# Financial constraints and eco-innovation:
# An empirical analysis on Small and Medium European companies

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**Abstract**

This article aims at understanding the impact of financial constraints on the development of eco-innovations. The empirical analysis is based upon a sample of European small and medium enterprises (SMEs) in different sectors that are involved in eco-innovation activities at different levels. Our results show that lack of internal funding decreases the probability to introduce eco-innovations, while access to external funding has only a positive effect for organizational innovation. Furthermore, reduction of material costs as well as an increase in energy prices are found to be important drivers of eco-innovation development.

**Keywords:** eco-innovation, financial constraints, SMEs

## 1. Introduction

The development of eco-innovations is an essential component of green growth, which has been set as a key priority in the EU. Within the Europe 2020 strategy, the recent European Eco-Innovation Action Plan is precisely aimed at promoting innovation that reduces pressure on the environment, by mobilizing financial instruments and support services for SMEs. This is motivated by the significant growth opportunities for environmental industries, especially as regards the creation of new jobs, as well as by the increasing awareness that cost savings from improving material efficiency are akin to increases in labour productivity (European Commission, 2013). This is partly the result of rising commodity prices. Such trends appear to combine environmental and economic objectives, but full integration of environmental sustainability with economic growth is still far from being reached. Increasing our understanding of the incentives and the obstacles for SMEs to introduce eco-innovations can therefore provide useful support to European policy efforts.

A firm introduces eco-innovation in order to reduce the necessary input of natural resources and the output of substances that are harmful to the environment. This not only benefits the community in which the firm operates, but it also benefits the firm itself. Eco-innovation, however, requires costly investments: the Secretariat of the United Nations Framework Convention on Climate Change (UNFCCC) estimates that an additional 200 billion USD in global investment and financial flows will be required annually by 2030 just to return GHG emissions to current levels (UNFCCC, 2007, quoted in Newell, 2010, p. 254*)*. In particular, financing constraints might reduce firms' effort to develop eco-innovation as much as they do for other innovations (Savignac, 2008; Mancusi and Vezzulli, 2013). This study, therefore, strives to understand how financial constraints affect the introduction of eco-innovation and whether such effects differ across different types of innovation, namely product, process and organizational eco-innovations. This is interesting in light on the extant differences among the three types of eco-innovations, which might require different time spans and resources to be implemented.While the literature on the economics and management of innovation has been largely investigating this issue, the analysis has mostly overlooked some of the key characteristics of eco-innovations and, in particular, has failed to account for the potentially relevant role of the regulatory framework in shaping the incentives to eco-innovate at different levels.

The empirical analysis is based on data from the 2011 Eurobarometer survey on eco-innovation, which includes information on 3045 SMEs within the EU27 countries. Our findings show that lack of funds within the firm negatively affects the probability to introduce eco-innovations. Moreover, the empirical analysis shows that firms tend to eco-innovate more once R&D activity is more intense and there is more cooperation among firms. Additionally, eco-innovations are influenced by regulations in place and raw material prices are high. Therefore, in order to eco-innovate, firms must have sufficient incentives or regulatory constraints, but also a good endowment of both financial and knowledge resources. Firms might mitigate through cooperation the lack of internal competences, but they appear not to be able to overcome difficulties arising from the lack of internal financial resources. The article is structured as follows. Section 2 introduces and discusses the concept of eco-innovation and reviews the literature on the impact of financial constraints on innovation and eco-innovation, highlighting in particular the role of internal financing and external financing. Section 3 presents the data and provides descriptive evidence on the sample. Section 4 illustrates the empirical model and presents the results. Finally, Section 5 concludes and provides some policy implications.

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

Eco-innovations can be defined as innovations that consist of new or modified processes, practices, systems and products which benefit the environment and contribute to environmental sustainability (Oltra & Saint Jean, 2009). Their environmental impact is lower than those of relevant alternatives and they are the least damaging to physical, biological and cultural systems (Clarke and Roome, 1995; Kemp & Oltra, 2011). Eco-innovations can also encompass environmental management strategies that reduce waste, energy and material use at the source, as well as changes in products or processes that are made more durable or easier to disassemble, refurbish and reuse (Shrivastava, 1995; Chen, 2001; Janssen and Jager, 2002; Sharma and Henriques, 2005). Beside the fact that eco-innovations can change the durability of products, they can also transform organisational processes. This is for example the case of 'Environmentally Conscious Manufacturing' (ECM) (Sarkis, 1995).

Eco-innovations can be introduced at any stage of the product life cycle, but their impact on efficiency is different. In particular, when a novel solution is introduced upstream (e.g. in the process of extraction of raw materials) the impact on efficiency in terms of resources utilized is maximized (Huber, 2008), since these innovations indirectly influence also the subsequent stages, increasing resource efficiency and lowering environmental impact. On the contrary, when eco-innovations are introduced in downstream stages, such as product utilization or consumer practices, the gains in terms of resource efficiency may be much lower.

