UNIVERSITAT ROVIRA I VIRGILI

STRATEGIES FOR INNOVATION AND SUSTAINABILITY: DETERMINANTS AND EFFECTS OF SPANISH AND EUROPEAN FIRMS

Elisenda Jove Llopis

UNIVERSITAT
ROVIRA i VIRGILI

DOCTORAL THESIS

STRATEGIES FOR INNOVATION AND SUSTAINABILITY: DETERMINANTS AND EFFECTS OF SPANISH AND EUROPEAN FIRMS

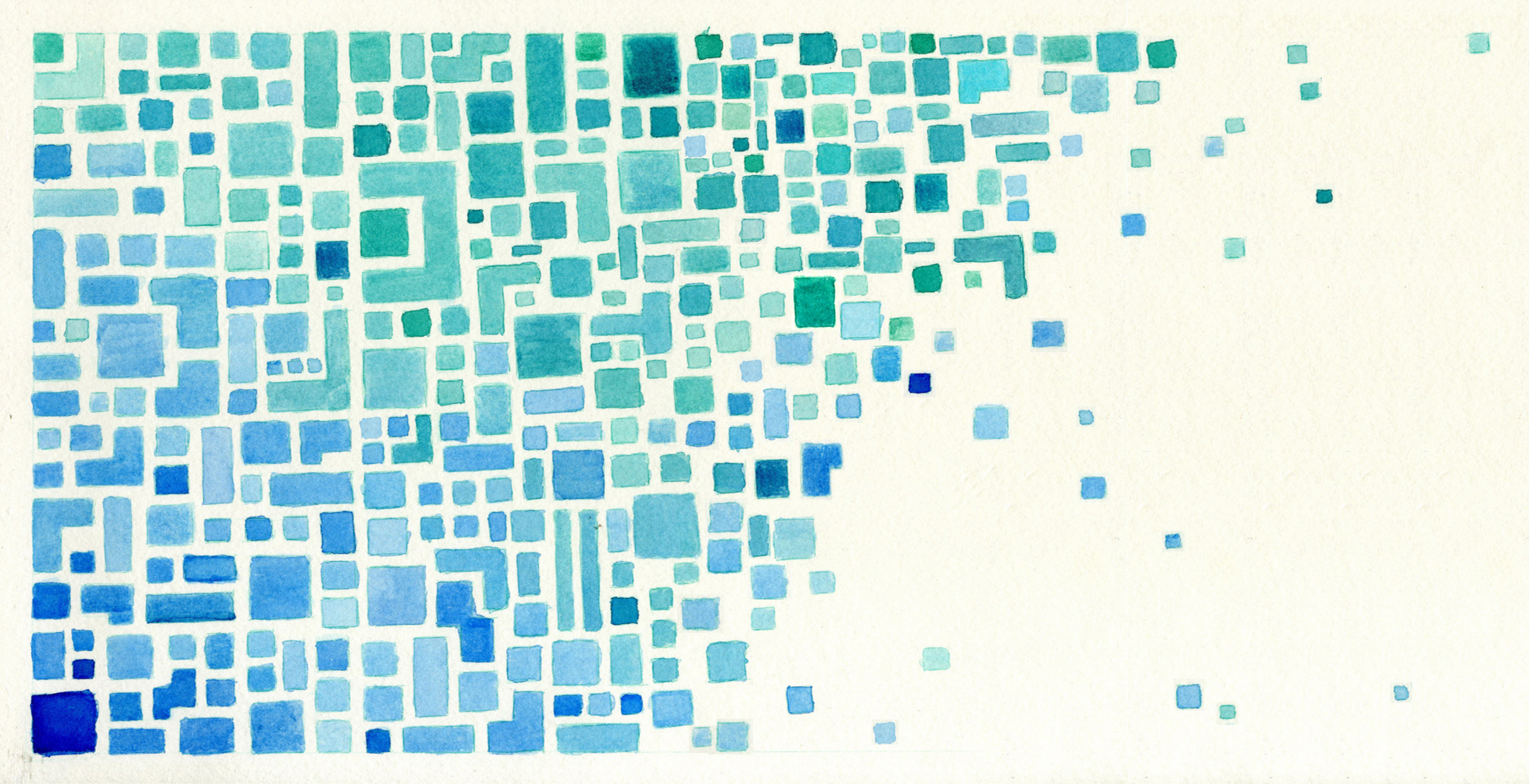
ELISENDA JOVÉ LLOPIS

2018

UNIVERSITAT
ROVIRA i VIRGILI

Strategies for innovation and sustainability: determinants and effects of Spanish and European firms

ELISENDA JOVÉ LLOPIS



DOCTORAL THESIS
2018

Elisenda Jové Llopis

STRATEGIES FOR INNOVATION AND SUSTAINABILITY: DETERMINANTS AND EFFECTS OF SPANISH AND EUROPEAN FIRMS

DOCTORAL THESIS

Supervised by

Agustí Segarra Blasco

Department of Economics

UNIVERSITAT ROVIRA i VIRGILI

Reus

2018

Department of Economics

Av. De la Universitat, 1

43204 Reus

I STATE that the present study, entitled *Strategies for innovation and sustainability: determinants and effects of Spanish and European firms*, presented by Elisenda Jové Llopis for the degree of Doctor of Philosophy in Economics, has been carried out under our supervision at the Department of Economics of this university, and that it fulfils all the requirements to receive the International Doctorate Distinction.

Reus, January 8th, 2018.

Doctoral Thesis Supervisor

Dr. Agustí Segarra Blasco

ACKNOWLEDGEMENTS

I could not have written this thesis without the assistance and support of many people and am deeply grateful to all of them for providing me with the best possible academic and personal support.

First and foremost, I would like to express my sincere gratitude to my supervisor Professor Agustí Segarra Blasco. I will always be grateful to him for his invaluable guidance and his encouragement to complete this dissertation. In fact, this thesis was probably only possible because I met him in 2010 through to the Chair for the Promotion of Business Innovation of the Universitat Rovira i Virgili. Prior to starting work on this thesis, he not only introduced me to the academic world, but also, was able to share his vocation for research and encouraged me to start this great challenge and uplifting journey. Thank you for the confidence you have constantly had in me, and many thanks for making my life easier through your constant support and constructive supervision at every stage of my PhD. I have learned much from your knowledge and professionalism, and hope to continue learning from you in the future.

I would also like to thank all the members of the Economics Department at URV and my research group, GRIT-GRIDE, whose assistance, suggestions, and the advice they provided have been crucial in preparing this thesis. All of them have influenced this work, and I especially extend my gratitude to Mercedes Teruel Carrizosa, Juan Antonio Duro Moreno and Josep Maria Arauzo Carod. I really appreciate the attention they have always offered me. In particular, very special thanks you to Mertxe for your invaluable feedback, for all our shared moments and, most importantly, for your patience and willingness to help each of the many times I came knocking on your door.

I am also grateful to José García Quevedo for many value suggestions and his help in introducing me Pierre Mohnen, greatly reducing the distance of more than 1,000 kilometres between Reus and Maastricht. I owe a huge debt of gratitude to Pierre Mohnen for giving me the opportunity of experiencing a rich and exciting research stay at the United Nations University – Maastricht Economic and Social Research Institute on Innovation and Technology (UNU-MERIT), well as for all his helpful comments and advice. To Maastricht, I also offer special thanks for the hospitality and warmth I received from my officemates and all the staff of the institution.

During this journey, I had the opportunity to meet researchers from various institutions who provided me helpful and supportive comments and to whom I would also like to give special thanks. Here particularly I must mention David Córcoles, Liliana Herrera, Rosina Moreno, Pablo del Río and Ángela Triguero.

I gratefully acknowledge the financial support provided by the Secretaria d'Universitats i Recerca del Departament d'Economia i Coneixement de la Generalitat de Catalunya (2015_FI_B00308), the Economics Department of the URV, CREIP, the Chair for the Promotion of Business Innovation of the URV, the Consolidated Group of Research 2014-SGR-1395, Xarxa de Referència en Economia Aplicada (XREAP), IND+I and the Associació Pacte Industrial de la Regió Metropolitana de Barcelona. I am also very grateful for the precious administrative support that helped me with the many necessary procedures over all these years.

Since the day I started at URV, and also during my PhD journey, I have had the opportunity to meet some amazing and lovely people, without whom these years would have been tough. A special mention to my second family "S.3.1", those who were already there when I arrived, and the new arrivals that have extended this enthusiastic family over the course of my time there. Thank you all for putting up with my downs, and not putting down my ups! Also, my most sincere thanks to "S Team" for your ongoing support, patience and friendship. Thank you all for being there when I needed you the most. I would also like to especially thank my "academic family" and the best niece I had, who has always been an amazing friend since the beginning. Thanks specially to my colleagues and friends—from the "ground floor" to the top—for all the shared moments (both academic, and decidedly non-academic) with whom I have had many stimulating conversations and from whom I have received much support.

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

1. BACKGROUND AND MOTIVATION

The future of a firm is strongly related to its ability to innovate. For decades, innovation has widely recognized by scholars and policy makers as an essential component of the performance of countries, industries, and firms.

The work of Joseph Schumpeter at the beginning of the 20th century was an outstanding stage in the development of the innovation field. In his two famous books, *The Theory of Economic Development* and *Capitalism, Socialism, and Democracy*, the Austrian economist was the first to claim that innovation represents the driving force of economic development (Schumpeter, 1934, 1942).

The first of these works describes an economic landscape where industries are characterized by turbulent environments with low technological entry barriers and where new entrants drive innovation. In a process known as "creative destruction", the new successful innovators replace the incumbents (Schumpeter Mark I).

In contrast, in his second contribution, *Capitalism, Socialism, and Democracy*, he presents a new model that considers industries in stable environments with high entry barriers (economies of scale) where innovations are carried out by large established firms which use their monopolistic power and accumulated knowledge resources. Firms in these industries employ a process known as "creative accumulation" whereby the incumbent firms introduce new innovations through their accumulated knowledge resources and consolidated technological competences (Schumpeter Mark II).

The empirical literature on attempts to validate Schumpeter's hypotheses and the nature of new knowledge, is extensive and well consolidated, mainly due to the seminal contribution of Griliches (1979) who estimated R&D returns at the firm level using an augmented production function with R&D capital. More recently, in 1998, Crépon, Duguet and Mairesse published a paper "Research Innovation and Productivity: An Econometric Analysis at the Firm Level" which followed the same outlines. The resulting CDM model has become one of the most influential contributions in recent literature on economics of innovation.

Crepon et al. (1998) proposed an original structural empirical approach to describe the link between R&D expenditure, innovation output and productivity which suggests a method of correcting for the model's inherent selectivity and endogeneity. The general structure of the model consists of four equations, two for research, one for innovation and one for productivity. Its first step models a firm's decision to engage, or not, in innovation activities (the selection equation), and then, a resulting group of firms decide how much they will invest in R&D activities. The process leading from innovation inputs to innovation outputs is subsequently modelled and, finally, the effects of innovation output and R&D on firm productivity is determined. Empirical studies usually find the effects of both R&D on innovation output and of innovation output on productivity, to be positive and significant (Griffith et al. 2006; Hall, Lotti, and Mairesse 2009; Hashi and Stojčić 2013).

In recent decades, there have been many attempts to discover the critical factors that indicate why not every firm innovates—the success or failure factors for R&D projects and new innovations. Largely thanks to the CDM, a considerable literature has emerged that examines the determinants and drivers of innovation activity in firms. In this respect, firm and market characteristic factors which include internal and external R&D (Veugelers and Cassiman 1999), cooperation (Cassiman and Veugelers 2002), human capital (Leiponen 2005), age of firm (Segarra-Blasco and Teruel 2012) and innovation subsidies (Busom and Vélez-Ospina 2017) have been identified as important drivers of innovation success. For a recent and exhaustive review of empirical studies of innovation activity and performance see Cohen (2010) and Ahuja et al. (2008).

The focus of innovation scholars on the role of R&D in the success of firms' innovative activity has left little room for an analysis of the alternative role of innovation strategies.

Even though the ability to generate new knowledge by R&D, or to invest in external R&D, are generally regarded as key drivers for innovation success of firm, nevertheless many innovation initiatives fail and, due to the lack of an innovation strategy, successful innovators find it difficult to systematically sustain their performance. As Pisano (2015), pointed out "*a strategy is nothing more than a commitment to a set of coherent, mutually reinforcing polices or behaviours aimed at achieving a specific competitive goal.*" The empirical fact is that firms are driven by different objectives when engaging in R&D projects and innovation activities, and it is valid to investigate the role of innovation strategies on innovation success.

Initially, the CDM model had limited impact on the research literature, but this has completely changed in recent years thanks to the increasing availability of new micro-economic data provided in particular by the Community Innovation Surveys in European countries data (Lööf and Heshmati 2002; Benavente 2006; Mohnen, Mairesse, and Dagenais 2006; Lööf, Mairesse, and Mohnen 2017). After almost 20 years of the CDM model, many refined versions are being used by several authors to enrich and enlarge the scope and methods of the empirical innovation literature. These treat a range of issues which include innovation and employment, innovation and trade, innovation and public support, barriers to innovation or more recently, environmental innovations (Blanchard et al. 2013; Busom and Vélez-Ospina 2017; Leeuwen and Mohnen 2017).

Because environmental issues are becoming a higher priority for policy makers, it is not surprising that some researchers are now working on a CDM-type green innovation model, in which the first step is the decision to invest, or not to reduce the environmental burden of the firm's operations and how much to invest. The second stage of the model describes the eco-innovation output function using eco-R&D and other eco-investments as input and, finally, the relationship between innovation outputs and productivity is examined (Marin 2014; Leeuwen and Mohnen 2017; Marin and Lotti 2017).

Many empirical papers have devoted attention to the drivers of eco-innovation (Ghisetti, Marzucchi, and Montresor 2015; Hojnik and Ruzzier 2015; Horbach 2016; Del Río, Romero-Jordán, and Peñasco 2017). Although existing research seems to have reached a robust understanding of the factors that determine which innovations positively impact the environment (Horbach 2008; Díaz-García, González-Moreno, and Sáez-Martínez 2015; Hojnik and Ruzzier 2015; Bossle et al. 2016; Del Río, Peñasco, and Romero-Jordán

2016), there is still some gaps in knowledge suggesting fruitful avenues for future research (Del Río, Peñasco, and Romero-Jordán 2016). Moreover, in terms of economic implications, there remains a question mark over whether these eco-strategies enhance firm performance. Consensus is yet to emerge on whether there are positive, negative, or mixed correlations between these factors, or indeed even on the existence of such correlations (Ambec and Lanoie 2008; Albertini 2013; Barbieri et al. 2016).

From the perspective of policy makers, the significance of these two topics (innovation and eco-innovation), has recognised in the Europe 2020 strategy that aims to create smart, sustainable and inclusive growth as a way to overcome structural weaknesses in the European economy (European Commission 2010a). This policy has been articulated in five objectives, which combine employment, innovation, climate change and energy, education and poverty and social exclusion goals into a broad and comprehensive strategy.[1]

In this policy framework, more systematic innovation success and sustainable economic growth are considered dependent on improvements in designing appropriate strategies for greener production. Currently, firms around the world are dealing with a range of environmental challenges that include global warming, natural resource depletion, pollution regulations and new consumers' preferences for eco-friendly products. These force corporate managers to refine their business strategy and to adopt new ways of mitigating their firms' environmental impact.

As a complement to the Europe strategy 2020, and to move towards a sustainable and low-carbon economy, the EU has set itself targets for reducing its greenhouse gas emissions progressively up to 2050 (the main roadmaps being a climate & energy framework by 2030 and a low carbon economy by 2050). A major objective of the Europe

---

[1] From a theoretical perspective, the main reason for providing public funding for innovation activities is the existence of market failures, among others, those of additionality, informational asymmetries, and knowledge spillovers. It is well-known that the knowledge market usually fails to provide enough incentives for innovation efforts (Nelson 1959; Arrow 1962). Thus, market failures of private innovation effort justify government intervention.

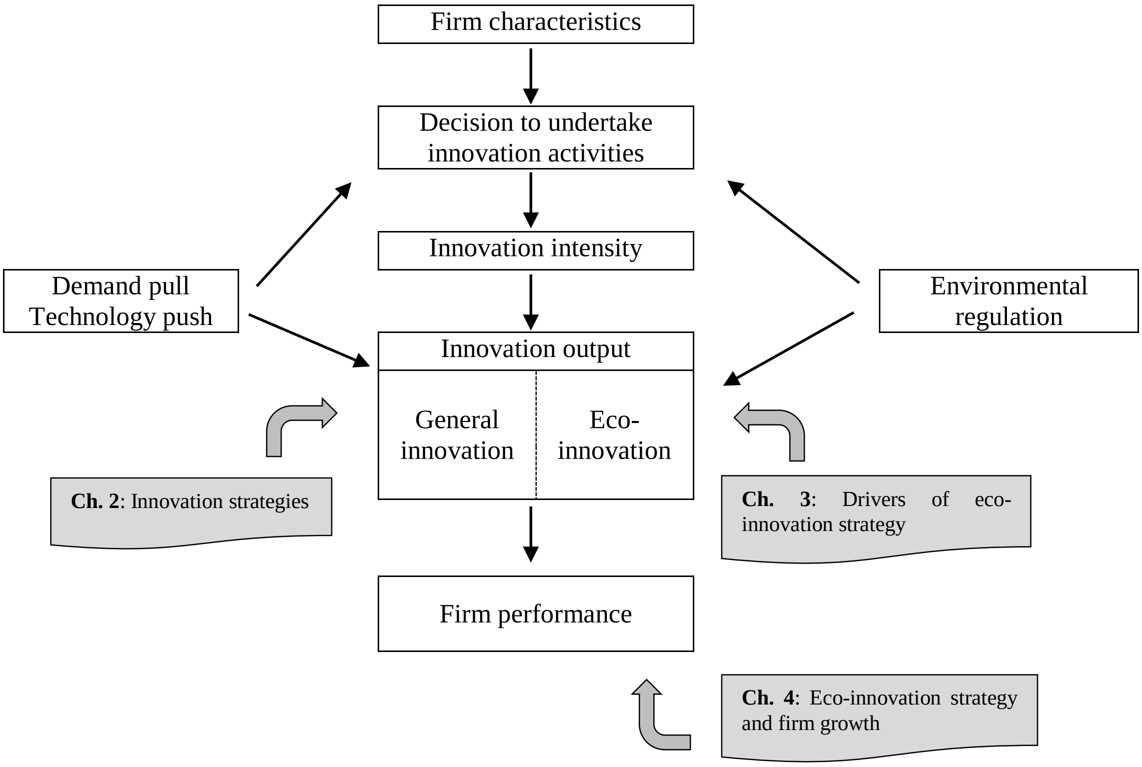
2020 framework is to promote successful innovative firms that dedicate time and effort to design more environmentally sustainable innovation strategies.

These moves towards greener growth depend upon the adoption or generation of eco-innovation by firms. In this sense, Esty and Winston (2009) note that their eco-innovation strategies seems offer firms the opportunity to differentiate themselves and to increase their competitive advantage.

Eco-innovations have some specific features that distinguish them from standard technological innovations, and which motivate investigating either their drivers or their effects. One of the broadest and more comprehensive definition of eco-innovation stemmed from a EU-funded research project called “Measuring Eco-Innovation” (MEI), which defined eco-innovation as the: “*production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives”* (Kemp and Pearson 2007). Since eco-innovation is characterized by the so-called double externality, providing both typical R&D spillovers and environmental externality, the introduction of innovation and also environmental policies to encourage eco-innovation adoption is justified (Rennings 2000).

This dissertation focuses on the study of firms’ innovation strategies as a key element in maintaining a firm’s competitiveness (Figure 1). Specifically, the thesis provides new evidence on three broad issues: 1) the role of innovation strategies on innovation success, 2) the determinants of eco-innovation strategy and 3) the relationship between eco-strategies and firms’ performance.

Figure 1
Thesis overview: the innovation process and firm performance



Source: own elaboration from CDM model and green CDM model.

2. OUTLINE OF THE THESIS

The remainder of the thesis is organized into four chapters. The current chapter summarizes the next three chapters which constitute the main body of the thesis, and which adopt different perspectives on the role of innovation strategy. Each individual chapter constitutes a distinct research topic its own right and is developed according to its own structure and methodological framework. Finally, Chapter 5 presents the main conclusions and considers future research directions.

CHAPTER 2, "*What is the role of innovation strategies? Evidence from Spanish firms",* focuses on the role of strategies adopted by firms during the innovation process. Over the last few decades, following the CDM approach, the empirical literature has mainly discussed the role of innovation strategies using traditional input or output innovator indicators. From an innovation input perspective, the empirical literature has distinguished between internal strategy (to make), external strategy (to buy) and, more recently, cooperation strategy (Veugelers and Cassiman 1999; Vega-Jurado, Gutiérrez-Gracia, and Fernández-de-Lucio 2009; Goedhuys and Veugelers 2012; Mata and Woerter

2013). On the other hand, from an innovation output perspective and in line with the Oslo Manual, four strategies (product, process, marketing and organisational) have been analysed (Hervas-Oliver, Sempere-Ripoll, and Boronat-Moll 2014; Jayaram, Oke, and Prajogo 2014; Tavassoli and Karlsson 2016).

The starting point of this chapter is the empirical fact that firms pursue different goals when engaging in R&D or innovation activities, often simultaneously pursuing multiple goals. Given that firms' innovation activities are driven by different motivations, the aim of this study is to understand the role of such innovation strategies in innovation success. Differentiating between various innovation strategies appears to be fruitful because it allows more insights with respect to the importance of factors fostering innovation success—these would remain hidden behind an overall variable of whether or not a firm designs an innovation strategy.

To do this, we employ data from the Spanish Technological Innovation Panel (PITEC), a dataset that comprises the annual Spanish Community Innovation Survey (CIS). Using a broad sample of 3,936 Spanish manufacturing and services firms for the period 2008–2014, we carry out our empirical analysis in two stages. Firstly, applying a principal component analysis, we identify a diverse range of innovation strategies (absence, mixed and oriented towards quality, production, cost, and environment). Then, we investigate the possibility of innovation strategies affecting the determinants of the innovation success and study their degree of fit by applying a random-effect panel probit model which allows us to address concerns of unobserved heterogeneity.

The main contribution of this chapter to existing literature, is to demonstrate that the success of innovation is dependent, not only on the effort made by firms in terms of creation, accumulation, and integration of new knowledge into the innovation process, but also on their ability to correctly design their strategies in accordance with specific innovation objectives.

CHAPTER 3, "*What spurs the decisions to undertake eco-motivations? A panel data analysis of Spanish service and manufacturing firms"*, focuses on the drivers of eco-innovation strategy. Any analysis dealing with eco-innovation strategy needs to understand their determinants, those elements which spur any adoption or generation by a firm. This is a crucial element as it can help managers and policy makers correctly foster the adoption and diffusion of eco-innovation strategies. Although the drivers for the adoption of an eco-innovation strategy have been widely explored in the recent literature, to date most of these studies have been restricted to manufacturing industries. Perhaps surprisingly, service industries have been given less attention, despite their rapid growth in most developed countries and their greater importance in overall economic activity.

Since the seminal contribution by Rennings (2000), the literature has highlighted the specificities of eco-innovation, including the double externality problem and the regulatory push/pull effect, that distinguish them from standard technological innovation. Consequently, researchers have accepted that general innovation theory which treats technology push and demand factors as the main drivers of innovation is not enough to explore the eco-innovation strategy. Numerous studies emphasize that general innovation theory has to be extended with respect to the analysis of the role of regulatory and institutional factors (Porter and Linde 1995; Jaffe and Palmer 1997; Rennings 2000; Rennings et al. 2006; Horbach 2008).

To explore the determinants of designing an eco-innovation strategy in a Spanish context, we again employ the Spanish Technological Innovation Panel (PITEC) database of the previous chapter. The availability of longitudinal, firm-level panel data allows us to consider the dynamic features of eco-innovation orientation and to focus on persistence. In estimating the dependence of past eco-innovation performance and the drivers of eco-innovation strategy, we introduce lagged dependent variables as explanatory terms and use a methodology to control for the initial conditions and unobserved heterogeneity. This leads us to employ a random effect dynamic probit model controlling for possible sample selection based on adaption of Wooldridge's proposal (2005).

The originality of this work in the eco-innovation literature lies in the decision to simultaneously incorporate both sectoral and temporal dimensions. We contribute to the existing body of literature on eco-innovation by examining the similarities and differences between service and manufacturing firms in the Spanish context. On the other side, by taking advantage of a large panel of 4,535 Spanish services and manufacturing firms for the period 2008–2014 we could examine long-term relationships between variables while controlling for non-observable heterogeneity and study persistence in eco-innovation over time. The latter is a topic that has received much attention in the general innovation literature (Raymond et al. 2010; Tavassoli and Karlsson 2015), but which has not previously been addressed in the literature on drivers of eco-innovation strategy.

CHAPTER 4, "*Eco-strategies and firm growth in European SMEs: when does it pay to be green?"*, continues with the analysis of eco-innovation strategy but now, instead of analysing the drivers, we focus on their effects on firm performance. On the one hand, the need for eco-strategies is continuously increasing. However, the primary incentive for an individual firm to invest in green strategies is that they are profitable. This motivated our firm level analysis, where the main research question was to understand, not only whether or not it generally pays to be green, but also in which cases, and for whom, it is worthwhile to be green.

The famous so-called "Porter hypothesis" (Porter and Linde 1995) according to which more stringent, but well-designed, eco-regulation may trigger an innovation effect, thus making production processes and products more efficient and enhancing productivity, has been extensively discussed from empirical and theoretical perspectives in the literature for over two decades (Lanoie et al. 2011; Ambec et al. 2013; Leeuwen and Mohnen 2017). Nevertheless, a consensus has not yet been reached. The studies reveal the presence of considerable diversity in the empirical results, ranging from negative through non-significant to moderately (or even strongly) positive links between eco-innovation and firm performance.

Understanding the economic implications of the adoption of an eco-innovation strategy on firm's performance would thus be an interesting contribute to the debate. This is the objective of Chapter 4, in which an analysis of the effects of eco-strategies on firms' performances in terms of sales growth is undertaken using a different database, the Flash Eurobarometer Survey 426 (FLE426) on *"Small and Medium Enterprises, Resources Efficiency and Green Markets, wave 3".* Specifically, we selected an extensive sample of 11,336 small and medium-sized enterprises (SMEs), located in 28 European countries. The eco-strategy is decomposed into multiple categories such as: water reduction, energy reduction, using renewable energy, saving materials, minimizing waste, selling scrap material to another company, recycling, and designing products that are easier to maintain, repair or use. We not only differentiated between typologies of resource efficiency practices, but also considered the intensity and the breadth of the eco-practices implemented.

The original contributions of this essay consist in clarifying the relationship between eco-innovation strategies and firm performance across 28 European countries considering both sector and country differences. In general, empirical studies are performed focusing on either a single country (central and western European countries) or a specific sector. Furthermore, we classify the EU28 countries into two clusters. The distinction between former (European Union-15) and new EU members (the group of more recent member that joined the EU from 2004 onward) is presently of great interest, bearing in mind that a considerable number of Central and Eastern European countries have become part of the European project in recent years and empirical studies for them are virtually non-existent (Hojnik and Ruzzier, 2016; Przychodzen and Przychodzen, 2015).

3. SUMMARY OF THE DATA AND ECONOMETRIC METHODOLOGY

To sum up, we highlight that the data used in this dissertation are drawn from two different databases. The exploitation of several data sources is an element of richness of the thesis, as it allows a better generalization of the results that emerged, and it is also a way to overcome the limited analysis alternatives of a single database.

As previously mentioned, in Chapters 2 and 3, the Spanish Technological Innovation Panel (PITEC) for an extensive sample of Spanish manufacturing and services firms during period 2008–2014 is used. This panel data is jointly developed by the Spanish National Institute of Statistics (INE), the Spanish Foundation for Science and Technology (FECYT), and the Foundation for Technical Innovation (COTEC). PITEC contains information on more than 12,000 Spanish firms since 2003. A high response rate to their questionnaire is obtained since answering the survey is mandatory for Spanish firms. The panel survey follows the Oslo Manual methodology applied in the Community Innovation Survey (CIS) with respect to the selection of variables and indicators. PITEC is characterized by its time dimension. It has panel data for the period 2003–2014, making it possible to analyse long-term relationships between variables and to control for standard econometric issues, such as unobserved heterogeneity and simultaneity problems that are hard to detect in simple cross-sectional data or time series (Baltagi 2008).

Furthermore, innovation surveys are constantly improving their quality and relevance and, from 2003 on, the innovation survey has been updated and new questions have been included, allowing researchers to pursue new lines of research in depth. Specifically, in

2008, Spanish firms were asked for the first time to indicate the importance of items in a list of innovation objectives when carrying out innovation activities. Such information is essential to undertake the analyses of Chapter 2 and 3.

In contrast, the empirical analysis of Chapter 4 is based on the Flash Eurobarometer Survey 426 (FLE426) on *"Small and Medium Enterprises, Resources Efficiency and Green Markets, wave 3"*. It is a survey conducted at the request of the European Commission, between the 1 and 18 September 2015, by TNS political & social to review the current levels of resource efficiency actions and the state of the green market amongst SMEs. The database includes the 28 members States of the European Union plus Albania, the Former Yugoslav Republic of Macedonia, Montenegro, Serbia, Turkey, Iceland, Moldova, Norway, and the US, and covers large companies and SMEs. One of the main advantages of FLE426 is that it is an extensive survey that includes three dimensions, namely country, sector, and firm size. Most environmental empirical databases offer only aggregate information at country level, so having three dimensions in the same database allows researchers many possible views and perspectives on the data. However, the main drawback is that it is a cross-sectional dataset, and so the problem of simultaneity is essentially unavoidable.

The three studies differ not only in their research hypotheses and the datasets they test, but also in their methodologies. Given the dataset structures and the nature of the dependent variables, the first two studies employed a panel data structure. Chapter 2 performed a random-effect panel probit regression, while Chapter 3 implemented random effect dynamic probit model (controlling for possible sample selection), to consider the dynamic features of eco-innovation orientation and the role of persistence. Finally, in Chapter 4, due to the particularities of the dependent variables, we used an ordered logit model. Together with the choice of multiple datasets, the heterogeneity of methodologies enriches the current research basis.

REFERENCES

Ahuja, G., Lampert, C. M., & Tandon, V. (2008). Moving Beyond Schumpeter: Management Research on the Determinants of Technological Innovation. *The Academy of Management Annals*, *2*(1), 1–98. doi:10.1080/19416520802211446

Albertini, E. (2013). Does Environmental Management Improve Financial Performance? A Meta-Analytical Review. *Organization & Environment*, *26*(4), 431–457.

doi:10.1177/1086026613510301

Ambec, S., Cohen, M. A., Elgie, S., & Lanoie, P. (2013). The Porter Hypothesis at 20: Can Environmental Regulation Enhance Innovation and Competitiveness? *Review of Environmental Economics and Policy, 7*(1), 2–22. doi:10.1093/reep/res016

Ambec, S., & Lanoie, P. (2008). Does it pay to be green? A systematic overview. *Academy of Management Perspectives*, *22*(4), 45–62. doi: 10.5465/AMP.2008.35590353

Arrow, K. J. (1962). The Economic Implications of Learning by Doing. *The Review of Economic Studies*, *29*(3), 155–173.

Baltagi, B. (2008). *Econometric Analysis of Panel Data*. Chichester: John Wiley and Sons.

Barbieri, N., Ghisetti, C., Gilli, M., Marin, G., & Nicolli, F. (2016). A Survey of the Literature on Environmental Innovation Based on Main Path Analysis. *Journal of Economic Surveys*, *30*(3), 596–623. doi:10.1111/joes.12149

Benavente, J. M. (2006). The role of research and innovation in promoting productivity in chile. *Economics of Innovation and New Technology*, *15*(4–5), 301–315. doi:10.1080/10438590500512794

Blanchard, P., Huiban, J.-P., Musolesi, A., & Sevestre, P. (2013). Where there is a will, there is a way? Assessing the impact of obstacles to innovation. *Industrial and Corporate Change*, *22*(3), 679–710. doi:10.1093/icc/dts027

Bossle, M. B., Dutra de Barcellos, M., Vieira, L. M., & Sauvée, L. (2016). The drivers for adoption of eco-innovation. *Journal of Cleaner Production*, *113*, 861–872. doi:10.1016/j.jclepro.2015.11.033

Busom, I., & Vélez-Ospina, J. A. (2017). Innovation, Public Support, and Productivity in Colombia. A Cross-industry Comparison. *World Development*, *99*, 75–94. doi:10.1016/j.worlddev.2017.07.005

Cassiman, B., & Veugelers, R. (2002). *Complementarity in the Innovation Strategy: Internal R&D, External Technology Acquisition and Cooperation*. C.E.P.R. Discussion Papers. http://econpapers.repec.org/RePEc:cpr:ceprdp:3284

Cohen, W. M. (2010). Fifty years of empirical studies of innovative activity and performance. In B. H. Hall & N. Rosenberg (Eds.), *Handbook of the Economics of Innovation* (Vol. 1, pp. 129–213). Elsevier. doi:10.1016/S0169-7218(10)01004-X

Crepon, B., Duguet, E., & Mairesse, J. (1998). Research, Innovation And Productivity: An Econometric Analysis At The Firm Level. *Economics of Innovation and New*

Technology, *7*(2), 115–158. doi:10.1080/10438599800000031

Del Río, P., Peñasco, C., & Romero-Jordán, D. (2016). What drives eco-innovators? A critical review of the empirical literature based on econometric methods. *Journal of Cleaner Production*, *112*(4), 2158–2170. doi:10.1016/j.jclepro.2015.09.009

Del Río, P., Romero-Jordán, D., & Peñasco, C. (2017). Analysing firm-specific and type-specific determinants of eco-innovation. *Technological and Economic Development of Economy*, *23*(2), 270–295. doi:10.3846/20294913.2015.1072749

Díaz-García, C., González-Moreno, Á., & Sáez-Martínez, F. J. (2015). Eco-innovation: insights from a literature review. *Innovation: Management, Policy & Practice*, *17*(1), 6–23. doi:10.1080/14479338.2015.1011060

Esty, D. C., & Winston, A. S. (2009). *Green to gold: how smart companies use environmental strategy to innovate, create value, and build competitive advantage*. Wiley: New Jersey.

European Commission. (2010). *A strategy for smart, sustainable and inclusive growth*. Brussels.

