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Environmental innovation and R&D cooperation: Empirical evidence from Spanish manufacturing firms

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ABSTRACT

This paper explores the relationship between firms' R&D cooperation strategies and their propensity to introduce environmental innovations.

Previous literature has supported that environmental innovations differ from other innovations as far as externalities and drivers of their introduction are concerned, highlighting mainly the importance of regulation to trigger them. Using data from the Community Innovation Survey on Spanish manufacturing firms (PITEC), this paper investigates specificities that affect rather how they are developed, and in particular the higher importance of R&D cooperation with external partners.

The econometric estimations, controlling for selection bias, suggest that environmental innovative firms cooperate on innovation with external partners to a higher extent than other innovative firms. Furthermore, cooperation with suppliers, KIBS and universities is more relevant than for other innovators, whereas cooperation with clients does not seem to be differentially important. Finally, the results bespoke of a substitution effect between cooperation activities and the internal R&D effort.

1. Introduction

The importance of the environmental agenda for industry has been rising exponentially at the international level in recent years. On the one hand, increasing consumers' awareness on the environmental impact of their consumption choices and their willingness to reduce the ecological footprint (Harrison et al., 2005) creates new market opportunities for companies. On the other hand, increasingly restrictive policies punishing environmentally harmful behaviors and the action of NGOs, which raises the attention on firms' polluting activities (Porter and van der Linde, 1995; Spar and Mure, 2003), encourage firms to control the effects of their activities on the environment to reduce reputation risks and avoid additional costs.

The way companies integrate environmental concerns into their strategies while consolidating their competitive advantage is through environmental innovations. Despite the interest on environmental innovations is on the rise, research on this field is still limited. A number of studies supported that those innovations differ from other innovations as far as externalities and drivers of their introduction are concerned, highlighting mainly the importance of regulation to trigger them (e.g., Porter and van der Linde, 1995; Rennings, 2000; Jaffe et al., 2002, 2005). However, there is still little empirical evidence on specificities of those innovations regarding how they are conceived and realized, notwithstanding the importance for policy-making and the development of firms' strategies. In this paper, it is argued that, given their systemic, credence and complex character, environmental innovations are peculiar in that R&D cooperation with external partners is even more important than for the introduction of other innovations. Evidence that networking activities may be an important driver for environmental innovation (Hemmelskamp, 1999; Mazzanti and Zoboli, 2005; Horbach, 2008) and especially that a strong partnership with suppliers and network partners may be a powerful spur to application of innovative environmental technologies (Andersen, 1999, 2002; Geffen and Rothenberg, 2000; Simpson et al., 2007) has been found. However, this literature is lacking in the empirical setting, being mainly qualitative or focused on restricted geographic areas and, with the notable exception of Horbach (2008), does not allow for comparison with non-environmental innovations.

Against this background, this paper investigates the relationship between R&D cooperation and environmental innovation through a statistical analysis based on the Spanish Innovation Survey (PITEC). The contribution of the paper is multifold. First, it provides a comparative analysis of the importance of R&D cooperation and internal technological capabilities for environmental innovation as compared to other types of innovation. If the majority of the quantitative analyses on green innovation so far has focused just on green innovators (see e.g., Mazzanti and Zoboli, 2005; Rennings et al., 2006), the approach used in this paper will allow comprehending

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if and to what extent they differ from other types of innovation. Second, it investigates R&D cooperation differentiating between types of cooperation partners – considering vertical, horizontal and lateral cooperative agreements – acknowledging the literature on innovation that highlights the different roles of these partners in the innovation process (Tether, 2002; Belderbos et al., 2004a,b). Finally, this paper contributes to the literature on environmental innovations from a methodological standpoint. The econometric model used allow testing the hypothesis against possible selection bias due to the necessary exclusion from the analysis of non-innovative firms, improving the scant empirical evidence in the literature (Horbach, 2008).

The remainder of the paper is organized in four sections. The following explores the relevant literature and specifies the hypotheses for the analysis, Section 3 describes the data, the variables and the econometric specification used in the empirical analysis and Section 4 presents the results. Finally, Section 5 contains the conclusions, the limitations of the study and indications for future research.

2. Conceptual background and hypotheses

2.1. Is green innovation different?

Green, sustainable, environmental or eco-innovation may be defined as "new or modified processes, techniques, practices, systems and products to avoid or reduce environmental harms" (Kemp et al., 2001; Beise and Rennings, 2005). This definition includes all the changes in the product portfolio or in the production processes that tackles sustainability targets, like waste management, eco-efficiency, reduction of emissions, recycling, eco-design or any other action implemented by firms to reduce their environmental footprint. It is worth noting that this definition is based on the effect of the innovation activities independent of the initial intent and includes both incremental and radical improvements.