Besides the already discussed outcomes obtained from investing in eco-innovation, there is evidence of positive spillovers for society, which generate the double externality issue (Rennings, 2000). Double externality occurs when the positive spillovers from eco-innovation are exploited by third parties that might directly compete with the innovator. For these entities, the marginal cost of absorbing knowledge form these innovations is very low (close to zero), therefore, this situation creates more competition for the innovator, who will have less incentive to invest in eco-innovation. At the same time, the introduction of eco-innovation can create social benefits and increase the well-being. In order to minimize the underinvestment problem generated by the externality, it is important that each country develops a solid environmental policy, which would work in coordination with the firms' innovation activities, stimulating the latter with subsidies and incentives.

There are three main types of eco-innovations: product (or service), process and organizational innovation. Product innovations refer to a good or service that is new or significantly improved with respect to its characteristics or intended uses and reduces the impact on the environment. Process innovations regard the development and application of environmental technologies, and concern the inputs of the production process (e.g. substitution for ecologically harmful inputs) or the production process (e.g. the integration of new process components) (Rennings, 2000). Finally, organizational innovations involve the implementation of a new organizational method in the firm's business practices, workplace organization or external relations, which improve the impact on the environment (Reid and Miedzinski, 2008)[1].

Randjelovic et al. (2003) argue that eco-innovation can be stimulated by regulation, technology and market forces. Regulations affect eco-innovation investments directly, by compelling firms to eco-innovate or limit their carbon footprint to a certain extent, or

[1] Other types of eco-innovation include marketing innovations – e.g. voluntary eco-labelling – and social innovations – e.g. changes in consumers' behavior (Renning, 2000; Reid and Miedzinski, 2008).

indirectly, by offering public subsidies or fiscal incentives. Despite the evidence from the literature is not conclusive, most authors seem to agree that there is a positive relationship between regulation and the development of eco-innovations (Green et al., 1994; Porter and van der Linde, 1995a,b; Kemp, 1997; Faucheux and Nicolai, 1998). Technology push drivers refer to the availability of new technologies that help firms decrease pollution or their impact on the environment and at the same time cut costs. Many studies have found that one of the most important reasons for firms to undertake eco-innovation is cost-savings (De Marchi, 2012; Horbach et al., 2012; Kesidou and Demirel, 2012). Even though it might initially require extra capital to implement environmentally friendly technologies, in the long run a firm would significantly benefit from the development of these innovations, making it more convenient to reduce the impact on the environment. Finally, eco-innovations can be introduced in response to demand-related factors, e.g. when the market demands more eco-friendly products or values a “green brand” image.

The focus of our empirical analysis is to investigate the role of different financing methods in influencing the investment in eco-innovation. As any other type of investment, investments in eco-innovation can be financed by the firm using internal funds and/or recurring to external finance. Furthermore, for reasons already discussed in the previous section, public financing may be particularly relevant. The three financing channels will be briefly introduced and explained below.

The first source of financing that a firm would use to finance innovative investment is internal liquidity. This is due to the imperfect substitutability between internal and external funds, which originates from informational asymmetries inducing a substantial difference between the cost of external finance, being it new debt or equity, and the opportunity cost of using internal finance generated through cash flow and retained earnings (e.g. Stiglitz and Weiss, 1981; Myers and Majluf, 1984). As a consequence, firms might invest in new technologies only when there is a surplus of cash, which means that they have extra liquidity available. Furthermore, informational asymmetries might prove to be particularly relevant for SMEs, because they are less transparent, have higher relative transaction costs and fewer assets that can be used as collateral. As a consequence, SMEs are likely to display higher sensitivity of the decision to invest in eco-innovation on the availability of internal finance, ceteris paribus.

The above considerations explain why most contributions studying the effects of financing constraints have focused on investment–cash flow sensitivity. Indeed, most studies have focused attention on innovation input (R&D investment) rather than output, and taken a measure of internal liquidity as proxy for financing constraints. Existing evidence from these studies is mixed. This might be due to the sunk cost nature of R&D investments, which makes the cost of adjusting the flow of R&D spending very high and thus induces firms to buffer it from transitory shocks. Indeed, a recent paper by Brown et al. (2012) finds strong evidence that the availability of finance matters for R&D once controls for (i) firm efforts to smooth R&D with cash reserves, and (ii) firm use of external equity finance are introduced in the regressions. The study by Brown et al. (2012) thus provides a framework for evaluating financing constraints when firms rely extensively on external finance and endogenously manage buffer stocks of liquidity to keep investment smooth and suggests it is important to control for alternative external sources of financing when studying the sensitivity of innovative investment decisions to internal finance availability. For this reason, we shall include in all regression an indicator of constraints on external finance, together with an indicator of constraints on internal liquidity. There are several ways to obtain external financing, and each of them has different characteristics and costs. Pecking order theory (Myers and Majluf, 1984) predicts that firms would first prefer debt finance such as bank loans to equity financing when internal financial resources appear to be insufficient. Banks can provide different solutions, such as corporate lending, project financing or mezzanine financing. Alternatively, firms may finance innovative investment through equity financing, which has several advantages over debt for financing R&D, primarily because there are no collateral requirements, and additional equity does not magnify problems associated with financial distress, which can be particularly costly for innovative firms (Hall, 2002). Furthermore, equity financing allows shareholders to share upside returns.

