Paper to be presented at the DRUID Academy 2012

on

January 19-21
at
University of Cambridge /The Moeller Centre

The determinants of eco innovative performance according to firms' strategic profiles : The case of French Industrial Firms

Simon Nadel
Université Toulouse 1
Lereps
simon.nadel@univ-tlse1.fr

Abstract

The aim of this article is to analyse the factors that influence French industrial firms in their eco-innovation behaviour and, using a general model as a basis, to build three models of adoption of eco innovations according to whether the motives for eco innovation are related to demand, costs or regulation. An econometric model for analysing the characteristics that are conducive to the adoption of eco innovations, on the one hand, and those that positively influence the intensity of firms' environmental innovation performance is tested using individual data on innovation that is representative of the French industrial sector (CIS8). The results highlight the structuring role of firms' internal characteristics, the co-evolution with other forms of innovation and the influence of firms' external environment on their eco-innovation performance. They show that these factors have different effects depending on firms' strategic profiles.

Jelcodes:O33,O

The determinants of eco innovative performance according to firms' strategic profiles: The case of French Industrial Firms

PAPER IN PROGRESS

Danielle GALLIANO[1*] and Simon NADEL[2]

[1]Institut National de la Recherche Agronomique (INRA-AGIR), BP 52627, 31326 Castanet Tolosan cedex, France. Tél : +33 (0)5 61 28 53 66 ; Fax : +33 (0)5 61 28 53 72 ; galliano@toulouse.inra.fr

[2]Université de Toulouse, UT1, LEREPS, 21, allée de Brienne, 31042, Toulouse cedex, France. Tél : +33 (0)5 61 12 87 09 ; Fax : +33 (0)5 61 12 87 08 ; simon.nadel@univ-tlse1.fr

Abstract : The aim of this article is to analyse the factors that influence French industrial firms in their eco-innovation behaviour and, using a general model as a basis, to build three models of adoption of eco innovations according to whether the motives for eco innovation are related to demand, costs or regulation. An econometric model for analysing the characteristics that are conducive to the adoption of eco innovations, on the one hand, and those that positively influence the intensity of firms' environmental innovation performance is tested using individual data on innovation that is representative of the French industrial sector (CIS8). The results highlight the structuring role of firms' internal characteristics, the co-evolution with other forms of innovation and the influence of firms' external environment on their eco-innovation performance. They show that these factors have different effects depending on firms' strategic profiles.

Key words: Environmental innovation, firm strategy, demand pull, regulation, cost savings, French industry

1.Introduction

According to the literature, and in a very large sense, environmental innovation consists of new or modified processes, techniques, systems and products to avoid or reduce environment damage and which contribute to environmental sustainability (Arundel et al, 2005, Horbach 2008). Driven by strong institutional and regulation related constraints (Rennings, 2000) and by increasing market pressure (Beise and Rennings 2005), environmental innovations are above all processes that develop and co-evolve with firms' overall strategies and more specifically with their innovation strategy. Following Porter's footsteps, the literature highlights three large categories of determinants of eco-innovation adoption: a regulatory push/pull effect – considered in the literature on Environmental innovation as largely dominant and precursory; and the "Market pull" or "technology Push" effects (Rennings 2000), two more traditional determinants identified in innovation economics literature. In this context, though many studies have sought to reveal the role of these three key determinants in firms' eco innovation behaviour, few have analysed the micro economic foundations of these strategic profiles. This dimension is all the more important as it can help to gain a better understanding of the structural and strategic foundations of eco-innovative behaviours and, as a result, to better guide public policies.

The purpose of this article is to analyse the factors that influence French industrial firms' behaviour in terms of environmental innovation adoption and, on the basis of a general model, to build three models of adoption so as to test the existence of different determinants according to the motive for innovating, i.e. respond to a cost related need, a demand from one's clients or an existing or even future regulation. Our goal is to better understand the foundations of the three strategic profiles of environmental innovators described in the literature. In this context, we will seek to highlight the role of firms' organizational structure, in its different internal and external dimensions, for each of these profiles. At the internal level, beyond the structural characteristics that are supposed to condition firms' technological bases and informational structure, we shall focus on revealing the role of the processes of co evolution of eco innovation and other forms of innovations: product or process innovations, but also organizational changes (changes in the organization of labour and in firms' relationships with external partners). Furthermore, the decision to eco-innovate results from the interaction between these internal factors and the different dimensions of the firm's environment. The sectoral dimension, as well as the market and geographic environment are determinants that have a structural role in a firm's behaviour both in terms of adoption and in terms of the intensity of their eco innovative performance.

An econometric model enabling us to analyse the characteristics that positively influence innovative behaviour, on the one hand, and those that condition the intensity of the firm's environmental performance on the other, is tested using individual data on innovation, representative of the French industrial sector. The results highlight the structuring role of firms' internal characteristics and of those of its external environment in its environmental performance. We intend to build - on the basis of a general model - different models of adoption of environmental innovations depending on the motives for adoption: respond to a demand from one's clients, to a cost issue or regulation related need.

To test our hypotheses, we use the case of French industrial firms and individual data from the « 2008 Community Innovation Survey » conducted by the INSEE in 2008, combined with the data from the Annual Survey of Firms conducted in 2007. The CIS 2008 survey enables us to test the determinants of eco innovation adoption and of innovation intensity for all the firms of the French manufacturing sector and all types of eco innovators.

This article is structured into four sections. The following section presents our theoretical framework, based on the adoption models and the specifications of the empirical model. Section 3 describes the data, variables and econometric model. Finally, section 4 presents the results of the general model of the French industrial sector, and then the three profiles of innovators.

2. The determinants of environmental innovation : Theoretical framework and hypotheses

2.1 The models of adoptions

The literature on environmental innovations has developed around two main contributions : that of Porter's hypotheses (Porter, 1991, Porter and van den Linde, 1995) and that of Rennings' notion of « double externality » and of « regulatory push/pull effect » stemming from it (2000).

Porter, with a « win win » approach, seeks to put an end to the opposition between ecology and economy, by bringing to the fore the fact that environmental innovation (following an environmental regulation) has the potential to have a double positive impact in terms of environment and of competitiveness.