Ghisetti, C., Marzucchi, A., & Montresor, S. (2015). The open eco-innovation mode. An empirical investigation of eleven European countries. *Research Policy*, *44*(5), 1080–1093. doi:10.1016/j.respol.2014.12.001

Goedhuys, M., & Veugelers, R. (2012). Innovation strategies, process and product innovations and growth: Firm-level evidence from Brazil. *Structural Change and Economic Dynamics*, *23*(4), 516–529. doi:10.1016/j.strueco.2011.01.004

Griffith, R., Huergo, E., Mairesse, J., & Peters, B. (2006). Innovation and Productivity across four European Countries. *Oxford Review of Economic Policy*, *22*(4), 483–498. doi:10.1093/oxrep/grj028

Griliches, Z. (1979). Issues in assessing the contribution and development of research to productivity growth. *The Bell Journal of Economics*, *10*(1), 92–116. doi:10.2307/3003321

Hall, B. H., Lotti, F., & Mairesse, J. (2009). Innovation and productivity in SMEs: empirical evidence for Italy. *Small Business Economics*, *33*(1), 13–33. doi:10.1007/s11187-009-9184-8

Hashi, I., & Stojčić, N. (2013). The impact of innovation activities on firm performance using a multi-stage model: Evidence from the Community Innovation Survey 4. *Research Policy*, *42*(2), 353–366. doi:10.1016/j.respol.2012.09.011

Hervas-Oliver, J.-L., Sempere-Ripoll, F., & Boronat-Moll, C. (2014). Process innovation strategy in SMEs, organizational innovation and performance: a misleading debate? *Small Business Economics*, *43*(4), 873–886. doi:10.1007/s11187-014-9567-3

Hojnik, J., & Ruzzier, M. (2015). What drives eco-innovation? A review of an emerging literature. *Environmental Innovation and Societal Transitions*, *19*, 31–41. doi:10.1016/j.eist.2015.09.006

Hojnik, J., & Ruzzier, M. (2016). The driving forces of process eco-innovation and its impact on performance: Insights from Slovenia. *Journal of Cleaner Production*, *133*, 812–825. doi:10.1016/j.jclepro.2016.06.002

Horbach, J. (2008). Determinants of environmental innovation—New evidence from German panel data sources. *Research Policy*, *37*(1), 163–173. doi:10.1016/j.respol.2007.08.006

Horbach, J. (2016). Empirical determinants of eco-innovation in European countries using the community innovation survey. *Environmental Innovation and Societal Transitions*, *19*, 1–14. doi:10.1016/j.eist.2015.09.005

Jaffe, A. B., & Palmer, K. (1997). Environmental Regulation and Innovation: A Panel Data Study. *Review of Economics and Statistics*, *79*(4), 610–619. doi: 10.1162/003465397557196

Jayaram, J., Oke, A., & Prajogo, D. I. (2014). The antecedents and consequences of product and process innovation strategy implementation in Australian manufacturing firms. *International Journal of Production Research*, *52*(15), 4424–4439. doi:10.1080/00207543.2013.849363

Kemp, R., & Pearson, P. (2007). *Final report MEI project about measuring eco-innovation*. UNU-MERIT, Maastricht. https://www.oecd.org/env/consumption-innovation/43960830.pdf

Lanoie, P., Laurent-Lucchetti, J., Johnstone, N., & Ambec, S. (2011). Environmental Policy, Innovation and Performance: New Insights on the Porter Hypothesis. *Journal of Economics & Management Strategy*, *20*(3), 803–842. doi:10.1111/j.1530-9134.2011.00301.x

Leeuwen, G. van, & Mohnen, P. (2017). Revisiting the Porter Hypothesis: an emperical analysis of green innovation for the Netherlands. *Economics of Innovation and New Technology*, *26*(1–2), 63–77. doi:10.1080/10438599.2016.1202521

Leiponen, A. (2005). Skills and innovation. *International Journal of Industrial Organization*, *23*(5–6), 303–323. doi:10.1016/j.ijindorg.2005.03.005

Lööf, H., & Heshmati, A. (2002). Knowledge capital and performance heterogeneity: A firm-level innovation study. *International Journal of Production Economics*, *76*(1), 61–85. doi:10.1016/S0925-5273(01)00147-5

Lööf, H., Mairesse, J., & Mohnen, P. (2017). CDM 20 years after. *Economics of Innovation and New Technology*, *26*(1–2), 1–5. doi:10.1080/10438599.2016.1202522

Marin, G. (2014). Do eco-innovations harm productivity growth through crowding out? Results of an extended CDM model for Italy. *Research Policy*, *43*(2), 301–317. doi:10.1016/j.respol.2013.10.015

Marin, G., & Lotti, F. (2017). Productivity effects of eco-innovations using data on eco-patents. *Industrial and Corporate Change*, *26*(1), 125–148. doi:10.1093/icc/dtw014

Mata, J., & Woerter, M. (2013). Risky innovation: The impact of internal and external R&D strategies upon the distribution of returns. *Research Policy*, *42*(2), 495–501. doi:10.1016/j.respol.2012.08.004

Mohnen, P., Mairesse, J., & Dagenais, M. (2006). Innovativity: A comparison across seven European countries. *Economics of Innovation and New Technology*, *15*(4–5), 391–413. doi:10.1080/10438590500512950

Nelson, R. R. (1959). The Simple Economics of Basic Scientific Research. *Journal of Political Economy*, *67*(3), 297–306.

Pisano, G. P. (2015). You Need an Innovation Strategy. *Harvard Business Review*, *93*(6), 44–54.

Porter, M. E., & Linde, C. van der. (1995). Toward a New Conception of the Environment-Competitiveness Relationship. *Journal of Economic Perspectives*, *9*(4), 97–118. doi:10.1257/jep.9.4.97

Przychodzen, J., & Przychodzen, W. (2015). Relationships between eco-innovation and financial performance - Evidence from publicly traded companies in Poland and Hungary. *Journal of Cleaner Production*, *90*, 253–263. doi:10.1016/j.jclepro.2014.11.034

Raymond, W., Mohnen, P., Palm, F., & Schim Van Der Loeff, S. (2010). Persistence of Innovation in Dutch Manufacturing: is it spurious? *The Review of Economics and Statistics*, *92*(3), 495–504. doi:10.1162/REST_a_00004

Rennings, K. (2000). Redefining innovation — eco-innovation research and the contribution from ecological economics. *Ecological Economics*, *32*(2), 319–332. doi:10.1016/S0921-8009(99)00112-3

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. doi:10.1016/j.ecolecon.2005.03.013

Schumpeter, J. A. (1934). *The Theory of Economic Development*. Cambridge, MA: Harvard University Press.

Schumpeter, J. A. (1942). *Capitalism, socialism and democracy*. New York: Harper.

Segarra-Blasco, A., & Teruel, M. (2012). An appraisal of firm size distribution: Does sample size matter? *Journal of Economic Behavior & Organization*, *82*(1), 314–328. doi:10.1016/j.jebo.2012.02.012

Tavassoli, S., & Karlsson, C. (2015). Persistence of various types of innovation analyzed and explained. *Research Policy*, *44*(10), 1887–1901. doi:10.1016/j.respol.2015.06.001

Tavassoli, S., & Karlsson, C. (2016). Innovation strategies and firm performance: Simple or complex strategies? *Economics of Innovation and New Technology*, *25*(7), 631–650. doi:10.1080/10438599.2015.1108109

Vega-Jurado, J., Gutiérrez-Gracia, A., & Fernández-de-Lucio, I. (2009). Does external knowledge sourcing matter for innovation? Evidence from the Spanish manufacturing industry. *Industrial and Corporate Change*, *18*(4), 637–670. doi:10.1093/icc/dtp023

Veugelers, R., & Cassiman, B. (1999). Make and buy in innovation strategies: evidence from Belgian manufacturing firms. *Research Policy*, *28*(1), 63–80. doi:10.1016/S0048-7333(98)00106-1

CHAPTER 2

WHAT IS THE ROLE OF INNOVATION STRATEGIES? EVIDENCE FROM SPANISH FIRMS

1. INTRODUCTION

It is well known that innovation is a decisive tool in ensuring the competitive position of firms in their markets. In fact, innovation is a process with high levels of uncertainty and a good innovation strategy can help firms to guide the process of achieving a lasting competitive advantage in dynamic environments (Cooper 1984b; Smith 2010). Hence, firms are well advised to dedicate time and effort to designing, ex ante the innovation strategies they wish to pursue to meet their objectives (Burgelman, Christensen, and Wheelwright 2004; Cooper and Edgett 2010). In this chapter, we analyse empirically the role that innovation strategies play in achieving innovation success. In particular, we ask which strategy has the greatest odds of improving innovation performance and also whether there is a fit between the innovation strategy pursued and innovation output as measured in terms of product and process innovations.

In recent decades, empirical research has attempted to identify why some firms have been more innovative than others, and also how firms may improve their odds of successful innovation (Cooper and Kleinschmidt 1987; Becheikh, Landry, and Amara 2006; Cohen 2010; Lööf, Mairesse, and Mohnen 2017). Today, a large body of research exists on the determinants of innovation, as well as on the effects of innovation on firm performance, largely thanks to the most explored model in the literature, the CDM model of Crepon, Duguet, and Mairesse (1998) that links R&D expenditures, innovation output and productivity.

Explorative studies from strategic management literature come to an agreement that an explicit innovation strategy enhances innovative success by providing a guideline for dealing with strategic issues, such as selecting which market to enter or developing new products (Ernst 2002; van der Panne, van Beers, and Kleinknecht 2003; Schroeder 2013). Not surprisingly, over the last few decades, the empirical literature has mainly discussed the role of innovation strategies using two perspectives along the lines of the CDM model. First, from the innovation input perspective, the empirical literature has distinguished between the role of R&D activities in terms of internal strategy (to make), external strategy (to buy) and, more recently, cooperation strategy (Veugelers and Cassiman 1999; Vega-Jurado, Gutiérrez-Gracia, and Fernández-de-Lucio 2009; Goedhuys and Veugelers 2012; Mata and Woerter 2013). On the other hand, in relation to innovation output view, product, process, marketing and organisational strategies have been analysed (Hervas-Oliver, Sempere-Ripoll, and Boronat-Moll 2014; Jayaram, Oke, and Prajogo 2014; Karlsson and Tavassoli 2016; Tavassoli and Karlsson 2016).

However, this literature has hardly explored a broader and long-term relationship between innovation strategies and innovation success, that is the importance of innovation goals and motivations as determinants of innovation success. Our approach to addressing this gap was to take a step back from previous studies on innovation determinants, starting with the innovation objectives since these are found to be the starting point of the innovation process and offer a broader and long term vision of the process (OECD - Eurostat 2005; Cooper and Edgett 2010). To do this, our data came from the Spanish Technological Innovation Panel (PITEC), a dataset that comprises the annual Spanish Community Innovation Survey (CIS) and follows the methodological guidelines defined in the OECD's Oslo Manual. Using a broad sample of 3,936 Spanish manufacturing and services firms for the period 2008–2014, we carried out our empirical analysis in two stages. Firstly, we identified the different kind of innovation strategies that a firm can design. Applying a principal component analysis to thirteen innovation objectives listed in the innovation survey, we defined the innovation strategies (absence, mixed and oriented towards quality, production, cost and eco) that firms may pursue to improve their odds of successful innovation. Then, by applying a random effect probit model we empirically tested how these different innovation strategies were related to the innovation success of firms and their degree of fit.

The contribution of this chapter is to attempt to expand innovation strategies analysis scope from a motivational perspective and move beyond the field of standard input or output innovation perspective to provide a much richer understanding of the effects of different strategies on innovation success. Secondly, given the increasing importance of service firms in most industrialized countries and the distinct nature of the innovative processes between manufacturing and service firms (Segarra-Blasco 2010; Leiponen 2012) we consider it appropriate and relevant to explore and study in more depth the differences between manufacturing and service firms. This allows us to detect and quantify differences between sectors.

The remainder of the chapter is structured as follows. Section 2 consists of a literature review. Section 3 presents the database, the variables and some descriptive statistics. Section 4 contains the econometric methodology. Section 5 shows our main findings. The last section presents our conclusions and the consequent policy implications.

2. LITERATURE REVIEW ON INNOVATION STRATEGIES

It is well known that innovation is a dynamic process subject to a complex sequence of decisions. Considering it as a process, from a temporal dimension, a firm's first strategic decision is whether or not to innovate. That is, whether to take on new challenges to survive or grow in the markets or, on the contrary, to opt for dynamic routines not taking into account changes in the environment and their consequences. When the decision to innovate has been taken, and innovation has become a priority in the firm, the second step consists in deciding which innovation strategy to develop. Due to scarce resources, a typical firm can only undertake a limited number of innovation activities and combination of innovation types. This constitutes the innovation strategy of the firm, the firm’s choice of long-term goals and it resource allocation for their achievement (Damanpour and Aravind 2012; Pisano 2015).

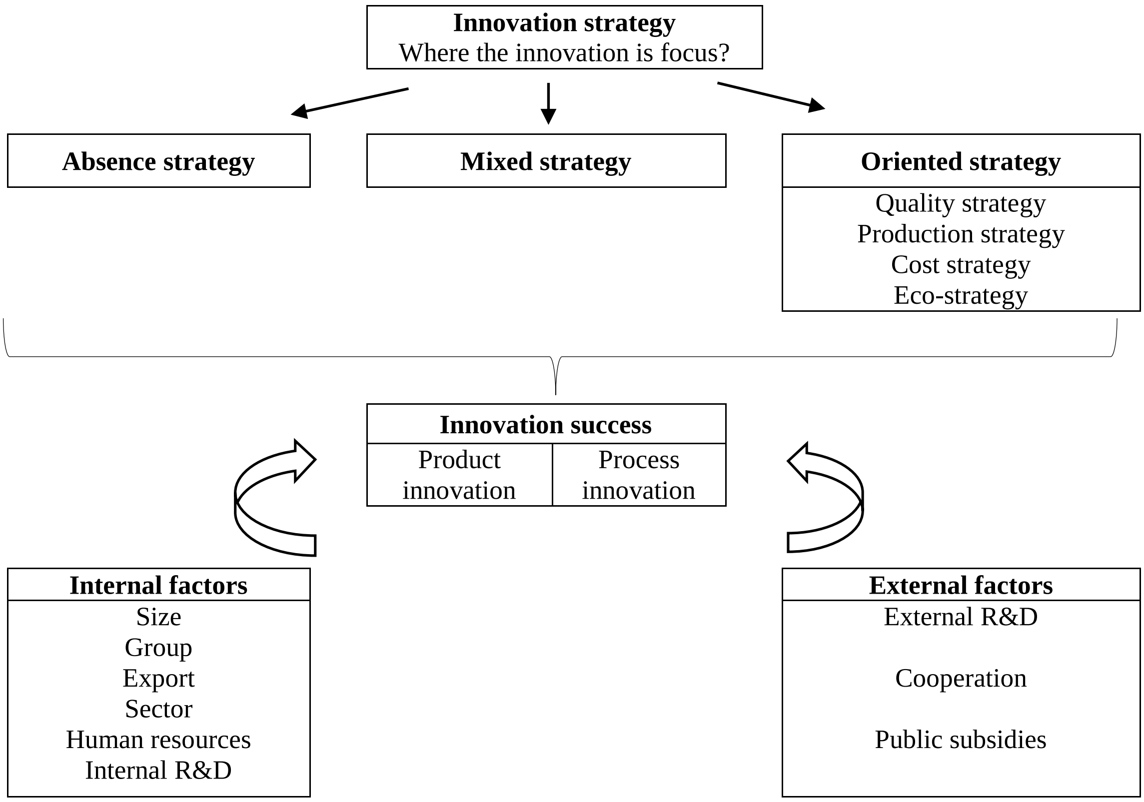
The main role of an innovation strategy is to guide the decisions on how resources are to be used to meet a firm's innovation objectives and, consequently provide value and build competitive advantage (Cooper 1984a; Porter 1985; Cooper and Edgett 2010; Talke, Salomo, and Rost 2010). As innovation activities require the acquisition of highly specialized assets (sunk costs), the presence of highly-educated and skilled employees (knowledge-related intangible assets), and involve a significant degree of uncertainty, information asymmetries and high risk (Hall 2002), adhering to long-term goals when allocating critical and scarce resources has been shown to be important for producing high-quality innovations and avoiding hasty decisions (Akman and Yillmaz 2008; Talke, Salomo, and Rost 2010). For instance, Gilbert (1994) highlighted that innovation strategy determines to what degree, and in what way, a firm uses innovation to perform its business strategy and enrich its performance. Hence, a planned and well-communicated innovation strategy is necessary in order to achieve maximal effectiveness and efficiency (Ramanujam and Mensch 1985; Ernst 2002; van der Panne, van Beers, and Kleinknecht 2003; Oke 2007).

The majority of innovation studies focus on the role of R&D as the determinant of innovation success, this is in part thanks to the CDM model, the main model that explores the links between R&D expenditures, innovation output and productivity (Crepon, Duguet, and Mairesse 1998). However, many innovation activities are not R&D-based, since innovation is a wide concept that concerns the search for, and the discovery, experimentation, development, imitation and adoption of new products, new production processes and new organizational set-ups (Dosi 1988), these being based primarily on new combinations of resources, people, ideas, knowledge and/or technologies. Hence, firms will choose to combine resources, people, ideas and knowledge to design the innovation strategies that they perceive to be best aligned with the dominant technological regime in which they are embedded.

The importance of managing different types of resource, knowledge and technologies in the innovation processes has been emphasized both in evolutionary economic theory and in the resource-based view (RBV) of the firm (Nelson and Winter 1982; Teece, Pisano, and Shuen 1997). The RBV's theoretical framework uses the internal characteristics of firms to explain their strategy and performance heterogeneity. According to the main RBV assumption, only firms with certain resources and capabilities with special characteristics will gain competitive advantages and, consequently, achieve superior performance. In fact, evolutionary economics claims that the heterogeneity of firms in their distinct problem-solving knowledge, yields different capacities for "doing things" which helps to explain their heterogeneity in terms of innovation strategies (Teece et al. 1994).

The starting point of our analysis is the empirical fact that firms pursue different goals when engaging in innovation activities, often pursing more than one goal at the same time. Given that firms are driven by different motives for innovation, the aim of this chapter is to investigate the role played by innovation strategies in coordinating resources, people, ideas, knowledge, and technologies to improve a firm's success in terms of product and process innovation. The research framework is shown in Figure 1.

Figure 1
The research framework



Source: own elaboration.

2.1 Recent empirical review

The empirical literature has considered specific classifications of innovation strategies, but few analyses have yet explicitly included individual motivations to explain the determinants of the innovation success, even though such motivations might be an important reason for starting specific innovation activities.[1] Understanding these reasons and the strategic behaviour may be helpful in defining suitable measures of innovation policy that can encourage a firm's success.

Firstly, according to R&D sources or innovation input, three strategies have been distinguished, internal (or make), external (or buy) and cooperation (Oerlemans, Meeus, and Boekema 1998; Veugelers and Cassiman 1999; Goedhuys and Veugelers 2012; Zuniga and Crespi 2013). This research found that a combination of internal and external knowledge sources is a key element of a successful innovation strategy as opposed to R&D being undertaken only in-house. Closely related to the role of networks, partnerships and linkages, a new growing body of literature investigates how resources allocation strategies (measured as breadth of external search for new ideas) impact on performance (Laursen and Salter 2006; Leiponen and Helfat 2010; Leiponen 2012). Their empirical results suggest that strategies based on allocating resources to a broader range of information sources are likely to affect innovation outcomes.

Secondly, related to the four type of innovations proposed by the Oslo Manual (3rd edition, 2005), some empirical papers have differentiated between technological strategies (product and process innovations) and non-technological strategies (marketing and organizational innovations) and test their impacts on firm performance (Jayaram, Oke, and Prajogo 2014; Oh, Cho, and Kim 2015; Karlsson and Tavassoli 2016; Tavassoli and Karlsson 2016). For a sample of Swedish firms, Karlsson and Tavassoli (2015) distinguish between sixteen strategies, which compose four type of innovation outputs from the Oslo Manuals, i.e. product, process, marketing and organizational (simple innovation strategies), plus various combinations of these four types (complex innovation strategies). They find that, in terms of a firm's future productivity, complex innovation strategies are better than simple ones.

Although an innovation strategy provides a guideline for survival in today's competitive environment and is helpful to the firm's technological capabilities, according to Page

[1] Some recent papers have started testing the effects of motivations on the innovation performance of collaborations with external partners (Arvanitis 2012) or using individual motivations to explain the determinants of the sources of information used (Volpi 2017). But the role played by firms' objectives is receiving less attention in empirical research on innovation success at the firm level (Leiponen and Helfat 2010).

(1993) and more recently to Dobni, Klassen and Nelson (2015), having one does not seem to be common practice among firms. Clearly, one of the most important barriers to innovation is the absence of well-defined innovation goals and objectives that provide a clear direction for the innovation process to follow (Oke 2007; Dobni, Klassen, and Nelson 2015).

Those firms that do not design a clear innovation strategy tend to have lower returns on R&D and innovation activities – this is because firms that wish to innovate in all areas may end by innovating in none, may innovate in areas not essential for the firm, may invest in innovation projects not aligned with the objectives of the firm, or their innovation efforts may just become a matter of chance (Pisano 2015). For instance, Akman and Yillmaz (2008) highlighted that without a strategy for innovation, innovation success is always harder and frequently impossible. This leads us to formulate the following hypothesis:

H1. Firms that do not design clear innovation strategies have lower odds of being a successful innovative firm.

When it comes to oriented strategies, the literature emphasises that an innovation strategy focused on specific innovation fields increases a firm's performance. To build an oriented strategy implies the use of common resources between related objectives within an innovation field and has been found to increase innovation outcomes by avoiding additional costs, coordinating resources or sharing learning processes (Salomo, Talke, and Strecker 2008; Bowonder et al. 2010; Leiponen 2012; Aniruddha 2013). Hence, firms with a strong specification of focus areas may perform better and are less likely to fail than firms with an absence of focus.

Nevertheless, not all innovative orientations are suitable for a given environment and different innovation orientations are associated with distinct degrees of innovation success (Manu and Sriram 1996). For example, product innovation outputs are primarily related to innovations orientations towards competition, market, and demand (e.g. increasing market share, range of products) while process or organisational innovations are strongly related to supply or new legislation orientations (e.g. reducing costs, improving production capabilities, reducing environmental impacts) (Balachandra and Friar 1997; van der Panne, van Beers, and Kleinknecht 2003; Tidd, Bessant, and Pavitt

2005; Paulraj 2009; Hervas-Oliver, Sempere-Ripoll, and Boronat-Moll 2014; Jayaram, Oke, and Prajogo 2014). This leads us to formulate our second hypothesis:

H2. Firms that design oriented innovation strategies have higher odds of being a successful innovative firm.

Based on the **"**recombinant growth**"** expression, the recombination of different types of knowledge or different types of innovations, it is accepted that the probability of obtaining innovation success is higher when there is more variety to be recombined (Weitzman 1998). Here, variety is taken as diversity in innovation orientations, which is reflected in the breadth of fields in a firm's innovation objectives.

A significant question in management studies is the effect of diversity on a firm's performance. Some results have shown that a diversified technology base positively affects the innovative potential of a firm (Garcia-Vega 2006a; Quintana-García and Benavides-Velasco 2008; Lin and Chang 2015). However, other studies found that the level of diversity matters, and that too much diversity causes high levels of coordination and integration costs and may lead to reduced opportunities for innovation (Leten, Belderbos, and Van Looy 2007). Similarly, Laursen and Salter (2006), Leiponen and Helfat (2010) and Leiponen (2012) investigated how resources allocation strategies (measured as breadth of external search for new ideas or pursuing multiple parallel objectives) impact on firm performance. In general, their empirical results suggest that strategies based on allocating resources to a broader range of information sources or objectives are associated with successful innovation. However, there are sectoral differences. For instance, Leiponen (2012) showed that breadth in terms of pursuing parallel innovation objectives appears to have a negative effect on innovation in service industries because some services firms may not have enough accumulated managerial processes and capabilities to benefit from these strategies.

In summary, based on the above literature review and discussion, our final hypothesis is proposed:

H3. Firms that design mixed innovation strategies have higher odds of being a successful innovative firm.

3. DATABASE, VARIABLES AND DESCRIPTIVE STATISTICS

3.1 Database

This analysis is based on firm level data from the Technological Innovation Panel (PITEC). PITEC is a specific statistical instrument for studying the innovation activities of large sample of Spanish firms over time and it is jointly developed by the Spanish National Institute of Statistics (INE), the Spanish Foundation for Science and Technology (FECYT), and the Foundation for Technical Innovation (COTEC).

PITEC is designed as a panel survey, based on the Community Innovation Survey (CIS), one of the most used datasets in innovation studies.[2] These innovation surveys are collected following the general guidelines of the Oslo Manual (OECD–Eurostat, 2005).

The PITEC database has two main advantages for this study.[3] First, and most importantly, it contains has detailed information about firms' innovation objectives. Innovation surveys are constantly improving their quality and relevance and, from 2003 on, the innovation survey has been updated and new questions have been included, allowing researchers to pursue new lines of research in depth. Specifically, in 2008, Spanish firms were for the first time asked to indicate the importance of items in a list of innovation objectives when carrying out innovation activities.[4] Such information is essential to this study.

---

[2] See Vokoun (2015), Cainelli *et al*. (2015), and Hashi and Stojčić (2013) for recent examples of empirical work using the Community Innovation Survey dataset and Segarra-Blasco and Teruel (2014); Barge-Gil and López (2014); Costa-Campi *et al*. (2015) for recent examples of empirical work using the PITEC dataset.

[3] However, the PITEC database is not free of limitations. One of the limitations of the innovation surveys like PITEC is the subjective nature of many of the questions addressed to the firm’s management or those responsible for R&D departments. Nevertheless, Mairesse and Mohnen (2005) provide evidence that the subjective measures of innovation surveys tend to be consistent with more objective measures of innovation, such as the probability of holding a patent and the share in sales of products protected by patents.

[4] In general, empirical research on innovation at the firm level has yet to incorporate the role of objectives, in particular, in studies of determinants of eco-innovation (Cainelli, De Marchi, and Grandinetti 2015; Costa-Campi et al. 2015; Jakobsen and Clausen 2016) and in studies of how the breadth of innovation objectives impacts on innovation (Leiponen and Helfat 2010; Leiponen 2012).

Second, PITEC is characterized by its time dimension. It has panel data for the period 2003–2014 which facilitates researchers in dealing more accurately with innovative behaviour of Spanish firms longitudinally and also treat standard econometric issues, such as unobserved heterogeneity and simultaneity problems that are hard to detect in simple cross-sectional data or time series (Baltagi 2008). In such temporal panels, containing data on the firms' innovation performance, it is easier to control common endogeneity problems by introducing lagged explanatory variables in the empirical specification or by using new methods which take into account the initial conditions of the model's dependent variable and firms' individual-specific effects (Semykina and Wooldridge 2010).

Our final database selection was subject to a process of filtering. The main filters were as follows: 1) data referred the period 2008–2014, because objectives questions were not included in the survey until 2008; 2) only innovative firms were examined, that is, firms that had introduced product or process innovations or firms with an intention of being innovative (i.e. firms that had taken an innovative project but later abandoned or it still remained to be completed);[5] 3) firms from the manufacturing and service sectors were analysed;[6] 4) firms that report confidentiality issues, mergers, employment incidents and other drawbacks were not incorporated in the sample.

After all filtering, our empirical analysis was based on a panel of 27,552 observations for the period 2008–2014. At this point, the dataset included 3,936 Spanish innovative firms of which 2,842 firms belong to the manufacturing sector and 1,094 firms to the service sector.

3.2 Variables

To measure innovation success among Spanish firms we considered two types of dependent variables: product innovation (the introduction of a good or service that is new or significantly improved from period t-2 to period t) and process innovation (the

[5] For instance, we take into account those firms that may be pursuing a certain innovation strategy and yet fail to attain innovation outcomes in a given period. Excluding non-innovative firms is based on the reason that these firms are unlikely to have any aspiration to innovation, in line with other studies using innovation dataset (Blanchard et al. 2013; Jakobsen and Clausen 2016).

[6] See Appendix 1 for a detailed classification.

implementation of a new or significantly improved production or delivery method during t-2 to t).

The key explanatory variables in our analysis represent the different innovation strategies that firms may design when engaging in innovation activities. In 2008, the Spanish CIS introduced a new question[7] *"Innovation activities carried out in your firm could be oriented to different objectives, how important were each of the following objectives*[8] *for your innovation activities during the three last years?"*[9] Firms were asked to evaluate the importance of each innovation objective on a Likert scale of 1 to 4, where 1 represents "high importance", 2 represents "intermediate importance", 3 represents "low importance" and 4 represents "factor not experienced". For each objective, listed in Table 1, we assign a binary value depending on its survey response. These dummy variables are equal to 1 when firm considers the innovative objective to have high importance and 0 when the importance is intermediate, low or not experienced.[10]

First, we distinguished between these firms that whose innovation process is guided by an innovation strategy and those that do not design a strategy. Firms designing an innovation strategy also are divided into two groups: mixed and oriented strategy. The former strategy includes firms that have an innovation strategy with different orientations (firms pursue some innovation objectives but not inter-related ones). The latter encompasses these firms with a clear innovation strategy oriented towards quality, production, costs or environmental and regulatory dimension.[11]

---

[7] The question was modified by the INE. In 2008, the question regarding the effects of innovation was replaced by innovation objectives. While "objectives" relate to a firm's motives for innovating, "effects" concern the actual observed outcomes of innovations (OECD - Eurostat, 2005).

[8] See Table 1 for a detailed classification.

[9] Some of qualitative questions in innovation surveys refer to a 3-year period, while quantitative ones refer to the actual year of the survey. In particular, questions on innovation objectives refer to a 3-year period.

[10] In 2008, the innovation survey included thirteen innovation objectives. In addition, in 2009, three new objectives relating to employment such as the increase in total employment, the increase in skilled employment and the maintenance of employment were appended to the thirteen objectives added the previous year. Due to the lack of data for the full period under analysis, the latter objectives about employment are not considered in this study.

[11] The exact definition of these variables (in the way that we use them in our analysis) is presented in Appendix 2. See Appendix 2 for a detailed definition.

In order to identify the oriented strategies, we group the thirteen innovation objectives by applying a multivariate statistical method. A principal component analysis (PCA) is undertaken on the thirteen innovation objectives reported from the innovation survey.[12] PCA analyses should be ideally applied to continuous variables or ordinal measures with broad enough scales. Hence, the categorical variables with relatively narrow scales (binary variables) are corrected for by using a tetrachoric correlation matrix as the input correlation matrix in the standard PCA, under the assumption that observed binary variables correspond to latent continuous variables.

Table 1
Component loadings after orthogonal rotation

	Innovation strategies			
Innovation objectives	**Quality**	**Production**	**Cost**	**Eco**
1. Increase range of goods or services	**0.4981**	-0.0023	-0.0771	0.0009
2. Replace products being phased out	**0.3102**	0.1644	0.0269	-0.0365
3. Enter new markets	**0.5214**	-0.1159	0.0320	0.0001
4. Increase market share	**0.5046**	-0.0499	0.0603	-0.0267
5. Improve product quality	**0.3572**	0.1749	-0.0578	0.0826
6. Increase flexibility of production	-0.0238	**0.6840**	-0.0494	0.0155
7. Increase capacity of production	-0.0198	**0.6376**	0.0341	-0.0099
8. Reduce labour costs per unit output	0.0103	0.2014	**0.4674**	-0.0693
9. Reduce material costs per unit output	0.0123	-0.0464	**0.6438**	-0.0291
10. Reduce energy costs per unit output	-0.0163	-0.0583	**0.5849**	0.0851
11. Reduce environmental impacts	-0.0020	-0.0587	0.0726	**0.5546**
12. Improve health or safety of employees	-0.0114	0.0486	-0.0237	**0.5772**
13. Fulfil government regulation or standards requirements	0.0088	0.0139	-0.0287	**0.5806**
Cronbach's alphas	0.7883	0.7498	0.7779	0.8488

Eighty percent of total variance was explained by the four components; principal components factoring with orthogonal varimax rotation. N=27,552. Larger components loadings appear in bold.
Source: PITEC database, own calculation.

After the extraction of principal components, orthogonal rotation of retained components was applied in order to enhance interpretability (Kline 1994).[13] The number of components to retain for rotation was subjective, based on the trade-off between simplicity (retaining as few as possible factors) and completeness (explaining most of the

[12] The main interest in this study is to use PCA to identify patterns of association across innovation objectives.

[13] Orthogonal rotation rotated components remain uncorrelated while oblique rotation allows for correlation between the rotated components. For additional robustness in analysing the patterns identified, we used oblique rather than orthogonal rotation, but the same patterns emerged.

variation in the data). There are some standard recommendations in this area (Kaiser 1958). Kaiser's rule, for example, recommends retaining only components with eigenvalues larger than one. Another common strategy is to examine the plot of the eigenvalues and determine whether there is a point beyond which the remaining factors explain considerably less variation. Taking these recommendations into account, four components were retained. In addition, Cronbach's coefficient was also used to evaluate internal consistency for each component retained. The Cronbach alphas for the four components were greater than 0.70, generally indicating an acceptable level of internal consistency.

Table 1 shows the component loadings that emerged after having retained four components. According to the results, the objectives can be broadly categorized as quality strategy (competing with better and more products), production strategy (improving the capacity and flexibility of production), cost strategy (competing with lowering production costs) and eco strategy (being environmentally friendly and satisfying standard requirements).

In addition to our variables of interest, innovation strategies, following the economic literature on the determinants of innovation (Becheikh, Landry, and Amara 2006; Keupp, Palmié, and Gassmann 2012; Pellegrino, Piva, and Vivarelli 2012) a set of variables related to the firm's assets, competences and capabilities were also included as internal factors (size, group, export, sector, internal R&D and training in innovation activities). Then, the technological opportunity (external R&D and cooperation) and government and public policies (subsidies) variables are included in the analyses as external factors. Appendix 2 summarises the list of variables and their definition, Appendix 3 descriptive statistics of variables included in the empirical analysis and Appendix 4 shows the correlation matrix.

3.3 Descriptive statistics

Based on an extensive sample of Spanish innovative firms, this section offers an overview of innovation strategies that can be designed. Table 2 lists the thirteen objectives that innovative firms can pursue in the course of their innovation activities, as well as the strategies proposed in this study. It can be seen that a large number of Spanish innovative firms have not designed an innovation strategy (29%). Some heterogeneity exists within the group of firms with an innovation strategy, in the sense that some firms have a mixed strategy (25%) and some firms specialize in a specific type of strategy. A quality strategy is the one most common across the sample. Nevertheless, if we compare strategies by sectors, this result changes slightly. A greater percentage of manufacturing firms pursue an environmental and regulatory strategy, while service firms are more interested in pursuing a production strategy. We also highlight that services firms have a higher percentage of mixed or, no strategy, than manufacturing firms.

Table 2
Importance of different innovation objectives and strategies (mean score in the sample)

(% of firms)	**All sample** Obs=27,552 F=3,936	**Manufactures** Obs=19,894 F=2,842	**Services** Obs=7,658 F=1,094	**Mean difference**
1. Increase range of goods or services	0.4317	0.4548	0.3764	-0.0783***
	(0.4953)	(0.4979)	(0.4845)	(0.0060)
2. Replace products being phased out	0.2859	0.2968	0.2598	-0.0369***
	(0.4518)	(0.4568)	(0.4385)	(0.0055)
3. Enter new markets	0.3468	0.3687	0.2942	-0.0745***
	(0.4759)	(0.4824)	(0.4557)	(0.0058)
4. Increase market share	0.3525	0.3761	0.2962	-0.0798***
	(0.4777)	(0.4844)	(0.4566)	(0.00529)
5. Improve product quality	0.4575	0.4566	0.4596	0.0030
	(0.4981)	(0.4981)	(0.4983)	(0.0060)
6. Increase flexibility of production	0.2809	0.2794	0.2847	0.0053
	(0.4494)	(0.4487)	(0.4513)	(0.0054)
7. Increase capacity of production	0.2905	0.2899	0.2917	0.0017
	(0.4540)	(0.4537)	(0.4545)	(0.0055)
8. Reduce labour costs per unit output	0.2253	0.2549	0.1546	-0.1002***
	(0.4178)	(0.4358)	(0.3616)	(0.0050)
9. Reduce material costs per unit output	0.1424	0.1735	0.0681	-0.1054***
	(0.3495)	(0.3787)	(0.2520)	(0.0042)
10. Reduce energy costs per unit output	0.1447	0.1737	0.0755	-0.0981***
	(0.3518)	(0.3788)	(0.2642)	(0.0041)
11. Reduce environmental impacts	0.2109	0.2421	0.1363	-0.1058***
	(0.4079)	(0.4283)	(0.3431)	(0.0049)
12. Improve health or safety of employees	0.2169	0.2517	0.1337	-0.1179***
	(0.4121)	(0.4340)	(0.3404)	(0.0049)
13. Fulfil government regulation or standards	0.2493	0.2896	0.1528	-0.1368***
requirements	(0.4326)	(0.4536)	(0.3598)	(0.0052)
Absence of strategy	0.2861	0.2712	0.3216	0.0504***
	(0.4519)	(0.4446)	(0.4671)	(0.0055)
Mixed strategy	0.2543	0.2452	0.2760	0.0307***
	(0.4354)	(0.4302)	(0.4470)	(0.0053)
Oriented strategy				
Quality	0.2298	0.2460	0.1912	-0.0547***
	(0.4207)	(0.4307)	(0.3933)	(0.0051)
Production	0.2040	0.2015	0.2099	0.0084***
	(0.4029)	(0.4011)	(0.4073)	(0.0049)
Cost	0.1474	0.1793	0.0712	-0.1081***
	(0.3545)	(0.3836)	(0.2572)	(0.0042)
Eco	0.2178	0.2543	0.1307	-0.1236***
	(0.4128)	(0.4354)	(0.3371)	(0.0050)

F: number of firms. Standard deviation in brackets.
Source: PITEC database, own calculation.