One last solution for raising external capital is through venture capital or private equity firms. The two have many differences, especially in the stage of financing. Recently, a new type of Venture Capital firm has emerged, with a specific interest in eco-innovation: Green Venture Capital. Its main goal is to invest in firms that are developing new technologies that lower environmental impact, while pursuing economic goals. In general, all of the other characteristics are similar to a "regular" Venture Capital (Randjelovic et al, 2003).

The downside of doing an IPO or receiving capital through a Venture Capital or private equity is mainly represented by a reduction of control and decision power. For this reason, contrary to the above mentioned pecking order theory, the theoretical approach emphasizing control rights (Aghion and Bolton, 1992) suggests that equity financing should not necessarily be preferred to debt financing. This may be true for R&D investments too, particularly for SMEs, for which equity financing is less accessible (see, for example, Mancusi and Vezzulli, 2013).

There is also a number of studies focusing on the relationship between innovation output and financing constraints. These are mostly based on survey data containing information on innovation output and, possibly, a direct indicator of financing constraints. Among these, Savignac (2008) and Hajivassiliou and Savignac (2008) analyze the existence and impact of financing constraints as a possibly serious obstacle to innovation by firms employing three direct measures of financing constraints from survey data collected by the Banque de France and the European Commission: (i) unavailability of new financing; (ii) searching and waiting for new financing; (iii) too high costs of new financing. Both papers account for the endogeneity of the financing constraints variable and find that it significantly reduces the likelihood that firms have innovative activities.

We will not be able to distinguish between different types of external finance, but shall rather have a unique indicator for how much this represents a constraint for eco-innovation, regardless of the source. Also, we shall focus on the role of financing constraints on innovation output, rather than on R&D investment, i.e. innovation input. The few studies focusing on innovation output typically do not account for the role of the regulatory framework, which is instead of quite relevance in the context of eco-innovation. Therefore, our equations explaining eco-innovation output will always include a control for regulation. They will also include a control for public funding, on which role for eco-innovation we focus next.

Public financing is given out to firms mainly when governments have specific goals to reach. One example could be the Kyoto protocol, which forces all of the industrialized countries among its signatories to reduce their carbon emissions. When governments have to meet these goals, they can directly intervene by imposing laws, or with more indirect solutions such as subsidies and grants. Legal impositions are not always well-received by firms due to their coercive nature; thus, the incentive-based indirect method should be utilized as well. One solution is represented by green public procurement: through purchasing practices, public authorities play the role of the final customer when commissioning public projects

with the goal of reducing environmental impact. As explained by Edler and Georghiou (2007), green public procurement could be the most powerful tool at the disposal of the public sector, with an estimated €1.5 trillion invested back in 2004 as reported by the European Commission (2005). Even though it is not technically a form of financing, green public procurement is very similar to granting a subsidy in terms of final results.
One last tool to encourage firm investment through public funds is granting subsidies. The presence of subsidies in one country is strictly related to the goal of the incentive, something that usually produces positive externalities with a social impact (just as eco-innovation). These subsidies can be assigned to firms that reach specific goals, regarding for example the overall percentage of sustainable products produced or processes carried out, or offer extra subsidies if the firm invests in new sustainable projects. This way, the burden of investing in something new, which might also not be strictly necessary to increase economic performance, will be lessened for the firm.

## 3. Data collection 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 DG Environment of the European Commission, Unit F3 – Communication. The sample includes 3045 European SMEs and it is representative of each EU27 countries.

79% of firms in the sample are small – i.e. with 10 to 49 employees – while 21% of firms are medium size – i.e. with 50 to 249 employees. Firms mainly operate in five sectors: agriculture (8.2% of the sample), construction (27.2%), water supply and waste management (3.6%), manufacturing (55.4%), and food service activities (5.6%). 48% of the firms in the sample carry out eco-innovation activities. The survey investigates the nature of these eco-innovations, with the aim of distinguishing among product, process or organizational eco-innovations. There are about 26% of the firms that have developed product eco-innovation, 31.5% that have introduced process eco-innovations and 24% that have implemented organization eco-innovation. Table 1 details some descriptive statistics of the sample. Annex 1 presents the correlation matrix.

[Table 1 about here]

Besides asking information about the main characteristics of the firms and the extent to which they engage in eco-innovations, the core of the survey aims at investigating firms' approach to eco-innovation investments. The questions are divided into four sections. The first analyses companies' material costs, asking information about the relevance of these costs, the evolution of material costs over time (and expectations for future changes), and most importantly the changes implemented by companies to reduce the costs. The second section directly examines the extent to which firms have engaged in different types of eco-innovative activities. The third and fourth sections investigate the barriers to and drivers for an accelerated uptake of eco-innovations, focusing on technology/supply side factors, market/demand-side factors and regulations.

## 4. Lack of funding and eco-innovation: an empirical analysis

The empirical analysis aims at understanding the relationship between financial constraints and the development of eco-innovations. As far as the development of eco-innovations is concerned, the survey asks whether respondents have introduced an eco-innovation over the past 2 years and (if yes) the type of eco-innovation introduced – product/service, process, organizational innovations. Starting from these questions, we build the variable ECOINNOV, which takes value 1 if the firm has engaged in (any) eco-innovation activity and 0 otherwise. Then, we build three dummy variables (INNOPROD, INNOPROC, INNOORG) for each of the three types of eco-innovations.