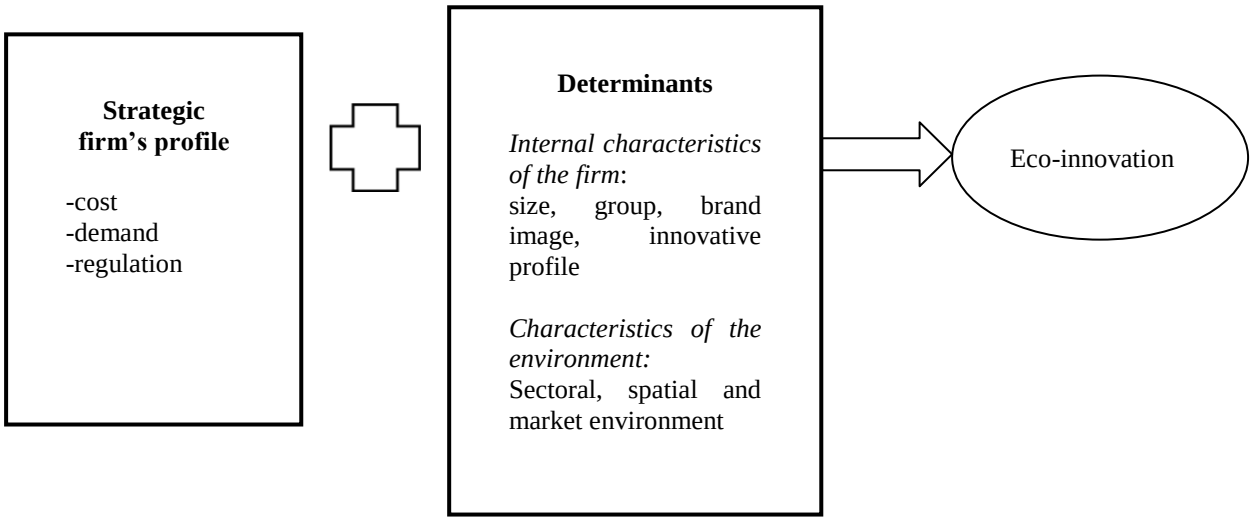
In parallel to this, Rennings, in an approach combining neoclassic theory and evolutionism, discusses the important role of regulation through the notion of « double externality » : one important specificity of eco innovations is that they produce positive spillovers in both the innovation and diffusion phases. The positive spillovers in the diffusion phase appear due to a smaller amount of external costs compared to competing goods and services on the market […] This peculiarity is called the *double externality* problem. The double externality problem reduces the incentives for firms to invest in environmental innovations. » (Rennings 2000, p. 315). In other words, it is this weakness of the incentive to eco-innovate that makes the role of regulation central to the development of environmental innovation, contrary to the case of classic innovation. From this specificity stems the importance of regulation - « the regulatory push-pull effect » - as a determinant of adoption of eco-innovations.

Apart from the regulatory dimension of « regulatory push/pull », which is specific to environmental innovation, the literature agrees in considering two other large categories of more traditional determinants – in innovation economics : « market pull » and « technology push », two concepts introduced, in particular, by Schon (1967). On the one hand, innovation is « pulled » by the level and the structure of the demand the firm faces. This « market pull » or « demand pull » dimension is particularly important for the firms for which satisfying the demand is critical (Griliches 1957 ; Schmookler 1962, 1966). On the other hand, a firm is encouraged to innovate, in a Schumpeterian perspective, by dimensions related to the supply and to technological evolutions, and more generally as a result of issues related to cost competitiveness : it is the « technology-push » dimension.
Pavitt (1984) articulates both categories of factors by showing that the « technology push » aspect is essential in the first stages of a product's life cycle, whereas the market related factors are so only in the diffusion phase.
Thus, the literature on environmental innovation agrees that beyond the traditional factors of the « market pull » and « technology pull » types highlighted in the literature on the economics of technical innovation, the factors related to regulation, of the type « regulatory push pull », are determinant (Rennings, 2000, Belin et al, 2009).

In this context, our goal is to test three models of innovation related behaviours, according to the firms' adoption profiles described in the literature : a « market pull » profile (pulled by the demand), a « technology push » profile and finally a « regulatory push pull » profile. These strategies of environmental innovation do not exclude one another but are « typical profiles » that can be tested empirically – which has seldom been done in the literature.

Finally, we note that the geographic factors have almost no impact on the adoption of environmental innovations: the geographic location of a firm's head office is no significant, with the exception of a very small negative effect - for firms that adopt innovations for demand related reasons - of being located in a rural area ; indeed, those firms are, quite logically, more turned towards consumption zones. The non significant effect of the location area tends to show the specificity of environmental innovations in relation to other types of innovations. They seem to be sensitive to the combined influence of knowledge spillovers, which are generally more urban, and the importance of the production zones, which are often located in peripheral areas. The adoption rate of firms in the same geographic area has no influence either on the firms' behaviour in terms of eco innovation adoption. The sectoral epidemic effects are the only ones that have an impact.

Figure 1 : The determinants of eco-innovation behaviour



2.2. The factors explaining environmental innovations

In their micro economic dimension, innovation processes are fundamentally cumulative and interactive and the organizational architecture of a firm plays a central role. It pertains to the analysis of the internal and structural characteristics of firms, their strategic behaviours and internal as well as external coordination systems. These characteristics constitute, in the innovation diffusion models, a set of factors that condition firms' behaviour in terms of innovation (rank effect, Karshenas and Stoneman, 1993) and their absorption capacity (Cohen and Levinthal, 1989). They are related to firms' internal specific technological characteristics (&2.2.1). In parallel to this, the decision to engage in environmental innovation is also shaped by many external factors related to the different aspects of the firm's environment - whether it be regulatory, sectoral, commercial or geographic – involving, as the geography of innovation has shown, relations of proximity and local exchanges of knowledge as determinants for eco-innovations adoptions (&2.2.2).

2.2.1The internal, structural and strategic characteristics of the firm : the technology push effects

The hypothesis is that firms possess their own specific characteristics - their size, the fact that they belong to a group or not, the fact that they invest in R&D – which constitute resources and pre conditions of their engagement in an innovation process. The relations between a firm's size and environment innovation have been the object of many research studies, many of which have emphasized a positive relation between both factors (Rehfeld et al. 2007, Rave et al., 2011). Some studies show the absence of effects (Horbach, 2008, for product eco innovations) or the existence of a U-shaped relationship between firm size and environmental innovations (Hemmelskamp, 2000). Small firms are generally organizations with a lower endowment of financial, human or technological resources than large firms and they may lack the internal expertise to develop eco-innovations. In the same vein, belonging to a group can foster innovation and help firms overcome the difficulties they experience during the innovation process (Lhuillery 2008).

Hypothesis 1 : the size of a firm and its belonging to a group should have a positive effect on its propensity to engage in eco-innovation.

Research has extensively shown the importance of consumers' behaviours, and particularly their need to be reassured about the quality and safety of the products they purchase and to be assured that the latter have no harmful impact on the environment (for a survey, refer to Srivastava, 2007). In this context, firms introducing new products can incur high marketing and advertising expenses to inform consumers (Verbeke, 2005). A firm's advertizing rate can provide information about the intensity of its investment in its identify (promotion of its brand image, information about quality, etc), and therefore about its role in the process of adoption of eco-innovations. This issue has been little researched. In this context, our goal is to test the relation between advertising and eco-innovation and to determine whether firms that invest a large proportion of their sales in advertising have a lower (substitute) or higher (complementary) probability of engaging in eco-innovation.

Hypothesis 2 : The promotion of the brand image is positively related to the adoption of eco innovations and to their intensity.

The eco-innovative behaviour of a firm strongly depends upon the firms' other internal resources, keeping in mind the idea of complementary with other types of innovation, whether they be product, process or organizational innovations. In keeping with Milgrom and Roberts (1990, 1995), Rennings (2000) stresses the co-evolution of the different forms of environmental innovations. Thus for Mazzanti et al. (2007), Wagner (2007) or Belin et al. (2009), organizational innovations are positively related to adoption or to the production of environmental innovation. We observe in particular that the generalization within firms of Environmental Management Systems (EMS), through the introduction of ISO 14001 standards for example, is frequently integrated in the econometric models that seek to better understand firms' behaviour in terms of eco innovation. Thus, it is considered, in many studies (Frondel et al. (2004); Mazzanti et al. (2006) ; Rehfeld et al. (2007); Wagner, 2008), as a positive factor of environmental innovation. Horbach, et al. (2011) show that EMS significantly trigger environmental innovation as well as "general organizational changes as new forms of organizational labour". For more about this question, see Ramirez, Khanna et al (2008) who link the adoption of EMS to the Total Quality management systems.

