Barriers to Environmental Innovation in SMEs: Empirical Evidence from French Firms

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Résumé :

La littérature récente explore les déterminants des innovations environnementales, en portant cependant peu d'attention à leurs obstacles. Cet article identifie dans quelle mesure les petites et moyennes entreprises (PME) perçoivent les obstacles à l'innovation avec des bénéfices environnementaux, par rapport aux obstacles liés à l'innovation technologique, en prenant en compte les types, nombres et intensités de ces barrières. En utilisant une base de données nouvelle et originale de 518 PME françaises, appariée avec la base de données Orbis, nous testons les différences d'effets d'un ensemble de barrières sur la probabilité d'introduire des innovations environnementales et technologiques non-environnementales. Nous évaluons également l'effet des barrières à l'innovation sur la probabilité d'introduire des innovations environnementales, en utilisant une méthode non-expérimentale basée sur de l'appariement, et nous montrons que les obstacles aux innovations environnementales sont non seulement plus nombreux mais également d'intensité plus forte que ceux relatifs aux innovations technologiques traditionnelles. Nous contribuons également à la littérature de deux manières en analysant, premièrement, les déterminants des innovations environnementales pour les PME, et deuxièmement, les obstacles à ce type d'innovation pour cet ensemble spécifique d'entreprises.

Mots-clés : Barrières à l'innovation ; Innovation environnementale ; PME.

Abstract:

Recent literature explores the determinants of environmental innovations, though with little attention on their obstacles. This article identifies the extent to which small and medium-sized enterprises (SMEs) perceive obstacles to innovations with environmental benefits versus obstacles to technological innovations, taking into account the types, number, and intensity of those barriers. Using a novel, original database of 518 French SMEs matched with the Orbis database, we test for differences in the effects of a given set of barriers on the probability of environmental innovation and non-environmental technological innovations. We also assess the effect of barriers to innovation on the probability of introducing environmental innovations, using a non-experimental method based on matching estimators, showing that obstacles to environmental innovations are not only more numerous but also more important than those for traditional technological innovations. We therefore contribute to the literature in two ways by analyzing, first, the determinants for SME's environmental innovations, second the obstacles to this type of innovation for this specific type of firms.

Keywords: Barriers to innovation; Environmental innovation; SMEs.

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1. INTRODUCTION

The past decade has been characterized by increasing concerns about firms' wrongdoing, especially in relation to the environment. To respond to pressures for a cleaner environment, firms can engage in environmental innovation (EI), which differs from "traditional" technological innovations in terms of externalities and drivers of its introduction. Moreover, regulations for adopting them often appear as necessary (e.g., Porter & van der Linde, 1995; Rennings, 2000; Jaffe, Newell & Stavins, 2002, 2005; Berrone & al., 2013). In line with the Porter's hypothesis, regulation has been shown to encourage EI and institutional pressures trigger such innovations even more among polluting firms (Berrone & al., 2013). The existing literature mainly explores the determinants of the adoption of several organizational practices that can reduce firms' impact on the environment. In contrast, we know little about the negative elements that hinder EI adoption. Specifically, we find limited research on their obstacles and the need for further empirical research has been stressed (Del Rio Gonzales, 2009).

To contribute to current debates on EI at both theoretical and empirical levels, we focus on obstacles to EI, investigating the possibility of transferring or adapting existing theories and conceptual frameworks (Horbach, 2008; Rennings, 2000; De Marchi, 2012) to environmental innovations, seen as more complex than other technological innovations (De Marchi, 2012). Theoretical and empirical research started to investigate the environmental benefits associated with innovations about a decade ago, including their drivers and determinants. Yet, few of them (Horbach, 2008; De Marchi, 2012) compare environmental with non-environmental innovations. Even fewer studies address these issues for small and medium-sized enterprises (SMEs) in spite of their potential contribution to environmental stakes. SMEs have less human and financial resources at their disposal than large firms, therefore more resource constraints than larger firms.

This article seeks to identify the extent to which SMEs perceive similarities or differences between obstacles to innovations with environmental benefits and obstacles to technological innovations. We take into account the types, number, and intensity of those barriers. Our research questions are as follows: What are the main obstacles to EI for SMEs? Are these obstacles specific to environmental innovations? For the purpose of this study, we conducted an original survey in the Rhône-Alpes region that we matched with the 2009–2011 Orbis data. We thereby seek to contribute to previous literature in several ways: First, we address two main dimensions of EI, namely, product and process innovations. We test for differences in the effect of a given set of barriers on the probability of EI on one hand and on the non-environmental technological innovation on the other hand. Second, we assess the effect of barriers to innovation on the probability of introducing EI, using a non-experimental method based on matching estimators. Third, our novel database of French SMEs, combined with the Orbis database, enables us to include conventional questions about innovation as well as consider various other sources and obstacles to innovation.

The rest of the paper is organized as follows. In Section 2, we present the theoretical framework and draw hypotheses about obstacles to EI compared with "traditional" innovations. We present the data and methodology in Section 3, and present the main results of the econometric models in Section 4. Finally, Section 5 discusses and concludes, providing the limitations and avenues for further research.

2. THEORICAL FRAMEWORK

Although the antecedents of environmental innovation have been well studied, including the effects of the regulatory and institutional frameworks (Porter & van der Linde, 1995; Jaffe, Newell & Stavins, 2002; Berrone & al., 2013), the factors that impede the development of EI remain unstudied, especially if we consider SMEs.

2.1. Definitions of environmental innovations

Environmental innovation has been defined in various ways according to the research tradition. Researchers include various kinds of innovation (technological, organizational, marketing, business models, etc.), according to their objectives and questions. Kemp (2010: 2) defines EI as "*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*". Rennings (2000: 322) views EI as "*measures of relevant actors (firms …) which: (i) develop new ideas, behavior, products and processes, apply or introduce them, and; (ii) contribute to a reduction of environmental burdens or to ecologically specified sustainability targets*".

EI has also been called green or eco-innovation, a broad term which also takes into account "unintended environmental innovations" (Arundel & Kemp, 2009). We here chose to use the term "environmental innovation", a more restricted expression adapted to our definition, which sees environmental innovation as a result, an output of the implemented strategy which has been assumed and decided by the firm. In this sense, "environmental innovation" seems to be more suitable to our study that other wordings such as eco-innovation. Moreover, "environmental innovation" seems to be the most used in the innovation literature (Schiederig, Tietze, & Herstatt, 2012).

For our purpose, we focus on technological innovation and approach environmental innovations as new or modified processes, products or services that reduce environmental harms (Beise & Rennings, 2005; De Marchi, 2012). This definition includes changes in products and production processes that have environmental benefits, whether those benefits are for final customers/clients (in the case of products) or the firm itself (processes). Note that this definition "*is based on the effect of the innovation activities independent of the initial intent and includes both incremental and radical improvements*" (De Marchi, 2012: 615).

