it is expected and confirmed that they foster eco-innovation.

In conclusion, we have to defend the role of supply and demand side instruments in supporting eco-innovation. The integration of environmental issues with business logic does not have to mean a loss in firm competitiveness. Basing in the review it is clear that a policy response must be appropriate to each type of eco-innovation (product, process or organizational), degree of novelty (new to the company vs. new to the market), etc.

There are some factors that the literature identifies as strong determinants of eco-innovation, especially the ones related to technological competence. We highlight the need to facilitate the investments in R&D, in training as well as the promotion of cooperation and networks. There is also a need for extending the responsibility of producers on their processes and products, and this is why voluntary schemes as a type of flexible policy instrument could be complementarily relevant. On demand side, it is important to provide information to customers and also not to ignore their requirements as they can signal a potential market segment.

Because of the social character of the benefits that eco-innovation can bring, we think it is convenient to claim a prominent role for a stringent public policy, which, whilst it obliges and contributes towards increasing firm awareness on the impact of its products and processes, it also encourages the active search of alternatives, even if it is only for cost savings or expanding market motivations.

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APPENDIX A

TABLE A.1.

SUMMARY: FOCUS AND MAIN RESULTS FROM THE LITERATURE REVIEW

AUTHOR	DATA SET	MAIN FOCUS	KEY VARIABLES	MAIN RESULTS
BELIN, J., HORBACH, J. and OLTRA, V. (2009)	4th CIS 2002-2004 for France and Germany (Mannheim Innovation Panel, 2005).	The paper aims to contribute to provide "international" stylized facts about determinants and also regional characteristics of eco-innovations.	• Market characteristics and competition conditions • Innovative activities of firms • Knowledge bases and information sources • Main effects of innovative activities • Appropriability of innovation • Barriers to innovation • Technological regimes and sectoral variables	• Central role of regulation and cost savings as motivations for eco-innovations. • Eco-innovative activities seem to require more external sources of knowledge and information than innovation in general.
DEMIREL, P. and KESIDOU, E. (2011)	289 UK firms, DEFRA Government Survey of Environmental Protection Expenditure by Industry, 2005 and 2006	The paper examines the role of external policy tools and internal firm specific factors for stimulating three different types of eco-innovations that range on a spectrum of lower to higher technological and environmental impacts: end-of-pipeline pollution control technologies, integrated cleaner production technologies and environmental R&D.	• External environmental policy instruments • Organizational capabilities in the area of environmental protection: EMS, ISO 14001 • Efficiency: cost savings and equipment upgrades undertaken with the purpose of environmental protection • Corporate image: Corporate Social Responsibility (CSR) • Firm structural characteristics: size, turnover, productivity, total capital	• End of pipe (EOP) Technologies and Integrated Cleaner Production Technologies are mainly driven by equipment upgrade motives with a view of improving efficiency. • Environmental regulations are effective in stimulating the EOP technologies and environmental R&D. • Market factors, mainly motivated by cost savings, are effective in driving environmental R&D. • ISO 14001 certification is effective in strengthening the positive impact of environmental management systems on both EOP technologies and environmental R&D.

AUTHOR	DATA SET	MAIN FOCUS	KEY VARIABLES	MAIN RESULTS
FRONDEL, M., HORBACH, J. and RENNINGS, K. (2007)	4,186 manufacturing facilities, OCDE survey on environmental policy tools and their impact on firm management practices in manufacturing, 7 countries, 2003.	The paper analyzes a variety of factors that might enhance firms' propensity to implement cleaner production technologies instead of end-of-pipe technologies.	• Motivations: corporate image improvements, cost savings, potential avoidance of environmental incidents. • Environmental policy instruments: market based instruments, information measures, voluntary agreements and subsidies; policy stringency. • Management tools: health and safety management systems and process or job control systems, written environmental policies, internal environmental audits, environmental accounting and public environmental reports. • Pressure groups: unions, internal forces and environmental green organizations. • Facility characteristics: size, turnover, officer responsible for environmental concerns, environmental R&D budget and competition.	• Regulatory measures and the stringency of environmental policies are more important for end-of-pipe technologies. • Cost savings, general management systems and specific environmental management tools tend to favour clean production.