Hypothesis 3 : The adoption of environmental innovations is positively influenced by the firm's innovation profile and its innovation intensity. Environmental innovation and organizational changes, particularly, co-evolve.

2.2.2 The factors related to the firm's external environment : Regulatory, Market and Geographic effects

A firm's interaction with its environment is a key factor of innovation and of its dynamics. Thus, different dimensions of the environment can be examined in order to gain a better understanding of firms' decision to eco-innovate and of the intensity of their eco-innovative performances.

The sectoral and commercial environment in which a firm's activity is conducted is a variable that is often put forward in the literature to characterize the technological bases of the firm. As noted by Carillo et al. « Technological alternatives and eco-innovation opportunities are likely to differ per sector » (2009). These technological opportunities are also more or less appropriable and can foster the development of more or less radical or incremental innovations. The sector also provides an environment for the development of specific regulatory frameworks. In terms of environment, quality standards, taxes and effective obligations at sectoral level are many. For example, firms that belong to sectors subjected to the *community emission quota exchange* system, such as chemistry, are financially sanctioned if their carbon dioxide emission exceeds the allowed volume (Directive 2033/87/CE). The evolutionist literature talks of an « environmental regime », which helps in understanding the importance of the sectoral dimension of the eco-innovative behaviour. For Belin, Oltra and Horbach (2009) : « the environmental regime captures the level and the source of environmental pressure in a given industry. [...] » For these authors, an environmental regime is characteized by indicators such as emission intensity but also by the policy context : the type, number and stringency the industry is subject to.
The empirical literature often takes account of the sector to highlight the technological environment in which the firm operates (Malerba 2005). Its influence as a variable explaining firms' behaviour in terms of eco-innovation is emphasized by Mazzanti et al (2006) and Wagner (2007). It is a traditional control variable in the literature on the determinants of environmental innovation (Frondel et al, 2007, Horbach, 2008 ; Horbach et al., 2011).

Hypothesis 4 : The sectoral environment, through its regulation framework, its technological opportunities and conditions of appropriability, plays an important role in firms' behaviour in terms of eco-innovation.

On the issue of market structures, there is little consensus in the literature concerning the question of the impact of the degree of market concentration on firms' eco-innovative performances and there is ambiguity with respect to which type of market structure leads to higher probabilities of innovating (Smolny 2003). As claimed by Horbach, “on the one hand, an increasing demand in the past and high capacity utilization indicate growing markets in the future (Horbach 2008), on the other hand , in periods of slack demand “non production activities such as the reorganization of production processes, R&D and training exhibit less opportunity costs in case of excess capacities (Smolny 2003)”.
Furthermore, several studies show the influence of the geographical dimension of the market and particularly on the positive effect of international exchanges on eco-innovation (Belin et al, 2009). Whereas for Rhefeld et al. (2007, p.98) exporting has no influence on the adoption of product eco innovation. For Horbach (2008) as well as for Conceicao et al (2006), in the case of Portuguese firms, high export shares have an impact: firms that are highly exposed to international competition are more likely to innovate.

Hypothesis 5 : Market concentration and international openness can favor eco innovations

With regard to firms' spatial environments, many studies that make use of the geography of innovation emphasize the role of agglomeration externalities and of proximity in the diffusion of innovations and knowledge (Feldman and Audresht 1996). It highlights different types of spatial externalities following the idea that diversified cities offer different benefits as compared with specialized areas (Jacobs' urban agglomeration effects, 1969 versus Marshall's location effects, 1890). Rural areas which, on the contrary, have a disadvantage related to the weakness of inter-firm relations, to the lack of diversity of human capital and of knowledge externalities (Massard et al. 2006, Galliano and Roux, 2006). On the other hand, the studies analyzing the determinants of eco innovation are still few and very recent. Costantini, Mazzanti and Montini (2011) integrate a regional variable to compare the environmental performances of the different Italian regions. A possible « industrial district » effect is mentioned by Mirat and Eimteirah, who suggest that « industrial symbiosis networks » play a role in the diffusion of eco innovation. This dimension is therefore little explored in the literature and presents various potential effects. The question is, among others, to test whether it is the traditional agglomeration economies that play in favor of eco innovation. Or can we on the contrary assume that the correlation between eco innovations and productive activities is sensitive to the geographic division of labour whereby productive activities are mostly located in peripheral areas (Ota and Fujita) and promotes the opportunities of realization of environmental innovations in these areas.

Hypothesis 6 : Environmental innovation varies according to the firm's geographic location

The question of externalities pertains more generally to that of the effects of networks and of firms' processes of adoption and of absorption of technologies developed by other firms located in their environment. Epidemic models assume, among other things, that a potential user can become a user by being in contact with an actor who has adopted the innovation. Thus, the larger the number of « adopters », the higher the probability for a « non-adopter » of being in contact with one adopter, and the higher of the former of getting « contaminated » (Hollenstein, 2004). These epidemic effects of neighborhood can be sector related in nature when a large part of the sector's firms use the technology in question, but they can also be spatial and relative to geographic neighborhood. This dimension has been little tested, with the notable exceptions of Mohr (2002) and later of Mads Greaker (2006), who take into account the role of spillovers in the diffusion of the effects of environmental regulation among the firms of the same sectors.

Hypothesis 7 : The adoption of environmental innovations by a firm is positively influenced by the level of eco-innovation adoption by the firms of the same sector or located in the same geographic area.

Finally, the intensity of environmental innovation is related to the firm's strategy. Beyond the generic factors mentioned, we can propose the hypothesis that the impact of the independent variables varies according to the firms' strategies. Thus, if the firm decides to eco-innovate for motives related to demand, cost or regulation issues, the factors influencing the firm's eco innovation behaviour will not be the same. The firms that produce or adopt environmental innovations in order to respond to demand related questions will tend to be sensitive to variables such as the brand image and the location of the main market. On the other hand, these factors do not seem to be significant in the adoption of innovations by firms whose goal is to reduce their expenses or to comply with regulations. A contrario, the firms that eco-innovate in order to comply to existing regulations or to anticipate future regulations will have a higher propensity to develop incremental innovations (« end of pipe ») than to make radical ones (« cleaner production »). As for the attempt to reduce costs, it will positively influence radical innovations. Thus, for Frondel et al. (2007) : « cost savings tend to favor clean production and (…) regulatory

measures and the stringency of environmental policy are positively correlated to end-of-pipe technologies ». Similarly, in the case of the firms of one sector subjected to specific sectoral regulations, we can make the hypothesis that the eco innovation performance of firms that adopt innovations for motives related to regulation will be highly correlated to sector related variables.