2.2. Specificities of environmental innovations

Because EI is of increasing interest for both firms and scholars, the question arises as to whether it requires a specific theory and public policy or not. Environmental regulation and management tools, as well as general organizational improvements, specifically encourage EI, in line with the Porter hypothesis. We retain Horbach, Rammer & Rennings' (2012) classification of four groups of antecedents (firm-specific factors, technology, regulation, and market) to environmental innovations and review the specific empirical studies made on SMEs[1].

[1] SMEs are defined by the European Commission (2003) as enterprises that employ fewer than 250 persons and have annual turnover not exceeding 50 million euros.

2.2.1. Regulatory determinants

According to the Porter's hypothesis, a suitable regulation favors environmental innovation and may compensate related costs (Porter & van der Linde, 1995). Wagner (2003) specifies that environmental regulation has to give incentives for innovation, in particular with environmental taxes and certificates, in order to make adequate settings for the Porter hypothesis. The subsequent literature has focused on two major aspects that differentiate EI from other innovations, linked to their externalities and drivers. Rennings (2000) refers to the "double externality problem" and the "regulatory push/pull effect". Just as innovation and R&D activities are characterized by positive externalities, green innovators produce an environmental positive externality (De Marchi, 2012). Because part of the value created is appropriated by society—in the form of reduced environmental damage—rather than just by the investing firms, there is a disincentive for firms to invest in products or processes that reduce environmental impacts (see Rennings, 2000; Jaffe, Newell & Stavins, 2005). This additional positive externality may prompt a substantial lack of investment or interest on behalf of firms, because direct returns are not easy for them to reap. The additional market failure induces a greater need for policy intervention to drive the introduction of EI (Rennings, 2000). As Horbach (2008: 164) indicates, "*there is no clear economic incentive to develop new environmentally benign products and processes. Therefore, the general innovation theory has to be enlarged with respect to the analysis of the influence of environmental policy and institutional factors*." However, there seems to be a positive correlation between regulation and environmental innovations (Horbach, Oltra & Belin., 2013) and environmental regulation is seen as the first incitation for firms to develop an environmental innovation process (Del Rio Gonzalez, 2009).

For SME's, although regulation is a powerful driver for environmental innovation, environmental regulation is more arduous than for larger firms (Brammer, Hoejmose & Marchant, 2012) due to a complicated regulatory system, such as certifications, policies or institutions. On a sample of Chinese SMEs, Zhu, Wittmann & Peng (2012) find that unclear laws or regulations and excessive taxation have a hampering effect for small firms, suggesting that regulation needs to be adequate to SMEs in order to support their environmental innovation process.

2.2.2. Market determinants

There is a strong incentive for firms to engage in EI which are congruent with the "customer benefits" (Kammerer, 2009). Kesidou & Demirel (2012) indicate that firms initiate EI to satisfy minimum customer and societal requirements. Triguero, Moreno-Mondéjar & Davia (2013) show that European SMEs which collaborate with various actors are likely to increase market demand for green products. Market share has a significant positive influence on eco-product innovations. Moreover, on the demand side, consumers and other public or private actors are important to consider (Horbach, 2008). Environmental consciousness is also a relevant parameter to consider by firms which innovate (Horbach, 2008).

Due to their size, SMEs are reluctant to implement EI as lots of customers are not willing to pay more for green products or services. This is increased by the fact that they often have a smaller visibility (Bianchi & Noci, 1998). However, SMEs' investment in EI is often perceived as a means to acquire a leader position on their market (Brammer, Hoejmose & Marchant, 2012). And proximity among the firm and its customers can help to implement an environmental innovation strategy (Madrid-Guijarro, Garcia & Van Auken, 2009).

2.2.3. Technological determinants

Technological determinants are here analyzed from the technology push (supply side) view (Horbach, 2008). Improving technological capabilities through R&D triggers EI. Kesidou and Demirel (2012), using a novel data set of 1566 UK firms, agree on the necessity of organizational capabilities and on the role of the resources allocated to the environmental innovation process. Kesidou and Demirel (2012) and Horbach, Oltra & Belin (2013) find that cost savings, especially in terms of material and energy, are important incentives for EI. Likewise, Del Rio Gonzalez (2009) affirms the weight of other actors like industrials and associations, public and private actors in a cooperation process to support EI. Similarly, Wagner (2007) emphasizes the role of collaboration with environmentally concerned stakeholders. Moreover, for Wagner (2007), Horbach (2008) and Kammerer (2009), according to the Resource Based View, environmental management systems (such as ISO norms for instance) favor the EI process.

Regarding the literature on SMEs, Brammer, Hoejmose & Marchant (2012) point that they face an important challenge to implement EI. Triguero, Moreno-Mondéjar & Davia (2013) analyze the drivers of different types of EI in European SMEs, and find that supply-side factors represent a potentially more important driver for environmental processes and organizational innovations than for environmental product innovations.

2.2.4. Firms' characteristics

The literature on determinants highlights the important role of regulation and cost savings, but also of a complex set of supply factors such as the endowment and availability of technological resources (including those acquired through R&D collaboration), the firm's sector of activity (polluting or not) and its characteristics (size, age, belonging to group or not) and strategy (type of growth). Del Rio Gonzales (2009) also add exportation related variables (firms with that characteristic are more conscious of environment pressure) the sectorial characteristics.

SMEs' informal structure and management are often the result of the manager-owner's personal choices (Brammer, Hoejmose & Marchant, 2012) that impact on environmental innovation choices and strategies (Moore & Manring, 2009). SMEs have more flexibility, due to their structure and size, than large firms, which gives them more reactivity (Aragón-Correa & al., 2008). Madrid-Guijarro, Garcia & Van Auken (2009) also highlight a lower bureaucracy.

To conclude this section, the literature does not seem to highlight any real specificity of the four main types of determinants for SMEs. Our empirical test will provide further insight on this question.

2.3. Obstacles to innovation

Previous studies of obstacles to (technological) innovation do not relate to environmental innovation. They mainly aim to understand the impact of obstacles on firms' attitude toward R&D activities (Asso & Pipitone, 2010; Blanchard, Huiban & Musolesi, 2011; Mohnen & Röller, 2001; Savignac, 2008; Segarra-Blasco, Garcia-Quevedo & Teruel Carrizosa, 2008;

Hyytinen & Toivanen, 2005; Mohnen & al., 2008; Wziatek-Kubiak & Peczkowski, 2011)[2]. Several barriers arise, mainly linked to uncertainty and the associated costs of innovation activities.

