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What are the determinants of investment in environmental R & D?

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ABSTRACT

To face the challenges posed by climate change, environmental R & D and innovation are critical factors if we hope to cut emissions; yet, investment in environmental R & D remains below the social optimum. The aim of this paper is to analyse the determinants of investment in environmental innovation and to detect the differences, if any, with the determinants of investment in general innovation. In addition, this paper examines the relationship between environmental innovation R & D expenditure and a range of policy instruments, including environmental regulation and other policy measures including R & D subsidies and environmental taxes. The empirical analysis is carried out for 22 manufacturing sectors in Spain for the period 2008–2013. To overcome problems of data availability, we construct a comprehensive database from different surveys. The main implications from our results are (1). Managerial strategy appears as a relevant driver of environmental R & D investments. (2) The establishment of a policy mix between environmental, energy and technological regulatory measures is recommended. (3) The promotion of self-regulation through actions that encourage companies to follow a policy that affects their energy efficiency and is environmentally friendly.

1. Introduction

The agreement reached in Paris in 2015 committed all country signatories to stem their greenhouse gas emissions over the coming century, with the objective of holding the increase in the global average temperature and, thereafter, of pursuing efforts to limit the temperature increase (UNFCCC, 2015). Europe meanwhile has revised its climate targets initially set for 2020. Thus, its 2030 framework for climate and energy calls for a 40% cut on 1990 greenhouse gas emissions compared to the 20% established in 2020 (European Commission, 2014). All this is clear evidence of the global concern for climate issues and of the steps needed to improve the environmental performance of countries around the world. In facing up to this challenge, environmental R & D and innovation represent key factors if emissions are to be cut. Indeed, the introduction of more ambitious targets requires stepping up current R & D and innovation efforts (European Commission, 2014).

Corporations are typically portrayed as being one of the main causes of the environmental problems the world faces, yet many firms are responding by adopting active roles in environmental management (Walker and Wan, 2012). While some firms merely advocate the importance of managing the environment and signal their commitment to it, others see their performance as an all-encompassing construct and tackle environmental and economic issues together by promoting green innovation. Increasing levels of public scrutiny, public pressure and public incentives, combined with stricter regulatory controls, induce firms to innovate with positive consequences for the environment (Bilbao-Osorio et al., 2012; Johnstone et al., 2008).

However, environmental innovation is affected by the problem of double externality (Rennings, 2000). The combination of the environmental externality and knowledge-market failures justifies the introduction of environmental and innovation policies to encourage the adoption of eco-innovations (Del Río et al., 2016). Although many of the determinants of environmental innovation are expected to be similar to those of general innovation (Rennings, 2000; Del Río, 2009), the empirical literature has in fact identified quite distinctive features in the case of eco-innovation (Hojnik and Ruzzier, 2015; Del Río et al., 2016). Specifically, and as a result of this double externality problem, regulation makes eco-innovation different (Del Río et al., 2015).

There has been a recent rise in interest in determining the drivers of investment in environmental innovation (Hojnik and Ruzzier, 2015; Del Río et al., 2016). As such, the aim of this paper is to contribute to this growing body of literature and to analyse the determinants of investment in eco-innovation and to detect differences, if any, with the determinants of investment in general innovation. To this end, we undertake an analysis of the drivers of environmental R & D. Indeed, while R & D investment is one of the main variables used in the field of

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the economics of innovation to analyse the technological activity of firms, data constraints have hampered its use for examining the drivers of investment in eco-innovation.

The literature to date reports that demand, regulation and stakeholder factors play important roles in the generation of investment in this sector (Rennings, 2000; Wagner, 2008; Kesidou and Demirel, 2012). In this same line, this paper seeks to shed further light on the relationship between environmental innovation investment and different policy instruments governing environmental innovation, that is, environmental regulations and a set of policy measures that include R & D subsidies and environmental taxes (Del Río, 2009; Horbach et al., 2012; Veugelers, 2012; Marin, 2014).

We report the results of an empirical analysis conducted for 22 manufacturing sectors in Spain for the period 2008–2013. The analysis of the determinants of R & D investment using industry-level data is especially common in the field of the economics of innovation (Cohen, 2010); however, to the best of our knowledge, such an analysis has yet to be performed for environmental R & D or eco-innovation. Industries have different technological opportunities and differ in their degree of eco-innovativeness. To overcome the lack of data, we build a comprehensive database drawing on different surveys on innovation, environmental issues and policy instruments. The use of industry-level data, although giving rise to certain limitations compared to the use of firm-level data, allows us to exploit the advantages of using panel data models. As Del Río et al. (2016) point out, econometric analyses using panel data are recommendable but they are virtually absent from the analysis of the drivers of eco-innovation owing to the unavailability of adequate data.