Hypothesis 8 : The determinants of innovation, and particularly the internal and environmental characteristics, vary according to the firm's strategy (demand, cost and regulation)

3. Data and methodological

3.1 Data

This study rests on data from two mandatory public surveys conducted by the French National Institute of Statistics (INSEE). The Community Innovation Survey (CIS8), is a declarative survey whose purpose was to understand the innovations performed by firms during the last three years (2006-2008). It makes it possible to characterize the different innovation processes that take place within firms, while taking into account the influence of the environment. Thus, we have a database of 4583 firms of 20 employees or more, representative of the French industrial manufacturing population.

Table 1 : Descriptive statistics

	Total Firm	Eco-innovative firms
Internal characteristics of the firm		
Size		
20 to 49 employees	39.40 %	24.87 %
50 to 249 employees	29.97 %	30.40 %
250 to 500 employees	17.49 %	23.06 %
More than 500 employees	13.15 %	21.68 %
Group	61.94%	74.54 %
Innovative profile		
Radical Innovation	11.97%	18.63 %
Incremental Innovation	12.63%	17.99 %
Incrémental/radical	19.60 %	33.56 %
Process innovation	42.80 %	70.05 %
Change in labour organisation	34.23 %	54.09 %
Change in inter-firm relations	17.16 %	28.64 %
EMS before 2006	16.76%	28.55%
EMS during the period 2006-2008	18.12 %	31.82 %
Characteristics of the environment		
Main market location		
Regional market	24.98%	16.14 %
National market	53.50%	54.83 %
Foreign Market	21.52%	29.03 %
Sector Agrofood C1	18.65 %	16.46 %
Consumer relatied activities C2	24.79 %	20.53 %
Equipement C3	17.10 %	20.66 %
Transport C4	5.10 %	5.43 %
Intermediates activities C5	34.36 %	36.91 %
Head office location :		

Urban	57.58 %	60.50%
Peri-urban	17.84 %	16.84 %
Rural	24.58 %	22.66 %

Sources : 2008 CIS and 2007 EAE surveys

3.2 The method

3.2.1. The model of adoption

To identify the factors of choice and intensity of eco-innovation, we will proceed in two steps. First, we apply a probit model, which can highlight the factors relating to the choice of adopting eco-innovation. Then in a second step, we make an ordered probit model that will allow to identify the elements relative only to the eco-innovative firms, thus enabling the highlighting factors on the intensity of eco-innovation.

The realization of a probit model allows to highlight the determinants of the choice of adopting eco-innovation by firms, differentiating adopters of non adopters. The probit-type models are used to explain a dichotomous dependent variable with the latent model is:

$$Y_i^* = \beta X_i + \varepsilon_i$$

Where X_i is a vector of independent variables

β is the vector of parameters to be estimated

ε_i the residual error, which follows a normal distribution

If Y *> 0 then the firm has developed an eco-innovation: Y the is observed variable indicating if is the firm is eco-innovative; Y is equal to 1 if the firm has adopted or produced at least one environmental innovation .

$$\begin{cases} Y_i = 1 \text{ si } Y_i^* > 0 \\ Y = 0 \text{ si } Y^* \leq 0 \end{cases}$$

The probability that the firm is eco-innovative is :

$P(Y_i=1) = P(Y_i^*>0) = P(\varepsilon_i = \gamma X_i) = \phi(\gamma X_i)$ with ö the distribution function of the normal distribution. This probability can be estimated by a probit model that allows us to assess the weight of the various determinants contained in X that influence the propensity of firms to eco-innovate.

3.2.2 The intensity model

Ordered probit models are used in the case of ordered and exclusive multinomial qualitative variables [59]. The outcome of our dependent variable are 0, 1,…, 9, for which a linear regression would treat the difference between a 3 and a 2 in the same as that between a 2 and a 1, whereas in fact they are only a ranking. The dependent variable measuring the intensity of environmental innovation is explained by the measurable factors x_i and certain unobservable factors ε_i. The model is built around a latent regression in the same manner as a binomial probit:

$$y^*_i = x'_i \beta + \varepsilon_i$$

Then, y^* is unobserved. What we observe is y, which provides incomplete information about y^* according to:

$$
\begin{aligned}
y_i &= 0 \quad if \quad y^* \leq 0 \\
&= 1 \quad if \quad 0 < y^* \leq \mu_1 \\
&= 2 \quad if \quad \mu_1 < y^* \leq \mu_2 \\
&\quad : \\
&= J \quad if \quad \mu_{J-1} \leq y^*
\end{aligned}
$$

where $j = 0, 1, \ldots, J$ represent the different modalities of the endogenous variable. The μ are unknown parameters (cut points between scores) to be estimated along with the parameter vector β. As in binomial probit models, the term ε_i is normally distributed across observations, the following probabilities are obtained:

$$\text{Prob}(y_i = j|x_i) = \Phi(\mu_j - x'_i \beta) - \Phi(\mu_{j-1} - x'_i \beta)$$

where Φ is the cumulative distribution function of the standard normal distribution.
As in probit models, ordered probits are estimated using a maximum likelihood procedure, and coefficients cannot be directly interpreted, only their sign indicate in which direction the probability change.

3.3 The variables

This section present, first of all, the dependent variables, which will be divided according to the type of eco-innovator ; and then the independent variables, which will be divided into different groups according to whether they are related to the firm's internal management or pertain to the latter's external environment.

3.3.1 The dependent variables.

This work involves three dependent variables : i) the probability of adoption, ii) the intensity of adoption (via a score variable) and iii) the three environmental innovation profiles.

i) To begin with, we estimate the probability that a firm is engaged or not in eco-innovation, using the dichotomous variable « AdopteIE ». The latter was created using the data from the CIS 2008 survey and takes value 1 if to at least one of the nine questions related to the firm's eco-innovating performance, the answer is « Yes » ; it takes value 0 otherwise (See table 1).

ii) Secondly, a SCORE variable is built to evaluate the intensity of eco innovation within firms. This involves using a qualitative ordered polytomous variable characterizing the intensity of the eco innovation adoption. The INSEE defines environmental innovation, using 9 modalities : 6 concerning innovation during the production process and 3 concerning innovation in the consumption process (See table 2).
Within the production process, one can distinguish two types of environmental innovations : those associated to questions of productivity of the resources (associated to the decrease in the input/output ratio and to the reduction of the energy consumption per output unit) and those relative to the reduction of environmental externalities. This has to do with the reduction of carbon dioxide emission by the firm, with the elimination of « polluting » or « dangerous » input , the reduction of ground, air and water pollution and the recycling of waste, water and raw materials.
Furthermore, the INSEE considers that a firm eco innovates if the innovation generates an environmental benefit during the consumption process ; a benefit that can take three forms : A reduction of the product's consumption of energy when it is being used ; a

reduction the ground, air or water pollution and, finally, better recycling of the products once they have been used.

