

## Management, Technological Innovation and Environmental Benefits in French Manufacturing Firms

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### **Abstract**

*This paper aims at studying the benefits of forms of innovations on the environment. Using two waves of Community Innovation Survey - CIS datasets, we are able to investigate the impact of four forms of innovations (Product, Process, Organizational and Marketing) during the 2004-2006 period on two types of environmental benefits (for the firm and for the end user) during the period 2006-2008. Our findings indicate that product innovation has no significant impact on environmental footprint whereas three other forms: process, organizational and marketing innovations have a positive and significant impact. Companies that implement specific procedures dedicated to measure and control their environmental impact are more prone to reduce their negative outcomes on the environment.*

**Keywords:** *Environmental Innovation; Forms of Innovation; Determinants; Empirical analysis; France.*

**JEL codes:** *Q55; D22; C10.*

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### **Introduction**

Firms have received a lot of pressure from different market actors (e.g. customers, stockholders, governments, etc.) to improve their impact on the environment. One of the major components by which firms could act in harmony with the environment is through investment in different kinds of environmental innovations. Currently, environmental innovations seem to have increased in quantity and quality. Many (overlapping) reasons could explain these phenomena such as - increasing consciousness regarding the impact of economic activities on the "ecological" environment, - regulations such as constraints and/or incentives to develop greener innovations, - internal incentives and strategies like cost reductions and/or market opportunities enabling to develop new eco- friendly products and increase sales and revenues. Moreover, investment in environmental innovation is often seen as the fastest and most cost-effective way to achieve competitive advantage on the market (e.g. Porter and van der Linde, 1995). Not surprisingly, environmental innovation and its policy implications has become a rich field of investigation. This previously mentioned literature underlines the importance of environmental innovation investment. However, there are relatively few studies that capture empirically the features that increase a firm's probability to invest in environmental innovation. Our research aims to answer the following questions: Which forms of innovations lead to which kind of environmental benefits? Is there a time lag between forms of innovations and environmental benefits? It is important to investigate the policies that encourage investment in environmental innovation in order to reduce the impact on the environment since these policies may differ from "traditional" innovations (Horbach, 2008). To answer empirically these questions we include in our analysis those factors that have been recorded in the relevant literature as

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possible incentives of environmental innovation investment. Then we turned to the literature on forms of innovations (product, process, organizational, marketing) and their associated environmental benefits for the firm and for the end-users.

This paper contributes to the existing literature in several ways. The limited empirical evidence related to the environmental innovation determinants led us to further investigate their nature and their intensity. What is more, we follow previous theoretical literature to explicitly categorize the factors that contribute to environmental innovation. Finally, we investigate the impact of the four different forms of innovation in period (t) on the introduction of innovation with environmental benefits in period (t+1). This time effect will then permit to study the strategies that aimed to reinforce the environmental outcomes of the firms. To our knowledge, this is also the first paper that examines this topic using a two-period sample of French manufacturing firms.

## **Literature Review**

Environmental innovation could be defined as "the introduction of a new or significantly improved product (good or service), process, method of organization or marketing, that generate an environmental benefit, compared to existing solutions" (OECD, Oslo manual, 2005). Environmental benefits can be the principal objective of the innovation or the outcome of an innovation aiming at achieving other objectives. Rennings (2000, p. 322) defined environmental innovation as "... measures of relevant actors (firms, ..., private households), which: (i) develop new ideas, behaviour, products and processes, apply or introduce them, and (ii) contribute to a reduction of environmental burdens or to ecologically specified sustainability targets". This kind of innovation is usually characterized as a process encompassing three major stages: invention, innovation and diffusion (Jaffe et al., 2002; del Río, 2009) and different actors, including users, manufacturers, suppliers and policymakers (del Río, 2009).

In order to examine which factors may influence on a firm's decision to invest in environmental innovation, we first review the literature concerning environmental innovation which will help us to theoretically identify four main factors that are associated to environmental innovation investment. (cf. del Río, 2009 for a literature review). Benefits and costs of environmental innovation: Environmental innovation would simultaneously be beneficial for the environment and for the firms, as it has been suggested by Porter and van der Linde (1995). However, empirical research shows contrasting conclusion indicating that environmental innovation is too costly which will influence negatively a firm's business performance (Walley and Whitehead 1994; Konar and Cohen, 2001). Environmental public policies (Incentives/Regulations) factors: The studies concerning the impact of public policies on environmental innovation are not conclusive. For instance, the results of Hemmelskamp (1999) suggest a negative influence of public policies on environmental innovation while Cleff and Rennings (1999) and Rehfeld et al. (2007) find a positive effect. This could be due to (i) differences in the variables and indicators used to measure regulations (pressures/ incentives) and their impact (strength/(perceived) stringency), (ii) differences in industries and countries' characteristics and (iii) differences in the type of environmental issues addressed and benefits associated to these innovations. It can also be argued that companies might postpone the decision to develop environmental innovation because they anticipate new regulations. Market driven factors: Another set of drivers that would motivate environmental innovation relates to the demand. Firms might develop green innovation that provides environmental benefits for their customers (Wagner, 2007; Praest-Knudsen et al., 2011). As indicated by Reinhardt (1998), firms may invest in environmental innovation to differentiate their products from others and thus gain a competitive advantage. What is more, consumers are ready to pay additional prices for green products. Internal strategies / environmental management systems (EMS) / capabilities factors: Here we include firm's internal strategies associated with green innovation investment. This covers several dimensions: (i) the