Pioneering research on barriers to innovation carried out for the Commission of European Communities includes contributions from several researchers in eight European countries (Piatier, 1984). The major barriers to innovation in European firms related to the education system and skilled labor, the effect of venture capital and banks on financing innovation, and the influences of norms, legislation, and public bureaucracy. In Canada, Baldwin and Lin (2002) study obstacles to advanced technology adoption among a sample of manufacturing firms and find five classes of impediments: cost-related, institution-related, labor-related, organization-related, and information-related. Galia and Legros (2004) investigate complementarities between obstacles to innovation using CIS2 data for a sample of French manufacturing firms; their findings show that firms postponing projects are more prone to face obstacles linked to economic risk, lack of skilled personnel, innovation costs, lack of customer responsiveness, lack of information on technologies, and organizational rigidities. In contrast, firms that abandoned projects tend to be more subject to economic barriers (costs, risks, and customer responsiveness) than to technological or organizational ones. Mohnen and Röller (2005) analyze complementarities between barriers to innovation with a sample of the CIS1 from Ireland, Denmark, Germany, and Italy. These obstacles constitute four groups, related to risk and finance, knowledge, the knowledge-skill outside the enterprise, and regulation. The lack of internal human capital (skilled personal) complements all other obstacles in almost all industries. Mohnen & al. (2008) use the Netherlands 2000–2002 CIS to show that financial obstacles significantly affect firms' decision to abandon, prematurely stop, seriously slow down, or not start an innovative project. Financial constraints matter but depend on firms' size and economic situation.

Overall, these studies show that many firms are constrained by financial obstacles in their quest for innovation. However, as noted by Mohnen & al. (2008), when obstacles to innovation are introduced as an explanatory variable of the R&D activity or innovation output,

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[2] A discussion on the determinants of obstacles to innovation (Baldwin & Lin, 2001; D'Este & al., 2008; Galia & Legros, 2004; Galia, Mancini & Morandi, 2012; Hölzl & Janger, 2011; Iammarino, Sanna-Randaccio & Savona, 2007; Mohnen & Rosa, 2000; Schneider & Veugelers, 2010; Tourigny & Le, 2004) is beyond the scope of this study.

a non-significant or even a significantly positive coefficient often results, such that firms facing stronger obstacles appear more likely to innovate, all else being equal. Different interpretations of such a counterintuitive result have been proposed. Baldwin and Lin (2002) and Tourigny and Le (2004) assert that obstacles to innovation, as defined in innovation surveys, might indicate how successfully a firm overcomes these obstacles. Clausen (2008) provides an alternative, original point of view: The key variable is not actual obstacles but their perception by managers. In that sense, those who wish to innovate are more inclined to perceive obstacles, and then the perception of obstacles relates positively to the will to innovate. Finally, D'Este & al. (2012) argue that, to understand the result, it is necessary to distinguish between deterring barriers to innovation, which deter firms from engaging in innovation activities, and revealed barriers, which firms experience alongside their innovative activities. Some other studies focus on the econometric dimension of the problem, including the endogeneity of the obstacles. In line with previous studies using CIS data (e.g. D'Este & al., 2012), for this article we analyze three major groups of barriers to EI related to cost, knowledge, and market.

Cost barriers explain a firm's difficulties in financing its innovation projects. During the innovation process, available financial resources may not be sufficient to cover the high investments required by such projects. High costs and a lack of financial resources (both internal and external sources) offer important obstacles to innovations. Knowledge barriers pertain to access to information about technology and skilled labor. Managers and employees qualified to effectively incorporate and support innovation as a business strategy represent a competitive advantage for the firms.

From this perspective, EI require specific information and knowledge, so qualified personnel and associated skills are important for exploring new environmental technologies. The ability to connect a technical opportunity to a market opportunity leads to successful innovations. Technology push– and demand pull–related obstacles instead may constrain innovative activity. Because technology and markets linked to EI are more complex and evolve more rapidly than traditional innovations, innovative firms with environmental benefits tend to be more prone to needing to deal with these two issues than innovative firms without environmental benefits. Finally, market barriers explain market structures and pull technology derived from demand.

Are the barriers the same for environmental innovation? At the European level, in an action plan, ETAP (the European Commission's Environmental Technologies Action Plan) pointed several barriers to environmental innovation: economic barriers, some regulations or standards inappropriate, insufficient and weak research system, and a lack of market demand (European Commission, 2004). As a precursor, Ashford (1993) provide a detailed list of barriers related to pollution prevention, and distinguish different categories of barriers: technological barriers, financial barriers, labor force-related barriers, regulatory barriers, consumer-related barriers, supplier-related barriers, and managerial barriers. Empirical studies indicate that EI is often more costly, which could negatively influence the firm's performance (Konar & Cohen, 2001). These additional costs might be due to the implementation of specific procedures designed to measure, manage, and adapt the benefits for the environment. Market uncertainty should increase for green products, due to their newness and the relative volatility of their consumers and clients. Similarly, access to knowledge about markets and technologies and skilled personnel are more difficult for goods that are not in the mainstream.

These barriers are reinforced for SMEs, which traditionally lack resources of all types and are more constrained by their day-to-day operations. Del Rio Gonzales (2009) adds that barriers to environmental technological innovation in SMEs are not the same as the one encountered by large firms. For SMEs in Cyprus, Hadjimamolis (1999) proposes a barriers' approach to innovation in the context of small, less developed countries and finds that the reduction of bureaucracy and the reorganization of technical education are very important for reducing obstacles to innovation. At a regional level, Freel (2000) observes barriers to product innovation among a sample of small manufacturing firms in the West Midlands area, breaking down resource constraints into four component sets: finance, management and marketing, skilled labor, and information. Madrid-Guijarro, Garcia & Van Auken (2009) consider the lack of financial resources, poor human resources, weak financial position, and high cost and risk as internal obstacles, as well as turbulence, lack of external partners, lack of information, and lack of government support as external obstacles. The cost of innovation affects Spanish SMEs more, and the barriers' impacts depend on the type of innovation. According to Madrid-Guijarro, Garcia & Van Auken (2009), costs represent the most significant barriers to innovation, with a disproportionately greater impact on small firms, probably because SMEs suffer more limited financial resources than large firms. In this sense, SMEs are especially subject to obstacles linked to the lack of financial resources and costs (Savignac, 2008; Iammarino, 2009). Alessandrini, Presbitero & Zazzaro (2010), considering Italian small firms during 1995–2003, show that their different time patterns lead process and product innovations to be associated with different kinds of financial constraints. Del Rio Gonzalez (2009) adds that small firms don't have enough human, technical and financial resources, which creates some barriers to environmental innovations. About size, Triguero, Moreno-Mondéjar & Davia (2013) indicates that small firms could have difficulties, more than large firms, to implement environmental innovation.