The endogenous IE score variable has the following form :

$Y_i = 0$ if there is no environmental innovation
$Y_i = 1$ if there is one environmental innovation
$= 2$ if there are two environmental innovations
.
.
$Y_i = 9$ *if the firm has undertaken all 9 types of environmental innovation*

Table 2 : Descriptive statistics on the different types of environmental innovation

	Total firms	**Eco-innovative firms**
Environmental benefits from the production of goods within the firm		
Reduced material use per unit of output	28,43%	56,72%
Reduced energy use per unit of output	26,41%	52,69%
Reduced CO 'footprint' (total CO production) by the firm	17,86 %	35,64%
Replaced materials with less polluting or hazardous substitutes	29,43%	58,72%
Reduced soil, water, noise, or air pollution	26,71%	53,29%
Recycled waste, water, or materials	35,76%	71,36%
Environmental benefits from the after sales use of a good by the end user		
Reduced energy use	20,56 %	41,03 %
Reduced air, water, soil or noise pollution	16,67 %	33,26 %
Improved recycling of product after use	18,16 %	36,23 %

Sources : 2008 CIS and 2007 EAE surveys

iii) Finally, we create three dependent variables, in order to characterize the sub-categories whose motivations for innovating differ ; we do this on the basis of questions 11.2 of the CIS2008 survey (see table 3) :
- « Adopt-cost » which takes value 1 if the firm reports having eco-innovated with « the goal of reducing costs », 0 otherwise.
- « Adopt-demand » which takes value 1 if the firm has eco-innovated « in response to a demand by clients to make environmental innovations », 0 otherwise.
- « Adopt- regulation », which takes value 1 if the firm reports to have eco-innovated in response to « existing environmental regulations or taxes on pollution » ; « environmental regulations or taxes which you expect will be applied in the future » or « the existence of governmental aids, subsidies or other financial incentives to engage in environmental innovations », 0 otherwise.
These three types of motives for eco-innovation are not exclusive from one another and the firm can be engaged in innovation for several reasons. Nevertheless, these three strategies do not overlap and most firms have one dominant strategy with regard to their eco innovation activities (see table 3).

Table 3 : Relations between the sub-categories : Populations of innovation adopters according to the motive for adoption

		Adopters-cost		Adopters-regulation	
		0	**1**	**0**	**1**
Adopters-cost	**0**			*2875*	*540*
	1			*430*	*858*
Adopters-demand	**0**	*3147*	*733*	*3092*	*788*
	1	*268*	*555*	*213*	*610*

Sources : 2008 CIS and 2007 EAE surveys

3.3.2 The independent variables

In the adoption models, we use three sets of independent variables to analyze firms' behaviours in terms eco innovation. With regards to the firms' internal structural characteristics, the variables are the size of the firm (sub-category), the fact that the firm belongs or not to a group of companies, and the advertising rate, calculated through the advertising expenses to sales ratio. The second set of variables pertains to the firm's innovation profile. The information is mostly about the occurrence of organizational changes relative to the organization of production, of labour and the changes in the firm's relations with its external environment. The 2008 CIS survey data then enables us to observe the importance of the implementation of the Environmental Management System (preparation for environmental audits, decision on goals of environmental performance to pursue, ISO 14001 certification) according to whether the adoption of the EMS occurred before 2006 or during the period of observation of environmental innovations (i.e. between 2006 and 2008). Finally, several factors enable us to test the hypotheses proposed concerning the process of co-evolution between the different forms of innovations: the adoption of product innovation (radical, incremental or both) and the adoption of process innovations. These different variables, which help us draw firms' innovation profiles constitute determinants that favor firms' engagement in eco innovation and its intensity.
The third set of variables pertains to the firm's external environment, with first of all, its sector of activity, calculated at level 17 of the 2008 French Nomenclature of Activities, which classifies the various industrial activities into six main groups of activities. The sectoral or spatial epidemic effects are measured by the ratio of eco-innovation adopters to the total number of firms belonging to the same sector or located in the same geographic area. Furthermore, with regard to the firm's commercial environment, class variables enable us to measure the impact of the market's location (regional, national, foreign) and the competitive dimension will be calculated through the index of market concentration (C4 index). Finally, in order to test the location effect, we use the area of location of the head office with three modalities : location in urban, peripheral and rural areas.

The explicative variables of the innovation intensity model are the same as those used in the adoption model ; We add to these variables the « adopte-cost », « adopte-demand » and « adopte-regulation » variables, which in this model become dependent variables.

4.The results

4.1Adoption behaviour and intensity of envrionment innovation of the French industrial sector as a whole

The general econometric model (table 4) shows us the importance of the firm's internal characteristics and of their environment, respectively, in the process of adoption of eco innovation and in the latter's intensity.
Thus, the probability of a firm engaging in an eco innovation process increases with the size of the firm ; and small firms of fewer than 50 employees are at a disadvantage in terms of choice and also in terms of intensity ; this latter point is relatively original in that a small size is often recognized as having a positive influence on innovation intensity. Furthermore, the advertizing rate, which is revealing of a strategy of brand image promotion, is also positively related to eco innovation. The results tend to show their complementarity and the fact that advertising influences the engagement in innovation rather than its intensity. Finally, the innovation profile of the firm plays a major role. The results show that radical innovation has a stronger impact than incremental innovation on the adoption of eco innovations (marginal effects of 0.187 and 0.088 respectively). They reveal the positive and significant effect of the organizational changes undertaken in the firm's relations with its external environment, and above all of the changes conducted in the firm's labour organization. With a marginal effect of 0.063, changes in labour organization is more influent in eco innovation adoption than firm's relations with its external environment, with a marginal effect of 0.022. Particularly visible here is the co-evolution of the eco innovation adoption and the implementation of the Environmental Management System, that is in agreement with Wagner (2007) results. Indeed, if the EMS was set up between 2006 and 2008 – ie during the observation period and therefore during which environment innovations were developed – the marginal effect is highly superior (0.24) to the marginal effect of the pre-2006 implementation of the EMS (0.14). On the other hand, the adoption of a EMS before the observation period has a more significant impact on the intensity of the eco innovation as observed between 2006 and 2008 than it does if it occured during this observation period ; This points to a path dependence and a learning process that positively influence the intensity.

As for the environment, it also has significant effects on firms' probability to eco-innovate and on the intensity of the eco innovation (Table 4). With regard to the commercial environment, market concentration has a stimulating influence on adoption but has no effect on the intensity, which seems to be influenced, rather, by the firms' openness to international markets. Thus, focusing exclusively on local and regional markets is not conducive to eco innovation. The results also highlight the influence of the firm's geographic location and the fact that, contrary to what literature traditionally reports, being located in a peripheral area have a more significant positive impact than agglomeration effects on eco innovation. The fact that a firm's head office is located in a peripheral or rural area is more conducive to adoption than being located in an urban center. As far as intensity is concerned, being located in a peripheral area have a positive impact, but there seems to be no difference between urban and rural firms in terms of their eco-innovation performance. As for the sectoral environment, it has a significant impact on adoption; in particular a firm in the intermediate goods sector has a higher probability of engaging in eco innovation than a firm in the agribusiness sector. Let us note that, during our observation period, belonging to the transport sector has a particularly negative influence on the decision to engage in innovation. However, the sectors have a lesser and less discriminating influence for the explanation of the intensity of eco-innovation. The epidemic effects are positive and significant both on the decision to innovate and on the intensity of innovation at both the levels of the sector and of the geographic environment of the firm. Thus, the mimetic effects related to the behavior of firms located in the same environment as a given firm also have an influence on environmental innovation performance.