Analysing the importance of the innovation objectives, over the 2008–2014 period, 46% of firms considered improving quality of goods or services to be their key innovation objective. Increasing the range of goods or services was indicated as the next most important objective (43%), and increased market share ranked third (35%); these results are in accord with the German ones, c.f. Aschhoff et al. (2013), and suggest that the main concern of most firms is their product and its characteristics.

Consequently, during the period analysed, Spanish firms tried to keep their market position and survive by creating differentiated products and services and by distinguishing themselves from competitors. This is the opposed to other countries like Chinese firms, where the main innovation objectives pursued relate to lowering production costs (Guan et al. 2009; Zheng 2014).

Next to objectives related to competition, demand and market, firms also took into account increasing the capacity and flexibility of production (29%) and fulfilment of laws or regulations (25%) Only the increase in health security (22%), the reduction in environmental impacts (21%), the reduction in labour costs (23%) and the reduction in material and energy unit costs (14%) seemed to be less strongly pursued among the highly important objectives.

When we distinguish between manufacturing and services firms, the results show only small changes in the innovation objectives rankings. In the manufacturing and services sectors, the improvement of product/service quality and the increasing range of product or services still ranked as the two most frequently stated objectives. Then, if we looked at the increase in capacity and flexibility of production objectives, a greater percentage of services firms stated that they pursue these objectives than was the case for manufacturing firms. However, the three objectives related to reducing costs were more followed by manufacturing firms than by service ones. Finally, the percentage of firms that stated that environmental and regulatory objectives were an innovation objective of high importance is significant. For instance, in the manufacturing sector this percentage rose to 24%, however, in the services sector this percentage was much lower (14%). As Cainelli *et al*. (2015) remark, manufacturing firms are increasingly challenged to include environmental innovations in their business activities because of the their higher environmental impact. In addition, manufacturing firms are usually subject to stricter environmental regulations and economics instruments such as environmental taxation than are services firms (EEA 2014).

4. ECONOMETRIC METHODOLOGY

For investigating our research questions, we analysed the effects of conducting various types of innovation strategies on a firm success. Given the binary character of the dependent variables, probit models were specified. In addition, we used panel estimators to further account for the endogeneity, by controlling for some unobserved time-invariant heterogeneity in the model, that is, an omitted variable bias in the relationship between innovation strategies and innovation success.

The two most common techniques of panel estimators are fixed effects and random effects. Although the Hausman test supports a fixed effect model, since there are quite strong assumptions underlying this test, one should not automatically interpret a rejection of the null hypothesis in a Hausman test as a rejection of the random-effect (Baltagi 2008). Hence, to address concerns of unobserved heterogeneity, we employed a random-effect model instead of a fixed-effect model because different reasons. Firstly, a fixed effect estimator may be inappropriate as many crucial determinants of our variables of interest are time invariant, that is innovation strategy variables have considerably lower within variation than their overall and between variations. Secondly, estimates computed using fixed-effects models can be biased for panels over short periods and large populations. Given that our sample was drawn from a large population and included data for only seven years, a random-effects model was the preferred approach. Finally, fixed effects models cannot include time-independent covariates. This limitation would have meant excluding some of the control variables (for example, the sectoral variables) that are crucial for understanding the innovation behaviours of firms.

Specifically, the following equation is estimated:

$$y_{it} = \beta_0 + \beta_1 STRAT_{it-1} + \beta_2 X_{it-1} + \mu_i + \varepsilon_{it} \qquad \text{Eq.[1]}$$

being $i = 1 \ldots N$ firms and $t = 1 \ldots T$ years and where y_{it} is the binary outcome variable that distinguishes between product innovation and process innovation. Among the explanatory variables in Equation [1], $STRAT_{i,t-1}$ is a vector of explanatory variables containing information about innovation strategies that firms can pursue, $X_{i,t-1}$ includes a set of firm characteristics and β_0, β_1 and β_2 are unknown parameter vectors to be estimated.

Additionally, a set of dummy variables related the temporal and sector dimension are included in all of the regressions to control for cyclical effects and specific industry characteristics, respectively. μ_i is a firm-specific effect which captures unobserved time-invariant firm heterogeneity (such as managerial ability or organizational culture) that may affect the innovation success of firms, ε_{it} is an idiosyncratic error term.

Innovation efforts need some time to have an impact on innovation outputs so, for that reason, our data take into account a potential time lag between innovation efforts and new product or process innovations. Following Audretsch, Segarra-Blasco, and Teruel (2014) and Santamaría, Nieto, and Miles (2012), in the regression analyses, the dependent variables refer to the year t while the explanatory variables refer to the year t–1. This time difference is used to mitigate endogeneity problems arising from reverse causality.

In addition, in order to control for potential multicollinearity problems, the variance inflation factor (VIF) was calculated. The individual VIF values were substantially below the recommended cut-off point of 10, indicating that multicollinearity problems do not exist in any of the models (the mean VIF was 1.54).

5. RESULTS

The main results of the empirical analyses are presented in this section. Tables 3–5 report the results of the average marginal effects of random probit model for the whole sample, and for the manufacturing and services firms, respectively.[14,15] All tables present two econometric models, first the baseline model, which includes the most common

---

[14] When presenting our results, marginal effects rather than coefficients are reported to better quantify the true impact of each explanatory variable on the estimated probabilities. While coefficients in probit models report the effect of a variable on the latent propensity for a positive result, the marginal effect shows the impact of a change in the chosen covariate on the probability of a positive outcome, which is substantially of much more interest.

[15] The statistical significance of the panel-level variance component over the total variance (ρ) indicated that the random effects estimator is preferred over the pooled probit estimator, indicating the appropriateness of considering the former.

innovation determinants, is presented, and this is followed by the innovation-strategy model, where we analyse the effect of different innovation strategies.

As we expected, for innovative firms, not designing an innovation strategy had a negative and significant impact on the likelihood of achieving successful innovation as measured in terms of product or process innovations. According to Dobni et al. (2015), the main barrier to innovation success is the absence of a well-articulated innovation strategy. Whereas firms that design an innovation strategy showed mixed results, depending on the innovation strategy and the innovation success pursued (product and process innovation).

Our results also indicated that, when innovation strategies were mixed, this increased the probability of innovation in products having a larger number of different innovation objectives was eventually associated with more innovation by the firm (this was in line with Leiponen and Helfat (2010) and Masso and Vahter (2012). While it decreased the probability of innovation in processes suggesting that managing multiple innovation objectives is challenging and Spanish firms have not the capacity to benefit from these strategies in terms of process success.

Regarding oriented strategy, our results seemed to confirm that a good fit between the innovation strategy pursued, and the innovation output obtained. Firms that followed a quality strategy showed a positive and significant impact on product innovation and negative impact on process innovation. In particular, those, firms that pursued a quality strategy had a likelihood of being a successful innovative firm in product innovations that was 37 percentage points higher than that of firms that did not undertake a quality strategy.

Comparing the average marginal effects between mixed strategy and focus on quality strategy, the results showed that the impact of oriented strategy on product innovation was higher. This result may suggest that best performing firms are these that are focused on their core business rather than those with a wide spectrum of innovation orientations which possibly generate, on the one hand, advantages from unrelated technologies and the possibility of creating more complex and developed products but, on the other hand, exhibit problems of multiple strategy coordination (Garcia-Vega 2006b). The results also showed that production, cost and eco strategy had a positive and significant impact on process innovation and a negative or insignificant impact on product innovation.

Table 3
Average marginal effects of random effect probit model (whole sample)

	Product innovation		Process innovation	
	Base model	**Innovation strategies**	**Base model**	**Innovation strategies**
lSize $_{t-1}$	0.0963***	0.0960***	0.294***	0.279***
	(0.0213)	(0.0208)	(0.0213)	(0.0208)
Group $_{t-1}$	-0.0593	-0.0525	-0.0579	-0.0739
	(0.0501)	(0.0492)	(0.0485)	(0.0476)
Export $_{t-1}$	0.168***	0.153***	0.0718	0.0651
	(0.0414)	(0.0409)	(0.0406)	(0.0403)
Human resources $_{t-1}$	0.231***	0.208***	0.628***	0.587***
	(0.0418)	(0.0418)	(0.0427)	(0.0427)
lInternal R&D $_{t-1}$	0.0749***	0.0653***	0.000472	-0.0103*
	(0.00506)	(0.00511)	(0.00505)	(0.00514)
lExternal R&D $_{t-1}$	0.00933	0.00698	0.0105*	0.00796
	(0.00540)	(0.00537)	(0.00516)	(0.00514)
Cooperation $_{t-1}$	0.352***	0.315***	0.273***	0.228***
	(0.0359)	(0.0359)	(0.0353)	(0.0354)
Subsidy $_{t-1}$	0.0531	0.0440	-0.0358	-0.0450
	(0.0362)	(0.0360)	(0.0353)	(0.0352)
HT manuf. and HKIS $_{t-1}$	0.579***	0.558***	-0.398***	-0.378***
	(0.0574)	(0.0558)	(0.0542)	(0.0524)
Absence strategy $_{t-1}$		-0.236***		-0.341***
		(0.0557)		(0.0555)
Mixed strategy $_{t-1}$		0.0459*		-0.179***
		(0.0508)		(0.0498)
Quality strategy $_{t-1}$		0.371***		-0.0951*
		(0.0445)		(0.0434)
Production strategy $_{t-1}$		-0.0258*		0.476***
		(0.0454)		(0.0451)
Cost strategy $_{t-1}$		-0.0137		0.0816**
		(0.0478)		(0.0480)
Eco strategy $_{t-1}$		0.00388		0.0248**
		(0.0458)		(0.0447)
Constant	-0.113	-0.0592	-0.0465	0.149
	(0.108)	(0.114)	(0.106)	(0.112)
Log likelihood	-10437.7	-10361.6	-10848.3	-10690.0
Wald test of χ^2	1366.2	1507.3	1644.4	1890.8
Prob> χ^2	0.0000	0.0000	0.0000	0.0000
Rho (ρ)	0.6972	0.6817	0.6798	0.6601
Likelihood-ratio test of ρ=0	5329.25	4873.77	5039.84	4496.54
Prob> χ^2	0.000	0.000	0.000	0.000
σ_u	1.5176	1.4637	1.4571	1.3967
	(0.0347)	(0.0338)	(0.0328)	(0.0457)
Observations		23,616		

Estimations control for time and industry dummies. Standard errors in brackets. Marginal effects are calculated for each case, and then averaging over all of the cases (average marginal effects). For dummy variables, change in probability for a discrete change of the dummy variable from 0 to 1. *, ** and *** correspond to significance levels of 1%, 5% and 10%, respectively.

Given the different nature of manufacturing and service sectors, we also focused on the differences that an innovation strategy may have exerted on the probability of innovating in these two sectors (Table 4 and Table 5). In general, the lack of an innovation strategy have a significant and negative influence on innovation success in manufacturing and services firms. However, the effect of this variable is quite heterogeneous across both sectors. A service firm not having an innovation strategy was associated with a 19 percentage points decrease in the probability of being a successful innovative firm as measured in terms of product innovation, while manufacturing firms were associated with a 24 percent decrease. This reveals notable sectorial differences.

Regarding oriented strategies our results seem to confirm that there is also a good fit between the innovation strategy pursued and the innovation output obtained by sectors. Firms that followed a quality strategy showed a positive and significant impact on product innovation and negative impact on process innovation. On the other hand, manufacturing firms that designed production and cost showed a positive and significant impact on process innovation. Manufacturing firms that innovated in order to meet legislative requirements performed better in term of process innovative output. In line with, Porter and Linde (1995), environmental regulations could boost technology innovation without necessarily harming competitiveness because regulation signalled firms of likely resource inefficiencies and potential technological improvements. In contrast, in services firms these results changed slightly, a negative relationship was obtained.

The sizes of the effect of these three strategies (production, cost and eco) on process innovation success were quite different. Production strategy showed the strongest effect, followed by cost and eco strategy. In addition, the results also showed sectorial differences. The likelihood of being a successful innovative firm, measured by process innovation, increased by 53 percentage points when manufacturing firms followed a production strategy or but only by 38 percentage points for a service firm which followed the same strategy.

Finally, with respect to the other variables extensively analysed, our results for the whole sample were in accordance with the literature (Becheikh, Landry, and Amara 2006; Mohnen, Mairesse, and Dagenais 2006; Ahuja, Lampert, and Tandon 2008). Regarding firm characteristics, size had a positive and significant impact on both product and process innovation success. A wide range of empirical studies has shown that larger firms have more capacity to generate innovations (Bhattacharya and Bloch 2004; Becheikh, Landry, and Amara 2006)

Table 4
Average marginal effects of random effect probit model (manufacturing firms)

	Product innovation		**Process innovation**	
	Base model	**Innovation strategies**	**Base model**	**Innovation strategies**
lSize $_{t-1}$	0.143***	0.144***	0.260***	0.248***
	(0.0299)	(0.0293)	(0.0289)	(0.0282)
Group $_{t-1}$	0.00356	0.0104	-0.0583	-0.0770
	(0.0629)	(0.0619)	(0.0596)	(0.0584)
Export $_{t-1}$	0.108	0.0918	0.0758	0.0685
	(0.0553)	(0.0549)	(0.0545)	(0.0543)
Human resources $_{t-1}$	0.228***	0.207***	0.634***	0.601***
	(0.0534)	(0.0534)	(0.0547)	(0.0549)
lInternal R&D $_{t-1}$	0.0776***	0.0678***	0.00517	-0.00532
	(0.00608)	(0.00614)	(0.00603)	(0.00615)
lExternal R&D $_{t-1}$	0.00671	0.00482	0.00716	0.00513
	(0.00655)	(0.00652)	(0.00630)	(0.00628)
Cooperation $_{t-1}$	0.250***	0.217***	0.328***	0.282***
	(0.0432)	(0.0433)	(0.0425)	(0.0426)
Subsidy $_{t-1}$	0.0796	0.0678	0.00228	-0.00651
	(0.0423)	(0.0421)	(0.0411)	(0.0411)
HT manuf. and HKIS $_{t-1}$	0.296	0.337	-0.379	-0.421
	(0.616)	(0.599)	(0.582)	(0.564)
Absence strategy $_{t-1}$		-0.241***		-0.361***
		(0.0663)		(0.0661)
Mixed strategy $_{t-1}$		0.0859**		-0.236***
		(0.0612)		(0.0602)
Quality strategy $_{t-1}$		0.384***		-0.102*
		(0.0522)		(0.0514)
Production strategy $_{t-1}$		-0.0665		0.536***
		(0.0541)		(0.0545)
Cost strategy $_{t-1}$		-0.0284		0.0296**
		(0.0543)		(0.0546)
Eco strategy $_{t-1}$		0.0238		0.0132**
		(0.0532)		(0.0520)
Constant	0.0108	0.0145	0.0459	0.275
	(0.517)	(0.506)	(0.498)	(0.485)
Log likelihood	-7331.5	-7272.5	-7704.7	-7577.2
Wald test of χ^2	987.5	1094.0	1252.7	1441.6
Prob> χ^2	0.000	0.000	0.000	0.000
Rho (ρ)	0.6982	0.6834	0.6774	0.6572
Likelihood-ratio test of ρ=0	3684.12	3391.73	3542.05	3166.48
Prob> χ^2	0.000	0.000	0.000	0.000
σ_u	1.5212	1.4694	1.4494	1.3848
	(0.0419)	(0.0408)	(0.0387)	(0.0122)
Observations	17,052			

Estimations control for time and industry dummies. Standard errors in brackets. Marginal effects are calculated for each case, and then averaging over all the cases (average marginal effects). For dummy variables, change in probability for a discrete change of the dummy variable from 0 to 1. *, ** and *** correspond to significance levels of 1%, 5% and 10%, respectively.

Table 5
Average marginal effects of random effect probit model (services firms)

	Product innovation		**Process innovation**	
	Base model	**Innovation strategies**	**Base model**	**Innovation strategies**
lSize $_{t-1}$	0.105**	0.102**	0.289***	0.281***
	(0.0332)	(0.0327)	(0.0343)	(0.0336)
Group $_{t-1}$	-0.169*	-0.162	-0.141	-0.148
	(0.0851)	(0.0841)	(0.0861)	(0.0849)
Export $_{t-1}$	0.0629	0.0545	-0.0342	-0.0419
	(0.0700)	(0.0695)	(0.0686)	(0.0681)
Human resources $_{t-1}$	0.255***	0.229***	0.626***	0.579***
	(0.0675)	(0.0676)	(0.0685)	(0.0686)
lInternal R&D $_{t-1}$	0.0662***	0.0573***	-0.00435	-0.0157
	(0.00951)	(0.00969)	(0.00957)	(0.00975)
lExternal R&D $_{t-1}$	0.0237*	0.0201*	0.00984	0.00631
	(0.00967)	(0.00964)	(0.00911)	(0.00909)
Cooperation $_{t-1}$	0.623***	0.579***	0.150*	0.108
	(0.0650)	(0.0652)	(0.0643)	(0.0648)
Subsidy $_{t-1}$	0.0126	0.0103	-0.0833	-0.0920
	(0.0717)	(0.0715)	(0.0707)	(0.0705)
HT manuf. and HKIS $_{t-1}$	0.341	0.351	-0.564	-0.476
	(0.408)	(0.399)	(0.444)	(0.433)
Absence strategy $_{t-1}$		-0.190*		-0.362***
		(0.105)		(0.105)
Mixed strategy $_{t-1}$		-0.00591		-0.103
		(0.0937)		(0.0909)
Quality strategy $_{t-1}$		0.292***		-0.0963
		(0.0867)		(0.0828)
Production strategy $_{t-1}$		0.0896		0.380***
		(0.0858)		(0.0836)
Cost strategy $_{t-1}$		0.0358		0.136
		(0.109)		(0.110)
Eco strategy $_{t-1}$		-0.00855		-0.0786**
		(0.0951)		(0.0930)
Constant	-0.557	-0.470	0.268	0.425
	(0.410)	(0.408)	(0.447)	(0.441)
Log likelihood	-3023.4	-3006.9	-3079.7	-3045.5
Wald test of χ^2	482.1	514.2	468.8	526.3
Prob> χ^2	0.000	0.000	0.000	0.0000
Rho (ρ)	0.6635	0.6500	0.6587	0.6416
Likelihood-ratio test of ρ=0	1358.24	1242.96	1295.74	1164.57
σ_u	1.4042	1.3630	1.3895	1.3380
	(0.0593)	(0.0195)	(0.0592)	(0.0579)
Observations	6,564			

Estimations control for time and industry dummies. Standard errors in brackets. Marginal effects are calculated for each case, and then averaging over all the cases (average marginal effects). For dummy variables, change in probability for a discrete change of the dummy variable from 0 to 1. *, ** and *** correspond to significance levels of 1%, 5% and 10%, respectively.

In addition, for innovation success, firm competences seem to be important. For instance, internal R&D came out as significantly positive for product innovation confirming the widely held belief that in-house R&D is critical for innovation success. In contrast, external R&D seemed to have very little significance for innovation output. Product and process innovation also showed a strong significance relationship with skilled human capital and firm size. It has been noted in the literature, that firms with highly qualified and experienced teams of scientists and technicians with diverse background may improve the innovation process (Hadjimanolis 2000; Souitaris 2002; Becheikh, Landry, and Amara 2006; Leiponen and Helfat 2010). A positive pattern was found for export activities and product innovation, this is because competing in international markets demands a continuous flow of new and improved products to maintain a position. Finally, the results indicated the absence of a statistically significant correlation between innovation output and being part of a group.

As regards external factors, we observed that, for the whole sample, firms that had cooperation agreements had an increased probability of being a successful innovation firm. We found that the effect of cooperation was especially large in services firms. In line with the literature cooperation with other agents allowed firms better access to new resources or expertise, to share costs of the innovative projects and reduced risks (Oerlemans, Meeus, and Boekema 1998; Vega-Jurado et al. 2008; Vega-Jurado, Gutiérrez-Gracia, and Fernández-de-Lucio 2009). With respect to public subsidies various studies have reported that the presence of financial constraints in the innovative activities, thus providing public subsidies governments encourages firms to carry out innovation projects which otherwise not be started by any firm or even be abandoned once started (Kemp et al. 2003). However, the insignificance of our dummy variable for public subsidies was in accordance with findings by Hashi and Stojčić (2013) indicating that subsidies lead to additional spending on innovation by firms but do not lead to additional innovation output. Finally, some sector differences were detected, high tech manufactures and highly knowledge-intensive services (KIS) had positive and significant impact on product innovation, but a negative impact on process innovation.

5.1 Robustness checks

To confirm the robustness of our results, we conducted additional analysis. First, we tested our model by introducing the thirteen innovation objectives (dummy variables identifying firms pursuing each of the objectives with high importance). When considering the analysis of each innovation objective (see Table A.5.1 in Appendix 5), we found that the results were very similar to those presented before. Quality objectives were positively related to product innovation; in particular, we found that three of five objectives were positive and significant, so a strong positive relationship was found. Firms that pursued Objective 1, increasing range of goods or services, showed the highest likelihood of being a successful innovative firm in product innovation. Objectives related to efficiency, such as increase in flexibility and capacity of production and reduction in labour costs per unit output had a positive relationship to process innovation. Firms that pursued the Objective 7 (increasing the capacity of production) increased their probability of having process innovations success by 32 percentage points. However, we did not find any positive and significant relationship between reduction in material and energy costs objectives and process innovation.

Secondly, as binary logit and probit models assume that the numbers of dependent variable cases scored as one, and scored as zero, are fairly equal. When there is a significant disparity, as in our case (70% of firms had introduced product or process innovations), generalized linear models (GLMs) with a binomial family and log-log link provide better estimations because of their asymmetric nature (Hardin and Hilbe 2012). As a second robustness check, we adopted GLMs models, to prioritise the positive skewness of the dependent variables.[16] The results are displayed in Table A.5.2, which shows that the results did not change qualitatively from the previous ones.

6. CONCLUDING REMARKS

This study examined the role played by innovation strategies, which refers to strategic decisions at firm level, on innovation success measured in terms of product and process innovation. The analysis was performed with data from the Technological Innovation Panel (PITEC) between 2008–2014 for a sample of 3,936 Spanish innovative firms in the manufacturing and services sectors. Firstly, we identified the innovation strategies that innovative firms can design (absence, mixed, or oriented strategy towards quality, production, cost and environment) by applying a principal component analysis. Secondly, after taking into account the panel data structure, we used a random effect probit model to examine the impact of these strategies.

[16] The GLMs also control for over-dispersion, which can be an important problem in models with binary responses, causing underestimation of the standard error of the estimated coefficient vector, and consequently non-significant variables can spuriously appear to have significant influences. To recognize possible over-dispersion, the GLMs provide the value of the Pearson $\chi 2$ or the deviance divided by the degrees of freedom. A Pearson's statistic close to 1 indicates that the models are not over dispersed (they are well specified). The Huber-White Sandwich technique was used to correct for possible heteroscedasticity problems.

Our econometrics results show that those firms that are able to design their innovation strategies tend to have a greater probability of being a successful innovative firm. Our results also show that there is a good fit between the strategies pursued by each firm and the innovation output obtained. Quality strategy orientation is positively related to product innovation success, whereas product, cost and eco strategy are positively related to process innovation success. Product innovation requires understanding both customers and technologies, and firms that carry out process innovation are enhancing the efficiency, effectiveness and flexibility of the firm.

To sum up, our results highlight that there are three classes of Spanish innovative firms: 1) a group of firms that do not have an explicit strategy and consequently perform worst; 2) a group of firms that pursue some objectives in the innovative field and want to innovate, but do not have enough capacity to focus their innovation and, finally, 3) a group of firms that have a capacity to design one or more oriented innovation strategy and that experience greater innovation success.

These results are of great interest from the perspective of policy-makers and managers. The analysis shows the need to take into account a broader range of characteristics, such as innovation strategy, that may influence innovation success. It is crucial for management to realize the importance of innovation strategy as a fundamental key of innovation success in a highly dynamic environment. In terms of managerial implications, these results suggest that encouraging innovation beginning with a clear and precise innovation strategy is likely to enhance innovative outcomes. For policy-makers, this study reveals a diverse range of strategic profiles in relation to innovation and emphasizes the importance and effects of innovation strategies in the manufacturing and services firms. From a public policy perspective, in order to develop appropriate innovation policies, it is very important for governments to understand how innovative firms define their innovation strategies. Many public policies for supporting innovation would benefit from the identification of the main forces that drive innovation activity in firms. In addition, evaluating and understanding the strategic orientation of innovative firms allows governments to develop appropriate innovation policies. Thus, innovation public policies should provide a series of tools to firms wishing to initiate internal reflection on their ability to innovate.

REFERENCES

Ahuja, G., Lampert, C. M., & Tandon, V. (2008). Moving Beyond Schumpeter: Management Research on the Determinants of Technological Innovation. *The Academy of Management Annals*, *2*(1), 1–98. doi:10.1080/19416520802211446

Akman, G., & Yillmaz, C. (2008). Innovative capability, innovation strategy and market orientation: an empirical analysis in Turkish software industry. *International Journal of Innovation Management*, *12*(1), 69–111. doi: 10.1142/S1363919608001923

Aniruddha, K. P. (2013). Innovation Objectives, Strategies and Firm Performance: A Study of Emerging Market Firms. In C. Mukhopadhyay, K. B. Akhilesh, R. Srinivasan, A. Gurtoo, P. Ramachandran, P. P. Iyer, et al. (Eds.), *Driving the Economy through Innovation and Entrepreneurship* (Springer I., pp. 3–12). Springer.

Arvanitis, S. (2012). How do different motives for R&D cooperation affect firm performance? An analysis based on Swiss micro data. *Journal of Evolutionary Economics*, *22*(5), 981–1007. doi:10.3929/ethz-a-010782581

Aschhoff, B., Baier, E., Crass, D., Hud, M., Hünermund, P., Köhler, C., et al. (2013). *Innovation in Germany - Results of the German CIS 2006 to 2010*. *ZEW Dokumentationen*.

Audretsch, D. B., Segarra-Blasco, A., & Teruel, M. (2014). Why don't all young firms invest in R&D? *Small Business Economics*, *43*(4), 751–766. doi:10.1007/s11187-014-9561-9

Balachandra, R., & Friar, J. H. (1997). Factors for success in R&D projects and new product innovation: a contextual framework. *IEEE Transactions on Engineering Management*, *44*(3), 276–287. doi:10.1109/17.618169

Baltagi, B. (2008). *Econometric Analysis of Panel Data*. Chichester: John Wiley and Sons.

Barge-Gil, A., & López, A. (2014). R&D determinants: Accounting for the differences between research and development. *Research Policy*, *43*(9), 1634–1648. doi:10.1016/j.respol.2014.04.017

Becheikh, N., Landry, R., & Amara, N. (2006). Lessons from innovation empirical studies in the manufacturing sector: A systematic review of the literature from 1993–2003. *Technovation*, *26*(5–6), 644–664. doi:10.1016/j.technovation.2005.06.016

Bhattacharya, M., & Bloch, H. (2004). Determinants of Innovation. *Small Business*

Economics, *22*(2), 155–162. doi:10.1023/B:SBEJ.0000014453.94445.de

Blanchard, P., Huiban, J.-P., Musolesi, A., & Sevestre, P. (2013). Where there is a will, there is a way? Assessing the impact of obstacles to innovation. *Industrial and Corporate Change*, *22*(3), 679–710. doi:10.1093/icc/dts027

Bowonder, B., Dambal, A., Kumar, S., & Shirodkar, A. (2010). Innovation Strategies For Creating Competitive Advantage. *Research Technology Management*, *53*(3), 19–32. doi:10.1111/1467-8691.00188

Burgelman, R. A., Christensen, C. M., & Wheelwright, S. C. (2004). *Strategic management of technology and innovation*. Boston: McGraw-Hill.

Cainelli, G., De Marchi, V., & Grandinetti, R. (2015). Does the development of environmental innovation require different resources? Evidence from Spanish manufacturing firms. *Journal of Cleaner Production*, *94*, 211–220. doi:10.1016/j.jclepro.2015.02.008

Cohen, W. M. (2010). Fifty years of empirical studies of innovative activity and performance. In B. H. Hall & N. Rosenberg (Eds.), *Handbook of the Economics of Innovation* (Vol. 1, pp. 129–213). Elsevier. doi:10.1016/S0169-7218(10)01004-X

Cooper, R. G. (1984a). The Strategy-Performance Link in Product Innovation. *R&D Management*, *14*(4), 247–259. doi:10.1111/j.1467-9310.1984.tb00521.x

Cooper, R. G. (1984b). New product strategies: What distinguishes the top performers? *Journal of Product Innovation Management*, *1*(3), 151–164. doi:10.1016/S0737-6782(84)80012-0

Cooper, R. G., & Edgett, S. J. (2010). Developing a product innovation and technology for your business. *Research Technology Management*, *53*, 33–40. doi:10.1080/08956308.2010.11657629

Cooper, R. G., & Kleinschmidt, E. J. (1987). Success Factors in Product Innovation. *Industrial Marketing Management*, *16*(3), 215–223. doi:10.1016/0019-8501(87)90029-0

Costa-Campi, M. T., García-Quevedo, J., Segarra, A., & Segarra-Blasco, A. (2015). Energy efficiency determinants: An empirical analysis of Spanish innovative firms. *Energy Policy*, *83*, 229–239. doi:10.1016/j.enpol.2015.01.037

Crepon, B., Duguet, E., & Mairesse, J. (1998). Research, Innovation And Productivity: An Econometric Analysis At The Firm Level. *Economics of Innovation and New Technology*, *7*(2), 115–158. doi:10.1080/10438599800000031

Damanpour, F., & Aravind, D. (2012). Managerial Innovation: Conceptions, Processes and Antecedents. *Management and Organization Review*, *8*(2), 423–454. doi:10.1111/j.1740-8784.2011.00233

Dobni, C. B., Klassen, M., & Nelson, W. T. (2015). Innovation strategy in the US: top executives offer their views. *Journal of Business Strategy*, *36*(1), 3–13. doi:10.1108/JBS-12-2013-0115

Dosi, G. (1988). Sources, Procedures, and Microeconomic Effects of Innovation. *Journal of economic literature*, *26*(3), 1120–1171. doi:10.2307/2726526

EEA. (2014). *Resource-efficient green economy and EU policies*. Luxembourg: Publications Office of the European Union. doi:10.2800/18514

Ernst, H. (2002). Success Factors of New Product Development: A Review of the Empirical Literature. *International Journal of Management Reviews*, *4*(1), 1–40. doi:10.1111/1468-2370.00075

Garcia-Vega, M. (2006a). Does technological diversification promote innovation? *Research Policy*, *35*(2), 230–246. doi:10.1016/j.respol.2005.09.006

Garcia-Vega, M. (2006b). Does technological diversification promote innovation?: An empirical analysis for European firms. *Research Policy*, *35*(2), 230–246. doi:10.1016/j.respol.2005.09.006

Gilbert, J. T. (1994). Choosing an Innovation Strategy: Theory and Practice. *Business Horizons*, *37*(6), 16–22.

Goedhuys, M., & Veugelers, R. (2012). Innovation strategies, process and product innovations and growth: Firm-level evidence from Brazil. *Structural Change and Economic Dynamics*, *23*(4), 516–529. doi:10.1016/j.strueco.2011.01.004

Guan, J. C., Yam, R. C. M., Tang, E. P. Y., & Lau, A. K. W. (2009). Innovation strategy and performance during economic transition: Evidences in Beijing, China. *Research Policy*, *38*(5), 802–812. doi:10.1016/j.respol.2008.12.009

Hadjimanolis, A. (2000). An investigation of innovation antecedents in small firms in the context of a small developing country. *R&D Management*, *30*(3), 235–246. doi:10.1111/1467-9310.00174

Hall, B. H. (2002). The Financing of Research and Development. *Oxford Review of Economic Policy*, *18*(1), 35–51. doi:10.1093/oxrep/18.1.35

Hardin, J. ., & Hilbe, J. . (2012). *Generalized Linear Models and Extensions* (Third Edit.). Texas, USA: Stata Press.

Hashi, I., & Stojčić, N. (2013). The impact of innovation activities on firm performance using a multi-stage model: Evidence from the Community Innovation Survey 4.

Research Policy, *42*(2), 353–366. doi:10.1016/j.respol.2012.09.011

Hervas-Oliver, J.-L., Sempere-Ripoll, F., & Boronat-Moll, C. (2014). Process innovation strategy in SMEs, organizational innovation and performance: a misleading debate? *Small Business Economics*, *43*(4), 873–886. doi:10.1007/s11187-014-9567-3

Jakobsen, S., & Clausen, T. (2016). Innovating for a greener future: the direct and indirect effects of firms' environmental objectives on the innovation process. *Journal of Cleaner Production*, *128*(1), 131–141. doi:10.1016/j.jclepro.2015.06.023

Jayaram, J., Oke, A., & Prajogo, D. I. (2014). The antecedents and consequences of product and process innovation strategy implementation in Australian manufacturing firms. *International Journal of Production Research*, *52*(15), 4424–4439. doi:10.1080/00207543.2013.849363

Kaiser, H. F. (1958). The varimax criterion for analytic rotation in factor analysis. *Psychometrika*, *23*(3), 187–200. doi:10.1007/BF02289233

Karlsson, C., & Tavassoli, S. (2016). Innovation strategies of firms: What strategies and why? *The Journal of Technology Transfer*, *41*(6), 1483–1506. doi:10.1007/s10961-015-9453-4

Kemp, R. G. M., Folkeringa, M., de Jong, J. P. J., & Wubben, E. F. M. (2003). *Innovation and firm performance*. *Scientific Analysis of Entrepreneurship and SMEs (SCALES)*. Zoetermeer.

Keupp, M. M., Palmié, M., & Gassmann, O. (2012). The Strategic Management of Innovation: A Systematic Review and Paths for Future Research. *International Journal of Management Reviews*, *14*(4), 367–390. doi:10.1111/j.1468-2370.2011.00321

Kline, P. (1994). *An Easy guide to factor analysis*. London: Routledge.