In summary, SMEs face relatively more barriers to innovation (and/or in a more intense way) than large firms because of their inadequate or insufficient internal resources and expertise. We investigate similarities and differences in the number and intensity of these obstacles for SMEs, according to the type of innovation, namely, environmental versus non-environmental. We thus hypothesize that:

H1: Barriers to EI are perceived as more numerous than those for non-environmental technological innovations by SMEs.

H2: Barriers to EI are perceived as more intense than those for non-environmental technological innovations by SMEs.

3. DATA AND METHODS

3.1. Data

We used data from two main sources, both related to French SMEs located in the Rhône-Alpes region. Rhône-Alpes region has an important research and innovation activity, it's the second region with high research potential (after Ile de France), with an important firm dynamism, and 15% of French patents are registered in Rhône-Alpes (CCI de Rhône-Alpes, 2014). In a specially designed survey, conducted in 2012, questionnaires provided to SMEs' top managers asked for information about innovation activity and different types of innovation (technological, non-technological, and/or innovations with environmental benefits for the firm or its end users). These questions matched those in the Community Innovation Surveys 2008 (CIS), on most of the covered areas, focusing on the propensity to innovate products and processes. This survey also provides detailed information about SMEs' sources of innovation and their perception of obstacles. The reference period was 2009–2011, except for the questions related to general information about firms, which refer to 2011. We obtained 671 questionnaires with fully reliable answers.

The second data set is the Orbis survey, which gathers balance sheet information for all SMEs located in Rhône-Alpes region; we used those from 2009–2011. As preconized by Arundel & Kemp (2009), we decided to link our first set of Rhône-Alpes data to another one more official, to acquire financial information for a better analysis. After merging the two databases, Orbis and our first original database, on variable "SIRET[3]", we obtained a sample of 518 (435 in the balanced sample) French SMEs that had 10–249 employees, belonging to all sectors. The final data set is representative of the SMEs located in Rhône-Alpes region across four sizes and four industry classes, though manufacturing SMEs are slightly overrepresented (see **Appendix 1**).

3.2. Dependent variables

Environmental innovation (EI) is generally measured using four types: input, intermediate output, direct output and indirect impact measures (Arundel & Kemp, 2009). As we consider a sample of SMEs, patent measures and research and development measures (input and intermediate output measures) are not relevant to consider. We choose to measure EI using a direct output measure, declarative measure, since we studied the results not the process. We asked to SMEs to answer, by yes or no, if over three years, 2009 to 2011, the firms has introduced significant novelties or improvements regarding its manufacturing processes or production of goods or services. A subsidiary question follows as if innovations have brought environmental benefits (such as reduction of energy consumption, of CO_2 emissions, waste recycling…) for the firm (yes or no answer), for customers (yes or no answer). Put together these two questions are used to create the EI variable. It can be notice that these questions are similar to those that was asked in the survey CIS 2008. Although the measure is subjective, it describes SMEs environmental innovation reality in a satisficing way and it is broadly admit as a measure of SME' environmental innovation studies. We also follow the measure of EI suggested in the Oslo Manual (2005).

[3] SIRET number is an identifier for firms.

To assess the effect of barriers to innovation on the probability of introducing environmental innovations, we used a non-experimental method based on matching estimators, according to Rosenbaum and Rubin (1983) This methodology is frequently used for public policy evaluation, and suitable for our study since we examined the net effect between SMEs with EI and without EI, which is similar to consider two groups with public subvention or without it. Comparatively, previous authors used econometric modeling like, Böhringer & al. (2012), to measure environmental innovation investment impact on production, however, unlike us, authors only consider environmental innovative firms and not the ones without EI. They measure a global effect among EI firms, whereas we take account the differential between innovative environmentally firms and others which are not, to have a more adjusted measure.

We follow the same kind of methodology as Linder & al. (2013). Thus we matched firms that have adopted environmental innovations (i.e., treated firms) with firms that have not adopted such innovations (i.e., untreated or control firms) with the same observed characteristics. Not two firms can be identical in their observable attributes, so the matching process is based on propensity scores, which reflect the probability of having introduced EI (treatment probability), which we estimated using a probit model, as requested by our methodology (EI, dependent variable is binary) and confirmed by Del Rio Gonzales (2009).

3.3. Independent variables

We introduced a series of variables from prior literature on the determinants of EI as explanatory factors. In line with the Porter hypothesis and subsequent empirical studies, public policies and regulation are powerful levers for inciting firms to adopt EI. Because institutional pressures trigger EI even more in heavily polluting firms (Berrone & al., 2013), we use this proxy to measure the impact of regulation and hypothesize that SMEs operating in "polluting sectors" are more prone to adopt. We also introduce some strategic variables. With their lack of resources, SMEs engaged in an "external growth" strategy likely allocate their resources to this strategic priority, to the detriment of other activities, especially those linked to innovation. In contrast, SMEs engaged in "R&D cooperation" with partners might compensate for their lack of resources to innovate, in line with Triguero, Moreno-Mondéjar & Davia (2013). If SMEs belong to a "cluster," they should be more innovative, because they can benefit from local knowledge spillovers. This argument has not been fully established though. Beaudry and Breschi (2003) show that clustering alone does not lead to greater innovative performance. Instead, location in a cluster densely populated by other innovative firms positively affects the likelihood of innovating. Moreover, the firm's implementation of a pollution reduction strategy and organization may significantly influence the decision to adopt EI in terms of products or processes ("environmental monitoring"). Wagner (2007) shows that environmental management systems' implementation is associated with the probability that firms to pursue innovation, and EI specifically. Similarly, "contractors" play a leading role in the diffusion of EI, such that Wagner (2007) cites a positive relationship between cooperation with predominantly environmentally concerned stakeholders and environmental product innovation.

Finally, variables control for a set of firm characteristics that affect the probability of adopting EI. One such variable is firm age (measured by the logarithm, *lnage*). Because efficient firms are more likely to survive and grow (Bartelsman & Doms, 2000), firms' age should have a positive impact on the decision to adopt. To measure firm size, we used the logarithm of the total number of employees (*lnsize*). For environmental product innovations, Hemmelskamp (1999) finds a U-shaped relationship with firm size, as suggested by Scherer (1992), from an evaluation of all relevant studies of the influence of firm size on innovation activities. We expect firm size to have a positive impact on the decision to adopt EI, because larger SMEs have more resources to pay for the fixed costs. When the firm is part of a group (*fgroup*), it benefits from the additional resources needed to adopt. In contrast, SMEs that face financial constraints (measured in 2010, with Orbis data, as operational revenues and debt ratio) should be less likely to adopt EI. Table 1 provides the definition of all the variables in the probit model.