Table 4 : The general model : adoption and intensity of eco-innovation by French industrial firms

	Eco-innovation adoption Coeff	Marginal effects	Intensity of eco-innovation
Internal characteristics of the firm			
Size			
20 to 49 employees	Ref.	Ref.	Ref.
50 to 249 employees	0.187***	0.022	0.125***
250 to 500 employees	0.235***	0.029	0.0997*
More than 500 employees	0.226**	0.028	0.171***
Group	-0.0270		-0.0348
Brand image	1.996***	0.21	0.906*
Innovative profile			
Radical Innovation	0.928***	0.187	0.579***
Incremental Innovation	0.555***	0.088	0.373***
Incremental/radical	0.797***	0.148	0.465***
Process innovation	0.941***	0.19	0.629***
Change in labour organisation	0.820***	0.136	0.437***
Change in inter-firm relations	0.301***	0.031	0.427***
EMS before 2006	0.770***	0.14	0.435***
EMS during the period 2006-2008	1.092***	0.24	0.408***
Adoption goal			
Adoption for costs			0.890***
Adoption for the demand			0.561***
Adoption for regulation			0.864***
Characteristics of the environment			
Market environment			
Main market location			
Regional market	Ref.	Ref.	Ref.
National market	0.151***	0.020	0.120***
Foreign Market	0.210***	0.026	0.211***
Market concentration	0.173***	0.018	0.0321
Sector environment			
Sectors : Agrofood C1	Ref.	Ref.	Ref.
Consumer relatied activities C2	0.0134	0.001	0.0268
Equipement C3	0.114*	0.013	0.0550
Transport C4	-0.238***	-0.020	-0.0714
Intermediates activities C5	0.283***	0.031	0.145***
Sector adoption rate	0.0913***	0.009	0.0704***
Spatial environment			
Geographic area adoption rate	0.0891***	0.009	0.0497***
Head office location : Urban	Ref.	Ref.	Ref.
Peri-urban	0.103**	0.004	0.0792**
Rural	0.120***	0.004	0.0347
Constant	-2.895***		
Observations	4583		4583
Pseudo R^2	0.433		0.275
Cut points			
cut1			2.029***
cut2			2.375***
cut3			2.778***
cut4			3.236***
cut5			3.613***
cut6			4.068***
cut7			4.406***
cut8			4.779***
cut9			5.156***

Sources : 2008 CIS and 2007 EAE surveys, with * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

4.2The determinants of adoption of environmental innovation according to strategic profile of the firm

Beyond the general determinants of adoption and of eco innovation intensity, we have divided the populations according to three types of behaviour such as they are described in the literature : the "adopter-cost", the "adopter-demand", and the « adopters- regulation». Our objective is to test whether the determinants related to the firm's internal characteristics and those related to their environment have a specific impact. For this purpose we build three probit models on each sub population, so as to test for the existence of different determinants according to the motive for the eco innovation adoption, i.e. respond to a cost related need, a demand from one's clients or an existing or even future regulation. (see table 5).

Table 5 : The determinants of adoption of environmental innovation according to the goal of the adopters

	Adopters-cost		**Adopters-demand**		**Adopters-regulation**	
	Coeff.	M.E*	Coeff.	M.E	Coeff.	M.E
Internal characteristics of the firm						
Size						
20 to 49 employees	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
50 to 249 employees	0.142***	0.013	0.0174		0.182***	0.015
250 to 500 employees	0.211***	0.020	0.179**	0.008	0.347***	0.033
More than 500 employees	0.220***	0.021	0.351***	0.018	0.461***	0.049
Group	0.0440		-0.0512		-0.0718**	-0.005
Brand image	-0.234		-2.764***	-0.097	2.376***	0.166
Innovative profile						
Radical Innovation	0.396***	0.045	0.573***	0.038	0.389***	0.039
Incremental Innovation	0.247***	0.025	0.486***	0.029	0.402***	0.041
Incrémental/radical	0.407***	0.046	0.765***	0.061	0.498***	0.055
Process innovation	0.531***	0.067	0.474***	0.028	0.567***	0.066
Change in labour organisation	0.511***	0.063	0.341***	0.017	0.394***	0.040
Change in external relations	0.225***	0.022	0.176***	0.008	0.281***	0.026
EMS before 2006	0.525***	0.066	0.365***	0.019	0.682***	0.087
EMS during the period 2006-2008	0.586***	0.073	0.681***	0.050	0.961***	0.152
Characteristics of the environment						
Market environment						
Main market location						
Regional market	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
National market	0.147***	0.013	-0.0240		0.0536	
Foreign Market	0.174***	0.016	-0.209***	-0.006	0.0927*	0.007
Market concentration	0.108***	0.009	-0.0540		0.0971***	0.007
Sector environment						
Sectors Agrofood C1	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Consumer relatied activities C2	-0.147***	-0.010	0.436***	0.025	0.00722	0.149
Equipement C3	-0.0854		0.405***	0.022	-0.0392	
Transport C4	-0.0751		0.556***	0.036	0.0597	
Intermediates activities C5	0.0177		0.393***	0.016	0.0840*	0.006
Sector adoption rate	0.0775***	0.006	0.0584**	0.002	0.0448*	0.005
Spatial environment						
Geographic area adoption rate	0.00255		-0.0252		0.0107	
Head office location : Urban	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Peri-urban	-0.0393		-0.0581		0.0410	
Rural	0.0141		-0.0881*	-0.003	0.0249	
Constante	-2.383***		-2.212***		-2.402***	
Observations	4583		4583		4583	
Pseudo R^2	0.236		0.236		0.292	

Sources : 2008 CIS and 2007 EAE surveys, with * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. M.E : Marginal effect

With regard to the firm's internal characteristics, we note, first of all that although the size (ie. the fact that a firm is large) has an overall positive role in the general model (see table 4), it has a different impact depending on the sub-population (see table 5). In terms of marginal effects, the size has a weaker impact for firms that adopt for demand related reasons than for those that adopt for cost or regulation related reasons. The correlation between the size and adoption is particularly significant for the firms that are sensitive to existing or future regulation. The latter are also distinguished by the negative effect of belonging to a group; the firms that adopt eco innovations for regulation related reasons are therefore, more specifically, independent firms. Furthermore, we note that the brand image, which has a significantly positive effect in the general model, is a variable that strongly differentiates the sub populations. It has no effect in the case of firms that adopt for cost related reasons ; it has a highly negative impact for the « adopters-demand », and a highly positive effect in the case of firms that adopt for regulation related reasons (with marginal effects of -0.097 and 0.166 respectively). This could translate the fact that the brand image is complementary to the eco innovation for the firms that eco innovate in order to respond to a regulation related requirement, whereas it pertains to a substitutability relation in the case of adopters-demand.
In terms of innovation profile, the results show that radical product innovation has a stronger impact than incremental innovation for the firms that adopt for cost or demand related reasons, which is in keeping with the general model. However, we observe an inverse correlation for the « adopters-regulation». Thus, consistent with the existing literature, the results show that regulation tends to be more conducive to end-of-pipe innovation than to « cleaner production » types of innovation (Frondel et al., 2007). Coevolution between organizational innovations and environmental innovations, observable with the EMS implementation during the innovation adoption period (2006-2008) exists for the three strategic profiles, being in particular strong for the "adopters-regulation". Concerning the impact of changes in firm's labour organization, it is for each strategic profile stronger than changes in firm's relations with external environment, particularly for the adopters-cost.

