Financial constraints and public funding of eco-innovation:
Empirical evidence from European SMEs

Grazia Cecere°, Nicoletta Corrocher*, Maria Luisa Mancusi^

°Institut Mines-Télécom/Télécom École de Management, 9 rue Charles Fourier, 91011 Évry, FRANCE.
Email: grazia.cecere@telecom-em.eu
*ICRIOS, Bocconi University, Via Roentgen 1, 20136 Milan, ITALY.
Email: nicoletta.corrocher@unibocconi.it
^Dipartimento di Economia e Finanza, Università Cattolica del Sacro Cuore,
Largo Gemelli 1, 20123 Milan, ITALY.
Email: marialuisa.mancusi@unicatt.it

Abstract

Financial constraints have an important impact on the development of eco-innovations but their effect varies according to the type of funding. This article studies the interaction between public funding on the one hand, and internal and external lack of funding on the other. The empirical analysis is based on a sample of European small and medium sized enterprises, and exploits information on firms' involvement in eco-innovation activities, their drivers, and obstacles. Our results show that, even accounting for demand pull effects and regulatory interventions, access to public funds and fiscal incentives is effective for improving the firm's ability to introduce eco-innovations, particularly if the company has ample funds from either internal or external sources. Our findings suggest also that public funding is perceived by firms as complementary to other external finance.

Keywords: eco-innovations, public funding, financial constraints, SMEs

JEL Codes: O31, Q55, G38

1. Introduction

Financing of eco-innovations is essential for "green" growth and sustainable development, which are policy agenda priorities for the European Union and other world countries. The European Eco-Innovation Action Plan, which is a part of the Europe 2020 strategy, aims at supporting and financing the innovative activities of firms to foster the transition towards a low carbon economy (OECD, 2009; Messeni Petruzzelli et al., 2011; European Commission, 2013). In particular, the European Union has committed to an 80% reduction in CO2 emissions by 2050 (compared to 1990 levels). Achieving this target requires the large-scale adoption of clean technologies, which are currently not competitive. While large companies are more likely to invest in green R&D to increase their environmental efficiency and contribute to sustainability in general, small and medium sized enterprises (SMEs) find it more difficult to commit their scarce resources to the development of green innovations (Del Brío and Junquera, 2003; Revell et al., 2010). The innovative activities of private firms need to be coupled with government interventions that address environmental and knowledge externalities specifically, and promote and participate in green R&D investments to make new technologies competitive (Olmos et al., 2012; Veugelers, 2012). Despite the important role played by demand pull policies and regulatory interventions, there is a need for proper public funding schemes that complement rather than replace private investment (Popp et al., 2009; Olmos et al., 2012). Therefore, it is important to have a better understanding not only of the financial barriers to eco-innovation – particularly for SMEs - but also and especially of the interplay between private and public funding of eco-innovation. This improved understanding would provide useful insights for European policy making.

The drivers of eco-innovation have been discussed extensively in the literature (Horbach, 2008; Montalvo, 2008; Horbach et al., 2012), which acknowledges the importance of supply-push, demand-pull and regulatory factors for their development. However, little attention has been paid to financial constraints, which are a major barrier to the conduct of green research projects (Kapoor and Oksnes, 2011; Ghisetti et al., 2017; Demirel and Parris, 2015). Innovation studies scholars have emphasized that access to finance is one of major barriers to firms' innovative activity and growth (Mina et al., 2013; Nanda and Kerr, 2015; Hall et al., 2016). If firms have insufficient internal funds to allocate to innovation, they need to find external funding in the form of bank loans, equity capital, or public financial support (e.g. subsidies, loans, tax incentives, venture capital). However, the returns to innovation are uncertain and skewed, and information asymmetries related to inputs (which are mostly intangible) and outputs make it hard to write accurate "state-contingent" contracts (Nanda and Kerr, 2015). This is even more problematic in the context of green innovations, where the risks and uncertainties are higher than in the case of standard innovations (Aghion et al., 2009; Cuerva et al., 2014; Ghisetti et al., 2017), due to externalities in both the introduction and diffusion phases. Therefore, in the transition towards a sustainable economy, eco-innovation activity needs to be public funded – at least partially - because of the weak competitiveness of clean technologies compared to the alternatives, and the uncertain effectiveness of regulation and other public policies mechanisms. However, the effectiveness of direct public funds for the development of eco-innovations is questionable (Alic et al., 2003), and the design of appropriate funding schemes needs to take account of technological and market characteristics (Olmos et al., 2012).

This study aims at understanding how different types of financial constraints – lack of internal finance vs. lack of external finance - affect the introduction of eco-innovations and,

most importantly, our original contribution is to study how they interact with the availability of public funds. This allows us to better evaluate the effectiveness of public support to eco-innovation, while accounting for demand-pull effects and regulatory interventions. In particular, our focus is on development of innovations that enable a sensible reduction in use of natural resources, which is an important element of eco-innovations according to the literature (Kemp and Foxon, 2007; Carrillo-Hermosilla et al., 2010; Ghisetti and Pontoni, 2015).

The empirical analysis is based on data from the 2011 Eurobarometer survey on eco-innovation, which includes information on the development of eco-innovations by SMEs from 27 EU countries. In our context it is particularly interesting to focus on SMEs, because they typically face higher human and financial resource constraints than large firms, but are strategic players in the process towards sustainable development. Our findings show that the lack of internal firm finance may hinder the development of eco-innovations, while the lack of external funds does not appear to be a significant barrier to eco-innovations. By contrast, we find that the access to public instruments such as public funds and fiscal incentives seems to be an important driver for the development of eco-innovations. In particular, our results show that the access to public incentives interacts significantly with the lack of external funds in affecting the probability to innovate and suggest that the two sources of funding are perceived as complementary by the firms.

In relation to other potentially relevant factors that might affect the likelihood of eco-innovation, we find that the probability of eco-innovation increases with firm size, share of innovation investment devoted to eco-innovation, and an expected increase in energy prices. We find also that firms with strong business networks and easy access to knowledge and technology are more likely to conduct eco-innovation activity. Finally, both regulatory and

demand factors are important for determining an increase in the probability of eco-innovation, which is in line with the literature.

The article is structured as follows. Section 2 presents the theoretical framework concerning the relationship between the availability of funds and the development of green innovations. We focus in particular on the existence of different types of lack of funds (internal vs. external), and on the role of public funds and fiscal incentives. Section 3 describes the data and the sample. Section 4 presents the empirical model and describes the explanatory variables. Section 5 presents and discusses the econometric results and section 6 concludes, providing some implications for policy.

2. Eco-innovation and financial constraints: a review of the literature

Financing of eco-innovation can facilitate a transition to a low carbon economy and is an important topic for both innovative companies (especially those at an early stage of their business development) and policy makers (OECD, 2012). The issue of innovation and how it should be financed is the subject of much discussion at the policy level because of the strategic role of green innovations (European Commission, 2011). The pursuit of green growth requires the involvement of different private and public actors and institutions within the economy – notably consumers, firms, and policy makers – and substantial investments. Therefore, the financial system (banks and institutional investors) as well as policy makers are important, since they are able to mobilize large amount of funds and to allocate them to long-term environmental projects often related to immature technologies or complex technological systems (Olmos et al., 2012). However, despite the emphasis on the need to finance efforts toward green growth and sustainable development, the design of a

suitable system of financial support for green innovations is at a very early stage (Cainelli and Mazzanti, 2013; Ghisetti et al., 2017).