Table 1. Definition of variables used in the probit model

Variables	Definition
EI	= 1 if firms have an environmental innovation, 0 otherwise
Polluting sector	= 1 if firms are part of a polluting sector, 0 otherwise
External growth	= 1 if firms have engaged in external acquisition of firms, 0 otherwise
R&D cooperation	= 1 if firms cooperate on R&D with other firms, 0 otherwise
Cluster	= 1 if firms belong to a cluster, 0 otherwise
Environmental monitoring	= 1 if firms have measured and reduced their environmental impact (e.g., environmental audits, ISO 14001), 0 otherwise
Contractor	= 1 if firms are contractors, 0 otherwise
Age (lnage2012)	Logarithm of firm age in 2012
Size (lnsize)	Logarithm of the firm's number of employees
Group (fgroup)	= 1 if firm belongs to a group, 0 if firm is independent
Op. revenue	Operational revenue of the firm in 2010 (data from Orbis)
Debt ratio	Ratio of debts in 2010 (data from Orbis) = sum of long-term debts and loans, divided by shareholders' funds and provisions in 2010

3.4. Sample description

Descriptive statistics are realized on balanced sample, thus on 435 firms. On our sample, 142 firms have adopted EI (32.64 per cent), whereas 293 firms have not (67.36 per cent). A large proportion of firms are not group member (94.48 per cent) and have not an acquisition strategy (75.17 per cent). Little firms are from a polluting sector (18.62 per cent), and part of a cluster (11.95 per cent).

After having divided our sample in two groups, EI and non-EI firms, we compare proportions and means on different variables, and we notice that, between these two groups, variables which have not the same proportions are related to environmental innovation characteristics, like R&D cooperation, External growth, Cluster, Environmental monitoring, Polluting sector. Other variables (like fgroup, lnage2012) have the same proportion between EI and non-EI. EI and non-EI groups are mainly different on their innovation activities, not on their "basics" characteristics. **Appendix 2** contains their descriptive statistics.

3.5. Methods

To be efficient, the non-experimental method based on matching estimators must respect the conditional independence assumption (CIA), so we assume that, after having controlled the set of observable variables, treatment participation does not depend on treatment outcome. Accordingly,

$$Y_0, Y_1 \coprod T \mid X \Rightarrow Y_0, Y_1 \coprod T \mid P(X) \quad [1]$$

where:

Y_0 = untreated firms that have not adopted environmental innovations;

Y_1 = treated firms that have adopted environmental innovations;

T = binary for treatment;

X = observable variables; and

$P(X)$ = probability of being treated or not.

In addition, T is a binary variable indicating if the firm has received a treatment ($T = 1$) or not ($T = 0$); Y captures the treatment, such that Y_0 (if $T = 0$) and Y_1 (if $T = 1$) are mutually exclusive outcomes that cannot be observed simultaneously. The observed outcome is thus given by:

$$Y = Y_1 T + Y_0(1 - T) \quad [2]$$

To compute the propensity score, we start by determining the region of common support of density, defined as the region in which distributions of the propensity score for treated and control groups overlap, such that

$$0 < P(T = 1|X) < 1 \quad [3]$$

Regarding the probit estimation, our region of common support of density is [0.11595126; 0.81824449], adequate for a matching procedure. Balancing properties are satisfied, and our sample is divided into five groups. We present the graphical representation in **Appendix 3.**

To determine the effects of barriers to innovation according to whether the firm has adopted environmental innovations or not, we estimate the average treatment effect (ATT), matching each treated observation to an untreated one with a similar propensity score. The ATT reflects the difference between firms that have adopted EI and firms that have not on an outcome variable:

$$ATT(x) = E(Y_1 \mid T = 1, X = x) - E(Y_0|T = 1, X = x) \quad [4]$$

The outcome variables were derived from a series of questions designed to identify barriers to innovation perceived by SMEs' top managers, consistent with those introduced in the 2008 French CIS, which was the first version to include questions related to environmental innovations. Each respondent indicated his or her perception of nine barriers to innovation related to (1) excessive costs of innovation, (2) lack of external financial sourcing, (3) lack of internal financial sourcing, (4) domination of markets by insiders, (5) demand uncertainty, (6) lack of skilled employees, (7) lack of information about technologies, (8) lack of information and visibility on markets, and (9) difficulties in finding partners with which to innovate.

Each barrier was measured on a five-point scale, from 0 (very low perception) to 5 (very high perception). Similar to previous studies, we constructed two measures of the perceived barriers. The first captured the perceived intensity of the barrier (*barriers' intensity*), corresponding to the sum of all barriers' scores given by the respondent. The second, the number of perceived barriers (*barriers' number*), equals the sum of high or very high barriers perceived by the firm (see Table 3). Finally, in line with previous empirical literature, we grouped the nine barriers to innovation into three theoretical coherent categories (financial, market-related, knowledge) and computed a measure of their intensity and number for each category. Each outcome is in Table 2. **Appendix 4** provides the descriptive statistics.

Table 2. Definition of outcomes

Outcome	**Definition**
Barriers' intensity *(barrieres)*	Sum of all barrier scores given by the firm, from 0 to 45 *for each of the 9 barriers, potential intensity scores go from 1 (very low) to 5 (very high)*
Barriers' number *(nbbarrieres)*	Sum of high or very high barriers perceived by the firm, from 0 to 9
Financial barriers' intensity *(BarrieresCOST_I)*	Sum of financial barrier scores given by the firm, from 0 to 15 *for each financial barrier (innovation costs too high, lack of external financial sourcing, lack of internal financial sourcing), potential intensity scores go from 1 (very low) to 5 (very high)*
Financial barriers' number *(BarrieresCOST)*	Sum of high or very high financial barriers perceived by the firm, from 0 to 3
Market-related barriers' intensity *(BarrieresMKT_I)*	Sum of market-related barrier scores given by the firm, from 0 to 10 *for each market-related barrier (market dominated by insiders, demand uncertainty), potential scores go from 1 (very low) to 5 (very high)*
Market-related barriers' number *(BarrieresMKT)*	Sum of high or very high market-related barriers perceived by the firm, from 0 to 2
Knowledge barriers' intensity *(BarrieresKNOW_I)*	Sum of knowledge barrier scores given by the firm, from 0 to 20 *for each barriers (lack of skilled employees, lack of information on technologies, lack of information and visibility on markets, difficulties in finding partners), potential intensity scores go from 1 (very low) to 5 (very high)*
Knowledge barriers' number *(BarrieresKNOW)*	Sum of high or very high knowledge barriers perceived by the firm, from 0 to 4

To estimate the ATT, we choose a kernel matching method that takes the full set of controls for each treated firm rather than using nearest neighbor matching or other estimation methods. Frölich (2004) demonstrated the finite-sample properties of kernel-matching estimators when the control to treated ratio is large, as is the case in our study (142 treated and 283 controls). The kernel-matching estimator is defined as:

$$\widehat{ATT} = \frac{1}{N}\sum_{i\in I_1}\left[y_i - \sum_{j\in I_0}\frac{K\left(\left(P(x_j)-P(x_i)\right)/h\right)}{\sum_{j\in I_0}K\left(\left(P(x_j)-P(x_i)\right)/h\right)}y_j\right] \quad [5]$$

Finally, we performed a sensitivity analysis for the matching estimators and the plausibility of the conditional independence assumption (CIA) is tested.