Eco-innovation is estimated by means of a logit model as follows:

$$\Pr(Y_i > j) = \frac{\exp(\alpha_i + X_i\beta_j)}{1 + [\exp(\alpha_i + X_i\beta_j)]} \quad j = 0, 1 \qquad (1)$$

where Y represents the dependent variable (ECOINNOV), X is the vector of the covariates and β the vector of coefficients. Thus, ECOINNOV depends on a set of firm-specific variables. Because of the potential endogeneity of indicators of financing constraints, and because our data does not include any potential instruments for them, the objective of our analysis is to highlight correlations between the development of eco-innovation and firm-specific characteristics, rather than identifying cause-effect relationships. We investigate, in particular, the impact of financing, by controlling for firm size, R&D activity, sector characteristics and, most importantly, the role of material costs and scarcity.

### 4.1 The determinants of eco-innovations

A question in the survey asks respondents to evaluate on a four point scale the importance of lack of financial barriers to eco-innovation – lack of funds with the firm, lack of external financing and difficulty in accessing public subsidies. These variables take values from 1 (not at all important) to 4 (very important) and account for the relevance of financial constraints. Starting from this, we build three variables, one for the lack of internal funding – INTFUND; one for the lack of external funding – EXTFUND – and one for the difficulty to access public subsidies - PUBFUND. As discussed before, we expect that shortage of internal funds or difficulty in obtaining external funding will be negatively associated with the development of eco-innovations.

The survey also asks respondents to evaluate on a four point basis a series of different drivers of eco-innovation which include: technological and management capabilities within the enterprise, secure or increased existing market share, current high material prices, limited access to materials, expected future material scarcity, collaboration with research institutes, agencies and universities, good access to external information and knowledge, good business partners, current high energy prices, expected future increases in energy prices, existing regulations, including standards, expected future regulations imposing new standards, access to existing subsidies and fiscal incentives, increasing market demand for green products.

In order to reduce the number of variables and identify the relevant factors driving eco-innovations, we perform a factor analysis with varimax rotation using all variables that measures the drivers of eco-innovation. Table 2 shows the results.

[Table 2 about here]

Four factors emerge out of the analysis. The first one – COOPERATION AND KNOWLEDGE – is explained by four main drivers: collaboration with research institutes, agencies and universities; good access to external information and knowledge; good business partners; technological and management capabilities within the firm. This factor accounts for the role of firm networks and specific competencies and knowledge in driving eco-innovation. The second factor – ENERGY PRICES – is explained by two drivers: current high energy prices and expected future increases in energy prices. This factor reflects the relationship between eco-innovation and energy prices and indicates cost reduction as one of the main triggers for eco-innovations. The third factor – REGULATION – is explained by two variables, i.e. existing regulations, including standards and expected future regulations imposing new standards, and indicates regulation as an important driver for eco-innovation. Finally, the fourth factor – MATERIAL SCARCITY – is explained by the following variables: limited access to materials and expected future material scarcity. We use these four factors as covariates in the analysis to represent the drivers of eco-innovation.

The literature also underlines the importance of material costs for the investment decisions related to the development of eco-innovations. In the questionnaire a question asks respondents whether material costs had decreased, remain unchanged, increased moderately or increased dramatically in the last five years. We build the variable MATCOSTTREND, which again takes values from 1 (decrease) to 4 (increase dramatically). This variable allows controlling for the effect of material costs evolution in the last 5 years on the eco-innovative firms.

As explained in the literature review, one of the most important factors influencing innovation and eco-innovation is investment in R&D. In the survey there is no direct questions regarding R&D investment. However, one question asks respondents to indicate whether they have implemented any change to reduce material costs in the past 5 years and developed more efficient technologies in-house. We build the dummy variable R&D, which takes value 1 if the firm has developed more efficient technologies in-house to reduce material costs in the last 5 years and 0 otherwise.

Finally, we include a variable that accounts for firm size - TURNOVER - a categorical variable taking value from 1 to 4, where 1 indicates a turnover up to 2 millions of euro (52% of the firms in our sample), 2 is associated with a turnover between 2 and 10 million euro (35%) , 3 indicates a turnover 10-50 million (11%) and finally 4 indicates a turnover superior to 50 million euro (2%). Country and sector dummies are also included in the analysis. Table 3 provides the descriptive statistics.

[Table 3 about here]

### 4.2 Results

Table 4 shows the results of our estimates. In particular, Model 1 includes eco-innovation as a dependent variable, while Model 2, 3 and 4 distinguish among product, process and organizational eco-innovation.