A crucial question environmental innovation scholars deal with is if those innovations, which are increasingly at the center of the policy action, need for a specific theory and policy or not. So far, the literature, especially neoclassical contributions, has focused mainly on two aspects that differentiate them from other innovations, which regard their externalities and drivers – what Rennings (2000) named the "double externality problem" and the "regulatory push/pull effect". As it has been widely discussed in the general innovation literature – the literature on innovation that do not focus specifically on the environmental one – innovation and R&D activities are characterized by positive externalities: the incentive for firms to invest in them lessen as they cannot fully appropriate the value created, because of knowledge spillovers that benefit other firms. In addition, green innovators produce also an environmental positive externality. Since part of the value created is appropriated by society – in the form of reduced environmental damage – rather than by the firms that invested in cleaner technologies, which bear higher costs than polluting competitors, there is a disincentive for firms to invest in products or process that reduce environmental impacts (see Rennings, 2000; Jaffe et al., 2005). The market-failure derived by the interaction of those two externalities induces a second peculiarity of eco-innovations: the greater importance of the policy intervention to drive their introduction (Rennings, 2000). The general innovation literature has highlighted the role of demand-pull and technology-push factors as determinants of innovation. Several contributions focusing on environmental innovations support that, given the low private incentives for firm to invest in them, the regulatory and institutional frameworks are to be considered as additional key determinants of their introduction (e.g., Porter and van der Linde, 1995; Cleff and Rennings, 1999; Kemp, 2000; Jaffe et al., 2002), especially for the development of the more radical changes of technological systems toward the greening of industries (Freeman, 1992; Rennings, 2000; Foxon and Andersen, 2009).

Table 1
Main peculiarities of environmental innovations as compared to other types of innovations, identified by neoclassical contributions in the environmental innovation economics literature.

	Environmental innovations	Other innovations
Externalities	Knowledge externalities and environmental externalities	Knowledge externalities
Drivers	Demand-pull, technology push and regulatory push/pull factors	Demand-pull and technology push factors

Table 1 summarizes those peculiarities of environmental innovations, which by now have received the highest attention in the literature on eco-innovations. If they have been corroborated by a vast empirical literature, less explored are other peculiarities, which affect rather how eco-innovations are developed, in particular with respect to the importance of cooperative arrangements for their realization. General innovation studies have underlined that, to develop new products or processes, firms increasingly cooperate with lead users, suppliers, universities and the like rather than relying just on internal resources (Von Hippel, 1988; Chesbrough, 2003; Belderbos et al., 2004b). The systemic, credence and complex character of environmental innovations suggest that, to develop them, cooperation may be even more important than when it comes to introduce other types of innovations.

Studies spanning from the innovation systems and evolutionary economic literatures describe environmental innovations as systemic, requiring a higher cooperative effort and implying higher complementarities with the activities performed by network partners (Andersen, 1999, 2002; Foxon and Andersen, 2009). Eco-innovation, in fact, very often requires changes in the raw materials or components used, the logistical and technical integration with external partners and the re-design of products. Cooperation with suppliers is important to ensure the supply of inputs or components with eco-friendly features – which may not be readily available on the market – to verify that they fulfill the requirements or to modify the internal production process accordingly (Geffen and Rothenberg, 2000; Meyer and Hohmann, 2000; Goldbach, 2003; Seuring and Müller, 2008). Technical and organizational interdependencies with suppliers and business clients are increasing as firms attempt to close their production cycles and enhance recyclability (see Seuring and Müller, 2008). Furthermore, to carry out a product that reduces environmental impacts is a rather complex task and often requires information and skills distant from the traditional knowledge base of the industry. Eco-innovations represent a technological frontier on which firms are still inexperienced and market and technological uncertainties increase as there are no widespread-accepted standards either in terms of specific technological solutions or of measures to evaluate the environmental performance of products and processes.

Finally, the environmental feature of a product or process is often a hidden attribute that cannot be disentangled even after the purchase (Andersen, 1999). Darby and Karny (1973) named the goods with these qualities "credence goods", since their value cannot be evaluated in normal use but, if possible, can be assessed just by acquiring additional costly information. Just in very few instances, when purchasing a product, it is possible to understand if it has been done through a less polluting production process or using a less impacting raw material. This information problem affects both consumers' purchases of final products and firm's purchases of raw materials or components. Firms therefore are