4. RESULTS

The results of the probit model and the propensity score matching are in Table 3.

Table 3. Results of the probit estimation: Propensity score

Variables	**Robust**		**Coef. (dF/dx)**	**VIF**
	Coef.	**St. Error**		
Polluting sector	0.289	0.167*	0.106	1.10
External growth	-0.506	0.163***	-0.167	1.12
R&D cooperation	0.216	0.140^{ns}	0.078	1.09
Cluster	0.521	0.163***	0.198	1.08
Environmental monitoring	0.268	0.149*	0.098	1.08
Contractor	0.135	0.134^{ns}	0.048	1.09
lnage2012	0.110	0.073^{ns}	0.039	1.04
Lnsize	0.216	0.099**	0.077	1.44
Fgroup	-0.370	0.324^{ns}	-0.119	1.10
Op. revenue	$-1.82.10^{-5}$	$9.21\ .10^{-6}$**	-6.47.10-6	1.30
Debt ratio	-0.002	0.007^{ns}	-0.0009	1.05
_cons	-1.571	0.371***		
Log likelihood	-256.818			
No. of obs.	435			
Pseudo R²	0.0653			

Notes: Percentage of correct predictions: 62.93%.[4] **Appendix 5** shows correlations between probit variables.

[4] The goal here is not to obtain the more precise model of prediction, but to determine useful variables where CIA is verified. A too much precise prediction of propensity scores may lead to not matching individuals.

As expected, environmental regulations had a positive effect on the probability of adopting EI. Regulations inevitably had a binding effect on SMEs' decision, and SMEs that exhibited strategic behavior were more likely to adopt EI. Being a member of a cluster strongly favored the probability of introducing innovations with environmental benefits. SMEs from polluting sector are likely to innovate environmentally much. Firms that were more conscious of their environmental impact were proactive in terms of their EI too.

Also as expected, pursuing an external growth strategy decreased the probability of introducing EI, likely due to the lack of resources available to implement the two strategies simultaneously. Surprisingly, R&D cooperation with partners exerted no effect on environmental innovations; it was circumscribed to technological innovations only. Among the control variables, firm size showed the significant, positive sign we expected, such that large SMEs were more likely to innovate in the environmental field than small ones, whatever their age or group membership. Financial constraints had no significant effect on EI. The results also showed that SMEs with high operational revenues did not invest in EI.

The estimated ATT in Table 4 show that all estimates were positive and significant with kernel matching. According to different ATTs, we found significant positive effects for barrier intensity and number of barriers. That is, firms that have adopted EI perceive more barriers, with a stronger intensity, than those that are not engaged in EI activity, whatever category of barriers to innovation we consider.

Table 4. Kernel estimation of barriers ATT

Barriers	**ATT**	**Std. Errors**	**[95% conf. inter.]¤**
Barriers *(total intensity)*	3.315	1.030***	[1.326;5.519]
Nbbarriers *(total number)*	0.906	0.315***	[0.262;1.500]
BarriersCOST *(number)*	0.315	0.118***	[0.714;0.555]
BarriersCOST_I *(intensity)*	1.282	0.469***	[0.427;2.297]
BarriersKNOW *(number)*	0.363	0.149**	[0.077;0.656]
BarriersKNOW_I *(intensity)*	1.423	0.461***	[0.386;2.320]
BarriersMKT *(number)*	0.229	0.088***	[0.720;0.416]
BarriersMKT_I *(intensity)*	0.609	0.290**	[0.036;1.226]

Notes: Bootstrapped standard errors are obtained with 1,000 replications.
*** Significant at 1%. ** Significant at 5%. * Significant at 10%. ns, non-significant.[5]
¤ 95% confidence intervals are bias-corrected (BC).

[5] Kernel estimations also were computed with 5000 bootstrap replications. Results are available on request.

To assess the robustness of our matching estimation when the CIA was not satisfied, we also followed Ichino, Mealli & Nannicini's (2008) recommendations. The probability of being innovative is not random across observable characteristics, because some unobserved characteristics constitute sources of differences between firms that have adopted EI and those that have not. For this sensitivity analysis, the methodology and detailed explanations are available in Ichino, Mealli & Nannicini (2008) and Rosenbaum and Rubin (1983). If CIA is not satisfied with x (observables), it is necessary to include a binary confounding factor U, to measure the unobservable characteristics. The U distribution can be specified by four parameters: $p_{11}, p_{10}, p_{01}, p_{00}$. Our first distribution of U was the baseline matching estimator, and $p_{11} = p_{10} = p_{01} = p_{00} = 0$. We then defined a neutral confounder where $p_{11} = p_{10} = p_{01} = p_{00} = 0.5$, and for the other confounders, we chose parameters that could imitate important observables covariates, based on significant binary variables of our probit model. For example, we simulated a distribution of U similar to the distribution of *Cluster* (i.e., being a member of a cluster). Here, 21% of SMEs belonging to a cluster adopted EI, so p_{11} e equaled 0.21, and 21% of SMEs in the sample show $U = 1$. We conducted estimates with and without these additional variables to measure the robustness of the initial results to this particular failure of the CIA.

Table 5 presents the results of the sensitivity analysis for two outcomes, barrier intensity and number of barriers.[6] Each row in the first six columns indicates the probabilities p_{ij}, which is the distribution of unobservable characteristics U, by innovation status and outcome. The seventh column reveals the outcome effect of U, and the eighth column represents the selection effect. The first row of the table provides the initial matching estimates of the differential barriers between ei and non-ei firms; the second row simulates matching estimation with a neutral confounder. Other rows display U calibrated with previously chosen covariates. According to the results of the sensitivity analysis, for the *Cluster* variable, unobserved characteristics increase barriers' effects for firms that have not adopted environmental innovations (Γ=3.241>1) and the probability of adopting environmental innovations (Λ=2.259>1). If CIA properties are not satisfied, the matching estimator is 3.160 and explains only 4.68%

[6] For other outcomes, the reasoning is the same. Results are available on request.

(3.315 – 3.160)/3.315 × 100) of the baseline estimate and thus remains non-significant statistically. The others confounders similarly seem to be affected by outcome and selection effects. Nevertheless, matching estimators remain, in each case, very close to the baseline estimator and statistically non-significant.