[Table 4 about here]

The focus of the empirical analysis is to investigate the impact of financial constraints on the development of eco-innovations, investigating separately the lack of funds within the enterprise and the lack of external financing. Our results confirm that the lack of internal funds has a negative impact on the dependent variables. This means that when a firm runs out of internal funds, it eco-innovates less. Furthermore, it is important to notice that lack of funds within the firm is the most relevant financial constraint. This is understandable, as internal financing is the first source of financing used by a firm when investing, as explained by the "pecking order theory of finance" (Myers and Majluf, 1984; Myers, 2000). The variables PUBFUND and EXTFUND have an unexpected positive sign, but are almost never significant. With reference to external funding, this may occur because firms tend to mainly invest internal funds and prefer not to pay interest on external capital borrowed to invest in eco-innovations, which, as mentioned before, is often considered an investment that does not necessarily generate enough cash flow to pay back the initial investment. However, it should also be noted that firm's characteristics positively related to the propensity to innovate, like R&D intensity, tangible assets, book-to-market value, will typically influence the probability that innovative firms take advantage of information asymmetry and moral hazard, which will in turn increase the probability of incurring into external financing constraints (Gompers, 1995). Furthermore, for firms involved into eco-organizational innovation the difficulty to access external funding has a positive effect on innovative activities. This might be explained by the fact that organizational innovation requires more a management organization rather than investment in a particular technology. As for the role of public funding, on the one hand the access to regional and national funding are often seen as too complex and often companies are reluctant to participate to public tenders, mostly because the activity is extremely time-consuming and the results are uncertain. On the other hand, access to public funding may not stimulate further innovation because it reduces the price for the firm, which consequently always has an incentive to apply for public R&D support, even if it could perform the R&D projects using its own financial means. In such a case, if public support is granted, the firm then might simply substitute public funds for its own private funds.

The second important result concerns the role of material costs. Our analysis confirms that firms whose costs have increased over the past five years are more likely to introduce eco-innovations. This finding confirms the hypothesis that the increase of material costs is an important driver of eco-innovation development. Furthermore, the variable ENERGY PRICE is positively correlated with the probability of developing eco-innovations, which indicates that firms already experiencing or expecting an increase in energy prices are more likely to develop eco-innovation. This is particularly true for process innovation, in line with the idea that changes in production processes are the ones that most immediately conduce to a reduction in energy costs.

Third, the factor COOPERATION AND KNOWLEDGE is highly significant, and has a positive impact on the likelihood of developing eco-innovations. This variable accounts for cooperation and relationships with other organizations - universities and research institutes, as well as business partners – and for the existing competencies of firms. Eco-innovations are more likely to be developed by firms who cooperate and learn from others, leveraging upon their own knowledge and skills. This result is coherent with the findings of De Marchi (2012).

As expected, the variable TURNOVER has a positive and significant coefficient. Larger firms may exploit economies of scale and/or economies of scope, which might increase the benefits accruing from eco-innovations. They might also have a richer resource endowment, including human capital, which can facilitate adoption and development of eco-innovations. Although our sample includes no large firms *per se*, it is still important to understand that such phenomena are still present and observable between small and medium firms.

Finally, as to be expected, R&D activity has a highly significant, strong and positive impact on the development of eco-innovation. Notwithstanding the differences between overall innovations and eco-innovations, SMEs with a relatively high propensity to innovate are expected to be active also in the field of eco-innovations.

## 5. Conclusions

This paper has aimed at shedding light on the importance of financial constraints on the development of eco-innovations by SMEs, whose innovative activities are crucial for green growth. In particular, both research and policy actions have emphasized that SMEs are more flexible than large firms and can benefit from the opportunities associated with the emerging paradigm (OECD, 2011). However, the process of green entrepreneurship by small firms faces important obstacles among which financing and resource constraints more in general represent two major challenges. For the purpose of investigating the effect of financial constraints on the development of eco-innovation by SMEs in Europe, the paper relies on a survey from Eurobarometer that contains relevant information on the eco-innovation practices among European SMEs and on the main drivers and barriers to the development of eco-innovations.

The results of the empirical analysis confirm that internal financial constraints reduce the probability to introduce eco-innovations, particularly with reference to eco-process and organizational innovations. The lack of Internal funding has a negative effect on eco-innovation especially in the case of process and organizational innovation. For SMEs carrying out product and process green innovations, the lack of external funds constitutes a relatively unimportant obstacle. This is in line with the idea that green innovators are usually well equipped in terms of resources It should be noticed that external funds are particular important for firms that introduce organizational innovation. As concerned lack of public funding play an important role in stimulating the development of product and process eco-innovations. The results show that to design innovation policy it is important to identify the type of eco-innovation that might be stimulated by the use of different financial instruments. This is particularly true for green SMEs, which suffer from lack of equity financing and shortage of loans and whose access to funding is not usually facilitated by banks and private institutions. Beside private funds, it can be argued that access to regional and national funding could be simplified in order to reduce the administrative burdens and allow the participation of SMEs.