The issue of finance for innovation has been investigated extensively in the literature (see Nanda and Kerr, 2015, and Hall et al., 2016 for recent reviews). Scholars have focused on the specific characteristics of R&D projects, and their consequences in terms of the constraints on funding innovation. Most contributions studying the effects of financing constraints on innovation focus on investment–cash flow sensitivity, consider innovation input (R&D investment) rather than output, and use measures of internal liquidity to proxy for financing constraints. The rationale of this approach is the idea that the first source of financing available to firm investing in an innovation project is internal liquidity. This is due to the imperfect substitutability between internal and external funds, which originates from information asymmetries and induce substantial difference between the costs of external finance, whether new debt or equity, and the opportunity cost of using internal finance generated from cash flows and retained earnings (Stiglitz and Weiss, 1981; Myers and Majluf, 1984).

The most relevant trait in R&D compared to other types of investment is that the former is highly risky and extremely uncertain, since the outcomes are unknown to potential investors (and sometimes to the innovator) (Hall and Lerner, 2010; Mina et al., 2013). Furthermore, the returns to innovation projects are extremely skewed (Hall and Lerner, 2010; Nanda and Kerr, 2015). Innovative projects are characterized by the presence of intangible assets and capital, since the knowledge is embedded in the human resources – researchers and technicians – employed by the company, and often remains tacit. Since employees can leave the firm and take with them at least part of the company's knowledge-base, firms often spread their R&D

investments over long time periods (Hall and Lerner, 2010). This increases the severity of the information asymmetries between investors and companies seeking funding for their innovative projects, and exacerbates the usual opportunistic behavior, adverse selection, and moral hazard problems (Mina et al., 2013; Hall et al., 2016). It follows that typically internal financial constraints will affect the decision to invest in research and firms will invest in new technologies only when they have a cash surplus[1]. However, internal funds inevitably are limited – especially in the case of SMEs – and therefore, firms need to look for external sources of funding if they are to continue with their innovation projects.

Financial constraints related to R&D projects are linked to the firm's structural characteristics, sectoral/technological context, and geographical setting (Canepa and Stoneman, 2007; Brown et al., 2012; Cincera et al., 2016; Lööf and Nabavi, 2016). In this respect, the literature provides evidence that eco-innovations that enable a sensible reduction in the use of natural resources are particularly constrained by lack of funds (Olmos et al., 2012; Cuerva et al., 2014; Ghisetti et al., 2017). Eco-innovations have some distinctive features compared to other innovation types. First, eco-innovations produce positive spillovers in both the introduction and diffusion stages – a feature known as the "double externality". This means that firms' incentives to develop eco-innovations are lower than in the case of non-eco-innovations (Rennings, 2000; Cecere et al., 2014). Second, eco-innovations are intrinsically more risky and uncertain than other investments, because they involve technologies that are in an initial stage of their development and therefore suffer from the existence of increasing returns (from knowledge, competencies, and infrastructure) in established, carbon-intensive technologies (Cecere et al., 2014). While the double externality

[1] Empirical evidence shows that firms use mostly internal funds to finance innovation and this reflects a gap in the cost of capital (Hottenrott and Peters, 2012).

issue requires policy intervention, the high uncertainty characterizing this type of innovation suggests that private funding is crucial to initiate innovative projects. Third, cost-related factors are cited in the literature as significant for the existing technological trajectory in a variety of sectors. Ayres (1991) argues that lock-in of whole technological systems is due, at least in part, to economies of scale. On the other hand, the payback period for eco-innovation investments is lengthy, since their capital costs are usually higher (Ghisetti et al., 2017). Moreover, the high costs associated to eco-innovations tend to be irreversible and this is problematic if prices are volatile (Cortazar et al., 1998). Fourth, since the financial capital market is biased towards short term profitability, the promotion of large-scale investments in eco-innovations, which allow reduced use of natural resources is counterproductive for it (Walsh, 2012). Finally, the evolution of and frequent changes in environmental regulation make the profitability of the eco-innovative projects uncertain (Rennings, 2000). As a result of path dependent processes in the social, institutional, and technological realms, most technological trajectories are often pollution-intensive (Cecere et al., 2014).

For all the above reasons, external finance is crucial to develop eco-innovative projects (Demirel and Parris, 2015; Ghisetti et al., 2017), and especially for SMEs. Similar to other types of investment, firms look for private or public external finance if internal funds are insufficient to support all their needs and activities. Private external financing instruments include bank loans, business angel capital, venture capital, corporate venturing, and crowd funding (Myers and Majluf, 1984; Hall, 2002; OECD, 2012). Among public external financing tools, it is possible to distinguish public loans/guarantees, publicly owned equity, and

subsidies in the form of prizes, tax credits, and other benefits related to green investments, grants, and contracts (Olmos et al., 2012)[2].

The role of public interventions in putting a market value on the environmental benefits is particularly important to ensure eco-innovation activity (Kapoor and Oksnes, 2011; Olmos et al., 2012; Cecere et al., 2014). Eco-innovations produce positive spillovers in both the introduction and diffusion stages – as mentioned before as the "double externality" issue - i.e. they can provide advantages to economic actors other than those who make the investments. These external benefits occur in the medium-long run, while the costs of eco-innovation are concentrated upfront and are often not monetized or fully captured (Kapoor and Oksnes, 2011). Due to these externalities, firms' incentives to carry out innovative projects are small, which typically results in under-investments (Rennings, 2000). Furthermore, the existing instruments to pull demand for green technologies – carbon pricing and deployment support measures – are insufficient to stimulate eco-innovation. However, public funding for innovation should complement rather than replace existing private funding (Olmos et al., 2012), since publicly managed innovative projects have some limitations, and the involvement of private actors (even in presence of public funds) would seem crucial. For example, Alic et al. (2003) provide evidence of both success and failure in use of public funds to support the development of green innovations. Therefore, it is reasonable to argue that firms able to exploit a combined portfolio of both internal and external funds are more likely to capture the benefits of direct public support in the form of funds and/or fiscal incentives. In terms of the impact of public funding on eco-innovation, the available empirical evidence on the effectiveness of subsidies (and tax incentives) to

[2] Subsidies can be assigned to firms that achieve specific goals regarding e.g. the overall percentage of sustainable products or processes developed, or to firms investing in new sustainable energy projects.

promote green innovations is not conclusive (Horbach et al., 2012; Costa et al., 2014) although some authors show that public subsidies drive the development of eco-innovations (Luiten and Block, 2003; Luiten et al., 2006; Horbach, 2008; Belin et al., 2011; De Marchi, 2012). Olmos et al. (2012) argue that the effectiveness of different types of public instruments to finance green innovations (specifically in the area of clean energy) depends on the size of the funding gap, i.e. of the difference between the project costs and the available private funds, the capacity of the technology to compete for public funds with others, the likelihood of technology failure, and the type of investor.

3. Data and descriptive evidence

Our empirical analysis is based on data from the Flash Eurobarometer survey ("*FL315 Attitudes of European entrepreneurs towards eco-innovation*"), conducted in 2011 on behalf of the European Commission DG Environment, Unit F3 – Communication. The original sample includes 5,222 European SMEs and is representative of the 27 EU countries.

The survey was designed to investigate firms' approaches to eco-innovation investments. Eco-innovation is defined as: "*…the introduction of any new or significantly improved product (good or service), process, organisational change or marketing solution that reduces the use of natural resources (including materials, energy, water and land) and decreases the release of harmful substances across the whole life-cycle*" (Eco-Innovation Observatory, 2012, p.8). The core questions were presented in four sections. The first section focused on materials costs and asked for information on the relevance of these costs to the firm, the firm's expectations about future changes to their materials costs, and the changes implemented by the firm to reduce the cost of their materials. The second section examined the firms' engagement in

different types of eco-innovative activities. The third and fourth sections investigated the barriers to and drivers of accelerated development of eco-innovations, focusing on technology/supply side factors, market/demand-side factors and regulation.

In the original sample, 79% of firms were small-sized – i.e. 10 to 49 employees, and 21% were medium– i.e. 50 to 249 employees. The firms operate mainly in five sectors: agriculture (8.2% of the sample), construction (28.3%), water supply and waste management (3.3%), manufacturing (53.1%), and food service activities (7%). Table 1 reports the distribution of the sample firms across sectors and size categories.