Laursen, K., & Salter, A. (2006). Open for innovation: the role of openness in explaining innovation performance among U.K. manufacturing firms. *Strategic Management Journal*, *27*(2), 131–150. doi:10.1002/smj.507

Leiponen, A. (2012). The benefits of R&D and breadth in innovation strategies: a comparison of Finnish service and manufacturing firms. *Industrial and Corporate Change*, *21*(5), 1255–1281. doi:10.1093/icc/dts022

Leiponen, A., & Helfat, C. E. (2010). Innovation objectives, knowledge sources, and the benefits of breadth. *Strategic Management Journal*, *31*(2), 224–236. doi:10.1002/smj.807

Leten, B., Belderbos, R., & Van Looy, B. (2007). Technological Diversification, Coherence, and Performance of Firms. *Journal of Product Innovation Management*, *24*(6), 567–579. doi:10.1111/j.1540-5885.2007.00272

Lin, C., & Chang, C.-C. (2015). The effect of technological diversification on organizational performance: An empirical study of S&P 500 manufacturing firms. *Technological Forecasting and Social Change*, *90*(B), 575–586. doi:10.1016/j.techfore.2014.02.014

Lööf, H., Mairesse, J., & Mohnen, P. (2017). CDM 20 years after. *Economics of Innovation and New Technology*, *26*(1–2), 1–5. doi:10.1080/10438599.2016.1202522

Mairesse, J., & Mohnen, P. (2005). The importance of R&D for innovation: a reassessment using French survey data. *Journal of Technology Transfer*, *30*, 183–197. doi:10.1007/s10961-004-4365-8

Manu, F. A., & Sriram, V. (1996). Innovation, marketing strategy, environment, and performance. *Journal of Business Research*, *35*(1), 79–91. doi:10.1016/0148-2963(95)00056-9

Masso, J., & Vahter, P. (2012). The link between innovation and productivity in Estonia’s services sector. *The Service Industries Journal*, *32*(16), 2527–2541.

Mata, J., & Woerter, M. (2013). Risky innovation: The impact of internal and external R&D strategies upon the distribution of returns. *Research Policy*, *42*(2), 495–501. doi:10.1016/j.respol.2012.08.004

Mohnen, P., Mairesse, J., & Dagenais, M. (2006). Innovativity: A comparison across seven European countries. *Economics of Innovation and New Technology*, *15*(4–5), 391–413. doi:10.1080/10438590500512950

Nelson, R. R., & Winter, S. G. (1982). *An Evolutionary Theory of Economic Change*. Cambridge, MA: Harvard University Press.

OECD -Eurostat. (2005). *Oslo Manual. Guidelines for collecting and interpreting innovation data* (Third edit.). Paris: OECD. doi:10.1787/9789264013100-en

Oerlemans, L. A. G., Meeus, M. T. H., & Boekema, F. W. M. (1998). Do Networks Matter for Innovation? The usefulness of the economic network approach in analysing innovation. *Tijdschrift voor Economische en Sociale Geografie*, *89*(3), 298–309. doi:10.1111/1467-9663.00029

Oh, C., Cho, Y., & Kim, W. (2015). The effect of a firm’s strategic innovation decisions on its market performance. *Technology Analysis & Strategic Management*, *27*(1), 39–53. doi:10.1080/09537325.2014.945413

Oke, A. (2007). Innovation types and innovation management practices in service companies. *International Journal of Operations & Production Management*, *27*(6), 564–587. doi:10.1108/01443570710750268

Page, A. L. (1993). Assessing new product development practices and performance: Establishing crucial norms. *Journal of Product Innovation Management*, *10*(4), 273–290. doi:10.1016/0737-6782(93)90071-W

Paulraj, A. (2009). Environmental motivations: a classification scheme and its impact on environmental strategies and practices. *Business Strategy and the Environment*, *18*(7), 453–468. doi:10.1002/bse.612

Pellegrino, G., Piva, M., & Vivarelli, M. (2012). Young firms and innovation: A microeconometric analysis. *Structural Change and Economic Dynamics*, *23*(4), 329–340. doi:10.1016/j.strueco.2011.10.003

Pisano, G. P. (2015). You Need an Innovation Strategy. *Harvard Business Review*, *93*(6), 44–54.

Porter, M. E. (1985). *Competitive advantage: creating and sustaining superior performance*. New York: Free Press.

Porter, M. E., & Linde, C. van der. (1995). Toward a New Conception of the Environment-Competitiveness Relationship. *Journal of Economic Perspectives*, *9*(4), 97–118. doi:10.1257/jep.9.4.97

Quintana-García, C., & Benavides-Velasco, C. a. (2008). Innovative competence, exploration and exploitation: The influence of technological diversification. *Research Policy*, *37*(3), 492–507. doi:10.1016/j.respol.2007.12.002

Ramanujam, V., & Mensch, G. O. (1985). Improving the strategy-innovation link. *Journal of Product Innovation Management*, *2*(4), 213–223. doi:10.1016/0737-6782(85)90021-9

Salomo, S., Talke, K., & Strecker, N. (2008). Innovation Field Orientation and Its Effect on Innovativeness and Firm Performance. *Journal of Product Innovation Management*, *25*(6), 560–576. doi:10.1111/j.1540-5885.2008.00322.x

Santamaría, L., Nieto, M. J., & Miles, I. (2012). Service innovation in manufacturing firms: Evidence from Spain. *Technovation*, *32*(2), 144–155. doi:10.1016/j.technovation.2011.08.006

Schroeder, H. (2013). Strategic Innovation for Business Performance: The Art and Science of Transformation. *Technology Innovation Management Review*, *3*(9), 6–12.

Segarra-Blasco, A. (2010). Innovation and productivity in manufacturing and service firms in Catalonia: a regional approach. *Economics of Innovation and New Technology*, *19*(3), 233–258. doi:10.1080/10438590802469594

Segarra-Blasco, A., & Teruel, M. (2014). High-growth firms and innovation: an empirical analysis for Spanish firms. *Small Business Economics*, *43*(4), 805–821. doi:10.1007/s11187-014-9563-7

Semykina, A., & Wooldridge, J. M. (2010). Estimating panel data models in the presence of endogeneity and selection. *Journal of Econometrics*, *157*(2), 375–380. doi:10.1016/j.jeconom.2010.03.039

Smith, D. (2010). *Exploring innovation*. London: McGraw-Hill Higher Education.

Souitaris, V. (2002). Technological trajectories as moderators of firm-level determinants of innovation. *Research Policy*, *31*(6), 877–898. doi:10.1016/S0048-7333(01)00154-8

Talke, K., Salomo, S., & Rost, K. (2010). How top management team diversity affects innovativeness and performance via the strategic choice to focus on innovation fields. *Research Policy*, *39*(7), 907–918. doi:10.1016/j.respol.2010.04.001

Tavassoli, S., & Karlsson, C. (2016). Innovation strategies and firm performance: Simple or complex strategies? *Economics of Innovation and New Technology*, *25*(7), 631–650. doi:10.1080/10438599.2015.1108109

Teece, D. J., Pisano, G. P., & Shuen, A. (1997). Dynamic Capabilities and Strategic Management. *Strategic Management Journal*, *18*(7), 509–533.

Teece, D. J., Rumelt, R., Dosi, G., & Winter, S. (1994). Understanding corporate coherence. Theory and evidence. *Journal of Economic Behavior and Organization*, *23*(1), 1–30. doi:10.1016/0167-2681(94)90094-9

Tidd, J., Bessant, J., & Pavitt, K. (2005). *Managing innovation : integrating technological, market and organizational change*. Chichester: John Wiley and Sons.

van der Panne, G., van Beers, C., & Kleinknecht, A. (2003). Success and Failure of Innovation: A Literature Review. *International Journal of Innovation Management*, *7*(3), 309–338. doi:10.1142/S1363919603000830

Vega-Jurado, J., Gutiérrez-Gracia, A., & Fernández-de-Lucio, I. (2009). Does external knowledge sourcing matter for innovation? Evidence from the Spanish manufacturing industry. *Industrial and Corporate Change*, *18*(4), 637–670. doi:10.1093/icc/dtp023

Vega-Jurado, J., Gutiérrez-Gracia, A., Fernández-de-Lucio, I., & Manjarrés-Henríquez,

L. (2008). The effect of external and internal factors on firms' product innovation. *Research Policy*, *37*(4), 616–632. doi:10.1016/j.respol.2008.01.001

Veugelers, R., & Cassiman, B. (1999). Make and buy in innovation strategies: evidence from Belgian manufacturing firms. *Research Policy, 28*(1), 63–80. doi:10.1016/S0048-7333(98)00106-1

Vokoun, M. (2015). Innovation behaviour of firms in a small open economy: the case of the Czech manufacturing industry. *Empirica*, *43*(1), 111–139. doi:10.1007/s10663-015-9296-0

Volpi, M. (2017). Sources of information for innovation: the role of companies's motivations. *Industry and Innovation*, *24*(8), 817–836. doi:10.1080/13662716.2016.1271974

Weitzman, M. L. (1998). Recombinant Growth. *The Quarterly Journal of Economics*, *113*(2), 331–360. doi:10.1162/003355398555595

Zheng, C. (2014). The inner circle of technology innovation: A case study of two Chinese firms. *Technological Forecasting and Social Change*, *82*, 140–148. doi:10.1016/j.techfore.2013.06.005

Zuniga, P., & Crespi, G. (2013). Innovation strategies and employment in Latin American firms. *Structural Change and Economic Dynamics*, *24*, 1–17. doi:10.1016/j.strueco.2012.11.001

APPENDIX

Appendix 1. Aggregations of manufacturing and services

Firms are grouped depending on their technological intensity according to Eurostat, NACE Classification.

Table A.1

Aggregations of manufacturing and services based on NACE Rev. 2

Manufacturing industries	
1. Industry: High Technology	
Manufacture of basic pharmaceutical products and pharmaceutical preparations	21
Manufacture of computer, electronic and optical products	26
Manufacture of air and spacecraft and related machinery	30.3
2. Industry: Medium High Technology	
Manufacture of chemicals and chemical products	20
Manufacture of electrical equipment, Manufacture of machinery and equipment n.e.c., Manufacture of motor vehicles, trailers and semi-trailers	27-29
Manufacture of other transport equipment (excluding 30.1 Building of ships and boats, and 30.3 Manufacture of air and spacecraft and related machinery)	30 –(30.1+30.3)
3. Industry: Medium Low Technology	
Manufacture of coke and refined petroleum products	19
Manufacture of rubber and plastic products, Manufacture of other non-metallic mineral products, Manufacture of basic metals, Manufacture of fabricated metal products, except machinery and equipment	22-25
Building of ships and boats	30.1
Repair and installation of machinery and equipment	33
4. Industry: Low Technology	
Manufacture of food products, beverages, tobacco products, textiles, wearing apparel, leather and related products, wood and of products of wood, paper and paper products, Printing and reproductions of recorded media	10-18
Manufacture of furniture, Other manufacturing	31-32
Services industries	
5. High-Tech Knowledge Intensive Services	
Motion picture, video and television programme production, sound recording and music publishing activities, Programming and broadcasting activities, Telecommunications, Computer programming, consultancy and related activities, Information service activities	59-63
Scientific research and development	72
6. Other Knowledge Intensive Services	
Financial and insurance activities	64-66
Legal and accounting activities, Activities of head offices; management consultancy activities, Architectural and engineering activities; technical testing and analysis	69-71
Advertising and market research, Other professional, scientific and technical activities	73-74
Veterinary activities	75
Human health and social work activities	86-88
Arts, entertainment and recreation	90-93

Appendix 2. Variable definitions

Table A.2

Variable definitions

Dependent variables	
Product innovation	Dummy variable which takes the value 1 if the firm has introduced new or significantly improved products during t–2 to t; 0 if not
Process innovation	Dummy variable which takes the value 1 if the firm has introduced new or significantly improved production processes during t–2 to t; 0 if not
Independent variables	
Firms' resources and capabilities	
Absence of innovation strategy	Dummy variable which takes the value 1 if the firm pursues fewer than two objectives with high importance during t–2 to t; 0 if not
Mixed strategy	Dummy variable which takes the value 1 if the firm purses two or more objectives with high importance during t–2 to t without an orientation; 0 if not
Quality strategy	Dummy variable which takes the value 1 if the firm has a strategy oriented towards the quality. That means that firm considers at least four of the following objectives with high importance during t–2 to t: (1) increase range of goods or services, (2) replace products being phased out, (3) enter new markets, (4) increase market share and (5) improve product quality; 0 if not
Production strategy	Dummy variable which takes the value 1 if the firm has a strategy oriented towards the production. That means that firm considers two of the following objectives with high importance during t–2 to t: (1) increase flexibility of production, (2) increase capacity of production; 0 if not
Cost strategy	Dummy variable which takes the value 1 if the firm has a strategy oriented towards cost reduction. That means that firm considers at least two of the following objectives with high importance during t–2 to t: (1) reduce labour costs per unit output, (2) reduce material costs per unit output and (3) reduce energy costs per unit output objectives; 0 if not
Eco strategy	Dummy variable which takes the value 1 if the firm has a strategy oriented towards environment and regulatory norms. That means that firm considers at least two of the following objectives with high importance during t–2 to t: (1) reduce environmental impacts, (2) improve health or safety of employees and (3) fulfil government regulation or standards requirements; 0 if not
Size	Log of the total number of firm's employees (in logs)
Group	Dummy variable that takes a value equal to 1 if the firm belongs to a group; 0 if not
Export	Dummy variable that takes a value equal to 1 if the firm exports; 0 if not
Internal R&D	Investment in internal R&D per worker (in logs)
External R&D	Investment in external R&D per worker (in logs)
Human resources	Dummy variable that takes a value equal to 1 if firm invests in training expenditure for innovation activities; 0 if not
High Tech manufacture and High KIS	Dummy variables which take the value equal 1 if the firm belongs to a high-tech manufacturing sector or to a high knowledge intensive service; 0 if not
Cooperation	Dummy variable that takes a value equal to 1 if the firm cooperates with other agents during t–2 to t; 0 if not
Public subsidies	Dummy variable that takes a value equal to 1 if the firm received any public financial support for innovation activities during t–2 to t; 0 if not

Appendix 3. Descriptive statistics

Table A.3
Summary statistics of sample 2008-2014 (mean score in the sample)

	Absence strategy	**Mixed strategy**	**Quality strategy**	**Production strategy**	**Cost strategy**	**Eco strategy**
	Obs=4,637	Obs=8,156	Obs=7,386	Obs=6,555	Obs=4,737	Obs=7,000
Size (workers)	228.84	248.60	352.80	390.59	370.70	365.10
	(574.26)	(1128.28)	(1502.31)	(1412.22)	(1251.08)	(1265.20)
Group[1]	0.4817	0.4646	0.4902	0.5374	0.5986	0.5411
	(0.4997)	(0.4990)	(0.4995)	(0.4986)	(0.4902)	(0.4983)
Export by sales[1]	0.6715	0.7078	0.7855	0.7282	0.7986	0.7807
	(0.4696)	(0.4547)	(0.4104)	(0.4448)	(0.4010)	(0.4137)
R&D training[1]	0.00733	0.1585	0.2213	0.2485	0.2309	0.2381
	(0.2606)	(0.3562)	(0.4151)	(0.4321)	(0.4214)	(0.4259)
Internal R&D per worker (€)	4361.65	7382.61	8097.64	7599.11	6639.05	7892.42
	(26623.12)	(37379.55)	(17051.79)	(24122.61)	(16302.49)	(17962.79)
External R&D per worker (€)	601.52	1313.05	1747.54	1524.5	1399.89	1940.97
	(3286.38)	(100035.36)	(10868.33)	(12172.4)	(8981.36)	(13995.14)
Cooperation[1]	0.2160	0.4198	0.4859	0.4892	0.5022	0.500
	(0.4116)	(0.4935)	(0.49983)	(0.4999)	(0.5000)	(0.4998)
Subsidy[1]	0.2512	0.4299	0.4855	0.4605	0.4777	0.4808
	(0.4337)	(0.4951)	(0.4982)	(0.4984)	(0.4995)	(0.4996)
HT manuf. and HKIS[1]	0.4607	0.5776	0.5318	0.4614	0.435	0.4981
	(0.4985)	(0.4995)	(0.4990)	(0.4985)	(0.4987)	(0.5003)

Note: All monetary variables were deflated using the Price Index of the National Statistics Institute (INE, Spain). The Industrial Price Index was used for manufacturing firms and the Services Sector Price Index for services firms.
[1]Percentage of firms.
Source: PITEC database, own calculation.

Appendix 4. Correlation matrix

Table A.4
Correlation matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Size	1.000													
2. Group	0.169*	1.000												
3. Export	-0.036*	0.078*	1.000											
4. Human resources	0.059*	0.029*	-0.001	1.0000										
5. Internal R&D	-0.026*	-0.004*	-0.012*	0.047*	1.000									
6. External R&D	0.008	0.036*	-0.001	0.033*	0.205*	1.000								
7. Cooperation	0.094*	0.136*	0.034*	0.160*	0.124*	0.084*	1.000							
8. Subsidy	0.018*	0.035*	0.069*	0.128*	0.164*	0.088*	0.362*	1.0000						
9. HT manuf. HKIS	-0.041*	-0.012*	0.077*	0.059*	0.132*	0.047*	0.049*	0.097*	1.000					
10. Absence strategy	-0.022*	-0.010*	-0.054*	-0.123*	-0.045*	-0.033*	-0.186*	-0.157*	-0.059*	1.000				
11. Mixed strategy	-0.021*	-0.037*	-0.025*	-0.033*	0.005*	-0.007*	-0.009	0.007*	-0.003	-0.291*	1.000			
12 Quality strategy	0.037*	-0.003	0.081*	0.068*	0.021*	0.016*	0.080*	0.075*	0.062*	-0.272*	-0.393*	1.000		
13. Production strategy	0.053*	0.049*	0.003	0.102*	0.009*	0.004*	0.077*	0.041*	-0.021*	-0.251*	-0.362*	0.230*	1.000	
14. Cost strategy	0.035*	0.095*	0.074*	0.063*	-0.008*	-0.001	0.075*	0.049*	-0.015*	-0.204*	-0.295*	0.214*	0.326*	1.000
15. Eco- strategy	0.042*	0.055*	0.072*	0.091*	0.015*	0.026*	0.094*	0.066*	0.020*	-0.262*	-0.378*	0.240*	0.247*	0.340*

* Significance at 5%.

Appendix 5. Robustness check

Table A.5.1
Innovation objectives. Average marginal effects of random effect probit model (whole sample)

	Product innovation		Process innovation	
	Baseline model	**Innovation strategies**	**Baseline model**	**Innovation strategies**
lSize $_{t-1}$	0.0963***	0.0974***	0.294***	0.268***
	(0.0213)	(0.0207)	(0.0213)	(0.0207)
Group $_{t-1}$	-0.0593	-0.0395	-0.0579	-0.0762
	(0.0501)	(0.0493)	(0.0485)	(0.0476)
Export $_{t-1}$	0.168***	0.141***	0.0718	0.0751
	(0.0414)	(0.0413)	(0.0406)	(0.0406)
Human resources $_{t-1}$	0.231***	0.205***	0.628***	0.594***
	(0.0418)	(0.0420)	(0.0427)	(0.0427)
lInternal R&D $_{t-1}$	0.0749***	0.0569***	0.000472	-0.0132*
	(0.00506)	(0.00518)	(0.00505)	(0.00520)
lExternal R&D $_{t-1}$	0.00933	0.00491	0.0105*	0.00687
	(0.00540)	(0.00537)	(0.00516)	(0.00513)
Cooperation $_{t-1}$	0.352***	0.295***	0.273***	0.234***
	(0.0359)	(0.0361)	(0.0353)	(0.0355)
Subsidy $_{t-1}$	0.0531	0.0278	-0.0358	-0.0453
	(0.0362)	(0.0362)	(0.0353)	(0.0353)
HT manuf. and HKIS $_{t-1}$	0.579***	0.529***	-0.398***	-0.361***
	(0.0574)	(0.0550)	(0.0542)	(0.0517)
Objective 1 $_{t-1}$		0.374***		-0.0614
		(0.0363)		(0.0356)
Objective 2 $_{t-1}$		0.0603		0.0677
		(0.0368)		(0.0357)
Objective 3 $_{t-1}$		0.149***		0.00477
		(0.0408)		(0.0389)
Objective 4 $_{t-1}$		0.188***		0.0252
		(0.0421)		(0.0406)
Objective 5 $_{t-1}$		0.0605		-0.0715*
		(0.0365)		(0.0360)
Objective 6 $_{t-1}$		0.0121		0.387***
		(0.0420)		(0.0417)
Objective 7 $_{t-1}$		-0.0555*		0.324***
		(0.0424)		(0.0421)
Objective 8 $_{t-1}$		-0.0886*		0.168***
		(0.0452)		(0.0448)
Objective 9 $_{t-1}$		0.103		0.0311
		(0.0582)		(0.0581)
Objective 10 $_{t-1}$		-0.0488		-0.0373
		(0.0575)		(0.0579)
Objective 11 $_{t-1}$		-0.0806		-0.0198
		(0.0505)		(0.0492)
Objective 12 $_{t-1}$		-0.0748		0.0672
		(0.0530)		(0.0518)
Objective 13 $_{t-1}$		0.114*		0.0509
		(0.0496)		(0.0483)
Constant	-0.113	-0.203	-0.0465	-0.0522
	(0.108)	(0.107)	(0.106)	(0.104)
Log likelihood	-10437.7	-9956.7	-10848.3	-10314.3
Wald test of χ^2	1366.2	1565.9	1644.4	1960.1
Prob> χ^2	0.000	0.000	0.000	0.000
Rho (ρ)	0.6972	0.6683	0.6798	0.6465
Likelihood-ratio test of ρ=0	5329.25	4331.66	5039.84	4086.79
σ_u	1.5176	1.4197	1.4571	1.3524
	(0.0347)	(0.0338)	(0.0328)	(0.0316)
Observations	23,616			

Estimations control for time and industry dummies. AME means average marginal effects (marginal effects are calculated for each case, and then averaging over all of the cases). For dummy variables, change in probability for a discrete change of the dummy variable from 0 to 1. Standard errors in brackets. *, ** and *** correspond to significance levels of 1%, 5% and 10%, respectively. Objective 1: increase range of goods or services, objective 2: replace products being phased out, objective 3: enter new markets, objective 4: increase market share, objective 5: improve product quality, objective 6: increase flexibility of production, objective 7: increase capacity of production, objective 8: reduce labour costs per unit output, objective 9: reduce material costs per unit output, objective 10: reduce energy costs per unit output, objective 11: reduce environmental impacts, objective 12: improve health or safety of employees and objective 13: fulfil government regulation or standards requirements.

Table A.5.2
Generalized linear models (GLMs, whole sample)

	Product innovation		**Process innovation**	
	Baseline model	**Innovation strategies**	**Baseline model**	**Innovation strategies**
lSize $_{t-1}$	-0.000191	0.00351	0.0290***	0.0302***
	(0.00233)	(0.00238)	(0.00254)	(0.00253)
Group $_{t-1}$	-0.0104	-0.00701	-0.00312	-0.00790
	(0.00633)	(0.00643)	(0.00659)	(0.00650)
Export $_{t-1}$	0.0678***	0.0553***	0.0604***	0.0471***
	(0.00596)	(0.00611)	(0.00613)	(0.00618)
Human resources $_{t-1}$	0.159***	0.120***	0.352***	0.298***
	(0.0103)	(0.0103)	(0.0118)	(0.0118)
lInternal R&D $_{t-1}$	0.0385***	0.0287***	0.0180***	0.00697***
	(0.000795)	(0.000877)	(0.000817)	(0.000913)
lExternal R&D $_{t-1}$	0.00528***	0.00289*	0.00425***	0.00279*
	(0.00117)	(0.00119)	(0.00110)	(0.00112)
Cooperation $_{t-1}$	0.132***	0.0923***	0.142***	0.0996***
	(0.00754)	(0.00788)	(0.00731)	(0.00757)
Subsidy $_{t-1}$	0.0180*	0.00611	-0.00465	-0.0156*
	(0.00772)	(0.00797)	(0.00734)	(0.00760)
HT manuf. and HKIS $_{t-1}$	0.0695***	0.0719***	-0.0664***	-0.0606***
	(0.00603)	(0.00612)	(0.00602)	(0.00610)
Absence strategy $_{t-1}$		-0.184***		-0.217***
		(0.0116)		(0.0120)
Mixed strategy $_{t-1}$		0.0308*		-0.0320**
		(0.0120)		(0.0121)
Quality strategy $_{t-1}$		0.159***		-0.0237*
		(0.0103)		(0.0104)
Production strategy $_{t-1}$		-0.0186		0.183***
		(0.0101)		(0.0109)
Cost strategy $_{t-1}$		-0.0104		0.0601***
		(0.0107)		(0.0115)
Eco strategy $_{t-1}$		0.00446		0.0306**
		(0.0101)		(0.0105)
Constant	-0.140**	0.173**	-0.0559	0.366***
	(0.0479)	(0.0604)	(0.0473)	(0.0604)
(1/df) Pearson	1.0069	0.9972	1.0095	0.9997
AIC	1.0823	1.0280	1.1878	1.1121
Log pseudolikelihood	-14,889.07	-14,134.93	-16,341.26	-15,293,14
Observations	23,616			

Estimations control for time and industry dummies. AME means average marginal effects (marginal effects are calculated for each case, and then averaging over all of the cases). For dummy variables, change in probability for a discrete change of the dummy variable from 0 to 1. Standard errors in brackets. *, ** and *** correspond to significance levels of 1%, 5% and 10%, respectively.

CHAPTER 3

WHAT SPURS THE DECISIONS TO UNDERTAKE ECO-MOTIVATIONS? A PANEL DATA ANALYSIS OF SPANISH SERVICE AND MANUFACTURING FIRMS

1. INTRODUCTION

In recent years, there is an increasing political and social awareness of the need to promote a European Union agenda based on smart, sustainable, and inclusive growth. This has led to a widespread consensus on the key role of innovations that positively impact the environment; these consequently, have become an important goal of the major EU policy strategies (OECD 2011; EEA 2014). For instance, within the framework of the Europe 2020 agenda, the European Commission launched a specific program, the Eco-Innovation Action Plan (EcoAP), with the aim of ensuring environment sustainability through innovation.[1]

Over the past decade, in response to pressures for a cleaner environment, many empirical papers have devoted attention on the drivers of eco-innovation (Horbach 2008; Carrillo-Hermosilla, Del Río, and Könnölä 2009; Del Río, Tarancón Morán, and Albiñana 2011; Triguero, Moreno-Mondéjar, and Davia 2013; Srholec 2014; Díaz-García, González-Moreno, and Sáez-Martínez 2015; Ghisetti, Marzucchi, and Montresor 2015; Hojnik and Ruzzier 2015; Horbach 2016). The primary motivation here may be because eco-innovation is characterized by the problem of double externality providing both the typical R&D spillovers and the environmental externality that justify both the

[1] To achieve the transformation towards a sustainable and low-carbon economy, the EU has set itself targets for progressively reducing its greenhouse gas emissions up to 2050 (the main roadmaps are: 2030 climate & energy framework and 2050 low carbon economy).

introduction of innovation and also environmental policies to encourage its adoption (Rennings 2000).

Consequently, as eco-innovations have been argued to play a relevant role in the path towards more competitive and environmentally sustainable societies, identifying the main factors that activate and hinder firms' decisions to eco-innovate in differentiated sectors can help policy-makers to implement suitable instruments to stimulate these determinants or to overcome these barriers.

Because of the higher environmental impact of manufacturing, most eco-innovation studies have been focused on the role played by these sectors. However, service industries have been given less attention, despite their rapid growth in most developed countries and their greater importance in overall economic activities.[2] Although, nowadays, service firms account for 60–70% of GDP in most OECD countries and are expected to be the engine of employment growth, so far, they have been little studied.

Since services generally create lower direct pressures on natural resources because their conventional view of immateriality—view recently criticized by Djellal and Gallouj (2015)—, the change of economic structure towards an increasing proportion of services in the economy is traditionally seen as positive to the environmental performance of the economy. Nevertheless, this favourable service effect cannot be taken for granted. For instance, the Spanish compound annual growth rate of CO_2 levels[3] in service firms

[2] Deriving from the seminal contribution of Gallouj and Weinstein (1997), the perspective of innovation in services has been extended in the literature, focusing on the nature of innovation in services and its production modes. The main question in the field of service innovation studies has been whether innovation in services differs from innovation in goods. Coombs and Miles (2000) suggested three analytical perspectives to address innovation in services: the assimilation perspective (service innovation is fundamentally similar to manufacturing innovation), the differentiation perspective (service innovation is highly distinctive) and the synthesis perspective (services innovation highlights neglected aspects of the innovation process that are widely distributed across the economy). For empirical analyses of innovation in services, see e.g. Tether (2005), Miles (2006), Cainelli et al. (2005) and Leiponen (2012) among others. For a recent review of the future of the service economy in Europe see Gallouj et al. (2015).

[3] Data refers to CO2 emissions from energy use and industrial processes.

increased by 2% over the period 2008–2013, while in manufacturing firms it reduced by 6%.[4]

In addition, many services demand high volumes of industrial inputs; while the direct pressure of services may be low, the final overall pressure may be higher when the interrelations with manufacturing industry are considered (EEA 2014). Consequently, from an integrated macro-level perspective, the shift to a service economy may be less green than might be expected (Cainelli and Mazzanti 2013). Despite these considerations, the service sector has not received attention comparable to the manufacturing sector, as del Río et al. (2016) highlighted in their recent review of firm-level determinants to eco-innovation.[5]

The main purpose of this study is to analyse the drivers of designing an eco-innovation strategy in Spanish services and manufacturing firms. To carry out the econometric analyses we used panel data drawn from the Spanish Technological Innovation Panel (PITEC). Using an extensive sample of 4,535 Spanish services and manufacturing firms for the period 2008–2014, we applied a dynamic random probit model controlling for sample selection. Our results show that manufacturing firms have a higher orientation towards the environment than do service firms and that the drivers affecting the eco-innovative orientation of firms are quite similar. In line with other contributions to the literature, our results confirm the importance of regulatory stimulus to eco-innovation for both service and manufacturing firms—however local and EU subsidies have significantly greater effects only in services firms. We also find that eco-innovation is highly persistent at the firm level in both sectors, so past eco-innovation behaviour is clearly of key importance in explaining the current state of eco-innovation orientation. The results also underline the fact that a firm's profile, including parameters such as firm size, is key when it comes to introducing eco-innovation strategies for manufacturing firms. In contrast, market factors are not found to be distinctive drivers for eco-innovative firms either in the services or in the manufacturing sectors.

[4] Source: EUROSTAT (2013).

[5] For some exceptions that analyse the drivers of eco-innovation in service sector, see: Cainelli and Mazzanti (2013) and Segarra-Oña et al. (2016)—both studies use a cross-sectional database.

This study makes several contributions. Firstly, as del Río et al. (2016) and Díaz-García et al. (2015) pointed out in their recent literature review on eco-innovation, analysis of the main drivers of eco-innovation in sectors other than manufacturing, is almost non-existent. Hence, we contribute to the existing body of literature on eco-innovations by exanimating the similarities and differences between service and manufacturing firms in the Spanish context. Secondly, the literature has strongly relied on German data (Rennings et al. 2006; Horbach 2008; Horbach et al. 2012; Horbach 2014) and few papers have focused on Southern Europe countries.[6] We consider Spain, a moderate innovation country ranked number 9 in the Eco-Innovation Scoreboard (Eco-IS 2015),[7] but with both a relatively low level of environmental regulation stringency and a low customer awareness for green products, as compared to European countries such as Netherlands, Finland and Germany. The specific Spanish characteristics which distinguish it from other European countries make this analysis well worthwhile. Thirdly, the econometric analysis on the eco-innovation literature has been mainly based on small and cross-sectional samples (Petruzzelli et al. 2011; Horbach, Rammer, and Rennings 2012; Cainelli and Mazzanti 2013; Horbach, Oltra, and Belin 2013; Triguero, Moreno-Mondéjar, and Davia 2013; Cuerva, Triguero, and Córcoles 2014; Horbach 2016), while there is almost no use of panel data.[8] We take advantage of a large panel database for Spanish firms (PITEC) that allows us to examine long-term relationships between

[6] For some exceptions that analyse the driver of eco-innovation in manufacturing sector in Southern Europe countries, see: Cainelli et al. (2012) for the Italian context and del Río et al. (2015), Cuerva et al. (2014) and Cainelli et al. (2015) for the Spanish context.

[7] The Eco-Innovation Scoreboard (Eco-IS) is the first tool to assess and illustrate eco-innovation performance across the EU Member States. The scoreboard aims at capturing the different aspects of eco-innovation by applying 16 indicators grouped into five thematic areas: eco-innovation inputs, eco-innovation activities, eco-innovation outputs, resource efficiency and socio-economic outcomes.

[8] Contributions using panel data do exist, but they have some peculiarities: 1) Some analysed at the industry level rather than at the firm level as in our study. These include the contribution from Jaffe and Palmer (1997) which empirically investigated the relationship between innovation and regulation policy using panel data for US manufacturing sector for the period 1976–1991 and the paper of Del Río et al. (2011) working with twelve Spanish industrial sectors, i.e., 84 observations for the period 2000–2006. 2) Some had a different analytical focus, for instance Elsayed and Paton (2005) which investigated the impact of environmental performance on firm performance. 3) Others had a similar focus to the present study, but failed to fully exploit the panel approach, merely using selected variables from a few earlier waves, or even the most recent one (Horbach 2008; Cainelli, De Marchi, and Grandinetti 2015).

variables and to control for non-observable heterogeneity Finally, we study persistence in eco-innovation over time, while this topic has received great attention in the general innovation literature (Raymond et al. 2010; Tavassoli and Karlsson 2015), persistence has not previously addressed in the literature on drivers of eco-innovation strategy.[9]

The remainder of this chapter is structured as follows. Section 2 consists of a literature review. Section 3 presents the database, the variables, and some descriptive statistics. Section 4 contains the econometric methodology. Section 5 shows our main findings. The last section presents our conclusions and the consequent policy implications.

2. DRIVERS FOR ECO-INNOVATION STRATEGY

2.1 Eco-innovation: definition and specificities

Defining eco-innovation is not a simple task, several definitions exist in the literature (Carrillo-Hermosilla, del Río, and Könnölä 2010; Díaz-García, González-Moreno, and Sáez-Martínez 2015; Hojnik and Ruzzier 2015). In an EU-funded research project called "Measuring Eco-Innovation" (MEI), eco-innovation was defined by Kemp and Pearson (2007) as the: "*production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives"*. More recently, the Eco-Innovation Observatory (EIO 2013) defines eco-innovations as the "*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 lifecycle"*. Sometimes, the various definitions lead to ambiguity between researchers regarding which term use to label this concept; four options are used interchangeably in the

[9] See some exceptions: Horbach (2008) who shows that being innovative in the past increases the probability of being eco-innovative in the present or the future (through a dummy variable indicating if the firm was an innovator in the preceding panel wave) and, more recently, Mothe and Nguyen-Thi (2016) who analyse whether persistent open knowledge search lead to more EI than sporadic search. However, none of them fully exploit the methodology to examine persistence because of the lack of firm-level panel data.

literature: eco-innovation, green-innovation, environmental innovation and sustainable innovation (Díaz-García, González-Moreno, and Sáez-Martínez 2015).[10]

Despite the lack of a commonly accepted term for eco-innovation, in general, these innovations differ from more general innovations in that eco-innovations result in both economic and environmental benefits, hence the positive environmental impact of innovation is the core element of its definition (Carrillo-Hermosilla, Del Río, and Könnölä 2009). From these definitions, it follows that eco-innovation can be part of any economic activity and it is neither sector- nor technology-specific. In addition, it can be intentional or not and relatively novel or significant as compared to conventional technologies.

Then, a crucial question that environmental innovation scholars deal with is whether those eco-innovations, increasingly the aim of the major EU policy strategies, can be treated as normal innovations or whether there is a need for specific management and policy approaches to foster them. Until now, the literature has mainly focused on two aspects that differentiate eco-innovations from general innovations with regard their externalities and drivers (Table 1).