Our findings also show that the current levels of and the expectations towards an increase in energy prices are important drivers of eco-innovations, as well as the existing propensity of firms to carry out R&D activity that improves the efficiency of production processes. The increase on energy price in the last years has driven innovative activities which can support the existence of induced technological change in the green innovative processes. Another important results in term of policy implications is the importance attributed to science based innovation, which is associated with the cooperation with research centers and universities. This suggests that, on the one hand, it is important to encourage cooperation between universities and firms in order to stimulate the development of eco-innovations; on the other hand, it suggests that innovation in this area seems to be driven not only by regulation and market needs, but also by science based development. In our results, regulation does not seem to affect eco–innovation. This result might be due to the fact that all firms in our sample tend to be small and instead of being proactive in the field of eco-innovations, they tend to react to external forces. As a consequence, their innovative activity is very often designed to meet regulation requirements so that regulation is not a distinctive driver of the most innovative firms, but affects all companies. One final remark concerns the fact that, even if the analysis confirms that addressing the financing gap should be high in the policy maker agenda, opportunities for strengthening non-financial support (e.g. prizes, information campaign, branding, etc.) should also be considered as important instruments to stimulate the development of eco-innovations.

**References**

Aghion P. and P. Bolton 1992. An Incomplete Contracts Approach to Financial Contracting. The Review of Economic Studies, 59(3), 473-494.

Álvarez, R. and G. Crespi 2011. Financing Gaps, Innovation Gaps?: New Evidence from Chile. Paper presented at the 2011 Globelics Conference.

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

Chen, 2001. Design for the Environment: A Quality-Based Model for Green Product Development. Management Science, 47(2), 250-263.

Clarke, S. and N. Roome 1995. Managing for environmentally sensitive technology: networks of collaboration and learning. Technology Analysis and Strategic Management, 7(2), 191-215.

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

Demirel, P. and E. Kesidou 2011. Stimulating different types of eco-innovation in the UK: Government policies and firm motivations. Ecological Economics, 70(8), 1546-1557.

Edler, J. and L. Georghiou 2007. Public procurement and innovation - resurrecting the demand side. Research Policy 36 (7), 949-963.

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

Faucheux, S. and Nicolaï, I. 2011. IT for green and green IT: A proposed typology of eco-innovation. Ecological Economics, 70, 2020-2027.

Gompers, P. 1995. Optimal investment, Monitoring, and the Staging of Venture Capital. The Journal of Finance, 50 (5), 1461-1489.

Green, K., McMeekin, A., Irwin, A., 1994. Technological trajectories and R & D for environmental innovation in UK firms. Futures 26, 1047–1059.

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

Hajivassiliou, V. and Savignac, F., 2008. Financing Constraints and a Firm's Decision and Ability to Innovate: Establishing Direct and Reverse Effects, Working papers 202, Banque de France.

Horbach, J., Rammer, C. and 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.

Huber, J.,2008. Pioneer countries and the global diffusion of environmental innovations: Theses from the viewpoint of ecological modernisation theory. Global Environmental Change 18(3), 360–367.

Janssen, M.A., Jager, W., 2002. Stimulating diffusion of green products, co-evolution between firms and consumers. Journal of Evolutionary Economics 12, 283–306.

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

Kemp, R. and V. Oltra, 2011. Research Insights and Challenges on Eco-Innovation Dynamics. Industry and Innovation, 18(3), 249-253.

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

Mancusi M.L. and A. Vezzulli. 2013 R&D and Credit Rationing in SMEs. Economic Inquiry, forthcoming.

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

Myers S.C. and 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.

Newell, R.G. 2010. The role of markets and policies in delivering innovation for climate change mitigation. Oxford Review of Economic Policy. 26(2), 253-269.

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

Oltra, V. and Saint Jean, M., 2009. Sectoral systems of environmental innovation: An application to the French automotive industry. Technological Forecasting & Social Change, 76, 567–583.

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

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

Randjelovic, J., O'Rourke, A.R., and Orsato, R.J. 2003. The emergence of green venture capital. Business Strategy and the Environment, 12, 240–253.

Reid, A. and M. Miedzinski 2008. Eco-innovation: Final report for Sectoral Innovation Watch, Technopolis Group, Brighton.

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

Sarkis, J. 1995. Manufacturing Strategy and Environmental Consciousness. Technovation, 15(2), 79-97.

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.

Sharma, S. and Henriques, I. 2005. Stakeholder influences on sustainability practices in the Canadian forest products industry. Strategic Management Journal, 26, 159-180.

Shrivastava, P. 1995. Environmental technologies and competitive advantages. Strategic Management Journal, 16, 183-201.

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

( Annex 1)

**Table1 - Breakdown statistics: Decomposition by size of sector**

| | *Percentage of firms with 10 to 49 employees* | *Percentage of firms with 50 to 249 employees* |
|---|---|---|
| **Agriculture** | 3.11 | 2.14 |
| **Construction** | 23.02 | 4.22 |
| **Water supply and waste management** | 2.79 | 0.82 |
| **Manufacturing** | 41.71 | 13.72 |
| **Food service activities** | 7.89 | 0.58 |
| **Total** | 21.48 | 78.52 |

Source: Author's elaboration on the data from Flash Eurobarometer survey ("*FL315 Attitudes of European entrepreneurs towards eco-innovation*")