The survey investigated the nature of the eco-innovations, which include product, process, and organizational eco-innovations. In the overall sample, 44% of firms have developed at least one type of eco-innovation (2292 firms in total); 54% of innovators have developed product eco-innovations, 66.6% have introduced process eco-innovations, and 51.5% have implemented organization eco-innovations. There are overlaps among the different types of innovation, mostly between product and process eco-innovations: 60% (65%) of the firms that have introduced product (organizational) innovations have also developed process innovations.

In the survey, resources efficiency achieved by an innovation was measured as a reduction in materials use per unit of output for the innovating firm. Interestingly, 33% of innovating firms achieved very low levels of efficiency (below 5% reduction in materials use per unit of output), and another 11% were unable to assess the efficiency contributions of their innovations. Our dependent variable is a unique indicator of innovation, which is equal to 1 if the firm introduced any kind of eco-innovation that affected resources efficiency, i.e. which

allowed at least 5% reduction in materials use per unit of output. For those innovations with a trivial efficiency impact, we set our innovation indicator equal to zero. The share of eco-innovators in the overall sample is 25%.

Table 1 Distribution of firms by size across sectors

	All sample	*Small firms*	*Medium firms*
Agriculture	8.27	76.39	23.61
Construction	28.30	83.83	16.17
Water supply and waste management	3.31	71.10	28.90
Manufacturing	53.14	76.25	23.75
Food service activities	6.97	88.46	11.54
Total	**100**	**79.09**	**20.91**

Columns 2 and 3 report the percentage of respectively small firms (10-49 employees) and medium firms (50-249 employees) within the sector.

If we look at the share of innovation investments devoted to eco-innovations (as an indicator of input), as expected, the distribution shifts to the right for eco-innovators compared to the average firm (Table 2).

Table 2 Share of innovation investment devoted to eco-innovation

	None	*Less than 10%*	*Between 10% and 29%*	*Between 30% and 49%*	*More than 50%*	*Total*
All firms	19.37	36.74	26.59	9.95	7.36	100
Eco-innovators	3.16	22.64	39.83	19.56	14.81	100

In relation to the sources of finance, the survey asked respondents to assess the importance of two different types of financing constraints for reducing the development of eco-innovation by the firm: lack of internal funds and lack of external funds. The question asked respondents to evaluate the importance of these constraints on a four point scale, from 1 (not at all important) to 4 (very important). Starting from this, we built our two key variables for the relevance of the lack of funds: LACK_INT_FUND, which indicates a constraint on the development of eco-innovation originating from the lack of internal financing; LACK_EXT_FUND, which identifies constraints originating from lack of external financing. Each is a dummy variable that is equal to 1 if the firm rated the corresponding lack of funds as somewhat or very important.

Table 3 reports the percentage of firms with financing constraints by source of funds, and shows that innovative firms appear to be more constrained in the development of eco-innovation than the average firm in the sample, with the percentage of constrained firms being particularly high for small innovative firms.

Table 3, which is based on firm's self-assessments, should be read in conjunction with Table 2: it shows that the distribution of the share of investment devoted to the development of eco-innovation shifts to the right for innovative firms with respect to the average firm. This suggests that innovative firms invest more and perceive themselves as being more constrained than the average firm. This suggests a potential identification problem in the estimation, due to selection bias and reverse causality between the firms' perception of barriers and their innovative activity (Mohnen and Röller, 2005; Savignac, 2008; D'Este et al., 2012; Mancusi and Vezzulli, 2014; Pellegrino and Savona, 2017). The source of selection bias

here is related to the presence of firms that are not willing or not interested in carrying out eco-innovation, and thus do not perceive themselves as being constrained financially. This might generate a spurious positive correlation between the perception of financial constraints and the innovative behavior, which could hide the negative effect of lack of funds on eco-innovation (Savignac, 2008; Mancusi and Vezzulli, 2014). Since we have only cross-section data and we do not have reliable instruments to conduct an instrumental variables estimation, following the literature on the topic we adopt an approach to control for endogeneity, which consists simply of excluding from the sample the firms that are most likely to originate the bias (Savignac, 2008; Mancusi and Vezzulli, 2014, Pellegrino and Savona, 2017). Therefore, we exclude from our sample those firms that contemporaneously satisfy the following three conditions: (1) they do not carry out *any* type of eco-innovation activity (including those with low resources efficiency); (2) they do not perceive *any* type of financial constraints; (3) they do not pursue any investment in eco-innovation. This excluded 304 firms which does not affect the distribution across sectors and size classes in the sample.

Table 3 Share of firms claiming lack of funds, by source of finance

	All sample	*Innovative firms*	*Small innovative firms*
Lack of internal financing	63.01	65.37	67.25
Lack of external private financing	56.84	62.64	65.18

4. Empirical model and covariates

The financial constraints variables (lack of internal financing, lack of external financing) described in the previous section are two of the key variables of interest in our analysis. As previously discussed, given the specific characteristics of eco-innovations, and the features of SMEs, we expect a shortage of internal funds and difficulty in obtaining external financing to have a negative association to the development of eco-innovations. By contrast, the development of eco-innovations should be favored by the access to public funds or fiscal incentives. In order to test for the relevance of these kinds of public incentives, we include in our regressions an indicator variable which is equal to 1 if the firm says that the access to existing subsidies and fiscal incentives is an important driver that could accelerate eco-innovation uptake (PUBLIC_INCENTIVES).

The availability of different indicators of financial constraints for different sources of financing, together with an indicator of the importance of public incentives for the development of eco-innovations, is unique and allows us to study their separate effects as well as the interaction of public incentives with the firm's internal and external financing. To do so, we introduce interactions between our PUBLIC_INCENTIVES variable, on the one hand, and the variables LACK_INT_FUND and LACK_EXT_FUND, on the other hand. We have no clear expectations about the direction of these effects, which depend on the type and effectiveness of public funding for eco-innovation. The literature would suggest that complementarity rather than substitution between public and private sources of funding will be more conducive to the development of eco-innovation, but the magnitude and significance of the interaction effects remain uncertain.

Regarding the other variables in the regression, since our model explains innovation output, we need first to introduce a measure of innovation input. We do not have firms' R&D investment in eco-innovations, but we know from the survey whether the firm devoted a share of its innovative investments to eco-innovations in the five years prior to the survey period. The survey also provides a measure of that share according to five size categories. Specifically, as Table 2 shows, we know whether the share of innovation investment related to eco-innovation is zero, positive but less than 10%, between 10% and 29%, between 30% and 49%, or more than 50%. We thus obtain a corresponding set of categorical variables for the different and increasing shares of innovation investments devoted to eco-innovation (INV1-INV5). This variable is lagged with respect to the period over which the survey evaluated eco-innovation, which reduces endogeneity concerns. Of course, our investment dummies do not allow us to control for the scale of R&D investment, which is relevant. However, our variable does allow us to distinguish between firms conducting R&D and firms not conducting R&D (for which the share is necessarily zero), and also provides information on the size of the firm's eco-innovation effort.

Next, we consider the main drivers of eco-innovation following the literature (Horbach, 2008; De Marchi, 2012; Horbach et al., 2012; Kesidou and Demirel, 2012; Triguero et al., 2013; Ghisetti et al., 2017), which shows the importance of technology-related factors, market variables, and regulation. We drew on the responses to a series of questions in the survey about the relevance of a set of drivers that might accelerate eco-innovation uptake and development by the firm. Drivers include expected future materials scarcity (as an incentive to develop innovative, less materials-intensive substitutes), current high materials prices (as an incentive to innovate, to use less material, and lower their cost), current high energy prices (as an incentive to innovative, to use less energy and lower its cost), and increasing

market demand for green products. For each of these drivers, we built a categorical variable equal to 1 if the firm evaluates the specific driver as at least somewhat important. We use the variables MSCARCITY, MPRICES, and EPRICES, each of which is equal to 1 if the firm states that materials scarcity, materials prices, and energy prices, respectively, are important drivers of eco-innovation. Analogously, the variable DEMAND is a categorical variable equal to 1 if the responding firm indicates that the drive originating from increasing market demand for green products is important for the development of eco-innovation. The fostering role of demand in relation to eco-innovations is widely acknowledged in the literature (Horbach, 2008; Rennings et al., 2006).