AUTHOR	DATA SET	MAIN FOCUS	KEY VARIABLES	MAIN RESULTS
FRONDEL, M., HORBACH, J. and RENNINGS, K. (2008)	899 German facilities OCDE survey on EMS adoption decision, 7 countries, 2003.	The paper tries to prove the correlation between the relevant incentives for a firm's voluntary adoption of an EMS and its environmental innovation behaviour.	• Pressure groups: public authorities, unions, internal forces, customers and environmental green organizations. • Motivations: corporate image improvements, cost savings, potential avoidance of environmental incidents and compliance with environmental regulation. • Environmental policy tools: market based instruments, regulatory measures, information measures and subsidies; policy stringency. • Facility characteristics: size, environmental impacts of pollution, department or officer responsible for environmental concerns.	• Environmental innovation activities are not associated with EMS implementation or any other single policy instrument. • Innovation behaviour seems to be mainly correlated with the stringency of environmental policy.
HORBACH, J. (2008)	Two German Panel database – 753 firms Institute for Employment Research (IAB), 2001 and 2004 - 4,846 firms Mannheim innovation panel (MIP) of the Centre for European Economic Research (ZEW)), 2001	The paper aims to explore the determinants of environmental innovations.	• Age, demand, environmental management tools, high qualified employees, overtime worked, profit situation, region, R&D, size, subsidies, sector dummies.	• The improvement of technological capabilities through R+D triggers environmental innovations. • Environmental regulation, environmental management tools and general organizational changes also encourage environmental innovation.

AUTHOR	DATA SET	MAIN FOCUS	KEY VARIABLES	MAIN RESULTS
HORBACH, J., RAMMER, C. and RENNINGS, K. (2011)	German CIS of 2009 - 7,061 firms from industrial and service sectors, and an additional telephone survey – 1,294 firms	The paper tries to test whether different types of eco-innovations (according to their environmental impacts) are driven by different factors.	• Policy measures: regulations, subsidies. • Self-commitment of industry. • Customer demand, cost savings. • Technology push: knowledge capital and infrastructure, environmental management systems. • Organizational innovations. • Information sources. • Cooperation. • Competition conditions. • Other control variables	• Current and expected government regulation is particularly important for pushing firms to reduce air, water or noise emissions, avoid hazardous substances and increase recyclability of products. • Cost savings are an important motivation for reducing energy and material use. • Customer requirements are another important source for eco-innovations, especially products with improved environmental performance and process innovations that increase material efficiency, reduce energy consumption and waste and the use of dangerous substances. • Firms confirm a high importance of expected future regulations for all environmental product innovations.

AUTHOR	DATA SET	MAIN FOCUS	KEY VARIABLES	MAIN RESULTS
KAMMERER, D. (2009)	Online survey of 92 German firms in the sector of electrical and electronic appliances, 2004-2006	The paper seeks to understand environmental product (EP) innovation by introducing and testing a novel research framework: EP-innovation is studied specifically for four environmental issues relevant to the target industry; customer benefit is included for the first time as explanatory variable; it measures the extent and level of novelty of EP-innovation.	• Regulatory stringency. • Customer benefit. • Green capabilities: certified EMS, use of products' environmental attributes in marketing, voluntary environmental targets for products, systematic environmental analysis of products environmental training for product developers. • Control variables: size, R&D expenditure.	• The results support the issue level as unit of analysis. • Customer benefit and regulation play a key role for environmental product innovation. • These factors also foster their broad application and their level of novelty.
KESIDOU, E. and DEMIREL, P. (2010)	1,566 UK firms - Government Survey of Environmental Protection Expenditure by Industry 2005-2006	This paper provides empirical insights on the drivers (environmental regulations and supply and demand side factors) of eco-innovations (decision and level investment)	• Demand side factors: Corporate Social Responsibility (CSR) and customer requirements. • Organizational capabilities: Environmental Management Systems (EMS). • Stringency of environmental regulations • Size, sector. • Abatement expenditure, cost savings, equipment upgrade.	• Demand factors affect the decision of the firm to undertake eco-innovations but not the level of investments in eco-innovations. • Increased investments in eco-innovations are stimulated by other factors such as cost savings, firms' organizational capabilities, and stricter regulations. • The stringency of environmental regulations affects eco-innovations of less innovative firms differently from those of the more innovative firms.

AUTHOR	DATA SET	MAIN FOCUS	KEY VARIABLES	MAIN RESULTS
MAZZANTI, M. and ZOBOLI, R. (2006)	Two surveys of 199 manufacturers firms in Emilia Romagna (north of Italy), 2002 and 2004.	The paper seeks to enhance empirical evidence at firm microeconomic level of exogenous and endogenous factors to spur environmental innovation.	• Structural variables: size, share of revenue in international markets, share of final market production, sector. • Environmental R+D. • Environmental policy and regulation costs. • Eco-auditing schemes. • Network activities. • Other organizational and technological innovations (no environmental): total quality management, technological process and product innovation; formal training employee coverage; organizational structure. • Quality / nature of industrial relationships.	• The structural characteristics of firms and their performance are less important than R&D, induced costs, networks, organizational routines and industrial relationships oriented to innovation. • Environmental policy and voluntary audit programs reveal important direct and indirect effects, although evidence is mixed.