The main specificity of eco-innovation is found in what is known as the "double externality problem" (Rennings 2000). Eco-innovation is characterized by the common positive externalities (knowledge spillovers and imitation) produced by innovation activities plus the environmental externalities generated. The effect of reducing the environmental damages is borne by the society as a whole instead of the firm that invested in green technologies and consequently took on higher costs than its non-green competitors, creating a disincentive for the firm to invest in eco-innovations. While general innovations face the usual knowledge spillovers, eco-innovations face both innovation and environmental externalities, hence an interdisciplinary approach should be adopted to environmental economics and innovation economics disciplines.

[10] Díaz-García et al. (2015) in their recent literature review found that despite environmental innovation being the predominant term; the term eco-innovation has become more relevant in the last few years.

Table 1
Specificities and drivers of eco-innovation

	Externalities	**Drivers**
Eco-innovations	Knowledge externalities Environmental externalities	Technology-push Demand-pull Environmental policy influences
General innovations	Knowledge externalities	Technology-push Demand-pull

Source: own elaboration from Horbach (2008) and Rennings (2000).

The second specificity, derived by the market-failure generated by the two externalities, is the need for greater public intervention, known as “regulatory push/pull effect” (Rennings 2000). Consequently, while the general innovation literature highlights the role of demand-pull, technology-push and firm characteristics factors as determinants of innovation, the literature on eco-innovations also emphasizes the role of regulations and institutional frameworks as additional elements to be considered in the adoption of eco-innovations (Porter and Linde 1995; Rennings 2000; Horbach 2008; Del Río, Tarancón Morán, and Albiñana 2011; De Marchi 2012; Triguero, Moreno-Mondéjar, and Davia 2013; Horbach 2016; Jakobsen and Clausen 2016).

2.2 Theoretical framework: drivers of eco-innovation orientation

Some theoretical approaches are used in the literature to explain the main determinants of designing an eco-innovation strategy.[11] Due to the above particularities of eco-innovation, some researchers have accepted that general innovation theory which includes technology push and demand factors as the main drivers of innovation is not enough to explore the decision to design an eco-innovation strategy. Hence, numerous studies emphasize that general innovation theory has to be extended with respect to the analysis of the role of regulatory and institutional factors (Porter and Linde 1995; Jaffe and Palmer 1997; Rennings 2000; Rennings et al. 2006; Horbach 2008). In particular, Horbach (2008) proposes the main elements of the environmental innovation theory that

[11] It is worth mentioning that there is no consensus in the literature on a theoretical framework, consequently each approach underlines some drivers and rejects others (Hojnik and Ruzzier 2015; Del Río, Peñasco, and Romero-Jordán 2016). The different approaches are not mutually incompatible and should be combined.

include demand side, supply side and environmental policy influences as drivers of eco-innovations.[12]

The determinants of eco-innovation are also based on the resource-based view (RBV). This theory argues that firms are heterogeneous, each firm having a specific set of resources and capabilities that have been developed over the time and which must be valuable, rare, imperfectly imitable and non-substitutable to constitute a competitive advantage (Barney 1991). Resource-based theory highlights the importance of the internal resources of firms; in contrast, more recently, the evolutionary perspective emphasizes the importance of innovation systems, the dynamic interaction between different actors and the internal and external factors influencing the innovation process (Nelson and Winter 1982).

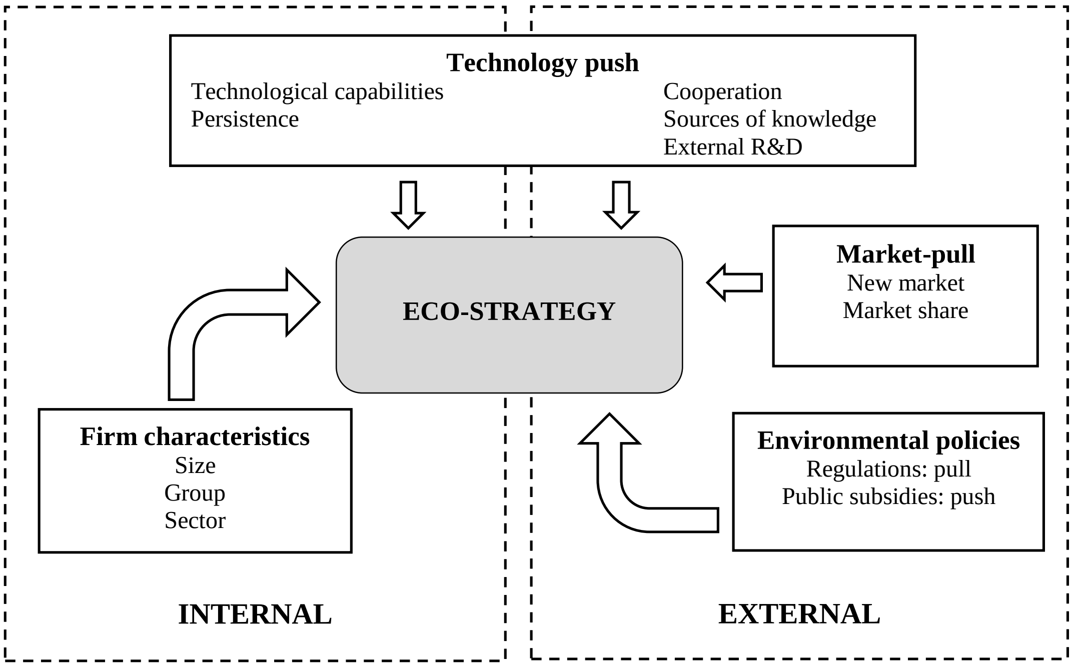
Furthermore, taking into account the resource-based and evolutionary perspective approaches some researchers have categorized the drivers of eco-innovation as internal and external factors (Carrillo-Hermosilla, Del Río, and Könnölä 2009; Del Río 2009; Demirel and Kesidou 2011; Cainelli, De Marchi, and Grandinetti 2015; Sáez-Martínez, Díaz-García, and Gonzalez-Moreno 2016). Factors internal to the firm refer to internal resources such as technological capabilities, qualified employees or financial resources. Meanwhile, external factors refer to a firm's interaction with other agents through cooperation, collaboration, networks and market relations.[13]

[12] This theoretical background in examining the drivers of eco-innovation has recently been adopted by other researchers (Horbach, Rammer, and Rennings 2012; Triguero, Moreno-Mondéjar, and Davia 2013; Cuerva, Triguero, and Córcoles 2014; Doran and Ryan 2016).

[13] Note that in the literature, some researchers also integrate the extended view of stakeholders on eco-innovation and also institutional theory (Sarkis, Gonzalez-Torre, and Adenso-Diaz 2010; Tang and Tang 2012; Tyl et al. 2015). Stakeholder theory argues that in order to survive and grow firms must take into account the impact and the role of different groups of stakeholders (Kassinis and Vafeas 2006; Carrillo-Hermosilla, del Río, and Könnölä 2010). In particular, internal stakeholders (managers and employees) and external stakeholders (customers, society, policy makers, and non-governmental organisations) are considered. The second theory, institutional theory, states that firms need to conform and comply with regulations and rules to ensure their legitimacy and survival. These two theories fall outside the scope of the present paper. For an overview of the subject see, for example, Aykol and Leonidou (2015) and Hojnik and Ruzzier (2015).

As some authors highlight, many of the studies which examine the driving forces of environmental orientation of the firms lack a theoretical framework (Aykol and Leonidou 2015; Del Río, Peñasco, and Romero-Jordán 2016). Hence, following the Horbach (2008) classification, we examine the drivers of eco-innovation strategy from the perspective of the supply side, demand side, environmental policy, as well as the firms' structural characteristics from internal and external perspectives. Horbach (2008) classification and internal and external factors can be combined (Del Río, Peñasco, and Romero-Jordán 2015). As a result, technology push factors can be internal (firm technological capabilities) or external (cooperation and networks). Public policies can be market-pull (regulations) or a supply-push (subsidies). Finally, market demand (consumers) can be external. Figure 1 summarizes the conceptual framework deployed here.

Figure 1
Main drivers influencing an eco-innovation orientation



Source: own elaboration.

2.2.1 Technology push factors

The first group of factors for designing an eco-innovation strategy, technology push factors, are linked to the development of technological capabilities. The most important factors to build up such technological capabilities are investment in R&D and having qualified employees (Horbach 2008; Mazzanti and Zoboli 2009; Horbach et al. 2012; Cainelli et al. 2015). Using a sample of German firms, Horbach (2008) shows that the improvement of technological capabilities measured in terms of R&D and high qualification of employees is a key determinant in favouring eco-innovations.

Nevertheless, the empirical evidence on the importance of internal R&D in fostering the introduction of an eco-innovation strategy is not conclusive. Based on an extensive sample of Spanish manufacturing firms, Cainelli et al. (2015) find that the presence of an R&D structure is positively and highly correlated with the introduction of eco-innovations. A similar positive relationship is found by Cuerva et al. (2014) for a sample of Spanish low-tech firms. On the contrary, findings from studies in France and Germany show a negative relationship between internal R&D and eco-innovation, internal R&D then not being the most important source of eco-innovation (Horbach, Oltra, and Belin 2013).

According to Jakobsen and Clausen (2016) these inconclusive results might be related to the differences in the national regulations and consumers' attitudes toward environmental concern, where leader innovation countries, such as Germany, have more stringent environmental regulations and consumer awareness compared to moderate innovation countries such as Italy or Spain.

H1: Internal technological capabilities are more relevant for eco-innovation oriented firms than for general innovators.

The high development of the innovation capacities of a firm (accumulation of human capital and available knowledge) may lead to further innovation success in the future. Evolutionary theory suggests that the learning by doing effect enhances knowledge stocks and, therefore, the probability of future innovations (Peters 2009). Following the seminal paper of Malerba et al. (1997), an increasing number of empirical publications in the general innovation literature began to devote attention to analysing the role of persistence, in other words, whether firms which innovate once have a higher probability of innovating again in subsequent periods (Martínez-Ros and Labeaga 2009; Peters 2009; Triguero and Córcoles 2013; Deschryvere 2014). Economic theory provides at least three potential explanations of why innovation might demonstrate state dependence over time: success breeds success, dynamic increasing returns, and sunk costs in R&D investments (Peters 2009; Raymond et al. 2010). This path dependency constitutes an important unexplored area in eco-innovation orientation. An exception is the Horbach (2008) paper that uses German sample data to show that being innovative in the past (in the preceding panel wave) increases the probability of being eco-innovative in the present or the future.

H2: Firms which eco-innovate once have a higher probability of eco-innovating again in subsequent periods.

Regarding external sources and cooperation, the literature stresses that eco-innovations are often more prone to cooperation and the search for new knowledge than are general innovations. This is because eco-innovations are characterized by a high level of uncertainty, novelty and the need to go beyond the firm's core competences (see Horbach (2008) for Germany, Horbach et al. (2013) for Germany and France, Triguero et al. (2013) for 27 European countries, Mazzanti and Zoboli (2009) for Northern Italy and De Marchi (2012) and Cainelli et al. (2015) for Spain). Possibly more so than for other innovations, the higher uncertainty in implementing an eco-innovation strategy implies a high propensity for relying on knowledge inputs from different, heterogeneous sources. For instance, in the manufacturing industry, De Marchi (2012) and Triguero et al. (2013) show that cooperation with public research institutes and universities becomes more relevant for firms with an environmental motivations than for other innovators. Similarly, and confirming the results in the literature for manufacturing firms, Cainelli and Mazzanti (2013) show that the relationships with clients, suppliers and industry associations are relevant for triggering eco-innovations in the service sector. Recently, Cainelli et al. (2015) and Ghisetti et al. (2015) argue that the wider the array of knowledge sources or partners on which the firm draws, the greater the likelihood that the firm designs an eco-innovation strategy.[14]

H3: External information and knowledge sources and cooperation are more relevant for eco-oriented firms than for general innovators.

2.2.2 Market-pull factors

The second set of drivers is related to market-pull factors. In general, studies show that the expectation of a future demand, created by environmentally conscious customers,

[14] The existing literature on the impact of external knowledge search on technological innovation highlights that when their innovation draws on many external sources of ideas and information, a firm's chance of success may increase. Leiponen and Helfat (2010) show that broader knowledge sources are associated with successful innovation.

triggers investments in environmental innovation. In particular, Horbach (2008) shows that, for a panel data of German firms, customer demand and public pressure are the key drivers of eco-innovations. Similarly, examining nine European countries (Belgium, France, Germany, Hungary, Netherlands, Norway, Sweden, Switzerland, United Kingdom), Wagner (2008) shows that market research on green products has a positive effect on a firm's propensity to carry out eco-innovations, since such research is likely to lead to a better understanding of profitable demand for eco-product innovations as well as to identifying eco-oriented customer segments. More recently, using a sample of 27 European countries, Triguero et al. (2013) find that increasing market demand for green products and market share are also relevant to implementing product or organizational eco-innovation. Nevertheless, in countries with low environmental awareness and low willingness to pay more for environmentally friendly products a market pull effect will be very low or non-existent.[15] For instance, using a sample of 3,341 Spanish manufacturing firms, del Río et al. (2015b) argue that demand-pull from the market is not perceptible and is not a driver either for eco-product innovation or for eco-process innovation.

H4: Market-pull is not a relevant determinant of eco-innovation orientation in Spanish firms.

2.2.3 Regulatory pull and push factors

The last category of drivers, known as regulatory pull and push factors, is linked to the double externality problem and the role of public policies in fostering eco-innovations. In many empirical studies, regulations have been identified as an important driver of eco-innovation (see the seminal contribution of Jaffe and Palmer (1997), one of the earliest empirical studies at the industry level in the US context or, more recently, in the European setting, Horbach et al. (2012) for Germany, Horbach et al. (2013) for Germany and

[15] According to the Special Eurobarometer (European Commission 2011a; European Commission 2014), Spain has improved its ranking in regard to willingness-to-pay more for eco-products, but it still ranks below the EU average. For instance, in Special Eurobarometer survey 2011, 60% of Spanish citizens agree that they would be ready to buy environmentally friendly products even if they cost a little bit more while in Special Eurobarometer survey 2014 this proportion had risen to 73%. However, the respective percentages in other countries are higher than in Spain: Sweden (89%, 94%), Denmark (81%, 87%), Germany (76%, 80%), Romania (65%, 75%).

France; Del Río et al. (2015) for Spain, or Horbach (2016) for 19 different European countries). Hence, environmental regulation is a highly relevant motivation for eco-innovations, a result postulated by the well-known famous Porter-hypothesis (Porter and Linde 1995).[16,17]

However, the impact of supply push instruments like subsidies on eco-innovation is not always clear in manufacturing firm literature. Horbach et al. (2012) and Horbach (2008), both for a Germany manufacturing sample, find a positive and statistically significant influence of subsides on eco-innovation. Similar results have recently been found by del Río et al. (2015a) and De Marchi (2012) in the Spanish manufacturing context. Nevertheless, this variable does not seem to be especially important for eco-innovation either in Horbach et al. (2013), using a sample from the Community Innovation Survey (CIS 4) for France and Germany, or in Triguero et al. (2013) for 27 European countries.

More recent, Horbach (2016) shows that regulation activities and environmentally related subsidies seem to be more important for the Eastern rather than the Western European countries.

In the service context, distinguishing between certain sectors and types of eco-innovation orientation also gives unclear results. Cainelli and Mazzanti (2013) find that, in general services, eco-innovation aimed at abating CO_2 emissions seems to be stimulated by local public funding. However, such funding has no any impact on eco-innovation aimed at increasing energy consumption. When some specific service sectors are examined, only

[16] Porter and Linde (1995) argue that more stringent but well-designed eco-regulation can stimulate innovation which by enhancing productivity, increases firm benefits.

[17] Additionality, an important contribution to the discussion was made by Kammerer (2009) and which showed the need to distinguish between eco-innovations that target energy from others because regulation effects vary depending on the environmental area. For instance, Horbach et al. (2012) using a German sample examined the determinants of eco-innovations by type of environmental impact and showed that regulation seemed to be important for many environmental innovations but not specifically for reducing the use of energy. Similar results are found by Horbach (2016) in a European context. In contrast, others authors show that regulations affect innovation behaviour that has the objective of reducing energy consumption (Veugelers 2012; Costa-Campi et al. 2015).

the transport sector is stimulated by local public funding, this being especially true for the reduction of CO_2 emissions.[18]

H5: Public policies, whether in the form of environmental regulation or subsidies, increase the likelihood of being a firm with eco-innovation orientation.

3. DATABASE, VARIABLES AND DESCRIPTIVE STATISTICS

3.1 Database

The analysis is based on firm level data from the Technological Innovation Panel (PITEC).[19] It is a specific statistical instrument for studying the innovation activities of large sample of Spanish firms over time and it is the result of the collaboration between the Spanish National Institute of Statistics (INE), the Spanish Foundation for Science and Technology (FECYT), and the Foundation for Technical Innovation (COTEC).

PITEC is a panel survey based on the Community Innovation Survey (CIS) framework, enabling us to compare our results with previous empirical results on similar datasets. In addition, it is one of the most used datasets in innovation studies and has recently been applied to studying eco-innovations (Cainelli, De Marchi, and Grandinetti 2015; Del Río, Peñasco, and Romero-Jordán 2015; Horbach 2016). The main advantage of the CIS dataset is that it contains detailed information on innovation behaviour at firm level thus allowing comparison between eco-innovators and non-eco-innovators[20] rather than just

[18] Specific service sectors analysed are the following: trade, transport and logistics, information and communication, finance and insurance, real estate activities, professional, scientific and technical activities, and administrative and support service activities.

[19] More information on the dataset is available at the FECYT website: https://icono.fecyt.es/pitec/descarga-la-base-de-datos

[20] It is worth mentioning that the CIS questionnaire is not specifically designed to investigate eco-innovation, for that reason several interesting variables are not reported (e.g. market demand for green product or different environmental policy instruments). However, a separate module on eco-innovation was introduced only for the CIS 2008 survey. Unfortunately, Spain does not include this environmental module.

analysing eco-innovators.[21] Such information is essential to this study. However, the CIS data has several constraints. One of its limitations is the subjective nature of many of the questions addressed to the firm's management or those responsible for R&D departments. Nevertheless, Mairesse and Mohnen (2005) provide evidence that the subjective measures of innovation surveys tend to be consistent with more objective measures of innovation, such as the probability of holding a patent and the share in sales of products protected by patents. Second, the CIS is a cross-sectional dataset; in contrast, PITEC is characterized by its time dimension. It has panel data for the period 2003–2014 making it possible to analyse long-term relationships between variables and to control for standard econometric issues, such as unobserved heterogeneity and simultaneity problems that are hard to detect in simple cross-sectional data or time series (Baltagi 2008).

Our final database selection was subject to a process of filtering. The main filters were as follows: 1) the data referred the period 2008–2014, because eco-innovation motivation questions were not included in the survey until 2008; 2) firms from the manufacturing and service sectors (knowledge intensive services (KIS)) were analysed; [22] 3) firms that reported confidentiality issues, mergers, employment incidents and so on were not incorporated in the sample. After all filtering, our empirical analysis is based on a panel of 4,535 Spanish firms for the period 2008–2014.

3.2 Variables

In this study, we consider eco-innovation motivation as the dependent variable. Although the PITEC database is not specifically designed to examine environmental innovations, in 2008, the panel survey introduced a new question asking firms for the first-time what goals they were pursuing when they introduced innovation into products or processes, thus offering the possibility of making an independent analysis of eco-innovation

[21] The literature on firm-level determinants of eco-innovate is abundant (Rennings et al. 2006; Wagner 2008; Kesidou and Demirel 2012; Cainelli and Mazzanti 2013; Triguero, Moreno-Mondéjar, and Davia 2013). In contrast, only recently have studies focused on driver to eco-innovation versus normal innovation using firm-level data (Cainelli, De Marchi, and Grandinetti 2015; Del Río, Peñasco, and Romero-Jordán 2015).

[22] See Appendix 1 for a detailed classification.

orientation.[23] In this set of objectives, there are two that can be strongly linked to the environmental orientation of the firm: the reduction in environmental impacts and the decrease in energy consumption per unit produced. Hence, we use a subjective measure of the motivational nature of the innovation from the survey to build our dependent variable (*eco-inn*) and differentiate firms that carry out eco-innovations than those firms that do not, an approach that has already been used in other studies on eco-innovation using CIS dataset (Horbach 2008; De Marchi 2012; Marzucchi and Montresor 2017).

Firms were asked to evaluate the importance of these two objectives on a Likert scale of 1 to 4, where 1 represents "high importance", 2 represents "intermediate importance", 3 represents "low importance" and 4 represents "factor not experienced". We have transformed these two-categorical variables into a single binary variable that is equal to 1 when a firm considers any one of the two objectives to have high or medium importance and equal to 0 when the importance is intermediate, low, or not experienced.[24,25]

Regarding the independent variables, we introduced a set of variables that the existing empirical literature lists as determinants of eco-innovation orientation in capturing factors related to: (1) technology-push factors, (2) market-pull factors, (3) regulatory factors, and finally, (4) a set of firm characteristics (among others, see Horbach (2008), Triguero et al. (2013), and Hojnik and Ruzzier (2015)). [26]

---

[23] In 2008 the survey introduces the following question: *"Innovation activities carried out in your firm could be oriented to different objectives, how important were each of the following objectives for your innovation activities during the three last years?"* In total 16 objectives were listed.

[24] We evaluate the internal consistency of our grouping by computing Cronbach's alpha value. The Cronbach alpha for the *eco-inn* variable is 0.85, indicating an acceptable level of internal consistency.

[25] As a robustness check, we also split the dependent variable (general eco-innovation strategy) and report the results across two different eco-innovation strategies. This enables us to observe whether different types of eco-innovation, according to their environmental motivations, are driven by different factors as highlighted by Horbach, Rammer, and Rennings (2012).

[26] Appendix 2 summarises the list of variables and their definition. Appendix 3 shows the correlation matrix (while some variables may appear to be highly correlated, a VIF test excludes this as a significant issue, the mean VIF being 1.51).

To test the role of technological factors in adopting an eco-innovation strategy, the variable *internal R&D effort* is included. It measures the total expenditures on internal R&D activities per employee as a proxy for the stock of technological competences.

Then, to explore further differences as to whether eco-innovators rely on external innovation resource, either by cooperating with other agents or acquiring such resources, a set of variables was used. We include the variable *external R&D effort* that measures the total expenditures on external R&D activities per employee and a dummy variable *cooperation* indicating whether a firm reported having cooperated on innovation with other partners. In addition, the nature of their sources of information is recoded in a count variable, *breadth innovation sources,* which ranges from 0 when the firm considers no innovation sources of information important, to 11, whether the firm considers the sources of information from all eleven of the following sources to be important: the enterprise or group (internal), suppliers, clients, competitors, private R&D institutions (market), universities, public research organizations, technology centres (institutional), conferences, scientific reviews and professional associations (others).

As proxies to capture demand pull factors we include two innovation objectives indicating an entry to the new markets (*new markets*) and an increase in market share *(market share).*

Concerning the environmental policy influences, we capture regulation and subsidies policy measures. *Regulation* measures how important is the fulfilment of environmental government regulations or standards for firms wishing to eco-innovate. *Local, national and EU* s*ubsidies* indicates whether the firm has received public funds at regional, national or EU level respectively.

The econometric analysis also includes a set of firm characteristics factors such as firm size (*size*), the number of employees (in natural logarithms), and whether the firm belongs to a group (*group*).

3.3 Descriptive statistics

The sample used in the econometric analysis includes 4,535 Spanish firms of which 3,201 firms belong to the manufacturing sector and 1,334 firms belong to the service sector Among the innovators (whether a normal innovator or an eco-innovator), which represent 69% of the firms in the sample, more than half of firms designed an eco-innovation strategy showing a growing trend among Spanish firms to have some concern for environmental damages and energy efficiency. Nevertheless, the comparative analysis points out the existence of industry heterogeneity (Table 2).

Table 2
Eco-innovators, non-eco-innovators and non-innovator firms by sector (2014)

	Number of firms	% of eco- innovative	% of Innovative	% of non-innovative
Manufacturing firms	3,201	48.98%	22.12%	28.90%
Services firms	1,334	28.19%	34.78%	37.03%
Total firms	4,535	42.87%	25.84%	31.29%

Source: PITEC database, own calculation.

It seems that a higher percentage of manufacturing firms design an eco-innovation orientation than do services firms (where just a minority are represented). That might be because manufacturing firms are usually subject to stricter environmental regulation and economic instruments than are service sectors (Cainelli and Mazzanti 2013). Consequently, it seems that manufacturing firms are one step further forward in their eco-innovative orientation than are service firms.

In Table 3, we analyse the main characteristics of Spanish eco-innovators broken down by sectors, other innovators and non-innovative firms. [27] The comparison highlights the following characteristics:

- Eco-innovation firms are larger, they more often belong to a group and seem to invest more in R&D activities,
- When we compare eco-innovative firms by sectors, we observe that manufacturing firms seem to rely more on demand pull policies instruments such

[27] "Other innovators" refers to those firms that have introduced a technological innovation but do not orientate their strategy towards environmental concerns (reduce environmental impact or decrease energy consumption per unit produced) and "non-innovators" refers to those firms that do not engage in any innovation activity or have attempted R&D activities but have failed to innovate.

as regulation. In contrast, we find than services firms are more oriented to supply push environmental regulations such as subsidies,[28]

- Eco-manufacturing firms are less prone than service firms to invest in R&D and to cooperate in R&D projects,
- Service firms with an eco-innovation orientation are larger and less often belong to a group than do manufacturing firms.

Table 3
Descriptive statistics for eco-innovative, innovative and non-innovative firms (mean values and standard deviation in brackets)

	Eco-innovative			Innovative	Non-innovative
Variable	**Total**	**Manufacturing**	**Services**	**Total**	**Total**
Technology-push factors					
Internal R&D effort	7513.78	4728.91	18999.95	6001.68	3172.91
(€ per employee)	(19260.07)	(9737.27)	(36692.16)	(35038.98)	(12888.8)
External R&D effort	1681.67	1175.18	3770.67	905.78	744.84
(€ per employee)	(12437.32)	(6913.65)	(24295.88)	(7050.58)	(9385.90)
Cooperation	0.4912	0.4609	0.6162	0.3444	0.1159
	(0.4999)	(0.4984)	(0.4863)	(0.4752)	(0.3201)
Internal sources	0.9346	0.9334	0.9394	0.7803	0.3025
	(0.2471)	(0.2491)	(0.2385)	(0.4140)	(0.4594)
Market sources	0.9229	0.9225	0.9247	0.7249	0.2690
	(0.2666)	(0.2673)	(0.2638)	(0.4465)	(0.4435)
Institutional sources	0.5142	0.4835	0.6405	0.2818	0.1648
	(0.4998)	(0.4997)	(0.4799)	(0.4499)	(0.3711)
Other sources	0.6450	0.6301	0.7065	0.3992	0.1684
	(0.4785)	(0.4827)	(0.4554)	(0.4897)	(0.3742)
Breadth sources innovation	1.8072	1.7622	1.9928	1.6279	1.482
	(1.8541)	(1.8490)	(1.8602)	(0.4897)	(1.874)
Market pull factors					
New market	0.8166	0.8308	0.7582	0.5412	0.2238
	(0.3869)	(0.3749)	(0.4282)	(0.4983)	(0.4168)
Market share	0.8378	0.8468	0.8006	0.5720	0.2292
	(0.3686)	(0.3601)	(0.3996)	(0.4948)	(0.4204)
Environmental policy					
Regulation	0.7974	0.8146	0.7264	0.1739	0.1614
	(0.4019)	(0.3885)	(0.4458)	(0.3790)	(0.3679)
Local subsidies	0.2939	0.2626	0.4227	0.2030	0.0933
	(0.4555)	(0.4401)	(0.4940)	(0.4022)	(0.2909)
National subsidies	0.3502	0.3165	0.4893	0.2398	0.1125
	(0.4770)	(0.4651)	(0.4991)	(0.4270)	(0.3160)
EU subsidies	0.0927	0.0537	0.2537	0.0541	0.0382
	(0.2901)	(0.2254)	(0.4352)	(0.2264)	(0.1918)
Firm characteristics					
Group	0.5323	0.5447	0.4808	0.4429	0.4890
	(0.4989)	(0.4980)	(0.4997)	(0.4967)	(0.4999)
Size (employees)	324.61	253.53	617.80	248.53	238.55
	(1214.65)	(697.31)	(2334.46)	(1077.98)	(498.6)
Observations	14,984	12,060	2,924	9,447	7,314

Source: PITEC database, own calculation.

[28] It is worth mentioning that the subsidies variable indicates if a firm receives public financial support for innovation activities from local or regional authorities. Our data base does not allow us to distinguish whether this public support is focused on eco-innovations activities.

4. ECONOMETRIC METHODOLOGY

In order to model the dynamic process of designing an eco-innovation strategy for Spanish services and manufacturing firms between 2008–2014 we applied a dynamic probit model correcting by sample selection arising from the exclusion of non-innovative firms from the analysis (Heckman 1979).[29] This methodology is based on a two-step procedure: the first stage equation, the selection equation, and the second stage equation, the outcome equation.

Innovation decision (selection equation):

$$innovative^{*}_{it} = \beta_{11}X_{it-1} + \beta_{12}Z_{it-1} + \alpha_{1i} + \varepsilon_{1it} \qquad \text{Eq. [1]}$$

$$innovative_{it} = 1 \; if \; innovative^{*}_{it} > 0, \qquad 0 \; otherwise$$

Eco-innovation orientation (outcome equation):

$$eco - inn^{*}_{it} = \beta_{21}eco - inn_{it-1} + \beta_{22}Y_{it-1} + \beta_{23}Z_{it-1} + \alpha_{2i} + \varepsilon_{2it} \qquad \text{Eq. [2]}$$

$$eco - inn_{it} = 1 \; if \; eco - inn^{*}_{it} > 0, \qquad 0 \; otherwise$$

Equation [1] estimates the probability that a firm innovates depending on a set of determinants related by the current literature.[30] *Innovative* $_{it}$ is a binary variable that takes the value 1 if firm *i* introduce a technological innovation between *t* and *t-2*. As explanatory variables (*X*), which are specifics in this equation we include the innovation input such as whether the firm invests in internal R&D or external R&D, the different sources of information for innovation activities (internal, market, institutional and other sources), whether the firm cooperates or not with other agents, whether the firm receives public funds at regional, national or EU level and whether the firm exported at least part of its production. As the selection equation should contain at least one variable that is not in the outcome equation we use this latter variable (*export*) as an exclusion restriction. We assume that being involved in international trade may affect the likelihood of being

[29] As is well known, the structure of the CIS, on which the PITEC survey is based, applies a filter to the questions asked to firms: that is, only innovative firms are required to complete the whole questionnaire. Thus, since, as the questions on eco objectives of the firm are posed to innovative firms only (i.e. that have introduced technological innovation), this implies the risk of a selection bias in our case. Consequently, our dependent variable is observable only for innovative firms. It is important to take this issue into consideration; otherwise the estimates would suffer from selection bias problems.

[30] See for instance: Vega-Jurado et al. (2008); Segarra-Blasco (2010); Hashi and Stojčić (2013) and Mate-Sanchez-Val and Harris (2014).

an innovative firm, but it has no effect on being an eco-innovative firm.[31] The residuals of this regression are used to construct a selection bias factor, which is equivalent to the Inverse Mill's Ratio. This factor accounts for the effects of all unmeasured characteristics which are related to the selection variable. The Inverse Mill's Ratio is introduced as an extra explanatory variable in the second stage of the Heckman procedure, which consists of estimating the eco-innovation orientation [Eq. 2].

Equation [2] measures the probability of designing an eco-innovation strategy. $Eco\text{-}inn_{it}$ is a binary variable that takes the value 1 if firm *i* states that an eco-innovation motivation has been high or medium important between t and *t-2*. $Eco - inn_{it}^{*}$, the second latent variable, may be observed only when $innovate_{it}^{*}$ is equal to 1. As explanatory variables (*Y*), which are specifics in this equation, we include technology push factors such as R&D effort, whether a firm reported having cooperated on innovation with other partners and the breadth of sources of information for innovation activities (internal, market, institutional and other sources). For the market market-pull factors we consider two innovation objectives, namely an entry to the new markets and an increase in market share. And regulatory factors captured by the variables regulation and subsidies.

In addition, both equations include different common sets of control variables (*6.*). We introduce firm characteristics such as firm size and whether the firm belongs to a group. We also include industry and time dummies to control differences in the probability of being an innovator and an eco-innovator oriented across sector-specific market or technological conditions and macro differences over time respectively. The inclusion of this set of covariates should mitigate the potential omitted variables bias in our

[31] Several contributions in the literature suggest that export is not a factor when explaining the decision to be green (Horbach 2008; Del Río, Romero-Jordán, and Peñasco 2017), whereas it has been demonstrated that being active in international markets supports the decision to innovate (Becheikh, Landry, and Amara 2006; Hashi and Stojčić 2013). Since the two phenomena of innovating and eco-innovating are quite similar it is very difficult to identify those variables that could affect the innovation decision per se, but not the adoption of eco-innovation conditional on the decision to perform innovation activities. In our dataset, another variable capable of distinguishing between eco-innovators as opposed to other innovators is the regulation variable. Several contributions in the literature suggest that regulation is a factor when explaining the decision to design an eco-innovation strategy, whereas it has been demonstrated that eco-regulation is not a factor when explaining the decision to innovate (see e.g. Hojnik and Ruzzier (2015) and Del Río, Peñasco, and Romero-Jordán (2016)). This variable is included in the outcome equation.

econometric estimations. Finally, $\alpha_i$is the time-invariant unobserved individual effects and ε_{it} is the idiosyncratic error term. In the regression analyses, we lag explanatory variables one period to mitigate endogeneity problems deriving from reverse causality.

To investigate persistence in eco-innovation we consider a model of eco-innovative behaviour in a dynamic panel data framework where binary responses are regressed on lagged responses. $Eco - inn_{it-1}$ is an indicator for eco-innovation during the previous period and captures the previous eco-innovation experience; β_{21} is the parameter of interest which indicate the level of persistence in the dependent variable. A positive and statistically significant estimate of β indicates the presence of eco-innovation persistence, which may occur for two reasons: because of state dependence (true state dependence) or because of unobserved effects or omitted variables that are correlated over time (spurious dependence).[32]

The estimation of dynamic panel data models poses two main problems: the treatment of unobserved individual effects, and the so-called initial conditions problem. Modelling the unobserved individual effects through fixed effects, in which the individual specific effect is correlated with the independent variables, leads to the 'incidental parameters' problem (Neyman and Scott 1948), which results in inconsistent maximum likelihood estimators when the number of periods is small. For this reason, the literature generally assumes a random effects specification in this kind of analysis (Raymond et al. 2010; Wooldridge 2010).

The second problem to how to handle concerns regarding the initial conditions. The simplest assumption is to take the initial conditions to be exogenous, but there are good reasons to believe that many firms in our sample did not start their eco-innovation processes at the beginning of the period of this study, i.e., 2008. This means that the initial

[32] *True* state dependence means that a causal behavioural effect exists in the sense that the decision to innovate in one period itself enhances the probability of innovating in the subsequent period. On the other hand, *spurious* state dependence means that firms may have certain characteristics which make them mostly prone to innovate. If these characteristics themselves show persistence over time, that will induce persistence in innovation behaviour as well. If such characteristics are unobserved (e.g. managerial or risk attitudes), but correlated over time and not appropriately controlled for in estimation, past innovation may appear to affect current innovation simply because it assimilates the effect of the persistent unobservable characteristics.

condition ($eco - inn_{i0}$), is presumable correlated with both future realizations of the variable (due to state dependence), and with the unobservable individual term (given that the unobservable term is part of the process that generates the variable). Therefore, the lagged dependent variable will be correlated with the unobservable term which would lead, not only to inconsistent estimators, but also to overestimation of the state dependence effect (unless the first observation in the process, the initial condition, is accounted for).