We also built a variable (REGULATION) for the importance of existing regulations, including standards. Although the literature does not provide conclusive evidence in this respect, most authors believe that there is a positive relationship between regulation and the development of eco-innovations (Porter and van der Linde, 1995a, b; Kemp, 1997; Antonioli et al., 2013). The empirical investigation in Kesidou and Demirel (2012) shows that environmental regulation stimulates investment in the field of green innovation in both the least innovative and the most innovative firms.

The survey also includes a group of questions on the importance of technology-push drivers related to firm networks, specific competences, and knowledge, which are expected to have a positive effect on the probability to eco-innovate (Messeni Petruzzelli et al., 2011). In particular, one of these questions addresses the role of in-house knowledge measured through technological and management capabilities within the firm, while a second one assesses the importance of external knowledge accessed through collaboration with research institutes, agencies, and universities. These two variables measure the importance of internal

and external knowledge as drivers of eco-innovation, which respondents rate on a 1 to 4 scale (1=not important; 4=very important).

Once again, for both drivers, we built a categorical variable equal to 1 if the firm evaluates the specific driver as at least somewhat important and 0 otherwise. We also include in our regressions a control variable for firm size – SIZE. This is a categorical variable that takes the values 1 to 4, where 1 indicates turnover up to 2 million euros (52% of the firms in our sample), 2 indicates turnover of 2-10 million euros (35% of firms), 3 indicates turnover of 10-50 million (11% or firms), and 4 indicates turnover above 50 million euros (2% of firms). Innovation has been found always to increase with firm size, hence we expect this variable to be relevant and to have a positive effect on the probability to eco-innovate. Finally, we include the variable SUFFER which is a dummy variable that is equal to 1 if there was a reduction in the firm's turnover in the two years prior to the survey. This controls for firm performance in the market beyond its current size, and we would expect a negative correlation to the probability of introducing eco-innovation.

Table 4 provides the descriptive statistics for the main explanatory and control variables with reference to the estimated sample of 3,823 observations, after accounting for missing values in the dependent and control variables. Table 5 reports the sample correlations.

[Insert Table 4 and Table 5 about here]

5. Results

Tables 6 to 8 report the results of our estimates. All regressions include country and sector dummies, which we not report here simply to save space.

[Insert Table 6 about here]

Table 6 reports the estimation results of our basic specifications. Our basic specification in column (1) includes all three variables of interest linearly, together with our control variables; columns (2)-(4) also include the interactions between public funds and fiscal incentives on the one hand, and lack of internal and external financing on the other.

The first four rows report the odds ratios of the different and increasing shares of investments devoted to eco-innovation (the excluded category is zero investments), i.e. our indicators for the firm's R&D effort related to eco-innovation. As expected, all are well above 1 and increasing: increasing the share of investments devoted to eco-innovation significantly increases the probability of eco-innovation. More precisely, the increase in the odds is always significant, but flattens when the share of investment devoted to developing eco-innovations rises above 30% (i.e. INV4 and INV5 are not statistically different).

Turning to the control variables, SIZE is positive and significant in affecting the probability of eco-innovation, while firms experiencing lower performance in the market have a lower probability of developing eco-innovations. Both results are as expected, since larger firms can exploit economies of scale and/or economies of scope which might increase the benefits accruing from eco-innovations. They might also have greater resources endowment including human capital, which could facilitate the adoption and development of eco-innovations. Recent experience of reduced turnover might be a signal of lower firm abilities, reflected in a lower probability to develop eco-innovations, as shown by the negative coefficient of the variable SUFFER.

The variable representing firm in-house technological capabilities is not found to be a relevant driver of eco-innovation, while the variable accounting for capabilities accessed through cooperation and relationships with universities and research institutes is only mildly and sporadically significant, suggesting that networks might strengthen eco-innovation activities (Messeni Petruzzelli et al., 2011; De Marchi, 2012).

With regard to potential drivers of eco-innovation associated to their characteristics and objective, i.e. reduced use of natural resources, only high energy prices (EPRICES) appear to be a significant stimulus for engagement in eco-innovation, while materials scarcity and prices do not appear to have any effect on the probability to pursue eco-innovation activity. We also have two variables for whether eco-innovation is induced by regulation (REGULATION) or stimulated by demand (DEMAND). Similar to other studies (e.g. Kesidou and Demirel, 2012; Antonioli et al., 2013), we find a significant role of regulation in the development of eco-innovations. SMEs' innovative activity often is aimed at satisfying regulatory requirements, so regulation is perceived and acts as a distinctive driver of eco-innovations. This result indirectly confirms the weaker Porter hypothesis according to which regulation has a positive impact on innovation. Analogously, our indicator for perceived change in the buying behavior of customers toward products using less energy, products that use reduced materials and other inputs, and products that are less harmful to the environment is always (and strongly) significant in our regressions and stimulates eco-innovation (Rennings, 2000; Rennings et al., 2006; Horbach, 2008, 2012).

We turn next to the results for the main variables of interest. The focus of our empirical analysis is the impact of financial constraints on the development of eco-innovations, distinguishing between lack of internal funds, lack of external financing, and access to public

incentives. In particular, we are interested in the interactions between public funding and incentives, on the one hand, and different types of private funding, on the other hand, in order to understand the extent to which public funds are effective complements/substitutes to private funds to stimulate eco-innovations. The variables indicating lack of financing show only mild and occasional significance, which does not allow drawing any strong conclusion on their effect.[3] By contrast, and interestingly, access to public funding or fiscal incentives is consistently found to have a significant and positive effect on the probability of developing eco-innovations, confirming the important role of direct public intervention to support the transition to a low-carbon economy, and, in our setting, suggesting that regulation-induced innovation incentives and other demand-pull measures cannot replace public funding support (Popp et al., 2009; Olmos et al., 2012).

Some interesting and suggestive results come from the analysis of the interaction effects between public funding and other sources of funding. In particular, public funding and fiscal incentives are interacted with the lack of external funds in specification (2) and with the lack of internal funds in specification (3). Specification in column (4) includes both interactions. The estimation output shows that the effect of public incentives for firms suffering external (internal) financing constraints is 0.72 (0.81) times that of firms without lack of external (internal) financing. So the interaction effect tells how much the effect of public incentives differs between firms with and without external (internal) financing constraints, but it does so in multiplicative terms. The results also show that the interaction with external financing constraints is not strongly significant and it is not significant with internal financing constraints. To ease interpretation of these interaction effects, we compute the marginal effect of public incentives as the difference between the expected odds of firms with and without

[3] There is some evidence of a negative effect of lack of internal funds, while the variable indicating the importance of lack of external funds is significant only in column (3), where it also appears interacted with the "public incentives" variable.

public incentives, rather than as the derivative of the expected odds with respect to public incentives. We will now call this the marginal effect as in Buis (2010). Table 7 reports the odds of eco-innovation for every combination of the variables involved in the interactions.

[Insert Table 7 about here]

First, note that the odds of each specific combination are similar whether we consider the specification that includes just that interaction (columns (2) and (3) in Table 6), or the specification with both interactions included (column (4) in Table 6). Therefore, we focus on the first two columns in Table 7 although our comments apply also to column (3).