With respect to the environment, the results emphasize that the sector based behaviours differ according to the motive for the adoption. For the « adopters-costs », the sector to which the firm belongs has no impact (with the exception of the consumer related activity sector ; for the « adopters-regulation » the sector has no impact either (with the exception of the intermediate goods sector). However, each sector has a highly significant and positive influence on the adoption of eco innovations in relation to the agribusiness sector, for the firms that eco innovate in order to respond to demand related needs.
As for the market area, it was positively correlated to the implementation of eco innovations in the general model. And this is true in particular of the « adopters-costs» and « adopters-regulation» sub-categories. But it is not the case for the « adopters-demand » for which responding to the demands of a foreign market, rather than to those of a regional market, has a highly significant and negative impact on the implementation of eco innovations, while responding to the needs of a national market has no influence in terms of adoption.
Finally, we note that the geographic factors have almost no impact on the adoption of environmental innovations: the geographic location of a firm's head office is no significant, with the exception of a small negative effect - for firms that adopt innovations for demand related reasons - of being located in a rural area. Indeed, those firms are, quite logically, more turned towards consumption zones. The non significant effect of the location area tends to show the specificity of environmental innovations in relation to other types of innovations. They seem to be sensitive to the combined influence of knowledge spillovers, which are generally more urban, and the importance of the production zones, which are often located in peripheral areas. The adoption rate of firms in the same geographic area has no influence either on the firms' behaviour in terms of eco innovation adoption. The sectoral epidemic effects are the only ones that have an impact.

4. Conclusion

The purpose of this article has been to analyse the factors that influence French industrial firms' behaviour in terms of environmental innovation adoption and, on the basis of a general model, to build three models of adoption so as to test the existence of different determinants according to the motive for innovating, i.e. respond to a cost related need, a demand from one's clients or an existing or even future regulation. Our goal is to better understand the micro economic determinants of the three strategic profiles of environmental innovators described in the literature. An econometric model enabling us to analyse the characteristics that positively influence innovative behaviour, on the one hand, and those of the intensity of the firm's environmental performance on the other, is tested using individual data on innovation, representative of the French industrial sector (CIS8).
The results of the general model highlight the structuring role of firms' internal characteristics and of those of its external environment in its environmental performance and the different processes at play in firms' engagement into eco-innovation activities and their intensity. They show that the factors of adoption strongly differ according to the dominant strategy implemented, the most marked difference being between the strategic profiles of firms that innovate for demand related reasons and those that do so for regulation related reasons.

Thus, the firms that innovate for demand related motives are, for the most part, large firms, turned towards local, mostly urban markets. Their adoption behaviour is negatively influenced by their being turned to foreign markets. Implementing strategies for promoting their brand image through advertising also has highly significant and negative effect on firms' decision to engage in eco-innovation activities. They are little affected by the market concentration but are influenced by sectoral dynamics ; we note, in particular, that belonging to the agribusiness sector has a highly negative impact. This profile is therefore relatively different from the intuitions on the basis of which it was created (Market pull).

The adoption of eco-innovations by firms that innovate for motives pertaining to regulation is, on the contrary, positively influenced by their openness to foreign markets and by the market concentration, but is little affected by the firms' sector adoption rate and geographic environment. They are generally large or medium sized firms, rely on strategies designed to promote their brand image, are characterised by a strong development of EMS practices during the observation period and the changes and innovations they implement tend to be process innovations. This profile reveals not only the compliance to regulation but also the importance of the firms' pro-actively anticipating it and using it as a part of a strategy of communication and of promotion of the brand image.

Finally the firms that innovate for cost related reasons have an intermediate profile. For these firms, being small, focusing exclusively on local and regional markets, and belonging to the consumer goods sector decreases the probability of eco innovating. The non significant effect of belonging to a group and of relying on a brand image promotion strategy distinguishes them other types of innovators and enhances the highly positive impact of their innovative activity at all levels (the role of radical innovation, of process or organizational innovations, of the past adoption of EMS. In keeping with Milgrom and Roberts (1990, 1995) this profile is characterized by the importance of the learning processes and of the co evolution of the different forms of innovation.
These results show that each profile presents specific factors, internal and external characteristics, which make each of them unique and carry their innovative behaviour. This microeconomic dimension allows us to better understand the structural bases and strategic behaviours of different profiles of eco-innovators, all confronted to the double externality problem. This way, we can

drive better environmental regulations and policies, fundamental in the management of the double externality issue.

Appendix 1 : Variables description

Variables	Description
Internal characteristics of the firm	
Size (n. of employees)	Qualitative variable with 4 modalities: 20 to 49 employees (reference); 50 to 249; 250 to 499; and more than 500
Group	= 1 if the firm is the subsidiary of a group, 0 if independent
Brand Image	The logarithm of the total advertisement expenses / turnover excluding taxes
Innovative profile	
Product Innovation -Radical Innovation -Incremental innovation -Radical /Incrémental	 = 1 if the innovation is new for the market = 1 if the innovation is new only for the firm = 1 if the innovation is new for the firm and the market
Process Innovation	= 1 if the firm introduces a process innovation, 0 otherwise
Change in labour organisation Change in external relations	= 1 if the firm introduces new methods of organising work responsabilities and decision making, 0 otherwise = 1 if the firm introduces new methods of organising external relations, 0 otherwise
Environmental Management System EMS before 2006 EMS during the period 2006-2008	 =1 if implementation of a EMS before 2006, 0 otherwise =1 if implementation of a EMS during the period 2006-2008, 0 otherwise
Characteristics of the environment	
Market environment	
Main market location	Qualitative variable with 3 modalities : Regional market (reference) ; National market; Foreign market
Market concentration	Logarithm of the C4 concentration ratio : cumulated market shares of the first four firms in the sector (at the NAF 700 level)
Sector environment	
Sector	Qualitative variable with 6 modalities: Agrofood (ref);Consumer related activities ; Equipement ;Transport ; Intermediates activities
Sector adoption rate	The logarithm of the average rate of eco-innovation adoption by the firms of the same sector
Spatial environment	
Geographic area adoption rate	The logarithm of the average rate of eco-innovation adoption by the firms located in the same département
Head office location	Qualitative variable with 3 modalities for the location of the firm's head office : Urban area (reference); Peri-urban area; Rural area

Appendix 2 : descriptive statistics on eco-innovation intensity

Number of eco-innovations	**Frequency**	**Percentage**
0	2,346	49.88 %
1	301	6.40 %
2	344	7.31 %
3	363	7.72 %
4	310	6.59 %
5	285	6.06 %
6	223	4.74 %
7	185	3.93 %
8	144	3.06 %
9	202	4.30 %
Total	**4703**	**100**

References :

Arundel, A, Kemp R., and Parto S. (2005) Indicators for Environmental Innovation: What and How to Measure, in International Handbook on Environment and Technology Management (ETM), edited by D. Marinova, J. Phillimore and D Annandale, Edward Elgar, Cheltenham,)

Autant-Bernard, Mangematin V. and Massard N.,(2006). "Creation of Biotech SMEs in France," Small Business Economics, Springer, vol. 26(2), p.173-187

Belin, J., Horbach. J and Oltra V, (2009). "Determinants and specificities of eco-innovations – An econometric analysis for France and Germany based on Community Innovation Survey." Working Paper DIME (DIME Workshop on Environmental Innovation, industrial dynamics and entrepreneurship).