The literature on nonlinear dynamic panel data models contains estimation techniques that properly handle these problems (Wooldridge 2005; Rabe-Hesketh and Skrondal 2013; Skrondal and Rabe-Hesketh 2014). Specifically, Wooldridge (2005) suggests a conditional maximum likelihood approach, where the individual effect is assumed to depend on the initial conditions of the dependent variable ($eco - inn_{i0}$), and all lag values of the time-varying explanatory variables (excluding the initial value). In practice, researchers often use a constrained version of the model where the lags of exogenous variables are replaced by the time average of each exogenous variable $\bar{x}_i$ namely:[33]

$$\alpha_{2i} = \delta_0^o + \delta_1^o eco - inn_{i0} \quad + \delta_2^o \bar{Y}_i + \delta_3^o \bar{Z}_i + \mu_{2i} \qquad \text{Eq. [3]}$$

where $\bar{Y}_i$ and $\bar{Z}_i$ represents the means of time-variant exogenous variables, $eco - inn_{i0}$ pertain to the first available observation for each firm. δ_1^o capture the dependence of the individual effects on the initial conditions. μ_i is assumed to be distributed N (0,σ_u^2) and

[33] These terms, known as Mundlak means, refers to Mundlak's (1978) proposal to relax the assumption that the observed and unobserved variables are uncorrelated.

independently of the explanatory variables, the initial conditions, and the idiosyncratic error term ε_{it}.[34,35]

Substituting Equation [3] into Equation [2] give:

$$eco-inn_{it}^{*} = \delta_{21}eco-inn_{it-1} + \beta_{22}Y_{it-1} + \delta_0^o + \delta_1^o eco-inn_{i0} + \delta_2^o\bar{Y}_i + \delta_2^o\bar{Z}_i + \mu_{2i} + \varepsilon_{2it} \qquad \text{Eq. [4]}$$

5. RESULTS

In this section, we present estimation results from the dynamic random probit model correcting by sample selection for each sector. The first step in our empirical model was to estimate the selection equation capturing the factors explaining the introduction of product or process innovations -eco or not eco- for manufacturing and services firms (Table 4).

From the estimation of these two probit models we obtained the correction terms (the inverse Mill's ratio) which were included in the second stage, focused on the study of the factors correlated with eco-innovation orientation propensity (Table 5 and 6).[36] Here the correction terms were included to account for the selection bias caused by the fact that we only observed the eco-innovation orientation for firms that innovate. The significance of the inverse Mill's ratio we found confirmed the necessity of correcting for sample selection bias and the appropriateness of this two-step method versus the standard probit one. In addition to general eco-innovation results, as a robustness check, we reported the

---

[34] It is worth mentioning that recently Rabe-Hesketh and Skrondal (2013) show that the original Wooldridge's auxiliary model that includes values of the time-varying explanatory variables at each period (excluding the initial period) performs correctly. In contrast, the popular and common specification that includes the within-mean of the time-varying explanatory variables performs poorly for short panels. Besides the Wooldridge's original auxiliary model, they also recommend including the initial-period explanatory variables as additional regressors.

[35] The approach considered in Eq. [3] allows the individual effects to be correlated with the regressors. However, because of the lack of variation over time (within variation) in our variables (see Appendix 4), we were unable to identify δ_2^o, and δ_3^o. Consequently, we followed the strategy adopted by Raymond et al. (2010) and assumed that the unobserved individual effects are correlated only with the initial values of $eco-inn_{it}$.

[36] Average marginal effects of the output equation are reported in Appendix 5 (see Table A.5.1 and A.5.2).

results obtained by estimating focal eco-innovation strategies (reduction in environmental impacts and reduction in energy consumption strategies separately).[37]

Table 4
Results of the selection equation: probability of innovating

	Manufacturing	**Services**
Internal R&D effort $_{t-1}$	0.0858***	0.0494***
	(0.00632)	(0.00961)
External R&D effort $_{t-1}$	0.0146*	0.0240*
	(0.00722)	(0.0101)
Cooperation $_{t-1}$	0.301***	0.420***
	(0.0488)	(0.0667)
Internal sources $_{t-1}$	0.689***	0.857***
	(0.0494)	(0.0719)
Market sources $_{t-1}$	0.565***	0.700***
	(0.0487)	(0.0714)
Institutional sources $_{t-1}$	-0.145**	-0.117
	(0.0492)	(0.0732)
Other sources $_{t-1}$	0.162***	0.187**
	(0.0450)	(0.0667)
Local subsidies $_{t-1}$	0.0919	0.133
	(0.0536)	(0.0798)
National subsidies $_{t-1}$	0.215***	0.0550
	(0.0543)	(0.0761)
EU subsidies $_{t-1}$	0.0454	-0.181
	(0.116)	(0.105)
Size $_{t-1}$	0.0645*	0.0983***
	(0.0252)	(0.0270)
Group $_{t-1}$	-0.0520	-0.156*
	(0.0550)	(0.0725)
Export $_{t-1}$	0.128**	0.0310*
	(0.0443)	(0.0694)
Constant	-0.770	-0.887**
	(0.404)	(0.274)
Log likelihood	-6303.0	-3048.1
Wald test of χ^2	2335.3	1214.6
Prob > χ^2	0.000	0.000
σ_α	1.0872	1.0463
	(0.3265)	(0.0220)
Rho (ρ)	0.5417	0.5226
	(0.0149)	(0.2209)
Observations	19,206	8,004

Estimations control for time and industry dummies. Standard errors in brackets. *, ** and *** correspond to significance levels of 1%, 5% and 10%, respectively.

In relation to the likelihood of innovating (selection equation), our results suggest that this depends closely on investments in internal and external R&D and participation in cooperative projects. National public funds seem to be important in introducing

[37] As it is observed, the statistical significant of the panel-level variance component over the total variance (ρ) indicates that the random effects estimator is preferred over the pooled probit estimator, indicating the accuracy of considering the former.

technological innovations, but mainly for manufacturing firms. Internal, market and other sources of information are the most important sources for innovation activities across both sectors. However, institutional sources of information show a negative and statistically significant impact in innovation. Finally, the largest firms are the most prone to innovate.

The results on the probability of eco-innovating for manufacturing and service firms (output equation) are given in Table 5 and 6 respectively. In order to show the importance of accounting for individual effects and handling the initial conditions problem we present estimation results for two variants of the dynamic probit model. Specifically, in the first pair of columns we report the estimation of the dynamic random effect probit model taking into account the unobserved individual heterogeneity, and assuming the initial conditions to be exogenous. These results are contrasted with the estimates in the second pair of columns resulting from estimation of the model with individual effects correlated with the initial conditions. The estimation results of both model variants are very similar.

In both manufacturing and services firms, there is a positive relationship between technology push factors and a firm's likelihood of developing an eco-innovation orientation (Hypothesis 1). As far as the internal R&D are concerned, the results suggest that eco-oriented innovators do differ from non-eco-oriented innovators in terms of expenditures on innovation activities per worker in either sector or type of eco-innovation orientation. This agrees with the manufacturing samples of Horbach (2008) and De Marchi (2012), and with Cainelli and Mazzanti (2013) for Italian services firms.

In terms of eco path dependence, the empirical analysis reveals that past eco-innovation behaviour is an important driver of current eco-innovation status, providing support for Hypothesis 2. As previously mentioned, any apparent persistence of eco-innovation might be spurious. The existence of true persistence can be ascertained only after accounting for individual effects and handling properly the initial conditions. Once this is done, two main conclusions arise.

First, the coefficients of the lagged dependent variables are positive and significant for both sectors and types of eco-innovation revealing that engaging in eco-innovation orientation during the previous year has a positive effect on the probability of being a green innovator in the current year. Hence, the results suggest a significant state dependence effect for eco-innovation strategies. Second, in line with previous findings in the literature, the hypothesis of exogenous initial conditions leads to overestimation of the degree of persistence.[38]

Results on external innovation resources are less straightforward; support for Hypothesis 3 is unclear. The coefficient of external R&D effort is positive and significant only in manufacturing firms. In other words, among manufacturing firms, buying external R&D services is more relevant in spurring the introduction of green innovations than are other innovations. Regarding the impact of cooperation, in contrast to del Río et al. (2015a) for Spain and Horbach (2008) for Germany, we find the role of participating in cooperative projects between manufacturing is not determinant in triggering an eco-innovation motivation. Similarly to us, Horbach et al. (2013) and Cuerva et al. (2014) are not able to confirm a positive relationship between an open innovation strategy and eco-innovation. They found that firms that follow and in-house strategy experience greater environmental innovation. In addition, when we look at some specific service firms, KIS firms, in line with Cainelli and Mazzanti (2013), we do not find that cooperation is especially important for promoting eco-innovation.

Concerning sources of information, in particular the variety of sources, is positively and significantly correlated with the probability of designing an eco-innovation strategy between both industries and eco-motivation. Suggesting that breadth of innovation sources may increase the firm’s coverage of the multiple knowledge needs entailed by the multi-dimensionality of eco-innovation (Mothe and Nguyen-Thi 2016).

In contrast, with the analyses made for other countries, the market does not provide a demand-pull for eco-innovation. The non-significant signs of the variables reflecting the importance given to the maintaining or increasing market share and entry to new markets do not confirm the role of demand-pull factors in eco-innovation either in manufacturing or in service industries (Hypothesis 4).

[38] The average marginal effects of the lagged dependent variables, reported in Appendix 5, support the emerging analysis and allow for the discussion of the magnitude of the relations identified above. Interestingly, the driver with the highest impact refers to the persistence in eco-innovation orientation followed by environmental policies such regulations and subsidies.

The estimations by focal eco-strategies show the robustness of this result and in neither of the two cases is the parameter obtained significant. This is in contrast to the findings of Horbach et al. (2013), who examined German and French data, of Veugelers (2012), who investigated data for Flanders and of Triguero, Moreno-Mondéjar, and Davia (2013) who examined 27 European countries. However, our results concur with those of Del Río et al. (2015) who find no evidence for market factors in Spanish manufacturing firms. The growing environmental awareness among Spanish customers in recent years, although still low as compared to other European countries, may explain the lack of statistical significance of the demand-pull variable.

In line with other contributions in the literature our results show that regulation and environmental public policies are crucial to eco-innovation (Horbach 2008; Demirel and Kesidou 2011; De Marchi 2012; Horbach, Oltra, and Belin 2013; Del Río, Peñasco, and Romero-Jordán 2015). Looking first at the regulatory variable, we note that the existing regulation is a positive and significant driver for Spanish firms to eco-innovate in both sectors and with both types of eco-orientation. In line with Costa-Campi et al. (2015), we also observe that innovation behaviour with the objective of reducing energy consumption is affected by regulations.

Comparing the different type of subsidies (local, national and EU), it seems that local and EU subsidies are the most important in triggering eco-innovation motivation, but this applies only among service firms. Whereas in manufacturing firms this variable is not significant. However, the modest magnitude of subsidy’s marginal effect compared with that of environmental regulation indicates that, while complementary, demand-pull policies have a greater impact on eco-motivations than supply-push instruments.

Finally, concerning a firm’s characteristics, in line with the findings in the literature (Carrillo-Hermosilla, Del Río, and Könnölä 2009; Hojnik and Ruzzier 2015; Del Río, Peñasco, and Romero-Jordán 2016), our results show that larger manufacturing firms are more likely to design an eco-innovation strategy (De Marchi 2012; Costa-Campi et al. 2015; Del Río, Peñasco, and Romero-Jordán 2015). Belonging to a group shows no relationship to being a green firm in any sector or at any eco-innovation orientation (Cainelli and Mazzanti 2013; Doran and Ryan 2016).

Table 5
Results of the output equation: probability of designing an eco-innovation strategy. Manufacturing firms

	Eco-innovation		**Reduce impacts**		**Reduce energy**	
	Exogenous initial conditions	**Correlated with initial conditions**	**Exogenous initial conditions**	**Correlated with initial conditions**	**Exogenous initial conditions**	**Correlated with initial conditions**
Persistence						
Eco-innovation $_{t-1}$	1.250***	0.995***				
	(0.0396)	(0.0415)				
Reduce impacts $_{t-1}$			1.350***	0.994***		
			(0.0417)	(0.0435)		
Reduce energy $_{t-1}$					1.395***	1.099***
					(0.0363)	(0.0382)
Initial conditions						
Eco-innovation		0.669***				
		(0.0466)				
Reduce impacts				0.773***		
				(0.0495)		
Reduce energy						0.654***
						(0.0463)
Technology-push factors						
Internal R&D effort $_{t-1}$	0.0436***	0.0423***	0.0431***	0.0421***	0.0329***	0.0326***
	(0.00538)	(0.00578)	(0.00534)	(0.00587)	(0.00540)	(0.00583)
External R&D effort $_{t-1}$	0.0115*	0.00983*	0.0123**	0.0121*	0.00969*	0.0108*
	(0.00484)	(0.00525)	(0.00468)	(0.00520)	(0.00462)	(0.00504)
Cooperation $_{t-1}$	0.0508	0.0326	0.0763*	0.0605*	0.0434**	0.0503**
	(0.0334)	(0.0361)	(0.0324)	(0.0358)	(0.0320)	(0.0347)
Breadth sources	0.0413***	0.0372***	0.0358***	0.0329**	0.0284**	0.0236*
innovation $_{t-1}$	(0.00985)	(0.0107)	(0.00937)	(0.0104)	(0.00912)	(0.00995)
Market pull factors						
New market $_{t-1}$	0.0700	0.0580	0.0759	0.0694	-0.0224	-0.0204
	(0.0412)	(0.0439)	(0.0406)	(0.0441)	(0.0406)	(0.0433)
Market share $_{t-1}$	-0.0334	-0.0394	-0.0127	-0.0211	0.0112	0.00570
	(0.0420)	(0.0449)	(0.0415)	(0.0453)	(0.0415)	(0.0444)
Environmental policy						
Regulation $_{t-1}$	0.352***	0.285***	0.239***	0.207***	0.256***	0.234***
	(0.0339)	(0.0364)	(0.0351)	(0.0384)	(0.0317)	(0.0341)
Local subsidies $_{t-1}$	0.0578	0.0591	0.0239	0.0297	0.0587	0.0619
	(0.0358)	(0.0386)	(0.0345)	(0.0380)	(0.0340)	(0.0367)
National subsidies $_{t-1}$	0.0369	0.0503	0.0284	0.0361	0.0108	0.00399
	(0.0357)	(0.0384)	(0.0343)	(0.0377)	(0.0336)	(0.0362)
EU subsidies $_{t-1}$	-0.0203	-0.0426	0.0828	0.0714	-0.128	-0.142
	(0.0778)	(0.0835)	(0.0755)	(0.0827)	(0.0714)	(0.0769)
Firm characteristics						
Group $_{t-1}$	0.0365	0.0499	0.0101	0.0255	0.0437	0.0255
	(0.0350)	(0.0395)	(0.0343)	(0.0404)	(0.0343)	(0.0391)
Size $_{t-1}$	0.117***	0.110***	0.124***	0.121***	0.122***	0.133***
	(0.0160)	(0.0181)	(0.0157)	(0.0185)	(0.0155)	(0.0178)
Mill's ratio	0.424***	0.353***	0.427***	0.369***	0.358***	0.332***
	(0.0839)	(0.0888)	(0.0849)	(0.0916)	(0.0860)	(0.0910)
Constant	-1.579***	-1.470***	-1.614***	-1.561***	-2.104***	-2.111***
	(0.280)	(0.317)	(0.282)	(0.333)	(0.284)	(0.323)
Log likelihood	-6612.9	-6471.8	-6963.5	-6791.0	-7321.5	-7188.7
Wald test of χ^2	2924.2	3050.9	3156.8	3248.3	2862.5	3133.6
Prob > χ^2	0.000	0.000	0.000	0.000	0.000	0.000
σ_α	0.413	0.573	0.411	0.626	0.440	0.611
	(0.0374)	(0.0336)	(0.0397)	(0.0336)	(0.0365)	(0.0319)
Rho (ρ)	0.146	0.247	0.144	0.281	0.162	0.272
	(0.0226)	(0.0218)	(0.0239)	(0.0215)	(0.0225)	(0.0207)
Censored obs.	4,086					
Uncensored obs.	15,120					
Observations	19,206					

Estimations control for time and industry dummies. Robust standard errors in brackets. *, ** and *** correspond to significance levels of 1%, 5% and 10%, respectively.

Table 6
Results of the output equation: probability of designing an eco-innovation strategy. Services firms

	Eco-innovation		**Reduce impacts**		**Reduce energy**	
	Exogenous initial conditions	**Correlated with initial conditions**	**Exogenous initial conditions**	**Correlated with initial conditions**	**Exogenous initial conditions**	**Correlated with initial conditions**
Persistence						
Eco-innovation $_{t-1}$	1.290***	1.056***				
	(0.0689)	(0.0706)				
Reduce impacts $_{t-1}$			1.426***	1.058***		
			(0.0761)	(0.0784)		
Reduce energy $_{t-1}$					1.339***	0.996***
					(0.0730)	(0.0737)
Initial conditions						
Eco-innovation		0.815***				
		(0.100)				
Reduce impacts				1.010***		
				(0.109)		
Reduce energy						0.901***
						(0.104)
Technology-push factors						
Internal R&D effort $_{t-1}$	0.0386***	0.0374***	0.0438***	0.0445***	0.0285**	0.0296**
	(0.00931)	(0.00993)	(0.00971)	(0.0106)	(0.00979)	(0.0106)
External R&D effort $_{t-1}$	0.00800	0.00502	0.0139	0.0120	0.00441	0.000412
	(0.00824)	(0.00887)	(0.00835)	(0.00930)	(0.00829)	(0.00904)
Cooperation $_{t-1}$	-0.0497	-0.0598	-0.0202	-0.0300	-0.109	-0.0846
	(0.0613)	(0.0652)	(0.0628)	(0.0688)	(0.0641)	(0.0692)
Breadth sources innovation $_{t-1}$	0.0318*	0.0263	0.0342*	0.0296	0.0414**	0.0390*
	(0.0153)	(0.0164)	(0.0153)	(0.0168)	(0.0148)	(0.0161)
Market pull factors						
New market $_{t-1}$	0.0469	0.0731	0.000455	0.0257	0.127	0.165*
	(0.0714)	(0.0756)	(0.0732)	(0.0795)	(0.0749)	(0.0804)
Market share $_{t-1}$	0.0737	0.0649	0.0610	0.0528	0.0645	0.0373
	(0.0731)	(0.0774)	(0.0751)	(0.0816)	(0.0764)	(0.0820)
Environmental policy						
Regulation $_{t-1}$	0.302***	0.217***	0.217***	0.158*	0.275***	0.248***
	(0.0597)	(0.0639)	(0.0647)	(0.0705)	(0.0587)	(0.0633)
Local subsidies $_{t-1}$	0.125*	0.117*	0.134*	0.125*	0.122*	0.0912*
	(0.0670)	(0.0718)	(0.0681)	(0.0753)	(0.0689)	(0.0750)
National subsidies $_{t-1}$	0.0215	0.0136	-0.0496	-0.0781	0.0471	0.0405
	(0.0654)	(0.0696)	(0.0668)	(0.0733)	(0.0671)	(0.0725)
EU subsidies $_{t-1}$	0.141*	0.119*	0.171**	0.156**	-0.0420	-0.0378
	(0.0899)	(0.0972)	(0.0889)	(0.0996)	(0.0874)	(0.0950)
Firm characteristics						
Group $_{t-1}$	0.0509	0.0492	0.00770	0.000874	0.0385	0.0360
	(0.0648)	(0.0723)	(0.0654)	(0.0765)	(0.0658)	(0.0748)
Size $_{t-1}$	0.0493*	0.0477	0.0798***	0.0873**	0.0224	0.0244
	(0.0228)	(0.0256)	(0.0232)	(0.0273)	(0.0229)	(0.0262)
Mill's ratio	0.409***	0.366**	0.490***	0.460***	0.419***	0.389**
	(0.106)	(0.112)	(0.109)	(0.118)	(0.114)	(0.122)
Constant	-1.654***	-1.822***	-2.081***	-2.415***	-1.793***	-2.056***
	(0.277)	(0.312)	(0.280)	(0.334)	(0.287)	(0.333)
Log likelihood	-2462.1	-2417.2	-2287.4	-2225.3	-2250.7	-2198.5
Wald test of χ^2	1064.9	1046.9	1140.3	1050.2	800.8	862.2
Prob > χ^2	0.000	0.000	0.000	0.000	0.000	0.000
σ_α	0.653	0.808	0.627	0.851	0.625	0.807
	(0.0635)	(0.0618)	(0.0693)	(0.0649)	(0.0681)	(0.0630)
Rho (ρ)	0.299	0.395	0.282	0.420	0.281	0.394
	(0.0407)	(0.0365)	(0.0448)	(0.0372)	(0.0440)	(0.0374)
Censored obs.	2,439					
Uncensored obs.	5,565					
Observations	8,004					

Estimations control for time and industry dummies. Robust standard errors in brackets. *, ** and *** correspond to significance levels of 1%, 5&% and 10%, respectively.

Table 7
Summary of the above discussion

Hypothesis	Variables within the econometric analysis	Results	
		Manufacturing	Services
H1: Internal technological capabilities are more relevant for eco-innovation oriented firms than for general innovators.	Internal R&D effort	+++	+++
H2: Firms which eco-innovate once have a higher probability of eco-innovating again in subsequent periods.	Persistence	+++	+++
H3: External information and knowledge sources and cooperation are more relevant for eco-oriented firms than for general innovators.	External R&D effort	+	0
	Cooperation	0	0
	Breadth sources innovation	+++	0
H4: Market-pull is not a relevant determinant of eco-innovation orientation in Spanish firms.	New market	0	0
	Market share	0	0
H5: Public policies, whether in the form of environmental regulation or subsidies, increase the likelihood of being a firm with eco-innovation orientation.	Regulations	+++	+++
	Local subsidies	0	+
	National subsidies	0	0
	EU subsidies	0	+

The table extracts the result of Table 5 and 6 in terms of significance and sign for the drivers of eco-innovation strategy. +++, ++, + indicate positive significance on a 1%, 5% and 10% level, respectively. 0 means no significant effect.

5.1 Robustness check

To verify the robustness of our results, we ran further regressions with different specifications of our main dependent variables. Firstly, we transformed the dependent variable into a binary one, taking the value 1 when a firm considers any of the two eco-objectives (reduce environmental impacts or reduce energy consumption) to have high importance and 0 otherwise. Second, as mentioned, the eco-innovation motivation variables in the PITEC database are measured using a variable with four values (high, medium, low and null impact). As a sensitivity analysis, we estimated the model when the intermediate answers were also taken into account. Hence, we ran a model using a random-effects ordered probit regression with sample selection.

The results, reported in Appendix 6 (Table A.6.1 and Table A.6.2), clearly show that there are hardly any changes regarding the sign and significance of the explanatory variables in the models when using a different specification of the dependent variables, from dichotomous with high and medium intensity to high intensity only and from a dichotomous specification to a multinomial one (four categories). Therefore, the results shown in the previous section are deemed robust.

6. CONCLUDING REMARKS

This chapter explores the determinants of designing an eco-innovation strategy in a Spanish context. In particular, because the growing importance of services in the economic activity we investigated the similarities and differences between Spanish service and manufacturing firms. While several studies have analysed manufacturing firm's eco-orientation in detail, services have received less attention due to their supposed lower environmental impact. Furthermore, to overcome at least some of the limitations of earlier studies, which have used mainly cross-sectional databases, the empirical analysis carried out in this chapter is based on the Technological Innovation Panel (PITEC), a panel data of 4.535 Spanish firms that covers the period 2008—2014. Hence, it provides novel results related to the sectoral and temporal dimension in the literature on eco-innovation orientation.

The availability of longitudinal, firm-level panel data allows us to consider the dynamic features of eco-innovation orientation and focus on the roles of persistence and individual unobserved heterogeneity of firms, a topic that has received great attention in the general innovation literature, but which is still unexplored in the eco-innovation context. In estimating the dependence of past eco-innovation performance and the drivers of both general eco-innovation and focal eco-innovation strategies such as reducing environmental impacts and reducing energy consumption, we introduced lagged dependent variables as explanatory terms and used a methodology to control for the initial conditions and unobserved heterogeneity: a random effect dynamic probit model controlling for possible sample selection based on adaption of Wooldridge's proposal (2005).

The empirical evidence in this study suggests that manufacturing has a higher orientation toward the environment than do service firms and that the drivers affecting the eco-innovative orientation of firms are quite similar. Nevertheless, few differences were found, and these might be explained by the particularities of each group.

The econometric analyses performed suggest that there is a support for the Hypothesis 1 that technology push factors, measured in terms of expenditures on innovation activities per worker, trigger an eco-innovation orientation in both manufacturing and services firms (Horbach 2008; De Marchi 2012; Cainelli and Mazzanti 2013). In addition, we find that temporal dimension matters and eco-innovation is highly persistent at the firm level in both sectors and types of eco-innovation strategies. Our empirical results reveal that past eco-innovation behaviour is an important driver for current eco-innovation status, thus confirming our previously proposed Hypothesis 2.

However, the roles of cooperation in R&D projects and external sources are less direct, and are closely related to the sector considered thus support for Hypothesis 3 is unclear. Regarding the impact of the external R&D and a greater breadth of knowledge sources, similarly to Del Río et al. (2015) for Spain and Horbach (2008) for Germany, we find that both variables are relevant driver for reducing environmental impacts and energy consumption in only manufacturing eco-innovators and not for services firms. In addition, the empirical results suggest that cooperation with external partners is non-significant in triggering eco-innovation motivation in any sector analysed.

Moreover, regarding the demand push factors our results indicate that they are not a distinctive determinant for Spanish firms to promote eco-innovation orientation. Thus, the market (Hypothesis 4) does not provide a demand-pull to design an eco-innovation.

In line with the existing literature, our empirical results confirm the importance of regulatory stimulus to eco-innovation mainly in form of demand pull (regulations) in both sectors and only in terms of demand push (subsidies) for service sectors (Hypothesis 5).

This analysis carries an important policy implication. Our results have shown that firms from different industries have similar attitudes toward eco-innovation orientation and few differences are found, so that similar supporting policies and tools can be deployed for both. Since eco-innovation is neither a sector- nor a technology-specific phenomenon, it is important that both managerial decisions and public environmental policies are correctly designed and targeted. Thus, for policy-makers, this study gives new insights into the drivers of eco-innovation strategies in manufacturing firms and emphasizes the drivers of the service sector. First, since eco-innovations are characterized by the double externality problem, public policy still retains a relevant role. Traditional environmental policy, in terms of existing regulations, is effective in the Spanish context in driving eco-innovation orientation in all the sectors, whereas local grants are a significant trigger only in the services sectors. Hence, public policies should also consider rewarding eco-oriented firms in the form of tax incentives, grants or subsidies as eco-innovations show high a level of uncertainty, novelty and face specific financial difficulties.

Second, given that we cannot rely either on the market-pull factor in any sector analysed or on cooperation main drivers to eco-innovate, there is still an important role for public polices in triggering an eco-innovation orientation. The role of governments in promoting eco-innovation concerns, not only new regulatory or economic instruments, but also the improvement of consumer awareness, the facilitation of partnerships and the encouragement of cooperation.

Third, as mentioned above, our analysis shows a high persistence in eco-innovation orientation. The results are of considerable interest for any public policy targeting innovation and eco-innovation. Government agencies or other institutions could provide incentives to engage in eco-innovation activities, but stability in eco-innovation activities over time is required to produce persistent and stable eco-innovators. Such a policy measure would promote competition and improve performance and would help non-eco-firms or occasional performers.

To sum up, the complex policy challenge based on support for eco-innovation requires a coordinated approach, one which simultaneously integrates innovation, research and environmental policy. As eco-innovations have both environmental and innovation externality (Rennings 2000), environmental policies can only be one component of the package of instruments needed to promote eco-innovation strategies. Thus, the promotion of eco-innovation requires a balanced strategy that combines different policy tools. However, fostering an eco-innovation orientation not only consists in applying specific instruments, also requires a policy framework that is well defined, stable over the years and based on consistent economic and environmental criteria (Economic Commission for Europe (UNECE) 2011). Spain’s relatively low level of R&D intensity (in particular with regard to government environmental and energy R&D investments), the low proportion of R&D personnel and researchers in the workforce, the political instability context and the lack of organisation and collaboration at institutional and governance levels all constitute barriers for eco-innovation that public policies should overcome (EIO 2015).

REFERENCES

Aykol, B., & Leonidou, L. C. (2015). Researching the Green Practices of Smaller Service Firms: A Theoretical, Methodological, and Empirical Assessment. *Journal of Small Business Management*, *53*(4), 1264–1288. doi:10.1111/jsbm.12118

Baltagi, B. (2008). *Econometric Analysis of Panel Data*. Chichester: John Wiley and Sons.

Barney, J. (1991). Firm Resources and Sustained Competitive Advantage. *Journal of Management*, *17*(1), 99–120. doi:10.1177/014920639101700108

Becheikh, N., Landry, R., & Amara, N. (2006). Lessons from innovation empirical studies in the manufacturing sector: A systematic review of the literature from 1993–2003. *Technovation*, *26*(5–6), 644–664. doi:10.1016/j.technovation.2005.06.016

Cainelli, G., De Marchi, V., & Grandinetti, R. (2015). Does the development of environmental innovation require different resources? Evidence from Spanish manufacturing firms. *Journal of Cleaner Production*, *94*, 211–220. doi:10.1016/j.jclepro.2015.02.008

Cainelli, G., Evangelista, R., & Savona, M. (2005). Innovation and economic performance in services: a firm-level analysis. *Cambridge Journal of Economics*, *30*(3), 435–458. doi:10.1093/cje/bei067

Cainelli, G., & Mazzanti, M. (2013). Environmental innovations in services: Manufacturing–services integration and policy transmissions. *Research Policy*, *42*(9), 1595–1604. doi:10.1016/j.respol.2013.05.010

Carrillo-Hermosilla, J., del Río, P., & Könnölä, T. (2010). Diversity of eco-innovations: Reflections from selected case studies. *Journal of Cleaner Production*, *18*(10), 1073–1083. doi:10.1016/j.jclepro.2010.02.014

Carrillo-Hermosilla, J., Del Río, P., & Könnölä, T. (2009). *Eco-Innovation. When Sustainability and Competitiveness Shake Hands*. London: Palgrave Macmillan. doi:10.1057/9780230244856

Coombs, R., & Miles, I. (2000). Innovation, Measurement and Services: The New Problematique. In J. S. Metcalfe & I. Miles (Eds.), *Innovation Systems in the Service Economy* (pp. 85–103). Springer US. doi:10.1007/978-1-4615-4425-8_5

Costa-Campi, M. T., García-Quevedo, J., Segarra, A., & Segarra-Blasco, A. (2015). Energy efficiency determinants: An empirical analysis of Spanish innovative firms. *Energy Policy*, *83*, 229–239. doi:10.1016/j.enpol.2015.01.037

Cuerva, M. C., Triguero, Á., & Córcoles, D. (2014). Drivers of green and non-green innovation: empirical evidence in Low-Tech SMEs. *Journal of Cleaner Production*, *68*, 104–113. doi:10.1016/j.jclepro.2013.10.049

De Marchi, V. (2012). Environmental innovation and R&D cooperation: Empirical evidence from Spanish manufacturing firms. *Research Policy*, *41*(3), 614–623. doi:10.1016/j.respol.2011.10.002

Del Río, P. (2009). The empirical analysis of the determinants for environmental technological change: A research agenda. *Ecological Economics*, *68*(3), 861–878. doi:10.1016/j.ecolecon.2008.07.004

Del Río, P., Peñasco, C., & Romero-Jordán, D. (2015). Distinctive Features of Environmental Innovators: An Econometric Analysis. *Business Strategy and the Environment*, *24*(6), 361–385. doi:10.1002/bse.1822

Del Río, P., Peñasco, C., & Romero-Jordán, D. (2016). What drives eco-innovators? A critical review of the empirical literature based on econometric methods. *Journal of Cleaner Production*, *112*(4), 2158–2170. doi:10.1016/j.jclepro.2015.09.009

Del Río, P., Romero-Jordán, D., & Peñasco, C. (2017). Analysing firm-specific and type-specific determinants of eco-innovation. *Technological and Economic Development of Economy*, *23*(2), 270–295. doi:10.3846/20294913.2015.1072749

Del Río, P., Tarancón Morán, M. Á., & Albiñana, F. C. (2011). Analysing the determinants of environmental technology investments. A panel-data study of Spanish industrial sectors. *Journal of Cleaner Production*, *19*(11), 1170–1179. doi:10.1016/j.jclepro.2010.05.001

Demirel, P., & Kesidou, E. (2011). Stimulating different types of eco-innovation in the UK: Government policies and firm motivations. *Ecological Economics*, *70*(8), 1546–1557. doi:10.1016/j.ecolecon.2011.03.019

Díaz-García, C., González-Moreno, Á., & Sáez-Martínez, F. J. (2015). Eco-innovation: insights from a literature review. *Innovation: Management, Policy & Practice*, *17*(1), 6–23. doi:10.1080/14479338.2015.1011060

Djellal, F., & Gallouj, F. (2016). Service Innovation for Sustainability : Paths for Greening Through Service Innovation. In *Toivonen M. (eds) Service Innovation. Translational Systems Sciences* (pp. 187–215). Springer, Tokyo.

Doran, J., & Ryan, G. (2016). The Importance of the Diverse Drivers and Types of Environmental Innovation for Firm Performance. *Business Strategy and the Environment*, *25*(2), 102–119. doi:10.1002/bse.1860

Economic Commission for Europe (UNECE). (2011). *Promoting Eco-innovation:*

Policies and Opportunities. Tel Aviv.

EEA. (2014). *Resource-efficient green economy and EU policies*. Luxembourg: Publications Office of the European Union. doi:10.2800/18514

EIO. (2013). *Europe in transition: Paving the way to a green economy through eco-innovation. Eco-Innovation Observatory. Funded by the European Commission, DG Environment, Brussels*.

Elsayed, K., & Paton, D. (2005). The impact of environmental performance on firm performance: Static and dynamic panel data evidence. *Structural Change and Economic Dynamics*, *16*(3), 395–412. doi:10.1016/j.strueco.2004.04.004

European Commission. (2011). *Attitudes of European citizens towards the environment. Special Eurobarometer 365*.

European Commission. (2014). *Attitudes of European citizens towards the environment. Special Eurobarometer 416*.

EUROSTAT. (2016). *Statistical Data. EUROSTAT, Luxembourg http://epp.eurostat.ec.europa.eu*.