Looking at column (1) of Table 7 and focusing on the first two rows, we can consider the marginal effect of public incentives when the firm has no lack of external financing as the difference between the expected odds in favor of eco-innovation for firms that see public incentives as important, and those firms for which access to public incentives is irrelevant, when LACK_EXT_FIN is equal to zero (Buis, 2010). That difference is equal to 0.29 and is statistically significant at the 1% level. Hence, for firms that do not perceive the lack of external financing as important, the access to public funds or fiscal incentives improves the odds of eco-innovation. By contrast, public funding appears ineffective for firms that perceive external financing constraints (3rd and 4th rows), which suggests that firms might perceive some kind of complementarity between external financing and public funding.

Column (2) in Table 7 allows us to obtain the marginal effect of public funding when the firm does not lack internal financing, as the difference between the expected odds in favor of eco-innovation for firms claiming the importance of public funding vs. those that do not consider

it important, when LACK_INT_FIN is equal to zero. That difference is equal to 0.34 and is statistically significant at the 1% level. Hence, access to public funds and fiscal incentives for firms that do not perceive the lack internal financing as important is effective for increasing the odds in favor of eco-innovation. We obtain the same result if the firm suffers from internal financing constraints, i.e. when LACK_INT_FIN is equal to 1, but in this case the difference in the odds is much smaller (0.11) and significant at the 5% level.

Finally, we run our different specifications on two separate subsamples: small firms (under 50 employees) and medium firms (50-249 employees). In this case, we exclude the variable SIZE from the analysis. We perform this simple additional exercise because the literature has emphasized the importance of financing constraints and public incentives particularly for small firms. The results are reported in Table 8 and show that all the effects we discussed are confined to small firms, confirming that this is the group of firms that suffers most from financing constraints, and for which public policy may be effective for increasing their innovation performance.

[Insert Table 8 about here]

6. Conclusions

The article aimed to shed light on the importance of financial constraints for the development of eco-innovations by SMEs, whose innovative activities are perceived as increasingly crucial for green growth. Both research and policy studies emphasize that SMEs are more flexible than large firms, and are better able to benefit from the opportunities associated with the emerging paradigm (OECD, 2011). However, the development of eco-

innovations in small firms faces important obstacles, among which financing, and resources constraints more generally, represent relevant challenges. Specifically, we investigated the extent to which internal and external private and public funds are conducive to the development of eco-innovations. Also, given the specificities of eco-innovations, we focused particularly on the interplay between the access to public funding and incentives and other sources of funding, and their effectiveness.

The results suggest that access to public funds and fiscal incentives may accelerate the development of eco-innovations, and that their effectiveness interacts in particular with firms' availability of external financing. Specifically, our results suggest that public support for eco-innovation is perceived by the firms as complementary to availability of external funds. In this respect, we support the idea of a complementarity between different types of external funding in the process of stimulating eco-innovations, which suggests that the marginal impact of public funding is effective, when other types of funding are also in place (Olmos, 2012: Ghisetti et al., 2017).

For the other variables, we found that knowledge, either developed within the firm or in cooperation with external sources (research agencies, universities, business partners), positively affect the probability to introduce eco-innovations, which corroborates previous empirical findings (De Marchi, 2012; Horbach et al., 2012). Also, incentives or constraints imposed by regulation appear to increase eco-innovation, suggesting that, at least in the case of SMEs, public funding support for the development of green innovations and regulatory support are both effective policy interventions (Olmos et al., 2012; Triguero et al., 2013).

Our results have important implications for policy. In particular, they show that in order to design suitable innovation policy mechanisms and to organize the provision of direct support for the development of eco-innovations, firm's financial constraints need to be taken into account. On the one hand, the availability of public funding and access to fiscal incentives are perceived by the firms as important facilitators of eco-innovations. This applies particularly to small companies that suffer from lack of equity and loan financing, and lack of access to funding from banks and private institutions. In this context, the access to regional and national funding could be simplified, in order to reduce the administrative burden and allow greater participation of SMEs. On the other hand, if this support is provided in the absence of adequate external financing, the risk of public funds being ineffective is high. Therefore, the public support for eco-innovation activity should complement rather than substitute for private sector funding.

Another important result for policy is the relevance of firms' knowledge, which is developed through networking with business actors, and with research centers and universities. This suggests that it is important to encourage cooperation between universities and firms in order to combine different knowledge bases and technological competences for the development of eco-innovations. However, the relevance of knowledge networks does not attenuate the negative effect of financial constraints, suggesting that policies aimed at stimulating the development of research networks in the area of sustainable development need to be accompanied by provision of direct financial support for private innovative activity.

Finally, both demand and regulation play important roles in the development of eco-innovation. First, at firm level, in order to get close to customers and exploit growing

demand for environmentally friendly products, firms need to improve their corporate image and pursue closer integration of their eco-innovation development and marketing functions. Second, policy makers should design policy mechanisms to support eco-innovation activity, which include both direct financial support to companies that show long-term and sustainable commitment to eco-innovations, and (and most importantly) demand pull measures (e.g. carbon pricing) for more mature technologies, as well as regulation induced innovation incentives, such as the definition of standards.

References

Aghion, P., Veugelers, R., Hemous, D. 2009. No green growth without innovation. Bruegel Policy Briefs 7, 1-8.

Alic, J.A., Mowery, D.C., Rubin, E.S. 2003. US technology and innovation policies: lessons for climate change. Pew Center for Global Climate Change, Arlington, VA. Available at: http://repository.cmu.edu/cgi/viewcontent.cgi?article=1095&context=epp.

Antonioli, D., Mancinelli, S. Mazzanti, M. 2013. Is environmental innovation embedded within high-performance organizational changes? The role of human resource management and complementarity in green business strategies, Research policy 42,975-988.

Ayres, R. 1991. Evolutionary economics and environmental imperatives. Structural Change and Economic Dynamics 2(2), 255–273.

Belin, J., J. Horbach, Oltra. V. 2011. Determinants and specificities of eco-innovations – an econometric analysis for France and Germany based on Community Innovation Survey. Cahiers du GREThA n° 2011-17.

Bos-Brouwers, H.E.J. 2010. Corporate sustainability and innovation in SMEs: evidence of themes and activities in practice. Business Strategy and the Environment 19(7), 417-435.

Brown J.R., Martinsson G., Petersen B.C. 2012. Do Financing Constraints Matter for R&D?. European Economic Review 56(8), 1512–1529.

Buis M.L. 2010. Interpretation of interactions in nonlinear models. The Stata Journal 10(2), 305-308.

Cainelli, G., Mazzanti, M. 2013. Environmental innovations in services: Manufacturing–services integration and policy Transmission. Research Policy 42 (9), 1595-1604.

Canepa, A., Stoneman, P. 2007. Financial constraints to innovation in the UK: evidence from CIS2 and CIS 3. Oxford Economic Papers 60, 711-730

Carrillo-Hermosilla, J., del Rio, P., & Konnola ¨, T. 2010. Diversity of eco-innovations: Reflections from selected case studies. Journal of Cleaner Production 18(10), 1073-1083.

Cecere, G., Corrocher, N., Gossart, C., Ozman, M. 2014. Eco-innovations and the evolutionary approach to technical change: a review of the literature. Journal of Evolutionary Economics 24 (5), pp. 1037-1065

Cincera, M., Ravet, J., Veugelers, R. 2016. The sensitivity of R&D investments to cash flows: comparing young and old EU and US leading innovators. Economics of Innovation and New Technology 25(3), 304-320.

Cortazar, G., Schwartz, E.S., Salinas, M. 1998. Evaluating environmental investments: a real options approach. Management Science 44(8), 1059–1070.

Costa, M.T., Garcia-Quevedo, J.,Segarra, A. 2014. Energy efficiency determinants: An empirical analysis of Spanish innovative firms. IEB Working Paper N. 2014/10.

Cuerva, M.C., Triguero-Cano, Á., Córcoles, D. 2014. Drivers of green and non-green innovation: empirical evidence in low-tech SMEs. Journal of Cleaner Production 68, 104-113.