Beise, M. and Rennings K. (2005). "Lead markets and regulation: a framework for analyzing the international diffusion of environmental innovations." Ecological Economics **52**: p.5-17.

Carrillo-Hermosilla, J., Del Rio Gonzalez P. and Könnöla T. (2009). Eco-Innovation Whensustainability and competitiveness shake hands. New York, Palgrave MacMillan.

Cohen, W., and Levinthal, D., (1989), "Innovation and Learning : the two faces of R&D", Economic Journal 99.

Costantini, V., Mazzanti M., and Montini A. (2011). "Environmental performance, innovation and regional spillovers." Quaderno DEIT n.3.

Conceicao, P., Heitor, M., and Vieira, P. (2006), " Are environmental concerns drivers for innovation?" Interpreting Portuguese innovation data to foster environmental foresight" Technological forecasting & social change, 73, p.266-276.

Feldman, M. and Audretsch D.(1999) "Innovation in cities:: Science-based diversity, specialization and localized competition," European Economic Review, Elsevier, vol. 43(2), p. 409-429.

Frondel M., Horbach J. and Rennings K, (2007) "End-of-pipe or Cleaner production? An empirical comparison of environmental innovation decisions across OECD countries, Business strategy and the environment 16, P.571-584.

Galliano D., Roux P., (2006), "Les inégalités spatiales dans l'adoption des TIC : le cas des firmes industrielles françaises", Revue Economique, vol 57, n°6

Greaker, M. (2006). "Spillovers in the development of new pollution abatement technology : a new look at the Porter-hypothesis." Journal of Environmental Economics and Management **52**: p.411-420.

Griliches Z. (1957) Hybrid Corn: An Exploration of the Economics of Technological Change.Technology, Education and Productivity: Early Papers with Notes to Subsequent Literature, p. 27–52. New York: Basil Blackwell, 1988 [1957].

Karshenas M. and Stoneman P. (1993),"Rank, Stock, Order, and Epidemic Effects in the Diffusion of New Process Technologies: An Empirical Model," RAND Journal of Economics, The RAND Corporation, vol. 24(4), pages 503-528.

Hemmelskamp, J. (2000), 'Environmental Taxes and Standards: An Empirical Analysis of the Impact on Innovation', in Hemmelskamp, J., K. Rennings and F. Leone, eds., Innovation Orientied Environmental Regulation. Heidelberg/New York: Physica-Verlag.

Hollenstein, H. (2004), "Determinants of the adoption of Information and Communication Technologies (ICT): An empirical analysis based on firm-level data for the Swiss business sector," Structural Change and Economic Dynamics, Elsevier, vol. 15(3), p.315-342.

Horbach, J. (2008). "Determinants of Environmental Innovations, New Evidence From German Panel Data Sources." Research Policy **ol. 37**: 163-73.

Horbach, J., Rammer C. and Rennings K., (2011). "Determinants of eco-innovations by type of environmental impact. The role of regulatory push-pull, technology push and market pull." ZEW Discussion Paper NO.11-027.

Kemp, R. and Volpi M. (2008) The diffusion of clean technologies: A review with suggestions for future diffusion analysis, *The International Journal of Cleaner Production*, 16 Supplement 1: S14-S21.

Lhuillery S. and Pfister E., (2009) "R&D cooperation and failures in innovation projects: Empirical evidence from French CIS data", Research Policy, vol. 38(1), p. 45-57

Malerba F., (2005). Sectoral systems of innovation: a framework for linking innovation to the knowledge base, structure and dynamics of sectors," Economics of Innovation and New Technology, Taylor and Francis Journals, vol. 14(1-2), pages 63-82

Marshall A. (1890), "Principles of economics", ed Macmillan

Mazzanti, M, Montini A. and Zoboli R. (2007). "Complementarities, firm strategy and environmental innovations- Empirical evidence for the manufacturing sector". DRUID Summer Conference 2006.

Mazzanti, M. and R. Zoboli (2006). "Examining the factors influencing environmental innovations." Nota di Lavoro 20.2006, Fondazione Eni Enrico Mattei.

Milgrom, P. and Roberts J. (1990). "The economics of modern manufacturing : technology, strategy and organization." American Economic Review **80**: p.511-528.

Milgrom, P. and Roberts J. (1995). "Complementarities and fit strategy, structure, and organizational change in manufacturing." Journal of Accounting and Economics, Elsevier, 19(2-3), April: p.179-208.

Mirata M. and Emtairah T., (2005), Industrial symbiosis and the contribution to environmental innovation : The case of the Landskrona symbiosis programme, Journal of cleaner production 13, p.993-1002.

Mohr, J. (2002). "Technical change, external economies, and the Porter hypothesis." Journal of Environmental Economics and Management **43**: 158-168.

Ota M. and Fujita M., (1993), "Communication Technologies and Spatial Organization of Multi-unit firm in Metropolitan areas." Regional Science and Urban Economics, 23, p.695-729

Pavitt, K. (1984). "Sectoral patterns of technical change: towards a taxonomy and a theory". Research Policy **13**: 343–373.

Porter, M. (1991), "American's Green Strategy", Scientific American, 264, 168.

Porter, M. and C. v. d. Linde (1995). "Green and competitive : ending the stalemate." Harvard Business Review: p.120-134.

Porter, M. and C. V. d. Linde (1995). "Towards a new conception of environment-competitiveness relationship." Journal of Economic Perspectives **9**: 97-118.

Rave, T., F. Goetzke, et al. (2011). "The determinants of environmental innovations and patenting : Germany reconsidered." Ifo Working Papers NO.97.

Rehfeld, K., Rennings K and Ziegler A., (2007). "Integrated product policy and environmental product innovations: An empirical analysis." Ecological Economics **6**: p.91-100.

Rennings, K. (2000). "Redefining innovation - eco-innovation and the contribution from ecological economics." Ecological economics **32**: 319-332.

Schmookler J. (1962). "Economic sources of inventive activity". The Journal of Economic History 2(1):19.

Schmookler J. (1966). "Innovation and economic growth", Harvard University Press, Cambridge.

Schon, D., (1967), "Technology and change : the new Heraclitus, Delacorte Press, New York.

Smolny W., (2003), "Determinants of innovation behaviour and investment estimates for west-german manufacturing firms", Economics of innovation and new technology, 12(5).

Srivastava, S., (2007) "Green supply-chain management: a state-of-the-art literature review", International Journal of management Reviews

Verbeke, W. (2005). Agriculture and the food industry in the information age. European Review ofAgricultural Economics 32(3), 347–368.

Wagner,M. (2007). "On the relationship between environmental management, environmental innovation and patenting : evidence from German manufacturing firms." Research Policy **36**: p.1587-1602.