Gallouj, F., Weber, K. M., Stare, M., & Rubalcaba, L. (2015). The futures of the service economy in Europe: A foresight analysis. *Technological Forecasting and Social Change*, *94*, 80–96. doi:10.1016/j.techfore.2014.06.009

Ghisetti, C., Marzucchi, A., & Montresor, S. (2015). The open eco-innovation mode. An empirical investigation of eleven European countries. *Research Policy*, *44*(5), 1080–1093. doi:10.1016/j.respol.2014.12.001

Hashi, I., & Stojčić, N. (2013). The impact of innovation activities on firm performance using a multi-stage model: Evidence from the Community Innovation Survey 4. *Research Policy*, *42*(2), 353–366. doi:10.1016/j.respol.2012.09.011

Hojnik, J., & Ruzzier, M. (2015). What drives eco-innovation? A review of an emerging literature. *Environmental Innovation and Societal Transitions*, *19*, 31–41. doi:10.1016/j.eist.2015.09.006

Horbach, J. (2008). Determinants of environmental innovation—New evidence from German panel data sources. *Research Policy*, *37*(1), 163–173. doi:10.1016/j.respol.2007.08.006

Horbach, J. (2016). Empirical determinants of eco-innovation in European countries using the community innovation survey. *Environmental Innovation and Societal Transitions*, *19*, 1–14. doi:10.1016/j.eist.2015.09.005

Horbach, J., Oltra, V., & Belin, J. (2013). Determinants and Specificities of Eco-

Innovations Compared to Other Innovations—An Econometric Analysis for the French and German Industry Based on the Community Innovation Survey. *Industry & Innovation*, *20*(6), 523–543. doi:10.1080/13662716.2013.833375

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. doi:10.1016/j.ecolecon.2012.04.005

Jaffe, A. B., & Palmer, K. (1997). Environmental Regulation and Innovation: A Panel Data Study. *Review of Economics and Statistics*, *79*(4), 610–619. doi: 10.1162/003465397557196

Jakobsen, S., & Clausen, T. (2016). Innovating for a greener future: the direct and indirect effects of firms' environmental objectives on the innovation process. *Journal of Cleaner Production*, *128*(1), 131–141. doi:10.1016/j.jclepro.2015.06.023

Kammerer, D. (2009). The effects of customer benefit and regulation on environmental product innovation. *Ecological Economics*, *68*(8–9), 2285–2295. doi:10.1016/j.ecolecon.2009.02.016

Kemp, R., & Pearson, P. (2007). *Final report MEI project about measuring eco-innovation*. UNU-MERIT, Maastricht. https://www.oecd.org/env/consumption-innovation/43960830.pdf

Kesidou, E., & Demirel, P. (2012). On the drivers of eco-innovations: Empirical evidence from the UK. *Research Policy*, *41*(5), 862–870. doi:10.1016/j.respol.2012.01.005

Leiponen, A. (2012). The benefits of R&D and breadth in innovation strategies: a comparison of Finnish service and manufacturing firms. *Industrial and Corporate Change*, *21*(5), 1255–1281. doi:10.1093/icc/dts022

Leiponen, A., & Helfat, C. E. (2010). Innovation objectives, knowledge sources, and the benefits of breadth. *Strategic Management Journal*, *31*(2), 224–236. doi:10.1002/smj.807

Mairesse, J., & Mohnen, P. (2005). The importance of R&D for innovation: a reassessment using French survey data. *Journal of Technology Transfer*, *30*, 183–197. doi:10.1007/s10961-004-4365-8

Malerba, F., Orsenigo, L., & Peretto, P. (1997). Persistence of innovative activities, sectoral patterns of innovation and international technological specialization. *International Journal of Industrial Organization*, *15*(6), 801–826. doi:10.1016/S0167-7187(97)00012-X

Marzucchi, A., & Montresor, S. (2017). Forms of knowledge and eco-innovation modes: Evidence from Spanish manufacturing firms. *Ecological Economics*, *131*, 208–221. doi:10.1016/j.ecolecon.2016.08.032

Mate-Sanchez-Val, M., & Harris, R. (2014). Differential empirical innovation factors for Spain and the UK. *Research Policy*, *43*(2), 451–463. doi:10.1016/j.respol.2013.10.013

Mazzanti, M., & Zoboli, R. (2009). Embedding environmental innovation in local production systems: SME strategies, networking and industrial relations: evidence on innovation drivers in industrial districts. *International Review of Applied Economics*, *23*(2), 169–195. doi:10.1080/02692170802700500

Miles, I. (2006). Innovation in services. In J. Fagerberg & D. C. Mowery (Eds.), *The Oxford Handbook of Innovation*. Oxford University Press. doi:10.1093/oxfordhb/9780199286805.003.0016

Mothe, C., & Nguyen-Thi, U. T. (2016). Persistent openness and environmental innovation: An empirical analysis of French manufacturing firms. *Journal of Cleaner Production*, *162*, S59–S69. doi:10.1016/j.jclepro.2016.12.063

Nelson, R. R., & Winter, S. G. (1982). *An Evolutionary Theory of Economic Change*. Cambridge, MA: Harvard University Press.

Neyman, J., & Scott, E. L. (1948). Consistent Estimates Based on Partially Consistent Observations. *Econometrica*, *16*(1), 1–32. doi:10.2307/1914185

OECD. (2011). *Better policies to support eco-innovation. OECD Studies on Environmental Innovation.OECD Publishing*.

Peters, B. (2009). Persistence of innovation: stylised facts and panel data evidence. *The Journal of Technology Transfer*, *34*(2), 226–243. doi:10.1007/s10961-007-9072-9

Petruzzelli, A. M., 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*(3), 291–310. doi:10.5172/impp.2011.13.3.291

Porter, M. E., & Linde, C. van der. (1995). Toward a New Conception of the Environment-Competitiveness Relationship. *Journal of Economic Perspectives*, *9*(4), 97–118. doi:10.1257/jep.9.4.97

Rabe-Hesketh, S., & Skrondal, A. (2013). Avoiding biased versions of Wooldridge's simple solution to the initial conditions problem. *Economics Letters*, *120*(2), 346–349. doi:10.1016/j.econlet.2013.05.009

Raymond, W., Mohnen, P., Palm, F., & Schim Van Der Loeff, S. (2010). Persistence of Innovation in Dutch Manufacturing: is it spurious? *The Review of Economics and Statistics*, *92*(3), 495–504. doi:10.1162/REST_a_00004

Rennings, K. (2000). Redefining innovation — eco-innovation research and the contribution from ecological economics. *Ecological Economics*, *32*(2), 319–332. doi:10.1016/S0921-8009(99)00112-3

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. doi:10.1016/j.ecolecon.2005.03.013

Sáez-Martínez, F. J., Díaz-García, C., & Gonzalez-Moreno, A. (2016). Firm technological trajectory as a driver of eco-innovation in young small and medium-sized enterprises. *Journal of Cleaner Production*, *138*, 28–37. doi:10.1016/j.jclepro.2016.04.108

Sarkis, J., Gonzalez-Torre, P., & Adenso-Diaz, B. (2010). Stakeholder pressure and the adoption of environmental practices: The mediating effect of training. *Journal of Operations Management*, *28*(2), 163–176. doi:10.1016/j.jom.2009.10.001

Segarra-Blasco, A. (2010). Innovation and productivity in manufacturing and service firms in Catalonia: a regional approach. *Economics of Innovation and New Technology*, *19*(3), 233–258. doi:10.1080/10438590802469594

Segarra-Oña, M., Peiró-Signes, Á., & Mondéjar-Jiménez, J. (2016). Twisting the twist: how manufacturing & knowledge-intensive firms excel over manufacturing & operational and all service sectors in their eco-innovative orientation. *Journal of Cleaner Production*, *138*, 19–27. doi:10.1016/j.jclepro.2016.01.010

Skrondal, A., & Rabe-Hesketh, S. (2014). Handling initial conditions and endogenous covariates in dynamic/transition models for binary data with unobserved heterogeneity. *Journal of the Royal Statistical Society: Series C (Applied Statistics)*, *63*(2), 211–237. doi:10.1111/rssc.12023

Tang, Z., & Tang, J. (2012). Stakeholder–firm power difference, stakeholders' CSR orientation, and SMEs' environmental performance in China. *Journal of Business Venturing*, *27*(4), 436–455. doi:10.1016/j.jbusvent.2011.11.007

Tavassoli, S., & Karlsson, C. (2015). Persistence of various types of innovation analyzed and explained. *Research Policy*, *44*(10), 1887–1901. doi:10.1016/j.respol.2015.06.001

Tether, B. S. (2005). Do Services Innovate (Differently)? Insights from the European Innobarometer Survey. *Industry & Innovation*, *12*(2), 153–184. doi:10.1080/13662710500087891

Triguero, Á., Moreno-Mondéjar, L., & Davia, M. A. (2013). Drivers of different types of eco-innovation in European SMEs. *Ecological Economics*, *92*, 25–33. doi:10.1016/j.ecolecon.2013.04.009

Tyl, B., Vallet, F., Bocken, N. M. P., & Real, M. (2015). The integration of a stakeholder perspective into the front end of eco-innovation: a practical approach. *Journal of Cleaner Production*, *108*, 543–557. doi:10.1016/j.jclepro.2015.07.145

Vega-Jurado, J., Gutiérrez-Gracia, A., Fernández-de-Lucio, I., & Manjarrés-Henríquez, L. (2008). The effect of external and internal factors on firms' product innovation. *Research Policy*, *37*(4), 616–632. doi:10.1016/j.respol.2008.01.001

Veugelers, R. (2012). Which policy instruments to induce clean innovating? *Research Policy*, *41*(10), 1770–1778. doi:10.1016/j.respol.2012.06.012

Wagner, M. (2008). Empirical influence of environmental management on innovation: Evidence from Europe. *Ecological Economics*, *66*(2), 392–402. doi:10.1016/j.ecolecon.2007.10.001

Wooldridge, J. M. (2005). Simple solutions to the initial conditions problem in dynamic, nonlinear panel data models with unobserved heterogeneity. *Journal of Applied Econometrics*, *20*(1), 39–54. doi:10.1002/jae.770

Wooldridge, J. M. (2010). *Econometric analysis of cross section and panel data*. MIT Press.

APPENDIX

Appendix 1. Aggregations of manufacturing and services

Table A.1

Aggregations of manufacturing and services based on NACE Rev. 2

Manufacturing industries	
1. Industry: High Technology	
Manufacture of basic pharmaceutical products and pharmaceutical preparations	21
Manufacture of computer, electronic and optical products	26
Manufacture of air and spacecraft and related machinery	30.3
Manufacture of chemicals and chemical products	20
Manufacture of electrical equipment, Manufacture of machinery and equipment n.e.c., Manufacture of motor vehicles, trailers and semi-trailers	27-29
Manufacture of other transport equipment (excluding 30.1 Building of ships and boats, and 30.3 Manufacture of air and spacecraft and related machinery)	30 –(30.1+30.3)
2. Industry: Low Technology	
Manufacture of coke and refined petroleum products	19
Manufacture of rubber and plastic products, Manufacture of other non-metallic mineral products, Manufacture of basic metals, Manufacture of fabricated metal products, except machinery and equipment	22-25
Building of ships and boats	30.1
Repair and installation of machinery and equipment	33
Manufacture of food products, beverages, tobacco products, textiles, wearing apparel, leather and related products, wood and of products of wood, paper and paper products, Printing and reproductions of recorded media	10-18
Manufacture of furniture, Other manufacturing	31-32
Services industries	
3. High-Tech Knowledge Intensive Services	
Motion picture, video and television programme production, sound recording and music publishing activities, Programming and broadcasting activities, Telecommunications, Computer programming, consultancy and related activities, Information service activities	59-63
Scientific research and development	72
4. Other Knowledge Intensive Services	
Financial and insurance activities	64-66
Legal and accounting activities, Activities of head offices; management consultancy activities, Architectural and engineering activities; technical testing and analysis	69-71
Advertising and market research, Other professional, scientific and technical activities	73-74
Veterinary activities	75
Human health and social work activities	86-88
Arts, entertainment and recreation	90-93

Appendix 2. Variable definitions

Table A.2

Variable definitions

Dependent variables	
Eco-innovation	Dummy variable that takes a value equal to 1 if the firm innovation objective is highly or medium oriented to reducing environmental impact or energy consumption per unit produced; 0 if not
Reduce impacts	Dummy variable that takes a value equal to 1 if the firm innovation objective is highly or medium oriented to reducing environmental impact; 0 if not
Reduce energy	Dummy variable that takes a value equal to 1 if the firm innovation objective is highly or medium oriented to reducing energy consumption per unit produced; 0 if not
Innovative	Dummy variable which takes the value 1 if the firm has introduced technological innovations or non-technological innovations; 0 if not
Independent variables	
Environmental policy	
Regulation	Dummy variable that takes a value equal to 1 if the firm innovation objective is highly or medium oriented to meet regulatory requirements; 0 if not
Subsidies	Local subsidies: dummy variable that takes a value equal to 1 if the firm receives any public financial support for innovation activities from local authorities; 0 if not National subsidies: dummy variable that takes a value equal to 1 if the firm receives any public financial support for innovation activities national authorities; 0 if not EU subsidies: dummy variable that takes a value equal to 1 if the firm receives any public financial support for innovation activities from the EU; 0 if not
Technology push factors	
Internal R&D effort	Expenditures in internal R&D activities per worker (in logs)
External R&D effort	Expenditures in external R&D activities per worker (in logs)
Cooperation	Dummy variable that takes a value equal to 1 if the firm cooperates with other agents during; 0 if not
Sources of information	Internal sources: dummy variable which takes a value equal to 1 if information from sources within the enterprise or group has high importance; 0 if not Market sources: dummy variable which takes a value equal to 1 if information from suppliers, clients, competitors or private R&D institutions has high importance; 0 if not Institutional sources: dummy variable which takes a value equal to 1 if information from universities, public research organizations or technology centres has high importance; 0 if not Other sources: dummy variable which takes a value equal to 1 if information from conferences, scientific reviews or professional associations has high importance; 0 if not
Breadth of sources	Variable ranging from 0 to 11depending on the number of sources of information (enterprise, suppliers, clients, competitors, private R&D institutions, universities, public research organizations, technology centres, conferences, scientific reviews and professional associations).
Market-pull factors	
New market	Dummy variable that takes a value equal to 1 if the firm innovation objective is highly or medium oriented to entering new markets; 0 if not
Market share	Dummy variable that takes a value equal to 1 if the firm innovation objective is highly or medium oriented to increasing or maintaining market share; 0 if not
Firm characteristics	
Group	Dummy variable that takes a value equal to 1 if the firm belongs to a group; 0 if not

Size	Log of the total number of firm's employees (natural logs)
Export	Dummy variable that takes a value equal to 1 if the firm sells its product in the international market

Appendix 3. Correlation matrix

Table A.3
Correlation matrix of variables in the outcome equation

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1. Internal R&D	1.0000										
2. External R&D	0.2237*	1.0000									
3. Cooperation	0.1500*	0.0942*	1.0000								
4. Breadth sources	0.1780*	0.1037*	0.3596*	1.0000							
5. New market	0.1113*	0.0369*	0.2940*	0.4007*	1.0000						
6. Market share	0.0936*	0.0398*	0.2827*	0.4032*	0.7476*	1.0000					
7. Regulations	0.0695*	0.0398*	0.2323*	0.3569*	0.4463*	0.4524*	1.0000				
8. Local subsidies	0.1753*	0.0939*	0.3205*	0.2446*	0.2028*	0.1866*	0.1529*	1.0000			
9.National subsidies	0.2041*	0.1023*	0.3743*	0.3137*	0.2559*	0.2400*	0.1750*	0.3222*	1.0000		
10. EU subsidies	0.2423*	0.1112*	0.2504*	0.2299*	0.1183*	0.0998*	0.0863*	0.2689*	0.3146*	1.0000	
11. Size	-0.0271*	0.0014	0.0895*	0.0440*	0.0067	0.0206*	0.0268*	-0.0156*	0.0459*	0.0411*	1.0000
12. Group	-0.0053	0.0347*	0.1178*	0.0186*	-0.0104	0.0164*	0.0298*	-0.0190*	0.0693*	-0.0169*	0.1602*

*Significant at 5%.

Appendix 4. Additional descriptive statistics

Table A.4
Descriptive statistics of variables in the outcome equation

	Mean	**Std. Dev.**		
		Overall	**Between**	**Within**
Technology-push factors				
Internal R&D effort [a]	6.0076	3.8152	3.4548	1.9354
External R&D effort [a]	2.4512	3.4383	2.7655	2.0001
Cooperation	0.4344	0.4956	0.3970	0.2994
Breadth sources innovation	2.0176	1.8223	1.4921	1.0579
Market pull factors				
New market	0.7101	0.4536	0.3613	0.2996
Market share	0.7350	0.4413	0.3513	0.2941
Environmental policy				
Regulation	0.5563	0.4968	0.3878	0.3207
Local subsidies	0.2587	0.4379	0.3307	0.2838
National subsidies	0.3075	0.4614	0.3527	0.2948
EU subsidies	0.0778	0.2679	0.2092	0.1608
Firm characteristics				
Group	0.4977	0.5000	0.4764	0.1560
Size [b]	4.461	1.3493	1.3304	0.2000
Observations		24,431		

[a] ln (R&D/ number of employees)
[b] ln (number of employees)

Appendix 5. Average marginal effects output equation

Table A.5.1
Average marginal effects of the output equation: probability of designing an eco-innovation strategy. Manufacturing firms

	Eco-innovation		Reduce impacts		Reduce energy	
	Exogenous initial conditions	**Correlated with initial conditions**	**Exogenous initial conditions**	**Correlated with initial conditions**	**Exogenous initial conditions**	**Correlated with initial conditions**
Persistence						
Eco-innovation $_{t-1}$	1.428***	1.143***				
	(0.0405)	(0.0433)				
Reduce impacts $_{t-1}$			1.505***	1.109***		
			(0.0422)	(0.0449)		
Reduce energy $_{t-1}$					1.493***	1.178***
					(0.0365)	(0.0392)
Initial conditions						
Eco-innovation		0.607***				
		(0.0448)				
Reduce impacts				0.723***		
				(0.0485)		
Reduce energy						0.613***
						(0.0454)
Technology-push factors						
Internal R&D effort $_{t-1}$	0.0431***	0.0445***	0.0422***	0.0438***	0.0334***	0.0339***
	(0.00446)	(0.00493)	(0.00445)	(0.00507)	(0.00460)	(0.00507)
External R&D effort $_{t-1}$	0.0121**	0.0108*	0.0121**	0.0124*	0.00992*	0.0112*
	(0.00455)	(0.00506)	(0.00442)	(0.00507)	(0.00445)	(0.00493)
Cooperation $_{t-1}$	0.0534	0.0411	0.0764*	0.0673*	0.0493*	0.0578*
	(0.0312)	(0.0345)	(0.0304)	(0.0346)	(0.0306)	(0.0336)
Breadth sources innov. $_{t-1}$	0.0394***	0.0378***	0.0341***	0.0333***	0.0278**	0.0239*
	(0.00916)	(0.0102)	(0.00875)	(0.0100)	(0.00868)	(0.00962)
Market pull factors						
New market $_{t-1}$	0.0695	0.0628	0.0727	0.0734	-0.0178	-0.0162
	(0.0391)	(0.0425)	(0.0387)	(0.0432)	(0.0394)	(0.0426)
Market share $_{t-1}$	-0.0233	-0.0258	-0.000752	-0.00666	0.0207	0.0163
	(0.0397)	(0.0433)	(0.0394)	(0.0441)	(0.0401)	(0.0434)
Environmental policy						
Regulation $_{t-1}$	0.310***	0.253***	0.203***	0.176***	0.247***	0.228***
	(0.0323)	(0.0354)	(0.0336)	(0.0376)	(0.0306)	(0.0333)
Local subsidies $_{t-1}$	0.0489	0.0537	0.0143	0.0232	0.0547	0.0593
	(0.0340)	(0.0374)	(0.0329)	(0.0372)	(0.0329)	(0.0360)
National subsidies $_{t-1}$	0.0349	0.0519	0.0307	0.0414	0.0144	0.00874
	(0.0339)	(0.0372)	(0.0327)	(0.0369)	(0.0326)	(0.0356)
EU subsidies $_{t-1}$	-0.0205	-0.0439	0.0817	0.0707	-0.126	-0.142
	(0.0738)	(0.0809)	(0.0721)	(0.0810)	(0.0692)	(0.0756)
Firm characteristics						
Group $_{t-1}$	0.0318	0.0444	0.00708	0.0213	0.0395	0.0239
	(0.0320)	(0.0373)	(0.0315)	(0.0387)	(0.0324)	(0.0378)
Size $_{t-1}$	0.107***	0.106***	0.113***	0.118***	0.116***	0.129***
	(0.0144)	(0.0169)	(0.0143)	(0.0175)	(0.0145)	(0.0170)

Standard errors in brackets. *, ** and *** correspond to significance levels of 1%, 5% and 10%, respectively.

Table A.5.2
Average marginal effects of the output equation: probability of designing an eco-innovation strategy. Services firms

	Eco-innovation		**Reduce impacts**		**Reduce energy**	
	Exogenous initial conditions	**Correlated with initial conditions**	**Exogenous initial conditions**	**Correlated with initial conditions**	**Exogenous initial conditions**	**Correlated with initial conditions**
Persistence						
Eco-innovation $_{t-1}$	1.460***	1.196***				
	(0.0703)	(0.0734)				
Reduce impacts $_{t-1}$			1.569***	1.164***		
			(0.0765)	(0.0804)		
Reduce energy $_{t-1}$					1.457***	1.087***
					(0.0732)	(0.0754)
Initial conditions						
Eco-innovation		0.737***				
		(0.0962)				
Reduce impacts				0.951***		
				(0.107)		
Reduce energy						0.845***
						(0.101)
Technology-push factors						
Internal R&D effort $_{t-1}$	0.0366***	0.0370***	0.0388***	0.0409***	0.0262**	0.0282**
	(0.00840)	(0.00917)	(0.00880)	(0.00992)	(0.00897)	(0.00994)
External R&D effort $_{t-1}$	0.00749	0.00497	0.0128	0.0114	0.00446	0.000782
	(0.00778)	(0.00856)	(0.00793)	(0.00907)	(0.00795)	(0.00883)
Cooperation $_{t-1}$	-0.0413	-0.0467	-0.0254	-0.0328	-0.108	-0.0809
	(0.0570)	(0.0619)	(0.0588)	(0.0658)	(0.0604)	(0.0663)
Breadth sources innovation $_{t-1}$	0.0302*	0.0258	0.0292*	0.0254	0.0380**	0.0367*
	(0.0142)	(0.0155)	(0.0143)	(0.0161)	(0.0140)	(0.0155)
Market pull factors						
New market $_{t-1}$	0.0388	0.0704	-0.00514	0.0249	0.120	0.161*
	(0.0682)	(0.0736)	(0.0704)	(0.0781)	(0.0724)	(0.0788)
Market share $_{t-1}$	0.0960	0.0878	0.0753	0.0644	0.0815	0.0552
	(0.0696)	(0.0750)	(0.0720)	(0.0797)	(0.0738)	(0.0803)
Environmental policy						
Regulation $_{t-1}$	0.270***	0.190**	0.186**	0.126*	0.265***	0.241***
	(0.0569)	(0.0621)	(0.0622)	(0.0693)	(0.0565)	(0.0618)
Local subsidies $_{t-1}$	0.116*	0.113*	0.122*	0.118*	0.118*	0.0888*
	(0.0636)	(0.0695)	(0.0651)	(0.0736)	(0.0663)	(0.0734)
National subsidies $_{t-1}$	0.00906	0.00457	-0.0523	-0.0797	0.0406	0.0360
	(0.0623)	(0.0676)	(0.0640)	(0.0719)	(0.0648)	(0.0711)
EU subsidies $_{t-1}$	0.126*	0.108*	0.160**	0.151**	-0.0487	-0.0451
	(0.0845)	(0.0935)	(0.0843)	(0.0970)	(0.0838)	(0.0927)
Firm characteristics						
Group $_{t-1}$	0.0467	0.0456	0.0134	0.00747	0.0360	0.0354
	(0.0593)	(0.0682)	(0.0606)	(0.0736)	(0.0617)	(0.0720)
Size $_{t-1}$	0.0460*	0.0465	0.0709***	0.0808**	0.0209	0.0237
	(0.0205)	(0.0239)	(0.0213)	(0.0260)	(0.0212)	(0.0250)

Standard errors in brackets. *, ** and *** correspond to significance levels of 1%, 5% and 10%, respectively.

Appendix 6. Robustness check

Table: A.6.1
Results of the output equation: probability of designing an eco-innovation strategy. Random-effects ordered probit regression with sample selection. Dependent variable: ordinal variable

	Reduce impacts		Reduce energy	
	Manufacturing	**Services**	**Manufacturing**	**Services**
Persistence				
Reduce impacts $_{t-1}$	0.506***	0.531***		
	(0.0232)	(0.0389)		
Reduce energy $_{t-1}$			0.543***	0.544***
			(0.0217)	(0.0400)
Initial conditions				
Reduce impacts	0.342***	0.445***		
	(0.0229)	(0.0446)		
Reduce energy			0.291***	0.381***
			(0.0219)	(0.0447)
Technology-push factors				
Internal R&D effort $_{t-1}$	0.0409***	0.0217*	0.0301***	0.0266**
	(0.00538)	(0.00920)	(0.00495)	(0.00875)
External R&D effort $_{t-1}$	0.00785	0.00812	0.00763*	-0.00302
	(0.00409)	(0.00696)	(0.00383)	(0.00710)
Cooperation $_{t-1}$	0.0391	0.0272	0.0539	0.0131
	(0.0296)	(0.0580)	(0.0279)	(0.0544)
Breadth sources innovation $_{t-1}$	0.0363***	0.0147*	0.0243**	0.0118*
	(0.00907)	(0.0140)	(0.00818)	(0.0139)
Market pull factors				
New market $_{t-1}$	0.0333	0.0187	-0.00791	0.107
	(0.0365)	(0.0646)	(0.0349)	(0.0616)
Market share $_{t-1}$	0.00242	0.0576	-0.00388	0.00783
	(0.0381)	(0.0644)	(0.0350)	(0.0653)
Environmental policy				
Regulation $_{t-1}$	0.00733*	0.00376*	0.110***	0.171**
	(0.0318)	(0.0572)	(0.0282)	(0.0520)
Local subsidies $_{t-1}$	0.00159	0.0496	0.0251	0.0649
	(0.0293)	(0.0598)	(0.0275)	(0.0551)
National subsidies $_{t-1}$	0.0233	-0.0577	-0.00864	0.00119
	(0.0281)	(0.0548)	(0.0268)	(0.0535)
EU subsidies $_{t-1}$	0.0482	0.186*	-0.104	0.0210
	(0.0554)	(0.0737)	(0.0575)	(0.0701)
Firm characteristics				
Group $_{t-1}$	0.00304	0.0309	0.0157	-0.0114
	(0.0350)	(0.0579)	(0.0314)	(0.0563)
Size $_{t-1}$	0.118***	0.0563*	0.109***	0.0145*
	(0.0163)	(0.0229)	(0.0144)	(0.0194)
Constant cut 1	1.891***	2.184***	2.199***	1.858***
	(0.297)	(0.333)	(0.211)	(0.288)
Constant cut 2	2.659***	3.072***	3.241***	2.903***
	(0.298)	(0.338)	(0.214)	(0.294)
Constant cut 3	3.995***	4.232***	4.512***	4.145***
	(0.301)	(0.345)	(0.218)	(0.303)
σ_{μ}^2	0.382***	0.537***	0.274***	0.422***
	(0.0384)	(0.0832)	(0.0306)	(0.0715)
Log likelihood	-15327.0	-4899.0	-15968.4	-4928.6
Wald test of χ^2	3702.4	1018.0	2441.3	841.4
Prob > χ^2	0.000	0.000	0.000	0.000
LR test vs oprobit regression	340.84***	161.16***	234.65***	115.57***
Observations	15,120	5,565	15,120	5,565

Estimations control for time and industry dummies. Robust standard errors in brackets. *, ** and *** correspond to significance levels of 1%, 5% and 10%, respectively. Mill's ratio is included in the estimations to control for sample selection bias. The reported likelihood-ratio test shows that there is enough variability between firms to favour a random-effects ordered probit regression over a standard ordered probit regression.

Table A.6.2
Results of the output equation: probability of designing an eco-innovation strategy. Dependent variable: high versus medium, low and null importance

	Eco-innovation		Reduce impacts		Reduce energy	
	Manufacturing	Services	Manufacturing	Services	Manufacturing	Services
Persistence						
Eco-innovation $_{t-1}$	1.183***	1.205***				
	(0.0417)	(0.0867)				
Reduce impacts $_{t-1}$			1.217***	1.172***		
			(0.0465)	(0.0975)		
Reduce energy $_{t-1}$					1.273***	1.428***
					(0.0491)	(0.116)
Initial conditions						
Eco-innovation	0.726***	0.997***	0.853***	1.219***		
	(0.0531)	(0.134)	(0.0626)	(0.163)		
Reduce impacts						
Reduce energy					0.770***	0.802***
					(0.0654)	(0.170)
Technology-push factors						
Internal R&D effort $_{t-1}$	0.0342***	0.0172*	0.0387***	0.0276*	0.0196**	0.0273*
	(0.00624)	(0.0118)	(0.00693)	(0.0136)	(0.00687)	(0.0133)
External R&D effort $_{t-1}$	0.00769	0.00365	0.00839	-0.00166	0.00337	0.0112
	(0.00525)	(0.00979)	(0.00574)	(0.0111)	(0.00575)	(0.0105)
Cooperation $_{t-1}$	0.0336	-0.109	0.0428	-0.0409	-0.00110	-0.157
	(0.0363)	(0.0758)	(0.0394)	(0.0856)	(0.0396)	(0.0856)
Breadth sources innovation $_{t-1}$	0.0418***	0.0305*	0.0400***	0.0304	0.0343**	0.0476**
	(0.0104)	(0.0172)	(0.0111)	(0.0190)	(0.0109)	(0.0182)
Market pull factors						
New market $_{t-1}$	-0.0157	-0.00304	-0.0227	-0.0329	-0.0495	0.0765
	(0.0458)	(0.0862)	(0.0503)	(0.0959)	(0.0511)	(0.100)
Market share $_{t-1}$	0.00856	0.0674	0.0477	0.0735	0.0375	0.0473
	(0.0475)	(0.0890)	(0.0524)	(0.0996)	(0.0534)	(0.102)
Environmental policy						
Regulation $_{t-1}$	0.158***	0.282***	0.177***	0.291***	0.110**	0.211**
	(0.0368)	(0.0693)	(0.0411)	(0.0798)	(0.0401)	(0.0767)
Local subsidies $_{t-1}$	-0.0148	0.0497	-0.0141	0.0895	0.0390	0.0522
	(0.0381)	(0.0815)	(0.0412)	(0.0910)	(0.0413)	(0.0911)
National subsidies $_{t-1}$	0.00912	0.0152	0.00764	-0.0343	0.0333	-0.0233
	(0.0374)	(0.0791)	(0.0404)	(0.0890)	(0.0405)	(0.0890)
EU subsidies $_{t-1}$	0.0143	0.143*	0.0589	0.123*	-0.120	0.0210
	(0.0793)	(0.101)	(0.0845)	(0.112)	(0.0856)	(0.110)
Firm characteristics						
Group $_{t-1}$	0.0234	0.0599	-0.00829	0.0432	0.0219	-0.0116
	(0.0413)	(0.0805)	(0.0457)	(0.0933)	(0.0446)	(0.0838)
Size $_{t-1}$	0.116***	0.0346*	0.119***	0.0744*	0.117***	0.0214*
	(0.0186)	(0.0284)	(0.0205)	(0.0331)	(0.0196)	(0.0294)
Mill's ratio	0.431***	0.242	0.560***	0.333*	0.305**	0.401**
	(0.0991)	(0.134)	(0.111)	(0.150)	(0.110)	(0.152)
Constant	-2.163***	-2.227***	-2.524***	-2.529***	-2.884***	-2.406***
	(0.351)	(0.350)	(0.403)	(0.391)	(0.402)	(0.363)
Log likelihood	-6595.6	-1787.0	-5736.5	-1517.9	-5260.4	-1199.2
Wald test of χ^2	3023.7	862.9	2754.3	725.2	2355.7	561.8
Prob > χ^2	0.000	0.000	0.000	0.000	0.000	0.000
	(0.108)	(0.183)	(0.108)	(0.186)	(0.129)	(0.293)
σ_α	0.645	0.804	0.718	0.935	0.625	0.624
	(0.0348)	(0.0737)	(0.0387)	(0.0869)	(0.0403)	(0.0915)
Rho (ρ)	0.294	0.393	0.340	0.466	0.281	0.280
	(0.0223)	(0.0437)	(0.0242)	(0.0462)	(0.0260)	(0.0591)
Censored obs.	4,086	2,439	4,086	2,439	4,086	2,439
Uncensored obs.	15,120	5,565	15,120	5,565	15,120	5,565
Observations	19,206	8,004	19,206	8,004	19,206	8,004

Estimations control for time and industry dummies. Robust standard errors in brackets. *, ** and *** correspond to significance levels of 1%, 5% and 10%, respectively.

CHAPTER 4

ECO-STRATEGIES AND FIRM GROWTH IN EUROPEAN SMEs: WHEN DOES IT PAY TO BE GREEN?

1. INTRODUCTION

It is widely recognized that a firm's competitive advantage cannot be pursued by ignoring the strategic management of innovation. The seminal contribution of Porter (1985) asserted that cost leadership and differentiation were the main traditional strategies that firms had at their disposal to gain a competitive advantage. But today, these traditional sources of gaining competitive advantages have been eroded and modern firms need to refine their business strategy. Firms around the world are dealing with varied environmental challenges including among others global warming, natural resource depletion, pollution regulations and new consumers' preferences for eco-friendly products that force corporate managers to refine their current business strategy and adopt new ways to mitigate firms' environmental impact.[1,2]

Esty and Winston (2009) state that eco-innovation strategy seems to offer firms an opportunity to differentiate themselves and to increase their competitive advantage. Tracking environmental perspective correctly can help to reduce costs and risks and raise revenues or a firm's reputation (Carrillo-Hermosilla, Del Río, and Könnölä 2009; Ambec

[1] Currently, environmental issues are top priorities among policy makers. In the European context, the growth strategy "Europe 2020" of the European Commission gains at a smart, sustainable and more inclusive economy by 2020 (European Commission 2010a). In this context, the European Commission's Eco-Innovation Action Plan (EcoAP) plays a key role in placing eco-innovation at the centre of the process.

[2] Ways to reduce firms' environmental impact include: pollution prevention, environmental management systems, reuse and recycle or energy efficiency.

et al. 2013; Del Río, Peñasco, and Romero-Jordán 2015). Consequently, one of the topics commonly addressed during political debates, and also faced by corporate managers, concerns the question of the effect on a firm's performance of strategies or practices to reduce environmental impact. In other words, whether eco-practices turn out to be profitable, or whether further policy interventions might be necessary.

There appears to be a broad consensus in the literature regarding the factors that determine which innovations positively impact the environment (Horbach 2008; Díaz-García, González-Moreno, and Sáez-Martínez 2015; Hojnik and Ruzzier 2015; Bossle et al. 2016; Del Río, Peñasco, and Romero-Jordán 2016), [3] but exactly how eco-strategies to reduce environmental impact affect firm performance is still widely debated.

Horváthová (2010), Ambec et al. (2013), Dixon-Fowler et al. (2013), Albertini (2013), and Barbieri et al. (2016) provide recent reviews and meta-studies summarizing the empirical work on the economic effects of eco-strategies. These studies exhibit considerable diversity in the empirical results, ranging from negative through non-significant to moderately (or even strongly) positive links between eco-innovation and firm performance. Such mixed results suggest that the relationship between eco-innovation strategies and firm performance is complex and poorly understood, indicating the need for greater effort in investigating the linkage. Ideally, this would provide a conclusive argument to help managers bring about a win-win situation in which both firms and society benefited from eco-innovation practices. In addition, a better evaluation of the relationship would be useful in designing effective future eco-innovation policies.

In this study, we therefore focus on the role played by eco-strategies, and we ask whether firms are creating economic opportunities (in terms of firm growth) by improving their eco-performance or are missing the opportunity of a sustainable competitive advantage in today's turbulent environment. For our study, we use the European Commission's

[3] The existing literature has mainly classified the determinants of eco-innovation into four groups: supply-side factors, demand-side factors, firm specific factors and environmental policy (Horbach 2008; Horbach, Oltra, and Belin 2013; Triguero, Moreno-Mondéjar, and Davia 2013; Cuerva, Triguero, and Córcoles 2014; Doran and Ryan 2016). Environmental policies seem to be the most important drivers for triggering eco-innovations. However, relying on external knowledge sources and cooperation are also more important for eco-innovators than general innovators (De Marchi 2012; Cainelli, De Marchi, and Grandinetti 2015).