De Marchi, V. 2012. Environmental innovation and R&D cooperation: Empirical evidence from Spanish manufacturing firms. Research Policy 41(3), 614-623.

Del Brío, J.Á., Junquera, B. 2003. A review of the literature on environmental innovation management in SMEs: implications for public policies. Technovation 23(12), 939-948.

Demirel, P., Parris. S, 2015. Access to finance for innovators in the UK's environmental sector. Technology Analysis and Strategic Management 27(7), 782-808.

D'Este,P., Iammarino, S., Savona, M.,von Tunzelmann, N. 2012. What hampers innovation? Revealed barriers versus deterring barriers. Research Policy 41, 482 – 488.

Eco-Innovation Observatory 2012. Methodological Report. European Commission, Brussels.

European Commission, 2011. Financing eco-innovation. Final Report, EIM and Oxford Research for the European Commission, DG Environment.

European Commission, 2013. Europe in Transition. Paving the way to a green economy through eco-innovation. Eco-innovation observatory, Annual Report 2012.

Hall B.H., 2002. The financing of research and development. Oxford Review of Economic Policy 18 (1), 35-51.

Hall B.H., Lerner J., 2010. The Financing of R&D and Innovation. In: Hall B.H. and Rosenberg N. (Eds.), Handbook of the Economics of Innovation. Elsevier-North Holland.

Hall, B.H., Moncada-Paternò Castello, P., Montresor, S., Vezzani, A. 2016. Financing constraints, R&D investments and innovative performances: new empirical evidence at the firm level for Europe. Economics of Innovation and New Technology 25(3), 183-196.

Horbach, J. 2008. Determinants of Environmental Innovation – New Evidence from German Panel Data Sources. Research Policy 37, 163-173.

Horbach, J., Rammer, C. , Rennings, K. 2012. Determinants of Eco-innovations by Type of Environmental Impact - The Role of Regulatory Push/Pull, Technology Push and Market Pull. Ecological Economics, 78, 112-122.

Hottenrott, H., Peters, B. 2012. Innovative capability and financinig constraints for innovation: More money, more innovation? Review of Economics and Statistics, 94(4), 1126-1142.

Kapoor, S., Oksnes, L. 2011. Funding the Green New Deal: Building a Green Financial System. Green European Foundation. Green New Deal Series Vol. 6.

Kemp, R., Foxon, T., 2007. Typology of eco-innovations. Deliverable 2. EU FP6 funded project 044513: 24. Maastricht.

Kemp, R. 1997. Environmental Policy and Technical Change. Edward Elgar, Cheltenham, Brookfield.

Kesidou, E., Demirel, P. 2012. On the drivers of eco-innovations: Empirical evidence from the UK. Research Policy 41(5), 862-870.

Lööf, H., Nabavi, P. 2016. Innovation and credit constraints: evidence from Swedish exporting firms. Economics of Innovation and New Technology 25(3), 269-282.

Luiten, E.E., Block, K. 2003. Stimulating R&D of industrial energy-efficient technology; the effect of government intervention on the development of strip casting technology. Energy Policy 31(13), 1339-1356.

Luiten, E., van Lente, H., Block, K. 2006. Slow technologies and government intervention: Energy efficiency in industrial process technologies. Technovation 26(9), 1029-1044.

Mancusi, M.L.,Vezzulli, A. 2014. R&D and Credit Rationing in SMEs. Economic Inquiry 52(3) 1153–1172.

Ghisetti C., Pontoni. F. 2015. Investigating policy and R&D effects on environmental innovation: A meta-analysis. Ecological Economics 1, 1857-66.

Ghisetti, C., Mancinelli, S., Mazzanti, M., Zoli, M. 2017. Financial barriers and environmental innovations: evidence from EU manufacturing firms. Climate Policy 17, sup1. S131-S147

Messeni Petruzzelli, A., Dangelico, R.M., Rotolo, D., Albino, V. 2011. Organizational factors and technological features in the development of green innovations: Evidence from patent analysis. Innovation: Management, Policy & Practice 13, 291-310.

Mina, A., Lahr, H., Hughes, A. 2013. The demand and supply of external finance for innovative firms. Industrial and Corporate Change 22(4), 1-33.

Mohnen, P., Roller, L.-H. 2005. Complementarities in innovation policy. European Economic Review 49(6), 1431-1450

Montalvo, C. 2008. General wisdom concerning the factors affecting the adoption of cleaner technologies: a survey 1990-2007. Journal of Cleaner Production 16, S7-S13.

Myers S.C., Majluf, N. 1984. Corporate Financing and Investment Decisions When Firms Have Information That Investors Do Not Have. Journal of Financial Economics 13(2), 187-221.

Nanda R., Kerr W.R. 2015. Financing Innovation. Annual Review of Financial Economics 7(1), 445-462.

OECD 2009. Measuring the Relationship between ICT and the Environment. OECD Publishing, Paris.

OECD 2011. SMEs and Entrepreneurship: Green Growth, Innovation and Employment. Centre for Entrepreneurship, SMEs and Local Development, OECD, Paris.

OECD 2012. Science, Technology and Industry Outlook. OECD, Paris.

Olmos, L., Ruester, S., Liong, S-J. 2012. On the selection of financing instruments to push the development of new technologies: Application to clean energy technologies. Energy Policy 43, 252-266.

Pellegrino, G., Savona, M. 2017. No money, no honey? Financial versus knowledge and demand constraints on innovation. Research Policy 46, 510-521.

Popp, D., Newell, R.G., Jaffe, A.B. 2009. Energy, the environment and technological change. NBER Working Paper 14832. Available at: http://www.nber.org/papers/w14832.pdf.

Porter, M.E., van der Linde, C. 1995a. Green and Competitive. Ending the Stalemate. Harvard Business Review, September– October, 120–134.

Porter, M.E., van der Linde, C. 1995b. Toward a new conception of the environment-competitiveness relationship. Journal of Economic Perspectives 9(4), 97-118.

Rennings, K. 2000. Redefining innovation — eco-innovation research and the contribution from ecological economics. Ecological Economics 32, 319–332.

Rennings, K., Ziegler, A., Ankele, K., Hoffmann, E. 2006. The influence of different characteristics of the EU environmental management and auditing scheme on technical environmental innovations and economic performance. Ecological Economics 57(1), 45–59.

Revell, A., Stokes, D., Chen, H. 2010. Small businesses and the environment: turning over a new leaf? Business strategy and the environment 19(5), 273-288.

Savignac, F. 2008. Impact of Financial Constraints on Innovation: What Can Be Learned from a Direct Measure? Economics of Innovation and New Technology 17(6), 553-69.

Stiglitz, J., Weiss A. 1981. Credit rationing in markets with imperfect information, American Economic Review 71, 393–410.

Triguero, A., Moreno-Mondéjar, L., Davia, M.A. 2013. Drivers of different types of eco-innovation in European SMEs. Ecological Economics 92, 25-33.

Veugelers, R. 2012**.** Which policy instruments to induce clean innovating? Research Policy 41(10), 1770-1778.

Walsh, P.R. 2012. Innovation nirvana or innovation wasteland? Identifying commercialization strategies for small and medium renewable energy enterprises. Technovation 32(1), 32–42.

Annex A.

SELECTED QUESTIONS USED

Questions used to build the dependent variable and the quality control on the dependent variable

D5. During the past 24 months have you introduced the following eco-innovation

- Yes 1

- No.....2

a. a new or significantly improved eco-innovative product or service to the market..... 1 2

b. a new or significantly improved eco-innovative production process or method..... 1 2

c. a new or significantly improved eco-innovative organisational innovation..... 1 2

Q0 How would you describe the relevance of innovation you have introduced in the past 24 months in terms of resource efficiency?