willingness to reduce (internal) costs (ex: energy consumption, packaging, waste, etc.) (e.g. Frondel et al., 2005), (ii) the adoption / implementation of environmental (quality) management systems, (e.g. EMAS, ISO 14000) (e.g. Rennings et al., 2006; Wagner, 2009; Ziegler and Nogadera, 2009), which have been viewed as a facilitator and seem to have a positive impact on environmental process innovations. However, the causality between these systems and technological environmental innovations is not clear (Ziegler, 2009).

Literature relating environmental innovation' forms (product, process, organizational, marketing) and their benefits is flourishing (Galia et al., 2015). For example Horbach (2008) states e.g. that improvements of technological capabilities (Knowledge Capital) by R&D triggers innovations (R&D) and that The introduction of new or relevant changes of organizational structures (organization) is especially important for environmental innovations. Kammerer (2009) argues that green products, besides their public benefits have private benefits for the customers. Praest Knudsen, Gertsberger, Stampe (2011) show that while market attention is important for new product development, green aspects of innovation and efficiency considerations for innovation are important for the energy efficiency of the production companies. They argue that product innovation and energy efficiency is a balancing act and that focusing on one will have detrimental effects on the other.

### **Empirical Analysis**

In order to investigate environmental innovations and related forms of innovation (Product, Process, Organization and Marketing), we use information from two waves, CIS 2008 and CIS 2006, of the Community Innovation Survey (CIS) – “Enquête Communautaire sur l’Innovation” for France carried out by INSEE (National Institute for Statistics and Economic Studies). CIS data are based on firm-level surveys that ask organizations to provide on their level and form of innovative efforts. These surveys are based on the Oslo Manual drawn up by the OECD, and revised in 1996. Although definitions of innovation and examples are provided to respondents, all the information relies on self-reported information by managers within these organizations (OECD, 2005). Overtime, CIS has become a central tool for researchers working on understanding the innovation process (see Smith, 2005 and Mairesse and Mohnen, 2002).

CIS 2008 covers the 2006-2008 period and include for the first time specific information on environmental benefits for the firms<sup>1</sup>. The survey population included 25,000 firms, drawn manufacturing, services and construction sectors. It was a mandatory survey and it received a response rate of 86 percent, including 7,389 firms from manufacturing sector. The last part of the CIS 2008 dedicated to environmental innovations concerned 4,412 innovative firms. Innovative firms are defined as firms that introduced at least one innovation among the four forms of innovation: Product, Process, Organization and Marketing<sup>2</sup>.

CIS 2006 covers the 2004-2006 period for 4,821 manufacturing firms. CIS 2006 is used to define all independent and controls variables in 2004 in order to avoid reverse causality with dependent variables. The originality of the paper is that using both waves of CIS we are able to investigate the impact of the four different forms of innovation in period

(t) on the introduction of innovation with environmental benefits in period (t+1). This time effect will then permit to study the strategies that aimed to reinforce the environmental outcomes of the firms. Merging CIS 2008 and CIS 2006, 1,361 innovative firms are used to analyze the characteristics of firms introducing environmental innovations related to the different forms of innovation (Product, Process, Organization and Marketing).

Innovation performance is investigated by four main types: product innovation, process innovation, organizational innovation and marketing innovation. The most introduced innovation is organizational

innovation (70%). Product innovation and Process innovation are introduced by six out of ten firms (respectively 67% and 61%). Marketing innovations concerns four firms out of ten (44%). A third of firms (33%) implement procedures that aimed at measuring and reducing their environmental impact. 86% of firms are operating in international markets and 81% of firms belong to a group. For 79.1% of innovative manufacturing firms, innovation has impact(s) on the environment (for the firm and/or for the end-users). This suggests that environmental issues and concerns are central for the majority of innovative firms. Environmental benefits can be produced in the production process (for 65.2% of innovative firms having developed an innovation with environmental benefit(s) for the firm) as well as during their use by end-users - consumers (42.5% of innovative firms having developed an innovation with environmental benefit(s) for end-users). This shows that environmental innovations led by French manufacturing firms are much more oriented towards process; they are internally oriented.

Environmental benefits for the firms: Looking in more details at innovations with environmental benefits for the firms, the intensity is in average 2.8 out of 6 environmental benefits. We find that more than half of innovative manufacturing firms introduced innovations dedicated to recycled waste, water or materials (58.6%) and that replacing materials with less polluting or hazardous substitutes concerns 50.3% of innovative firms. Reducing materials use per unit of output is introduced by 48.6% of innovative firms. Reducing energy use per unit of output and reducing soil, water, noise or air pollution concerns respectively 48.2% and 47.3% of innovative firms. The last environmental benefit for firms is the reduced CO2 footprint by 35.2% of innovative firms. Environmental benefits for the firms indicate that recycling comes first and is followed by benefits that are directly associated to cost reductions (energy, packaging/unit). This is in line with the motivations/reasons presented below. Benefits relating to the reduction of gas emissions and pollution - air, water, soils or noise - are less frequently cited. It may be argued that this might be associated to the adoption of codes of good practices and existing environmental regulations and taxations. Finally, the "frequency" of types of benefits is similar (except for recycling, the most frequently mentioned by respondents, and gas emission CO2, the less frequently mentioned).