The rest of this article is structured as follows. The next section reviews the literature. The third section presents the model and the variables and describes the data. The fourth section discusses the main results. The last section concludes and presents some policy recommendations.

2. Background

Businesses are coming under increasing pressure to take an active role in the achievement of greening goals alongside their more traditional financial goals (Johnstone et al., 2008). Since one of the mechanisms firms can adopt in dealing with the changing environment is that of innovation (Schoonhoven et al., 1990), green innovation represents a suitable option for countering this mounting pressure and promoting a green, sustainable environment (De Marchi, 2012; Johnstone et al., 2008).

The terms environmental innovation, green innovation and eco-innovation are used here synonymously (Tietze et al., 2011) and we adhere to the following common definition:

> "(...) innovation is the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization (...) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives" (Kemp and Pearson, 2007: 7).

We adopt a simple framework for separating the four determinants of eco-innovation identified in the literature: firm strategies, technology, market/demand and regulation (Horbach et al., 2012; Horbach and Rennings, 2013). For firms to develop environmental innovations, Rennings (2000) argues that technology-push and market-pull factors alone do not provide sufficient incentives. While society as a whole benefits from environmental innovations, the costs are borne by individual firms. Despite the fact that certain environmental innovations can be marketed successfully, a firm's ability to appropriate the profits from such an innovation can be hindered if environmental benefits have the character of a public good or the corresponding knowledge is easily accessible and copied. Technology and market factors alone do not provide sufficient incentives. Consequently, the regulatory framework for environmental policies becomes another important driver of environmental innovations (Green et al., 1994; Rennings, 2000; Rennings and Zwick, 2002; Brunnermeier and Cohen, 2003; Hojnik and Ruzzier, 2016). Here, we focus specifically on policy measures and firm strategies leaving all other factors as controls.

While the world is moving towards more sustainable development, and as environmental innovation reduces the impact on the environment (at the same time inducing a high demand, according to Wagner, 2008), green innovation remains relatively new and unknown to firms (Horbach et al., 2013). Thus, while various technologies have been developed for the renewable production of energy, including solar, wind, water, and biomass sources, these technologies remain unstable and far from perfect. This means many opportunities can still be exploited and firms that successfully develop and market their green innovations can profit from being among the first-movers in this sector and from establishing green standards. The absorption of internal and external knowledge could alleviate the problems of spillover effects on potential imitators, thus overcoming threats of imitation and concerns of appropriation.

As innovative output is the product of knowledge generating inputs (Griliches, 1979), we need to determine where firms search for knowledge inputs for their eco-innovations. Hence, here we pay particular attention to firms' sourcing strategies for green innovations, given that a successful innovation depends on how adept firms are at the identification of, deliberate search for, reaching out to, managing and implementing these promising sources (Cohen and Levinthal, 1990; von Hippel, 1988). If the wrong sourcing strategy is pursued, firms may easily lose their opportunities or competitive advantage. Thus, good knowledge sourcing can provide firms with a competitive strategy for investing in appropriate R & D or new product development and so they are better able to provide green products and boost their sales.

Resource-based theory highlights the importance of using internal capabilities and resources to maintain the sustainability of competitive advantage (Chen, 2008, Leonidou, 2013). These resources entail human knowledge, information technology and capital. Investment in these resources will necessarily lead to greater environmental efforts. In line with these arguments, we therefore formulate the following hypotheses:

H1a. Investment in the production process to prevent pollution increases environmental R & D.

H1b. Investment in end-of-pipe solutions to prevent pollution increases environmental R & D.

H1c. The acquisition of energy products increases environmental R & D.

The green business literature usually draws a distinction between firms that adopt a proactive stance, and which consider a variety of forces other than government regulations, and firms that are compliance-driven and that merely seek to meet their legal requirements (Buysse and Verbeke, 2003). As Kesidou and Demirel (2012) recognise, increasing investments in eco-innovation are influenced by a firm's capabilities – specifically, those related to organisational skills, source reduction, recycling, pollution prevention, and green product design. Recently, Demirel and Kesidou (2011) have identified a firm's organisational capabilities and its environmental management systems (EMS) as being key drivers of eco-innovation intensity. Stakeholders (internal and external) usually exert influence on managers to adopt accreditations or certifications as a way to improve reputations and therefore performance. Here, the introduction of different levels of EMS can act as one of several facilitator factors in both the development and adoption stages of eco-innovation. Among the EMS certifications (ISO 14001, ISO 9001 and EMAS), only ISO 14001 stimulates