Less than 5% reduction of material use per unit output..... 1

Between 5% to 19% reduction of material use per unit output..... 2

Between 20% to 39% reduction of material use per unit output..... 3

Between 40% to 60% reduction of material use per unit output..... 4

More than 60% reduction of material use per unit output 5

Question used to build the variables on lack of internal and external funds

Q7. I will list you some barriers that could represent an obstacle to accelerated eco-innovation uptake and development for a company. Please tell me for each of them if you consider them a very serious, somewhat serious, not serious or not at all serious barrier in case of your company?

- Very serious 4

- Somewhat serious 3

- Not serious 2

- Not at all serious 1

a. Lack of funds within enterprise 0 1

b. Lack of external financing..... 0 1

Question used to build the variable on access to public funds and fiscal incentives

Q8. I will list you some drivers that could accelerate eco-innovation uptake and development for a company. Please tell me for each of them if you consider them a very important, somewhat important, not important or not at all important driver in case of your company?

- Very important..... 4

- Somewhat important 3

- Not important..... 2

- Not at all important 1

n. Access to existing subsidies and fiscal incentives 0 1

Question used to build the variables on supply-side, demand-side and regulation

Q8. I will list you some drivers that could accelerate eco-innovation uptake and development for a company. Please tell me for each of them if you consider them a very important, somewhat important, not important or not at all important driver in case of your company?

- Very important..... 4

- Somewhat important 3

- Not important..... 2

- Not at all important 1

SUPPLY-SIDE VARIABLES (INTERNAL AND EXTERNAL KNOWLEDGE)

a. Technological and management capabilities within the enterprise..... 0 1

f. Collaboration with research institutes, agencies and universities..... 0 1

REGULATION

l. Existing regulations, including standards 0 1

DEMAND

o. Increasing market demand for green products 0 1

MPRICE

c. Current high material prices (as an incentive to innovate, to use less material and decrease the cost) 0 1

EPRICE

i. Current high energy prices (as an incentive to innovative, to use less energy and decrease the cost) ……..... 0 1

MSCARCITY

e. Expected future material scarcity (as an incentive to develop innovative, less material-intensive substitutes).....0 1

Question used to build the variable on the innovation investment related to eco-innovation

Q6. Over the last 5 years, what share of innovation investments in your company were related to eco-innovation, i.e. implementing new or substantially improved solutions resulting in more efficient use in material, energy and water?

- More than 50% 1

- Between 30% and 49%.....2

- Between 10% and 29%.....3

- Less than 10%.....4

- None 5

Annex B.

TABLES

Table 4 - Descriptive statistics:

Variable		Mean	Std.	Min	Max
INV2	Takes value 1 if the innovation investment related to eco-innovation is less than 10%, 0 otherwise.	.40	.49	0	1
INV3	Takes value 1 if the innovation investment related to eco-innovation is between 10 and 29%, 0 otherwise.	.28	.45	0	1
INV4	Takes value 1 if the innovation investment related to eco-innovation is between 30 and 49%, 0 otherwise.	.10	.30	0	1
INV5	Takes value 1 if the innovation investment related to eco-innovation is more than 50%, 0 otherwise.	.08	.27	0	1
SIZE	1 indicates a turnover up to 2 million euros, 2 is associated with a turnover of 2-10 million euros, 3 indicates a turnover of 10-50 million, 4 indicates a turnover of more than 50 million euros.	1.62	.76	1	4
SUFFER	Takes value 1 if the company's annual turnover decreased over the past two years, 0 otherwise.	.45	.50	0	1
INHOUSE_CAP	Takes value 1 if the company declares that technological or management capabilities within the firm are important or very important drivers of eco- innovation, 0 otherwise.	.80	.40	0	1
RES_COLL	Takes value 1 if the company declares that collaboration with research institutes, agencies, and universities are important or very important drivers of eco- innovation, 0 otherwise.	.55	.50	0	1
MSCARCITY	Takes value 1 if the company declares the expected future material scarcity as an important or very important driver of eco-innovation, 0 otherwise.	.67	.47	0	1
MPRICES	Takes value 1 if the company declares the current high material prices as an important or very important driver of eco-innovation, 0 otherwise.	.80	.40	0	1

EPRICES	Takes value 1 if the company declares the current high energy prices as an important or very important driver of eco-innovation, 0 otherwise.	.85	.36	0	1
DEMAND	Takes value 1 if the company declares the increasing market demand for green products as an important or very important driver of eco-innovation, 0 otherwise.	.72	.45	0	1
REGULATIONS	Takes value 1 if the company declares existing regulations imposing new standards as an important or very important driver of eco-innovation, 0 otherwise.	.76	.43	0	1
PUBLIC_INCENTIVES	Takes value 1 if the company declares existing subsidies and fiscal incentives as a very important driver of eco-innovation, 0 otherwise.	.46	.50	0	1
LACK_INT_FUND	Takes value 1 if the company declares the lack of internal funds as important or very important, barrier to eco-innovation, 0 otherwise.	.67	.47	0	1
LACK_EXT_FUND	Takes value 1 if the company declares the lack of external funds as an important or very important barrier to eco-innovation, 0 otherwise.	.61	.49	0	1

Table 5 Correlations matrix dependent variable and explanatory variables

	INV2	INV3	INV4	INV5	SIZE	SUFF.	INHOUSE_CAP	RES_COL	MSCARCITY	MPRICES	EPRICES	DEMAND	REGUL.	LACK_INT_FUND	LACK_EXT_FUND	PUBLIC INCENTIVES
INV2	1.00															
INV3	-0.51	1.00														
INV4	-0.28	-0.21	1.00													
INV5	-0.24	-0.18	-0.10	1.00												
SIZE	-0.02	0.04	0.06	0.05	1.00											
SUFFER	0.04	-0.03	-0.03	-0.05	-0.10	1.00										
INHOUSE_CAP	-0.08	0.05	0.06	0.02	-0.01	-0.01	1.00									
RES_COL	-0.06	0.05	0.07	0.04	0.06	0.01	0.27	1.00								
MSCARCITY	-0.06	0.05	0.05	-0.02	0.02	-0.01	0.23	0.26	1.00							
MPRICES	-0.06	0.06	0.05	-0.02	-0.00	0.03	0.22	0.16	0.34	1.00						
EPRICES	-0.05	0.07	0.01	-0.01	-0.02	0.01	0.20	0.17	0.25	0.40	1.00					
DEMAND	-0.08	0.07	0.06	0.06	0.02	-0.01	0.22	0.25	0.28	0.21	0.21	1.00				
REGULATION	-0.04	0.03	0.02	0.01	0.00	0.00	0.27	0.22	0.23	0.20	0.21	0.20	1.00			
LACK_INT_FUND	-0.07	0.01	-0.03	-0.02	-0.16	0.14	0.13	0.10	0.16	0.14	0.12	0.10	0.13	1.00		
LACK_EXT_FUND	-0.06	0.03	-0.01	-0.02	-0.12	0.11	0.14	0.16	0.16	0.14	0.13	0.14	0.13	0.43	1.00	
PUBLIC_INCENTIVES	-0.08	0.03	0.00	0.01	-0.10	0.05	0.17	0.23	0.17	0.13	0.15	0.15	0.17	0.20	0.24	1.00