**Table 2 – Factor analysis: drivers of eco-innovations**

| | *Cooperation and Knowledge* | *Energy Prices* | *Regulation* | *Material scarcity* |
|---|---|---|---|---|
| **Technological and management capabilities within enterprise** | 0.57 | | | |
| **Secure or increased existing market share** | 0.40 | | | |
| **Current high material prices** | | 0.49 | | |
| **Limited access to materials** | | | | 0.53 |
| **Expected future material scarcity** | | | | 0.54 |
| **Collaboration with research institutes, agencies and universities** | 0.51 | | | |
| **Good access to external information and knowledge** | 0.61 | | | |
| **Good business partners** | 0.64 | | | |
| **Current high energy prices** | | 0.70 | | |
| **Expected future increases in energy prices** | | 0.66 | | |
| **Existing regulations, including standards** | | | 0.56 | |
| **Expected future regulations imposing new standards** | | | 0.56 | |
| **Access to existing subsidies and fiscal incentives** | 0.41 | | | |
| **Increasing market demand for green products** | 0.36 | | | |

**Table 3 - Descriptive statistics**

| Variable | Description | Obs. | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|---|
| ECOINNOVATION | Takes value 1 if the firm introduces any eco-innovation, 0 otherwise | 2798 | .4907 | .500 | 0 | 1 |
| INNOPROD | Takes value 1 if the firm introduces product eco-innovation, 0 otherwise | 2769 | .2618 | .440 | 0 | 1 |
| INNOPROC | Takes value 1 if the firm introduces process eco-innovation, 0 otherwise | 2770 | .3162 | .465 | 0 | 1 |
| INNOORG | Takes value 1 if the firm introduces organizational eco-innovation, 0 otherwise | 2761 | .2441 | .430 | 0 | 1 |
| PUBFUND | Insufficient access to existing subsidies and fiscal incentives from 1 (not at all important) to 4 (very important) | 2798 | 2.901 | 1.018 | 1 | 4 |
| INTFUND | Lack of funds within enterprise from 1 (not at all important) to 4 (very important) | 2798 | 2.937 | 1.044 | 1 | 4 |
| EXTFUND | Lack of external funds from 1 (not at all important) to 4 (very important) | 2798 | 2.832 | 1.052 | 1 | 4 |
| COOPERATION AND KNOWLEDGE | Factor loading from the factor analysis on the first factor | 2798 | .007 | .881 | -3.285 | 1.353 |
| ENERGY PRICE | Factor loading from the factor analysis on the second factor | 2798 | .009 | .847 | -3.278 | 1.029 |
| REGULATION | Factor loading from the factor analysis on the third factor | 2798 | .007 | .811 | -3.012 | 1.231 |
| MATERIAL SCARCITY | Factor loading from the factor analysis on the fourth factor | 2798 | .005 | .797 | -2.682 | 1.219 |
| R&D | Takes value 1 if firm has developed more efficient technologies in-house in the last five years, 0 otherwise | 2798 | .587 | .492 | 0 | 1 |
| MATCOSTTREND | The material costs change in the last 5 years (1), Increased moderately (2) Remained unchanged (3) decreased (4) | 2798 | 2.824 | .916 | 1 | 4 |
| TURNOVER | Annual turnover in €: (1) up to 2 million; (2) 2-10 million; (3) 10-50 million; (4) 50 million and over | 2798 | 1.638 | .754 | 1 | 4 |
| AGRICULTURE | Takes value 1 if the firm is in the agriculture sector, 0 otherwise | 2798 | .082 | .275 | 0 | 1 |
| CONSTRUCTION | Takes value 1 if the firm is in the construction sector, 0 otherwise | 2798 | .272 | .445 | 0 | 1 |
| WATER | Takes value 1 if the firm is in the water supply or/and sewage sector, 0 otherwise | 2798 | .036 | .186 | 0 | 1 |
| MANUFACTURE | Takes value 1 if the firm is in the manufacturing sector, 0 otherwise | 2798 | .554 | .497 | 0 | 1 |