All simulations are consistent with the robustness of the matching estimates. Unobservable characteristics influence the outcome and selection effects, but they have no effect on the estimation of barriers' effect differentials across firms that have adopted EI and those that have not adopted this kind of innovation.

Table 5. Sensitivity analysis

	Fraction of U=1 by EI and barriers				**Fraction U=1 by EI**		**Outcome effect (Γ)**	**Selection effect (Λ)**	**Matching estimator**	**Standard error**
	p_{11}	p_{10}	p_{01}	p_{00}	$p_{1.}$	$p_{0.}$				
Baseline matching estimator	0.00	0.00	0.00	0.00	0.00	0.00	-	-	3.315	0.905***
Neutral confounder	0.50	0.50	0.50	0.50	0.50	0.50	1.033	1.045	3.344	0.962***
Confounders										
Cluster	0.21	0.11	0.14	0.06	0.17	0.10	3.241	2.259	3.160	0.930***
Pollution reduction	0.36	0.30	0.30	0.20	0.34	0.25	1.756	1.571	3.271	0.901***
Polluting sector	0.26	0.18	0.20	0.13	0.23	0.16	1.755	1.742	3.249	0.951***
External growth	0.21	0.12	0.30	0.26	0.18	0.28	1.179	0.603	3.373	0.950***

Notes: Bootstrapped standard errors are obtained after 50 replications.
*** Significant at 1%. ** Significant at 5%. * Significant at 10%. ns, non significant.

5. DISCUSSION AND CONCLUSION

This study is the first, to our knowledge, to test for obstacles to environmental innovation, especially for SMEs. It provides several important results. First, regarding the antecedents of EI, we found that:

- On one hand, the effect of regulation is confirmed as firms in polluting sectors tend to introduce more environmental innovations;

- On the other hand, beyond these regulatory aspects, firms that have the highest probability to introduce environmental innovations are those that are the most mature in terms of environmental strategy. Two major antecedents appear which relate to the firms' individual characteristics: belonging to a cluster, and environmental monitoring. These firms are less constrained by financial aspects as they are among the largest ones and have high operational revenues.

The probit estimation shows that environmental innovations are not only driven by environmental regulation but also by firms' strategic behavior. However, defensive motives (e.g., decreasing costs and risks) are much more important than offensive motives (e.g., stimulating growth) when environmental innovations are concerned. The introduction of practices and tools dedicated to environmental cost reduction favors EI while an external growth strategy affects negatively this type of innovation. This result is not surprising as this type of strategy is extremely costly so that firms cannot combine both types of strategies (and investment). The positive effect of being part of a cluster confirms that firms learn more from ideas offered by nearby firms than a growth-oriented strategy. Not surprisingly, only the largest SMEs that have sufficient available financial resources are encouraged to adopt environmental innovations. According to our analysis, it is possible to conclude that coercive and mimetic pressures (DiMaggio & Powell, 1983) represent crucial levers to SMEs' environmental adoption. Regulations, as opposed to supply chain partners (contractors), are a significant source of coercive pressures, reflecting the effectiveness of regulatory efforts in guiding green behaviors. Geographical proximity effects can also reduce the uncertainty associated with green practices. The perceived favorable outcomes provide a more convincing rationale for adoption.

Taken together, these results tend to confirm the Porter hypothesis (initially developed for large firms, on a theoretical level as well as successive empirical studies) for SMEs.

Second, as far as obstacles are concerned, SMEs face not only more barriers but also perceive them as more intense. Indeed, we here deal with the perceptions that SMEs' managers have. Our measures, which relate to the representations of the difficulties faced by small firms, tend to show that firms have to perceive the right opportunities in order to engage in environmental innovations. Moreover, this suggests that public policies could not be totally effective as the tools that are implemented should be oriented towards changing representations instead of, what is generally done, providing incentives, tools or instruments that relate mainly to regulatory or financial aspects. This result is in line with that of Horbach, Oltra & Belin (2013) which indicate that EI relies on more important external sources of knowledge compared to other innovations. Future policy implications to support environmental innovation should therefore be oriented towards information diffusion, technology transfer, public private partnership policies, in order to reduce barriers' representation effect.

Considering our results on the Probit model, firms that are active in collective actions such as in clusters could benefit, first, from information and knowledge diffusion about the benefits of EI, second from cluster governance actions in terms of advice and assistance. Therefore, taking into account the types, number, and intensity of barriers to innovation, we find that all measures are significantly more important for firms engaged in EI than for firms that do not innovate to pursue environmental benefits. Differences in the effects of a given set of barriers on the probability of EI on one hand versus non-environmental technological innovation on the other hand are all statistically significant. This confirms that the benefits of environmental innovation are not still fully recognized. Due to the inherent uncertainty of the outcomes of green practices, making successful adoptions known to potential adopters will provide strong incentives and provide useful guidance in their decision-makings. In this context, the actions engaged by French competitiveness clusters aimed at supporting non-technological innovations and SMEs' growth appear to be essential. Moreover, the effect of barriers to innovation on the probability to introduce EI, according to our robust non-experimental method and matching estimators, is significant.

Our papers points out several interesting points. First, SMEs should have strategic goals in order to facilitate their adoption of EI. Second, they should be engaged in collective actions in order to decrease the perceived numerous and intense obstacles of this type of innovation. Indeed, SMEs face informational and knowledge asymmetries, since they are under-informed about public subsidies and environmental innovation strategies. Public subsidies are also unequally distributed among firms: they benefit to firms with small innovation activities or, on the contrary, to firms with intense innovation activities (Blanes & Busom, 2004; Lööf, & Hesmati, 2004). Horbach, Oltra & Belin (2013) demonstrate that eco-innovation activities require more information and knowledge than non-environmental innovation. An important informational work should thus be undertaken by public bodies to inform non innovative firms about opportunities, gains of EI, and related subsidies in order to encourage EI adoption. We also suggest to SMEs to be part of a cluster, which represents an innovative environment which could favor EI.

Our findings are subject to several caveats. In particular, individual barriers in the same category could have different influences. Tourigny and Le (2004) and Mohen and Rosa (2000) find that though the lack of financial resources is less likely to be perceived as an important hampering factor by large firms (cf. small ones), the opposite holds for the high costs of innovation (Iammarino, 2009). We combined these two obstacles into one category. We also did not separate product and process environmental innovations but considered them together; further research should delimitate whether obstacles differ according to the type of environmental innovation or its beneficiary (firm or client). Finally, it would be interesting to compare these results with those obtained on a sample of large firms, to find whether, for example, R&D cooperation has a more substantial influence on large than small firms. Future research perspectives also include the impact of the manager's profile, since it has a crucial role to play for SMEs' strategies. Likewise, interactional effects among different categories of barriers could be studied, as obstacles could be interrelated (Aschford, 1993). A lot remains to be done to understand the levers of and barriers to EI. Such extensions are critical because of the importance of EI for the sustainable growth of our economies and societies.