Table 6 Logistic regressions on the probability to introduce any eco-innovations

Dependent variable : ECOINNO	(1)	(2)	(3)	(4)
INV2	3.140***	3.136***	3.134***	3.133***
	(0.651)	(0.649)	(0.649)	(0.648)
INV3	10.29***	10.30***	10.27***	10.29***
	(2.108)	(2.108)	(2.103)	(2.105)
INV4	17.75***	17.73***	17.69***	17.70***
	(3.956)	(3.947)	(3.940)	(3.939)
INV5	18.38***	18.31***	18.38***	18.31***
	(4.237)	(4.217)	(4.236)	(4.217)
SIZE	1.138**	1.140**	1.140**	1.140**
	(0.0629)	(0.0631)	(0.0630)	(0.0631)
SUFFER	0.761***	0.763***	0.761***	0.763***
	(0.0641)	(0.0644)	(0.0642)	(0.0644)
INHOUSE_CAP	1.069	1.065	1.066	1.064
	(0.122)	(0.121)	(0.121)	(0.121)
RES_COLL	1.162*	1.156	1.160*	1.156
	(0.103)	(0.103)	(0.103)	(0.103)
MSCARCITY	0.944	0.942	0.941	0.940
	(0.094)	(0.094)	(0.094)	(0.094)
MPRICES	1.213	1.209	1.213	1.210
	(0.150)	(0.150)	(0.150)	(0.150)
EPRICES	1.682***	1.669***	1.675***	1.667***
	(0.236)	(0.234)	(0.235)	(0.234)
DEMAND	1.406***	1.409***	1.405***	1.409***
	(0.148)	(0.149)	(0.148)	(0.149)
REGULATION	1.269**	1.268**	1.266**	1.267**
	(0.132)	(0.132)	(0.132)	(0.132)
LACK_INT_FUND	0.839*	0.835*	0.920	0.869
	(0.0818)	(0.0814)	(0.113)	(0.112)
LACK_EXT_FUND	1.073	1.235*	1.070	1.214
	(0.103)	(0.150)	(0.103)	(0.153)
PUBLIC_INCENTIVES	1.205**	1.486***	1.397**	1.544***
	(0.103)	(0.205)	(0.205)	(0.248)
LACK_EXT_FUND*PUBLIC_INCENTIVES		0.724*		0.751

		(0.123)		(0.140)
LACK_INT_FUND*PUBLIC_INCENTIVES			0.807	0.913
			(0.140)	(0.173)
baseline	0.021***	0.019***	0.020***	0.019***
	(0.008)	(0.008)	(0.008)	(0.008)
Country dummies	yes	yes	yes	yes
Sector dummies	yes	yes	yes	yes
Observations	3,844	3,844	3,844	3,844

Odds-ratios. Robust standard errors in exponential form reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 7 Odds ratios for lack of funds interactions

	Odds from specification (2) in Table 6	Odds from specification (3) in Table 6	Odds from specification (4) in Table 6
LACK_EXT_FUND=0, PUBLIC_INCENTIVES=0	0.405***		0.404***
	(0.0330)		(0.0330)
LACK_EXT_FUND=0, PUBLIC_INCENTIVES=1	0.697***		0.699***
	(0.0776)		(0.0779)
LACK_EXT_FUND=1, PUBLIC_INCENTIVES=0	0.522***		0.521***
	(0.0421)		(0.0421)
LACK_EXT_FUND=1, PUBLIC_INCENTIVES=1	0.591***		0.592***
	(0.0420)		(0.0420)
LACK_INT_FUND=0, PUBLIC_INCENTIVES=0		0.464***	0.466***
		(0.0411)	(0.0413)
LACK_INT_FUND=0, PUBLIC_INCENTIVES=1		0.797***	0.796***
		(0.0920)	(0.0919)
LACK_INT_FUND=1, PUBLIC_INCENTIVES=0		0.458***	0.459***
		(0.0346)	(0.0349)
LACK_INT_FUND=1, PUBLIC_INCENTIVES=1		0.569***	0.569***
		(0.0400)	(0.0400)

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 8 Logistic regressions with lack of funds interactions by firm size

	(1) small	(2) small	(3) small	(4) small	(5) medium	(6) medium	(7) medium	(8) medium
INV2	3.237***	3.240***	3.236***	3.239***	2.380**	2.373**	2.367**	2.346**
	(0.725)	(0.724)	(0.724)	(0.724)	(1.021)	(1.019)	(1.018)	(1.012)
INV3	11.11***	11.17***	11.11***	11.17***	6.316***	6.316***	6.254***	6.231***
	(2.453)	(2.462)	(2.453)	(2.462)	(2.681)	(2.679)	(2.661)	(2.654)
INV4	16.54***	16.68***	16.59***	16.68***	16.51***	16.60***	16.13***	16.20***
	(3.962)	(3.991)	(3.972)	(3.991)	(7.576)	(7.609)	(7.417)	(7.456)
INV5	16.93***	16.92***	16.97***	16.92***	18.94***	18.96***	18.84***	18.86***
	(4.256)	(4.246)	(4.266)	(4.248)	(9.011)	(9.013)	(9.001)	(9.021)
SUFFER	0.757***	0.757***	0.758***	0.757***	0.767	0.762	0.774	0.764
	(0.0707)	(0.0708)	(0.0708)	(0.0708)	(0.136)	(0.137)	(0.138)	(0.138)
INHOUSE_CAP	1.158	1.147	1.153	1.146	0.892	0.889	0.898	0.895
	(0.146)	(0.144)	(0.145)	(0.144)	(0.201)	(0.201)	(0.203)	(0.202)
RES_COLL	1.151	1.148	1.152	1.148	1.163	1.170	1.141	1.150
	(0.113)	(0.113)	(0.113)	(0.113)	(0.214)	(0.215)	(0.211)	(0.212)
MSCARCITY	0.948	0.943	0.944	0.942	0.922	0.920	0.923	0.917
	(0.105)	(0.105)	(0.105)	(0.105)	(0.191)	(0.191)	(0.191)	(0.190)
MPRICES	1.201	1.196	1.200	1.196	1.241	1.242	1.235	1.235
	(0.165)	(0.165)	(0.165)	(0.165)	(0.331)	(0.331)	(0.330)	(0.331)
EPRICES	1.643***	1.642***	1.637***	1.641***	2.097**	2.121**	2.096**	2.158**
	(0.253)	(0.253)	(0.252)	(0.253)	(0.665)	(0.680)	(0.665)	(0.695)
DEMAND	1.359***	1.355**	1.357***	1.355**	1.534**	1.529**	1.539**	1.528**
	(0.161)	(0.160)	(0.160)	(0.160)	(0.320)	(0.320)	(0.322)	(0.320)
REGULATIONS	1.318**	1.312**	1.314**	1.312**	1.205	1.205	1.204	1.204
	(0.156)	(0.156)	(0.156)	(0.156)	(0.259)	(0.259)	(0.259)	(0.259)
LACK_INT_FUND	0.788**	0.783**	0.863	0.792	0.921	0.924	1.043	1.111
	(0.0855)	(0.0850)	(0.119)	(0.115)	(0.179)	(0.180)	(0.254)	(0.282)
LACK_EXT_FUND	1.119	1.354**	1.117	1.348**	0.907	0.861	0.907	0.792
	(0.119)	(0.184)	(0.118)	(0.191)	(0.181)	(0.218)	(0.180)	(0.208)
PUBLIC_INCENTIVES	1.210**	1.609***	1.398**	1.627***	1.100	1.023	1.335	1.208
	(0.114)	(0.248)	(0.230)	(0.293)	(0.194)	(0.277)	(0.372)	(0.369)
LACK_EXT_FUND*PUBLIC_INC.		0.649**		0.656**		1.127		1.365

		(0.122)		(0.135)		(0.397)		(0.533)
LACK_INT_FUND*PUBLIC_INC.			0.814	0.975			0.740	0.646
			(0.157)	(0.206)			(0.253)	(0.246)
BASELINE	0.0253***	0.0232***	0.0241***	0.0231***	0.0196***	0.0199***	0.0183***	0.0185***
	(0.0104)	(0.0095)	(0.0099)	(0.0095)	(0.0152)	(0.0155)	(0.0143)	(0.0144)
Sector dummies	yes	yes	yes	yes	yes	yes	yes	yes
Country dummies	yes	yes	yes	yes	yes	yes	yes	yes
Observations	3,263	3,263	3,263	3,263	867	867	867	867

Robust standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1