AUTHOR	DATA SET	MAIN FOCUS	KEY VARIABLES	MAIN RESULTS
RAVE, T., GOETZKE, F. and LARCH, M. (2011)	Large scale anonymous survey among 1,572 firms on the manufacturing industries from Amadeus database and 612 from the regular innovation survey of the Ifo Institute for Economic Research, 2007 and 2009	The paper provides new evidence on the objectives and determinants of different types of innovations and patents, environmental as opposed to other innovations and patents. It also investigates how firm-specific and sector-specific driving forces differ by innovation type, and outlines the functions that different innovation types have for environmental and innovation policies.	• Size, age, EMS. • No obstacle: cost, demand, information, personnel, partner, rigidities, capital, legal, subsidies. • Objective: new products, more products, market, new market, technology, cost. • Determinant: technology, market, new markets, networks, firm, energy costs, environmental regulation, society, subsidies, demand, society.	• Eco-innovations pay relatively more attention to the reduction of energy and resource costs compared to other innovators. • Cost pressure and predictable and strict framework conditions of environmental policy are an important driver for incremental, firm-level eco-innovations. • Patented eco-innovations are driven by the opportunity to create new markets and by government subsidies.
REHFELD, K-M., RENNINGS, K. and ZIEGLER, A. (2007)	Survey on 558 German firms from six manufacturers sectors 2002/2003.	The paper examines the relationship between environmental organization measures that are considered IPP-measures by the European Commission and environmental product innovations.	• IPP-measure variables: EMS, waste disposal of own products, life cycle assessment, eco-label • Compliance with environmental policy • R&D activities • Market pull variables: Customer satisfaction, exports • Firm characteristics: ISO 9001, size, age	• Certification of environmental management systems has a highly positive effect in environmental product innovations. • Measures related to waste disposal and take back systems of own products are more important drivers for environmental product innovation. • Other factors such as environmental policy, technology push and market pull factors, as well as other specific characteristics have a positive influence on environmental product innovation.

AUTHOR	DATA SET	MAIN FOCUS	KEY VARIABLES	MAIN RESULTS
RENNINGS, K., ZIEGLER, A., ANKELE, K. and HOFFMAN, E. (2006)	Telephone survey – 1,277 EMAS validated German manufacturing facilities, 2002	The paper examines the effects of different characteristics of EMAS on technical environmental innovations.	• Maturity of EMS. • Strategic importance of EMAS. • Learning processes by EMS. • Organizational scope of EMAS. • Technical environmental innovations and environmental organizational measures. • Environmental innovation targets. • Importance of factors for economic performance. • Facility-specific variables: age, size, employee qualification, share of turnover with industrial customers, share of exports, legal independence. • Industry • Domestic region (country)	• The maturity of environmental management systems and the strong participation of specific departments in the further development of EMSA such as the R&D department are important determinants of environmental process innovations. • Learning processes by EMS have a positive impact on environmental product innovations. • Learning processes and environmental process innovations have a positive influence on economic performance.
WAGNER, M. (2007)	342 German manufacturing firms, data collected during a survey on the state of environmental management in practice and patent data (41,112 patents), 1999-2004	The paper analyses the relationship between environmental innovations, environmental management and patenting.	• Firm characteristics: sector, age, size, quality management system. • Environmental management system index. • R&D intensity • Degree of environmental concern of stakeholders.	• The implementation level of environmental management systems has a positive effect exclusively on environmental process innovation. • The implementation level of EMS is negatively associated with the level of a firm's general patenting activities. • There is a positive relationship between environmental product innovation and patented environmental innovations with environmental concerned stakeholders, and a negative link with environmentally neutral stakeholders.

AUTHOR	DATA SET	MAIN FOCUS	KEY VARIABLES	MAIN RESULTS
WAGNER, M. (2008)	European Business Environment Barometer (EBEB), 2001 (Belgium, France, Germany, Hungary, Holland, Norway, Swede, Switzerland, United Kingdom).	The paper analyses the hypothesis that environmental management systems and managerial activities to reduce negative environmental impacts which are not part of EMS have a positive influence on the probability of firms to carry out environmental innovations.	• Firm characteristics: sector, age, size, quality management system. • Environmental management system index. • Managerial activities: informing consumers, market research on green products, eco-labelling.	• Environmental management systems are linked to process innovations. • Providing information to consumers and eco-labelling activities are positively associated to product innovation. • Market research on the potential of environmental innovation is positively related to both process and product innovation. • Firm's size does not seem to affect the possibility to develop product or process environmental innovations.