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APPENDICES

Appendix 1. Repartition by sector and size (Rhône-Alpes firm population and our balanced database)

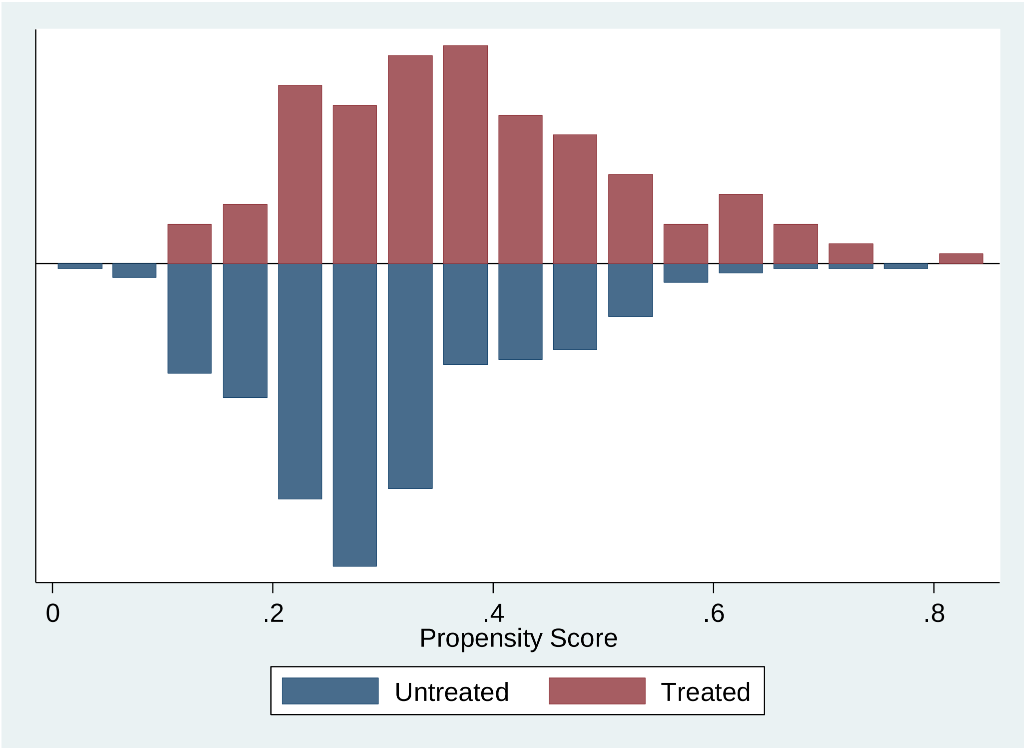
Sectors / **Size**	**Industry**	**Commerce**	**Services**	**Construction**
10 to 49 employees	**78.68 %** / *76.33 %*	**92.42 %** / *86.86%*	**78.45%** / *82.74%*	**91.07%** / *88.94%*
50 to 249 employees	**21.32%** / *22.63%*	**7.58%** / *13.14%*	**21.55%** / *17.26%*	**8.93%** / *11.06 %*

Balanced database (435 firms)
Rhône-Alpes firms (from 10 to 250 employees)

Appendix 2. Descriptive statistics of probit variables

Variables	**Firm with environmental innovation (St. dev.)**		**Firm without environmental innovation (St. dev.)**	
Polluting sector	0.246	(0.432)	0.157	(0.364)
External growth	0.183	(0.388)	0.280	(0.450)
R&D Cooperation	0.401	(0.492)	0.317	(0.466)
Cluster	0.190	(0.394)	0.085	(0.280)
Environmental impact	0.331	(0.472)	0.235	(0.425)
Contractor	0.423	(0.496)	0.437	(0.497)
Age of the firm (lnage)	2.888	(0.902)	2.749	(0.900)
Size of the firm (lnsize)	3.395	(0.769)	3.287	(0.789)
Part of a group (fgroup)	0.042	(0.202)	0.061	(0.241)
Operational revenue	5 294.169	(7 066.431)	6 308.232	(10 136.22)
Debt ratio	-0.024	(5.167)	0.231	(8.362)
Number of observations	142		293	

Appendix 3. Propensity score graphic



Appendix 4. Descriptive statistics of outcomes variables on barriers

Outcomes	**Firm with environmental innovation (St. dev.)**		**Firm without environmental innovation (St. dev.)**	
Barriers *(total intensity)*	19.894	(9.628)	15.833	(10.412)
Nbbarriers *(total number)*	7.099	(3.032)	5.966	(3.443)
BarriersCOST *(number)*	2.324	(1.133)	1.928	(1.311)
BarriersCOST_I *(intensity)*	6.697	(4.241)	5.174	(4.513)
BarriersKNOW *(number)*	3.204	(1.366)	2.727	(1.544)
BarriersKNOW_I *(intensity)*	8.873	(4.639)	7.055	(4.601)
BarriersMKT *(number)*	1.570	(0.766)	1.311	(0.877)
BarriersMKT_I *(intensity)*	4.324	(2.665)	3.604	(2.959)
Number of observations	142		293	

Appendix 5. Correlations

	Ei	External growth	Cluster	Size of the firm (lnsize)	Operational revenue	Environmental monitoring	Polluting sector	R&D Cooperation	Age of the firm (lnage)	Part of a group	Contractor	Debt ratio
Ei	1.0000											
External growth	-0.1101*	1.0000										
Cluster	0.1140*	0.0749	1.0000									
Size of the firm (lnsize)	0.0490	0.3073*	0.1323*	1.0000								
Operational revenue	-0.0552	0.1490*	0.1613*	0.4643*	1.0000							
Environmental monitoring	0.0980*	0.0567	0.0840	0.2116*	0.1596*	1.0000						
Polluting sector	0.0835	0.0032	0.1698*	0.0329	-0.0273	0.0722	1.0000					
R&D cooperation	0.0892*	0.0473	0.1795*	0.1198*	0.1127*	0.1260*	-0.0208	1.0000				
Age of the firm (lnage)	0.0544	0.0191	-0.0077	0.0920*	0.0214	-0.0249	0.1400*	-0.0587	1.0000			
Part of a group	-0.0305	-0.0654	0.0693	0.1446*	0.2615*	0.0503	0.0519	0.0816	-0.0376	1.0000		
Contractor	-0.0020	-0.0030	-0.1556*	-0.0989*	-0.0505	-0.0351	-0.1898*	-0.1203*	-0.0650	-0.0073	1.0000	
Debt ratio	-0.0256	0.0218	0.0128	-0.0937*	-0.0111	0.0269	0.0210	-0.1058*	-0.0108	-0.1471*	0.0378	1.0000

* : significant at 5% or more