Environmental benefits for end-users: The intensity of environmental benefits for the end-user is in average 0.9 out of 3. 36.1% of innovative firms introduced innovations for end-users dedicated to reduce energy use. Improving recycling of product after use is introduced by 29.9% of innovative firms. Reducing air, water, soil or noise pollution concerns 29.1% of innovative firms. These three benefits are relatively low (29% to 36% of firms) compared to the benefits for the firms (35% to 58% of firms). The main environmental benefit for end-users/customers is the reduction of energy use. This result is surprising, because benefits produced during the use of the innovation by customers are present for 61 % of innovative firms having developed an innovation with environmental benefit(s). This could be due to the limited number of items presented in the questionnaire (3 items). Another explanation is that green innovations in French firms would be primarily oriented towards the internal benefits discussed above, and process innovations and/or that their environmental innovations to the benefit of their customers would be limited. To conclude this section, descriptive statistics indicate that environmental innovations by French innovative manufacturing firms are mainly internally oriented (process innovations) and primarily aim at reducing costs. Firms' behaviors regarding environmental innovations seem to be reactive (external pressures/drivers like existing regulations) rather than proactive.

We explain the six environmental benefits for innovative firms and the three environmental benefits for end-users using probit models. These nine models include the four innovation types Product innovation, Process innovation, Organizational innovation and Marketing innovation as independent variables and the following control variables: Firm performance, Size, R&D, Environmental procedures, International market, Group membership and Sectors.

Product innovation in 2004-2006 has no impact on the environmental benefits for the firms in 2006-2008 period. We find that firms that introduced Process innovation are more likely to introduce all the 6 types

of innovation with environmental benefits in the 2006-2008 period except replaced materials with less polluting or hazardous substitutes. In other words, firms with new product(s) have no benefits for the environment, whereas firms that changed their way to produce reduce significantly their impact on the environment. Firms that introduced Organizational innovation within 2004 and 2006 impact positively and significantly the benefit associated to the reduced energy use per unit of output in the future period 2006-2008. Marketing innovation has a positive and significant influence on the three environmental benefits associated to the reduced CO2 footprint, replaced materials and recycled waste, water and materials. This imply that implementing new ways to organize the work within the firm and implementing new ways to design, package and distribute the products will permit to the firm to reduce significantly their impact on the environment in the future. Furthermore, firms implementing Environmental procedures in the 2004-2006 period are more likely to introduce all the 6 types of innovation with environmental benefits in the 2006-2008 period. This confirms previous studies investigating exploring environmental innovations.

The two types of technological innovation, Product innovation and Process innovation, in 2004-2006 have no impact on the environmental benefits for the end-users in 2006-2008 period. In that case, firms with new product(s) and/or new way(s) to produce have no environmental benefits for the customer. Technological innovations will not permit to the firm to reduce its environmental footprint in the future. Firms that introduced Organizational innovation within 2004 and 2006 impact positively and significantly the benefit associated to the reduced air, water, soil or noise pollution and the one associated to the recycling of product after use. Marketing innovation has a positive and significant influence on the two benefits for the customer associated to the reduced energy use and the one associated to the recycling of product after use. New organizations within the firm and new ways to design, package and distribute the products will permit for the customer in the future to reduce significantly the product's energy used, the product's pollution and will increase the recycling of the products. Looking to the control variables, we observe that Size have a positive and significant impact on environmental benefits for the customer. Furthermore, firms implementing Environmental procedures in the 2004-2006 period are more likely to introduce all the 3 types of innovation with environmental benefits in the 2006-2008 period. These results indicate that larger firms and that are undertaking environmental strategies are also more likely to impact positively the environment. The amount of R&D reduces the energy use and improves the recycling of the products. Group membership has no impact on environmental benefits.

## **Conclusion**

This paper has permitted to identify the firm's characteristics that influence the environmental benefits of innovations. Process, organization and/or marketing innovation have a significant and positive impact on the environmental benefits for the firms. Only organizational and marketing innovations have a positive and significant impact on environmental benefits for end-users. We can conclude that innovation strategies can lead to environmental benefits in the sense that the company should not only focus on environmental policies but also on innovation policies. Companies can reduce their environmental footprint by introducing new ways to produce, new ways to organize and/or new ways to market their products. Furthermore, we found that companies that are proactive in using specific environmental procedures are more prone to master their environmental impact. These results and main implications open research avenues to further investigate the links between environmental and innovation policies. The objectives of these policies would be to inform and support firms in their effort to reduce their environmental footprint and, at the same time, support innovation in a competitive context. Innovation is an opportunity for firms to be aware of their environmental footprint and to change their behavior in order to reduce their negative impact on the environment.

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