**Table 4 – Results**

| DEPENDENT VARIABLE | (1) ECOINNOVATION | (2) ECOPRODUCT | (3) ECOPROCESS | (4) ECOORGANIZATION |
|---|---|---|---|---|
| PUBFUND | 0.060 | 0.119** | 0.089* | 0.026 |
| | (0.049) | (0.055) | (0.054) | (0.056) |
| INTFUND | -0.095** | -0.043 | -0.144*** | -0.144*** |
| | (0.048) | (0.054) | (0.051) | (0.055) |
| EXTFUND | 0.003 | 0.004 | 0.002 | 0.117** |
| | (0.048) | (0.055) | (0.052) | (0.057) |
| COOPERATION AND | 0.357*** | 0.327** | 0.312** | 0.283** |
| KNOWLEDGE | (0.112) | (0.128) | (0.125) | (0.133) |
| ENERGY PRICE | 0.237** | 0.028 | 0.195* | 0.097 |
| | (0.094) | (0.107) | (0.106) | (0.114) |
| REGULATION | -0.042 | -0.006 | -0.049 | 0.044 |
| | (0.126) | (0.147) | (0.143) | (0.147) |
| MATERIAL SCARCITY | -0.156 | 0.033 | -0.113 | 0.007 |
| | (0.122) | (0.138) | (0.135) | (0.136) |
| R&D | 1.067*** | 0.879*** | 1.164*** | 1.028*** |
| | (0.088) | (0.104) | (0.101) | (0.111) |
| MATCOSTTREND | 0.083* | 0.106** | 0.103** | 0.092* |
| | (0.046) | (0.051) | (0.051) | (0.056) |
| TURNOVER | 0.360*** | 0.244*** | 0.412*** | 0.266*** |
| | (0.058) | (0.062) | (0.061) | (0.064) |
| AGRICULTURE | -0.089 | -0.605** | 0.332 | -0.201 |
| | (0.233) | (0.265) | (0.251) | (0.249) |
| CONSTRUCTION | -0.345* | -0.141 | -0.111 | -0.308 |
| | (0.195) | (0.219) | (0.214) | (0.210) |
| WATER | -0.060 | 0.225 | 0.471 | -0.663** |
| | (0.272) | (0.300) | (0.303) | (0.327) |
| MANUFACTURE | -0.314* | -0.300 | 0.026 | -0.506** |
| | (0.188) | (0.212) | (0.206) | (0.201) |
| _CONS | -1.364*** | -2.263*** | -2.466*** | -2.286*** |
| | (0.375) | (0.405) | (0.400) | (0.415) |
| COUNTRY DUMMY | Yes | Yes | Yes | Yes |
| *WALD CHI2* | 330.05 | 199.52 | 324.36 | 265.64 |
| *N* | 2798 | 2769 | 2770 | 2761 |

Standard errors in parentheses. * p<.10, ** p<.05, *** p<.01

Annex 1 Correlation Matrix

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ECOINNOVATION | 1 | 1 | | | | | | | | | | | | | | | | | |
| ECOPRODUCT | 2 | 0.62 | 1 | | | | | | | | | | | | | | | | |
| ECOPROCESS | 3 | 0.71 | 0.34 | 1 | | | | | | | | | | | | | | | |
| ECOORGANIZATION | 4 | 0.59 | 0.29 | 0.41 | 1 | | | | | | | | | | | | | | |
| PUBFUND | 5 | 0.07 | 0.10 | 0.06 | 0.08 | 1 | | | | | | | | | | | | | |
| INTFUND | 6 | -0.01 | 0.02 | -0.02 | 0.03 | 0.38 | 1 | | | | | | | | | | | | |
| EXTFUND | 7 | 0.03 | 0.05 | 0.02 | 0.09 | 0.42 | 0.53 | 1 | | | | | | | | | | | |
| COOPERATION AND KNOWLEDGE | 8 | 0.16 | 0.15 | 0.14 | 0.16 | 0.41 | 0.30 | 0.32 | 1 | | | | | | | | | | |
| ENERGY PRICE | 9 | 0.15 | 0.12 | 0.13 | 0.15 | 0.35 | 0.28 | 0.30 | 0.75 | 1 | | | | | | | | | |
| REGULATION | 10 | 0.15 | 0.14 | 0.13 | 0.15 | 0.39 | 0.29 | 0.32 | 0.88 | 0.81 | 1 | | | | | | | | |
| MATERIAL SCARCITY | 11 | 0.14 | 0.14 | 0.12 | 0.16 | 0.36 | 0.30 | 0.30 | 0.85 | 0.82 | 0.85 | 1 | | | | | | | |
| R&D | 12 | 0.27 | 0.19 | 0.27 | 0.21 | 0.09 | 0.04 | 0.09 | 0.19 | 0.17 | 0.17 | 0.18 | 1 | | | | | | |
| MATCOSTTREND | 13 | 0.05 | 0.05 | 0.05 | 0.05 | 0.04 | 0.05 | 0.05 | 0.04 | 0.09 | 0.06 | 0.08 | 0.04 | 1 | | | | | |
| TURNOVER | 14 | 0.13 | 0.08 | 0.14 | 0.06 | -0.10 | -0.17 | -0.14 | -0.06 | -0.04 | -0.04 | -0.03 | 0.07 | 0.04 | 1 | | | | |
| AGRICULTURE | 15 | 0.03 | -0.03 | 0.05 | 0.04 | 0.06 | 0.04 | 0.01 | 0.08 | 0.07 | 0.07 | 0.04 | -0.01 | 0.03 | -0.03 | 1 | | | |
| CONSTRUCTION | 16 | -0.05 | 0.00 | -0.06 | 0.00 | 0.03 | 0.00 | 0.03 | 0.00 | -0.02 | 0.01 | -0.02 | -0.08 | -0.06 | -0.06 | -0.18 | 1 | | |
| WATER | 17 | 0.01 | 0.02 | 0.02 | -0.04 | -0.05 | -0.02 | -0.05 | -0.03 | -0.04 | -0.04 | -0.06 | -0.05 | 0.00 | 0.02 | -0.06 | -0.12 | 1 | |
| MANUFACTURE | 18 | 0.02 | 0.00 | 0.03 | -0.03 | -0.05 | -0.03 | -0.03 | -0.04 | -0.03 | -0.05 | 0.00 | 0.10 | 0.03 | 0.11 | -0.33 | -0.68 | -0.22 | 1 |