Eurobarometer Survey 426 which provides a valuable opportunity to examine the role of eco-strategies in firm growth in SMEs in European countries.

Applying an ordered logistic model for 11,336 European SMEs, our empirical developments derive some interesting results. First, not all eco-strategies are positively related to better performance in terms of growth in turnover. We find that European firms using renewable energies perform better. In addition, undertaking eco-strategies aimed at recycling or designing products that are easier to maintain, repair or use increase firm growth in the European Union-15 (EU15). Firms seeking to reduce water or energy pollution, on the other hand, seem to show a negative correlation with the growth of the firm. Second, our results indicate that high investment in eco-strategies improves firm growth, particularly in the new member states that joined the EU from 2004 onwards. Finally, we observe a U-shaped relationship between eco-strategies and firm growth, implying that a greater breadth of eco-strategies is associated with higher firm performance. However, few SMEs are able to either make large invests or to undertake multiple eco-strategies.

This study contributes to the previous literature in several ways. First, despite the important role that SMEs play in advanced economies, the impacts of eco-strategies on firm performance have received less attention in the literature than on large firms (Aragón-Correa et al. 2008; Jo et al. 2015). Nowadays SMEs are the economic backbone of the European Union, representing 99% of European business and accounting for more than two thirds of employment. As well as being economically important, the analysis of eco-strategies across SMEs is relevant since the costs of investing in these strategies in the short term are high and, at the same time SMEs face greater financial barriers than larger firms, especially regarding difficulties when accessing external sources of funding (Ghisetti et al. 2016). We therefore contribute to the existing debate with a detailed investigation of SMEs.

Second, cross-country analyses of eco-strategies at firm level are still scarce (Lanoie et al. 2011; Colombelli, Krafft, and Quatraro 2015). In general, empirical studies are performed focusing on either a single country or a specific sector.[4] However, this study

[4] Examples of specific country analyses include: Italy (Marin and Lotti 2017; Riillo 2017), Germany (Ghisetti and Rennings 2014; Rexhäuser and Rammer 2014), Ireland (Doran and Ryan 2012), the

enhances previous research by giving more clarity to the relationship between eco-innovation strategies and firm performance across 28 European countries taking into account both sector and country differences.

Finally, to compare how much eco-strategies vary across countries, we classify the EU28 countries into two clusters. The distinction between established (European Union-15) and new EU members (the group of more recent member that joined the EU from 2004 onward) is of great interest today, bearing in mind that in a considerable number of Central and Eastern European countries have become part of the European project in recent years. Despite the fact that the connection between eco-strategies and firm performance has been examined extensively for countries that have been members of the EU for many years, evidence is virtually non-existent for new members (Przychodzen and Przychodzen 2015; Hojnik and Ruzzier 2016; Ryszko 2016).

The remainder of the chapter is structured as follows. Section 2 consists of a literature review. Section 3 presents the database, some descriptive statistics, the variables and the econometric methodology. Section 4 shows our main findings. The final section presents our conclusions and the consequent policy implications.

2. ECO-INNOVATION STRATEGIES AND FIRM PERFORMANCE: THEORETICAL CONSIDERATIONS AND LITERATURE OVERVIEW

While eco-innovation is expected to have a beneficial effect on the environment, its effect on firms' performance is less straightforward.[5] Historically, the conventional economic approach held that investing in environmental activities to reduce an externality like pollution involved an additional cost to a firm with no resulting benefits, this in turn eroding a firm's overall competitiveness (Walley and Whitehead 1994; Palmer, Oates, and Portney 1995). However, two decades ago, a new green perspective emerged that

---

Netherlands (Leeuwen and Mohnen 2017) and, Slovenia (Hojnik and Ruzzier 2016). Analyses of specific sectors include: the automotive sector (Aragón-Correa et al. 2008) and the paper industry (Wagner et al. 2002), among others.

[5] In an EU-funded research project called "Measuring Eco-Innovation" (MEI), eco-innovation was defined by Kemp and Pearson (2007) as the: "*production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives*".

considered that investments in eco-innovation activities would offset operational costs and increase firm performance in the long term (Porter (1991) and Porter and Linde (1995).

Many scholars are increasingly emphasizing the win-win idea (reducing the environmental impact without reducing firm profits). Relying primarily on case studies, Porter and Linde (1995) argue that more stringent but well-designed eco-regulation (mainly in the form of market-based instruments such as pollution taxes and tradable permits) can stimulate innovation which, by enhancing productivity, increases firm benefits.[6] This is generally known in the literature as the Porter Hypothesis (henceforth PH), according to which eco-regulation is a means whereby a firm can benefit from environmental and economic performance. It has, therefore, attracted much attention among researchers and policy-makers because it goes against the conventional wisdom that environmental protection always has a negative effect on economic growth.

In the past 20 years, PH has been extensively discussed from empirical and theoretical perspectives in the literature, without any clear consensus emerging. To test the theory and the empirical evidence of the PH, Jaffe and Palmer (1997) distinguished among the "weak", "narrow", and "strong" versions of PH (Figure 1). Weak and strong hypotheses refer to the effect of eco-regulations on eco-innovations and firm performance respectively.[7] The "narrow" version of PH argues that flexible regulatory policies stimulate innovation and thus are better than prescriptive forms of regulation, following the idea that instrument design does matter.[8] A number of studies have found a positive link between eco-regulation and innovation giving support for the weak version of PH. However, little corroboration exists of the strong version of PH (see Lanoie et al. (2011),

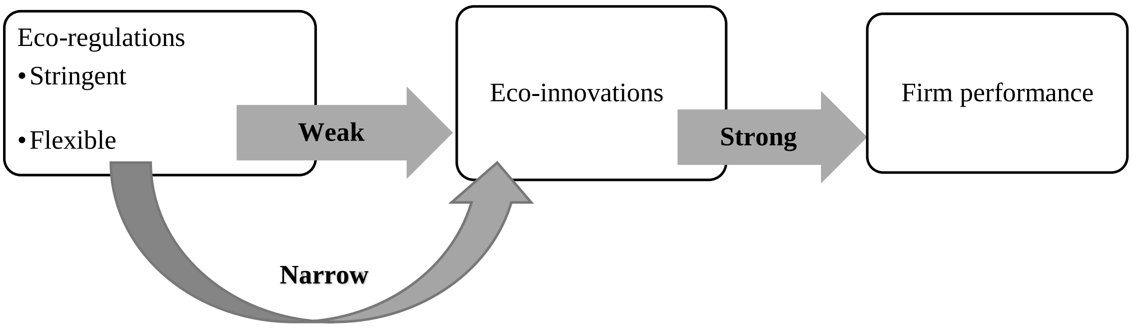
[6] Since eco-innovations are characterized by the "double externality" problem (Rennings 2000), policy measures are often used to stimulate them. According to Porter and Linde (1995), regulation-induced eco-innovation is more likely to have positive impact on long-term performance than short-term measures.

[7] In particular, the term "weak" refers to properly designed eco-regulation having the capacity to spur innovation. Whereas "strong" deals to the situation where eco-regulation may lead to an increased firm competitiveness by offsetting additional regulatory costs.

[8] The above-mentioned contribution by Jaffe and Palmer (1997) based on a panel of U.S manufacturing industries over the 1973–1991 period find evidence supporting the weak PH when using R&D expenditure as a proxy for innovation activities, while no effect is found when considering total patents.

Ambec and Lanoie (2008) Ambec et al. (2013) and Cohen and Tubb (2017) for extended reviews).[9]

Figure 1
The Porter Hypothesis casuality chain



Source: own elaboration based on Lanoie et al. (2011).

In addition, some authors have recently emphasized the need to investigate PH through a structural modeling approach than using single-equation models for estimating the contribution of eco-regulation to firm performance.

For instance, Marin (2014) and Leeuwen and Mohnen (2017) propose an extension of the Crepon-Duguet-Mairesse (CDM) model to investigate the effects of eco-innovation on productivity for a sample of Italian and Dutch firms respectively. As is well known, the CDM model is an empirical structural model composed of three steps (Crepon, Duguet, and Mairesse 1998). In the first step, firms decide whether or not to undertake formal R&D projects and the amount of resources to devote to R&D activities. In a second step, firms use innovation inputs and other internal or external resources to obtain an innovation output (knowledge production function). While, in the last step, the relationship between innovation output and productivity as a measure of economic performance is analysed. In a green CDM model, the first step consists in the decision on how much to invest to reduce the environmental burden of the firm's operations. The second block of the model describes the eco-innovation output function with eco-R&D and other eco-investments as an input and finally the relationship between innovation outputs and productivity is examined.

[9] The focus of the above studies, however, is on identifying the effect of eco-policies on economic performance.

Over the last three decades, economists have posited that eco-innovation may be not merely a higher cost and technical risk that a firm must bear, but rather a potential business opportunity. Successful eco-innovation activities may also lead to other benefits such as cost savings, enhanced corporate image, improve organizational capabilities and product quality following the natural-resource-based view (Hart and Dowell 2011), allow access to new green markets and creation of new markets among others (Sharma and Vredenburg 1998).[10] For instance, Porter and Linde (1995), as well as, Demirel and Kesidou (2011), stress that a firm introducing an eco-innovation may enjoy a first mover advantage or may increase its competitiveness by obtaining a niche market with more environmentally conscious consumers.

2.1 Review of existing empirical studies

Over the last few years, a range of empirical studies have set out to analyse the relationship between eco-strategies and performance at firm-level. Despite the accumulation of empirical work on this topic over the last decade, there is no general consensus on the direction and magnitude of the relationship.[11] The emergence of heterogeneous results can be explained in the light of several dimensions such as the scope of analysis (firm or aggregate level, small or large samples), the variety of performance measures (productivity, growth, profitability), the hybrid indicators to measure eco-strategies (clean technologies, end-of-pipe techniques, pollution prevention, resource efficiency measures, etc.), the empirical approaches adopted, and the availability of data.[12]

[10] In fact, the market for eco-friendly goods and services has grown by around 7% a year since 2000. This represents about 2.5% of Europe's Gross Domestic Product (GDP) and is expected to triple by 2030 (European Commission 2011b).

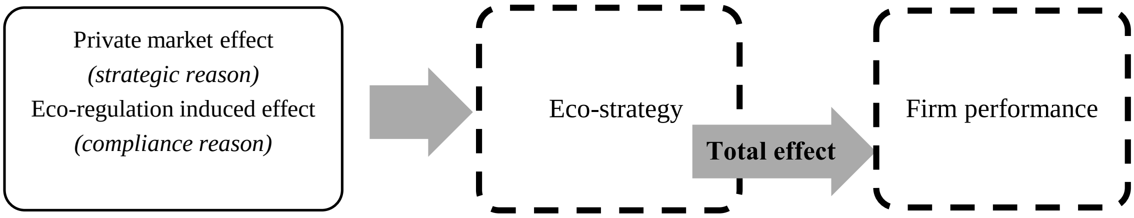
[11] For instance, the results of the study undertaken by Horváthová (2010) highlighted those inconclusive results. Based on 64 US and Canadian empirical studies between the period 1978 and 2008 showed that 55% of them found a positive, 16% a negative, and 30% an insignificant (or no) effect of environmental orientation on economic performance.

[12] See Barbieri et al. (2016) for a recent literature review on the economic effects of eco-innovations and also some examples: Ambec and Lanoie (2008); Aragón-Correa et al. (2008); Cainelli et al. (2011); Doran and Ryan (2012); Elsayed and Paton (2005); Ghisetti and Rennings (2014); Hojnik and Ruzzier (2016); Horváthová (2010); Lee and Min (2015); Riillo (2017).

Concerning the latter, most of the empirical contributions employ two typologies of data sources to analyse the economic effects of eco-strategies: patent data or survey questionnaires (such as the Community Innovation Survey (CIS) or Eurobarometer Special surveys in the European context). Although valuable and based on official datasets, we believe that the value of evidence focusing on patent data is limited because patents are likely to be skewed towards innovation in large firms and technologically intensive sectors, whereas most of the firms in the EU28 are small or medium sized and not included in the patent data.

Figure 2 provides a synthetic overview of the framework used in our empirical analysis. Note that our empirical investigation does not examine the full chain of causality from eco-policies to eco-innovation and firm performance, since we cannot disentangle the effects driven by eco-policies and private market (strategic reasoning). Because of data limitation, this analysis focuses on the relationship between eco-innovation strategies and SME performance in terms of turnover growth, and we therefore measure the total effects of eco-strategies (the direct effect stemming from private eco-investment and the indirect effect stemming from policy). Nevertheless, the present study is still relevant for policy-makers, as it indicates whether current eco-policies are sufficient to make eco-strategies profitable or whether policy adjustments are needed.

Figure 2
Framework of analysis



Source: own elaboration.

In the following, a summary is made of the recent empirical literature on the economic effects of eco-strategies on firm performance.[13] Different concepts are used to measure

[13] Note that in the literature there is also a stream of research focusing on eco-strategies and employment effects. This falls outside the scope of the present study. For an overview of the subject see for example: Gagliardi et al. (2016); Horbach and Rennings, (2013); Kunapatarawong and Martínez-Ros (2016).

firm performance, such as productivity (including, for example, value added, gross output and turnover per employee), growth (in terms of sales), and financial measures (e.g. operating margins, return on sales, Tobin's Q ratio). Table 1 summarizes the relevant literature described in this section according to which dimension of firm performance is considered.

In the European context, Doran and Ryan, (2012) using a cross-sectional Irish sample, found that firms that engage in eco-innovation in general have higher levels of turnover per employee than firms that do not.[14] Similarly, Hojnik and Ruzzier (2016), exploring Slovenian firms, and Przychodzen and Przychodzen (2015), examining a sample of Polish and Hungarian firms, suggest that process eco-innovation practices have no adverse effect on firm performance (in terms of profitability and growth) and conclude that it pays to be an eco-innovator. Meanwhile the study by Antonioli et al. (2016), which also analyses the general effect of eco-innovation on firm performance for a group of firms in the Emilia-Romagna region in Italy in 2010 and 2011, found that some firms' productivity performances (such us revenues over total labour cost) are positively related to eco-innovations.[15]

However, contrary to this positive evidence of the impact of eco-innovation strategies on firm performance, some research indicates that not only is there no correlation between the two variables, there is not even a trade-off.[16]

---

[14] Eco-innovation in general refers to whether a firm undertakes eco-innovation without specifying the exact typology.

[15] In addition, Antonioli et al. (2016) show that there is no significant or even negative influence on other kinds of profitability measures such as the ratio between revenues and the total labour cost in the very short run, which may probably be due to profitability taking longer to emerge in these areas than in others.

[16] Some studies indicate that even when a positive association between eco-strategy and firm performances is demonstrated, the findings would be subject to various limitations in terms of methodology or the data used (Elsayed and Paton 2005; Horváthová 2012). For instance, Elsayed and Paton (2005) using a UK sample for the period 1994–2000 compare the results of cross-section, static and dynamic panel data models and find that eco-initiatives have a neutral impact on financial performance in terms of profitability measures using a panel data sample. In contrast, when they estimate a cross-section a strong positive correlation is found. In particular, they highlight that some of the previous results finding a positive link between eco-innovation orientation and firm performance, are subject to model misspecifications because are not able to control properly for unobservable firm-specific effects.

Table 1
Summary of the related literature

Research themes	Studies	Sample	Main findings
Eco-strategies and productivity	(Riillo 2017) *Turnover per employee*	890 Italian firms 2007 survey of SMEs Observatory	Green practices are U-shaped related to performance
	(Soltmann, Stucki, and Woerter 2015) *Value added*	12 OECD countries Sector level (patents)	
	(Marin and Lotti 2017) *Real value added per employee*	11,938 Italian manufacturing firms (Survey on Manufacturing Firm Unicredit) (patents)	Eco-innovations exhibit a lower return relative to other innovations
	(Leeuwen and Mohnen 2017) *Gross output per employee*	5,989 Dutch firms The Survey on Environmental Costs of Firms, CIS survey, and The Production Statistics survey (PS)	Resource-saving eco-innovations increase TFP, whereas end-of-pipe eco-innovations tend to reduce TFP
	(Doran and Ryan 2012) *Turnover per employee*	2,181 Irish firms CIS 2008	Positive and significant effect of eco-innovation on firm performance
	(Antonioli, Borghesi, and Mazzanti 2016) *Value added per employee* *Total labour cost*	555 Italian firms (own questionnaire)	Some firms' productivity performances are positively related to eco-innovation +: revenue over total labour cost n.s.: value added per employee
	(Doran and Ryan 2016) *Turnover per employee*	2,181 Irish firms CIS 2008	Only two of the nine types of eco-innovation positively impact firm performance (reduced CO 'footprint' and recycled waste, water, or materials)
Eco-strategies and growth	(Cainelli, Mazzanti, and Zoboli 2011) *Turnover growth*	773 Italian service firms CIS II and System of the Enterprise Account (SEA)	Negative effect of eco-innovation on growth in turnover and not significant or even negative effect on labour productivity growth
	(Colombelli, Krafft, and Quatraro 2015) *Turnover growth*	456,240 firms 6 European countries Bureau van Dijk (BVD) ORBIS database and OECD RegPat Database (patents)	Firms producing eco-innovations are characterized by higher growth rates than those generating generic innovations
	(Hojnik and Ruzzier 2016) *Turnover growth*	223 Slovenian firms (own questionnaire)	Positive and significant effect of eco-innovation and firm growth
Eco-strategies and finance performance	(Miroshnychenko, Barontini, and Testa 2017) *Tobin's q and ROE*	3490 publicly-traded companies from 58 countries Thomson Reuters Dataset	Internal green practices (pollution prevention and green supply chain management) are the major eco-drivers of financial performance
	(Albertini 2013) *Market-based, accounting-based and organizational measures*	Meta-analysis of 52 studies over a 35-year period	Green research and development is positively related to financial performance
	(Przychodzen and Przychodzen 2015) *ROE, ROA*	439 Polish and Hungarian publicly traded firms Infinancials Database	
	(Ghisetti and Rennings 2014) *Operating margins*	1,063 German firms Mannheim Innovation Panel	Reduction in the use of energy or materials per unit of output positively affects firms' competitiveness. Contrarily, externality reducing innovations hamper firms' competitiveness
	(Rexhäuser and Rammer 2014) *Operating margins*	3,618 German firms Mannheim Innovation Panel	
	(Elsayed and Paton 2005) *Tobin's q, ROA and ROS*	227 UK firms Management Today Survey	Limited evidence of a significant impact of eco-performance on financial performance (dynamics effects)
	(Wagner et al. 2002) *ROCE, ROS, ROE*	37 firms from Germany, Italy, The Netherlands, and United Kingdom (own questionnaire)	Negative or not significant relationship
	(Earnhart and Lizal 2007) *Profit-based rate of return and operating profits*	436 Czech Republic firms Private data vendor Aspekt	Better pollution control neither improves nor undermines financial success
	(Trumpp and Guenther 2017) *ROA and TSR*	696 manufacturing and services firms Carbon Disclosure Project Global 500, S&P 500, and FTSE 350	U-shaped relationship between carbon and waste intensity performance and profitability

Note: CIS (Community Innovation Survey), ROA (Return on assets), ROCE (Return on capital employed), ROE (Return on equity), ROS (Return on sales), TPF (Total factor productivity effect), TSR (Total shareholder return).

Cainelli et al. (2011), for instance, using a sample of Italian services firms, show a negative link between eco-motivations and growth in employment and turnover in the short term. Wagner et al. (2002), focusing on the industry (paper) in four European countries (Germany, Italy, the Netherlands and the United Kingdom), also provide evidence of a negative relationship, although only for one specific financial performance measure (return on capital employed (ROCE)), and report no evidence of a significant relationship between two other economic performance indicators (return on sales (ROS) and return on equity (ROE)). On the basis of patent analysis, Marin and Lotti (2017) more recently used a sample of Italian manufacturing firms and observed that eco-innovations exhibit a lower return relative to other innovations, at least in the short run. This differential effect seems to be especially true for polluting firms facing higher compliance costs for eco-regulations than other firms. In the context of transition economies, there is some evidence that better pollution prevention strategies, generated by improved production processes neither improve nor undermine financial success in the Czech Republic (Earnhart and Lizal 2007).

Beyond the extensive literature that looks at the link between eco-strategies in general, without distinguishing what type of eco-innovation is being implemented, and firm performance, some researchers have recently started to claim that most of the empirical studies analysing the relationship between eco-innovation practices and firm competitiveness should go further, distinguishing between different types of eco-strategy, rather than just focusing on the question “whether it pays to be green” (Ghisetti and Rennings 2014; Riillo 2017).

Using a complementary approach on a German sample, Ghisetti and Rennings (2014) consider two typologies of eco-innovation: one aimed at reducing externalities and the other aimed at increasing energy and resource efficiency. Their econometric analysis, based on two waves of the Mannheim Innovation Panel, suggests that innovations leading to a reduction in the use of energy or materials per unit of output have a positive effect on firm competitiveness in terms of higher profits. However, innovations aimed at reducing externalities such as air, water, noise pollution, and harmful materials have the opposite effect. Using the same German data for 2009, Rexhäuser and Rammer, (2014) found similar results, as did Miroshnychenko et al. (2017) using over 3,000 publicly-traded firms across 58 countries.

Two other recent papers deal with the heterogeneity effect of eco-innovation strategies on firm performance. Doran and Ryan (2016), examining a sample of Irish firms, decomposed the eco-innovation variable into nine different types of eco-innovation practices, only two of which (reduced CO footprint and recycled waste, water or materials) were able to impact positively on firm performance in terms of turnover per employee. These findings suggest that the question as to whether it pays to be green should be reformulated and better qualified in terms of the typologies of eco-innovation orientation. Similarly Leeuwen and Mohnen (2016), using a Dutch dataset, investigated the full chain of causality from eco-regulatory stringency to environmental and firm performance. They found that only resource-saving eco-innovations (those that can be assimilated into process-integrated eco-innovations) have a positive effect on total factor productivity (TFP), whereas pollution-reducing or end-of-pipe eco-innovations tend to reduce it.[17]

In terms of firm growth, it is surprising that, despite the great importance of the current policy debate on green and sustainable growth in the European Union, the number of studies that examine the role of eco-innovation orientation in promoting firm growth is relatively small, especially when compared to the number of studies focusing on the growth effects of general innovations. Although technological innovations are generally recognised as contributing to firms' growth (for a review see Coad (2009)), the effects of eco-strategies are still little researched and unclear (Cainelli, Mazzanti, and Zoboli 2011; Colombelli, Krafft, and Quatraro 2015).

[17] The end-of-pipe (EPO) practices are devices added at the end of the production process which allow firms to comply with environmental requirements, without necessarily modifying the production process or altering firm resources and capabilities and are relatively easy to purchase and install. In contrast, cleaner production technologies reduce environmentally damaging impacts at the source (not at the pipe) by substituting or modifying less clean technologies (Frondel, Horbach, and Rennings 2007; Triguero, Moreno-Mondéjar, and Davia 2015). Cleaner technologies are often superior to end-of-pipe technologies (least efficient solutions) as they are preventive measures diminishing material inputs and decreasing levels of waste and are frequently introduced for economic reasons such as market share or cost reduction that may lead to economics benefits. Instead EOP technologies are reactive and introduced for motivations of compliance with eco-regulation and involve sunk costs and do not lead to an increase in the efficiency of the production process.

Cainelli et al. (2011) using the CIS sample of Italian firms, found a negative link between environmental motivations in general and growth in both employment and turnover in the short term. Colombelli et al. (2015), however, analysing a sample of over 400,000 firms located in Germany, France, Italy, Spain and Sweden during the period 2002-2011, showed that those oriented towards eco-innovation (identified on the basis of green patents) are characterized by higher growth rates than those carrying out only generic innovations.

On the basis of all this and with the aim of understanding and explaining the mixed results of the empirical research into the relationship between eco-strategies and firm performance across European countries, we formulate the following overarching research question: do eco-strategies have a positive link on firm performance? To help us arrive at an answer, we coherently test three hypotheses.

The first of these, following the existing literature mentioned above, looks at the different nature of eco-strategies and their effects on firm performance.

H1: The economic effects of eco-strategies on firm growth patterns are heterogeneous and conditioned by the type of eco-strategy considered.

The second is in line with more recent studies that suggest there is a need to investigate the intensity of eco-strategies rather than the fact of their adoption.[18] Antonioli and Mazzanti (2009), using a sample of Italian firms, showed that the level of eco-innovation investment plays a role in determining firms' productivity, whereas a non-significant effect is found it for the adoption. The negative or nonsignificant effect of the adoption might be explained by the fact that eco-strategies need time for their effects to be felt, or because a minimum level of intensity is needed to cause a change in production efficiency or demand before any return on these strategies can be reaped (Cainelli, Mazzanti, and Zoboli 2011). This leads us to the second hypothesis:

H2: The intensity of investments in eco-strategies triggers better firm performance.

[18] Nevertheless, eco-innovation intensity as a variable has scarcely been analysed since it is absent from most survey data (for instance, some waves of the CIS survey include an eco-module but do not deal with intensities).

As mentioned above, firms investing in eco-strategies have high risks and costs in the short term before they start to reap any benefit, because eco-strategies are characterized by a high level of uncertainty, novelty and the need to go beyond the firm's core competencies. These characteristics are especially important for SMEs, which face major difficulties in obtaining credit for their eco-investments compared to larger firms, which often have better access to equity and long-term loans (Ghisetti et al. 2016).

As known from general innovation theory, given the inherent risk of innovation, firms have the incentive to diversify or develop multiple external linkages and strategies in order to maximize their chances of success (Quintana-García and Benavides-Velasco 2008; Leiponen and Helfat 2010; Tavassoli and Karlsson 2016). However, diversification comes at a price. A firm needs additional training for its employees, new equipment, and time to integrate and assimilate new strategies.

The empirical results generally suggest that wider horizons as regards innovation objectives and knowledge sources are associated with better performance. However, studies into the effect of a greater breadth of eco-strategies on firm performance are still missing.

Using industry-level data from 12 OECD countries, Soltmann et al. (2015) showed that the general relationship between the number of green inventions and firm performance in terms of value added is U-shaped. They concluded that the turning point is quite high and consequently only relevant for a few industries. For most industries, therefore, an increasing stock of green inventions has a negative effect on firm performance. The same empirical evidence of a U-shaped relationship between environmental performance and profitability for firms in the manufacturing and service industries was recently provided by Trumpp and Guenther (2017).

Our third hypothesis is therefore:

H3: Firms with a greater breadth of eco-strategies experience better firm performance.

These three hypotheses are calibrated in the econometric work developed below. This analysis was only made possible because of our dataset containing the environmental patterns of European SMEs drawn from the information obtained from a survey of a large sample of SMEs located in EU28 member countries.

3. DATABASE AND DESCRIPTIVE STATISTICS

3.1 Database and country groups

The source of the data used in this study is the Flash Eurobarometer Survey 426 (FLE426) on *"Small and Medium Enterprises, Resources Efficiency and Green Markets, wave 3"*.[19] It is a survey conducted by TNS political & social[20] at the request of the European Commission between the 1 and 18 September 2015, and follows earlier Eurobarometers (FL342 in 2012 and FL381 in 2013)[21] in reviewing the current levels of resource efficiency actions and the state of the green market amongst SMEs. The database includes the 28 members States of the European Union, plus Albania, the Former Yugoslav Republic of Macedonia, Montenegro, Serbia, Turkey, Iceland, Moldova, Norway, and the US, and covers large companies and SMEs.

In FLE426 a total of 15,020 managers (13,114 from the EU28) were interviewed by telephone from the TNS e-Call centre.[22] Firms were selected from an international business database (with some additional sample from local sources in countries where necessary) using a stratification procedure along the dimensions of firm size (four categories: 1–9 employees, 10–49 employees, 50–249 employees, 250 employees or more) and sector (four categories: manufacturing, retail, services and industry). Therefore, the survey covers businesses employing at least one person in the manufacturing, retail activities, services, and industry sectors.[23]

---

[19] SME enterprises are defined as those with a staff headcount below 250. In addition to the staff headcount ceiling, an enterprise qualifies as an SME whether it meets either the turnover ceiling or the balance sheet ceiling, but not necessarily both. The full definition can be found at: http://ec.europa.eu/growth/smes/business-friendly-environment/sme-definition/index_en.htm

[20] TNS is an established organization in the area of international data collection and has been consistently responsible for conducting the Flash Eurobarometer surveys from September 2011 onward.

[21] Each Flash Eurobarometer is a cross-sectional survey and consequently is conducted with a completely new sample of firms. The data are, therefore not panel data and a merging of the data sets is not possible.

[22] It is important to stress that, as in any survey, the information gathered relies on the interpretation made by the manager answering the questions. Despite the subjective nature of many of the questions we believe that, on average, the information obtained via these questions is a good proxy for the general attitude of top management toward eco-issues.

[23] Quotas were applied on both company size and sectors. These quotas were adjusted according to the country's universe but were also reasoned in order to ensure that the sample size was large enough in every

One of the main advantages of the FLE426 is that it is an extensive survey that includes three dimensions: country, sector, and firm size. Most environmental empirical databases offer only aggregate information at the country level, so having three dimensions in the same database allows researchers many possible views and perspectives on the data. However, the main drawback is that it is a cross-sectional dataset, and so the problem of simultaneity is somewhat unavoidable. So far this has been a problem common to all studies that use Flash Eurobarometer datasets (Hoogendoorn, Guerra, and van der Zwan 2015; Marin, Marzucchi, and Zoboli 2015).

Due to the focus of our analysis (the relationship of eco-strategies to turnover growth in SMEs across the EU28) and the data cleaning procedure (discarding observations with missing values for the relevant variables), the final sample includes 11,336 firms. After the filtering process, we control for country differences by defining groups of countries that have roughly the same position in eco-innovation performance.

To examine the differences between EU countries in some depth, we also classify the EU28 countries into two clusters: the European Union-15 (EU15) and new members of EU (the group of recent member states that joined the EU from 2004 onwards). Internal differences in eco-performance in these two clusters are found to be important, especially for the new EU members, which operate further from their respective eco-technological frontiers (Davidescu et al. 2015; Horbach 2016; Beltrán-Esteve and Picazo-Tadeo 2017).

Table 2 gives an overview of the final sample. The EU15 group includes 6,104 firms and the new members group 5,232. The sample is dominated by the services and retail sectors, and by very small firms with one to nine employees in both country groups.

---

cell. An overview of the numbers of interviews in each country and names of the TNS institutes that are responsible for data collection is provided in the Annexes: Technical specifications of the following document of the European Commission (2015): Report Flash Eurobarometer 426 “SMEs, Resource Efficiency and Green Markets”.
http://ec.europa.eu/commfrontoffice/publicopinion/index.cfm/Survey/getSurveyDetail/instruments/FLASH/surveyKy/2088

Table 2
Distribution of the sample by clusters, sectors, and firm size

EU15 members			**New EU members**		
Country	**Firms**	**Percent**	**Country**	**Freq.**	**Percent**
FR - France	463	4.08	CY - Cyprus	184	1.62
BE - Belgium	407	3.59	CZ - Czech Republic	436	3.85
NE - The Netherlands	428	3.78	EE - Estonia	452	3.99
DE - Germany	358	3.16	HU - Hungary	423	3.73
IT - Italy	397	3.50	LV - Latvia	481	4.24
LU - Luxembourg	176	1.55	LT - Lithuania	466	4.11
DK - Denmark	413	3.64	MT - Malta	164	1.45
IE - Ireland	429	3.78	PL - Poland	456	4.02
GB - United Kingdom	375	3.31	SK - Slovakia	429	3.78
GR - Greece	452	3.99	SI - Slovenia	471	4.15
ES - Spain	441	3.89	BG - Bulgaria	411	3.63
PT - Portugal	461	4.07	RO - Romania	426	3.76
FI - Finland	452	3.99	HR - Croatia	433	3.82
SE - Sweden	457	4.03			
AT - Austria	395	3.48			
Total EU15	***6,104***	***53.85***	***Total new members***	***5,232***	***46.15***
Firms by sectors					
Manufacturing (NACE C)	1,274	20.87	Manufacturing	1,286	24.58
Retail (NACE G)	1,921	31.47	Retail	1,701	32.51
Services (NACE H/I/J/K/L/M/N)	2,134	34.96	Services	1,488	28.44
Industry (NACE B/D/E/F)	775	12.70	Industry	757	14.47
Firms by employees					
1 to 9	2,681	43.92	1 to 9	2,346	44.84
10 to 49	2,228	36.50	10 to 49	1,864	35.63
50 to 249	1,195	19.57	50 to 249	1,022	19.54

Source: Flash Eurobarometer Survey 426, European Commission.

3.2 Descriptive statistics

Table 3 displays the characteristics of the sample by country group. About 40% of the firms in the sample say that annual turnover increased over the previous two years while over 25% reported a decrease in their growth rate. When comparing established members against new EU members, SMEs in the first group are more likely to have increased their annual turnover (43% vs. 39%).

Most of the SMEs (86% of the sample) are taking action to become more resource efficient. This may be because the period under observation was one in which major policies were being implemented at EU and national levels (Europe 2020 strategy and subsequent roadmaps). The most common resource efficiency actions taken by the EU-28 are those aimed at saving energy (63%), minimising waste (57%), and saving materials

(56%). In contrast, SMEs are less likely to be taking actions to use predominantly renewable energy (13%). When we look at all the countries involved, firms are implementing on average of three eco-strategies to become more resource efficient. However, the country group analysis shows a slight degree of variation in the number of resource efficiency actions being taken by SMEs. Firms in the new member states that joined the EU from 2004 onwards are likely to implement fewer green practices than their counterparts.

Overall investment in resource efficiency actions is low, with almost 50% of SMEs that are taking action investing less than 1% of their turnover in this area in the previous two years, and 40% investing 1-5%. Only 10% invested more than 6% in eco-strategies. The small amounts of money assigned to resource efficiency practices may indicate that firms invest the minimum simply to comply with environmental legislation. Otherwise there are no great differences between country groups in the proportions they invest in eco-strategies, although new members still show less favourable investment indicators.

Among SMEs that have taken resource efficient actions, 58% rely on their own financial resources and 50% on their own technical expertise. Comparatively few firms rely on external support (18%). There are few differences between SMEs based on country groups, EU15 are more likely to receive external support to be more resource efficient than their counterpart (24% vs 12%). In contrast, the proportion of SMEs from new country members relying on their own financial resources is larger. [24]

In short, the values reflected in the two clusters of countries, together with the substantial significance of the t-test, suggest that the profile of SMEs from EU15 differs slightly from those in new member countries. The first group presents greater sensitivity to the undertaking of resource efficiency practices to be greener and invests slightly larger amounts of money in fostering them thanks to their own technical expertise and greater external finance.

[24] Unfortunately, our database only allows us to observe the existence of specific eco-strategies and the intensity of all strategies together (through categorical values on an interval scale), and are unable to capture each separate eco-strategy intensity.

Table 3
Descriptive statistics by country clusters (mean values)

	Total sample	**EU15 members**	**New members**	**Mean differences**
Dependent variable: Turnover growth (% firms)				
Decrease	0.2694	0.2622	0.2779	0.0156
	(0.4437)	(0.4399)	(0.4480)	(0.0083)
Remain	0.3167	0.3078	0.3272	0.0193***
	(0.4652)	(0.4616)	(0.4692)	(0.0087)
Increase	0.4137	0.4298	0.3948	-0.0350***
	(0.4925)	(0.4950)	(0.4888)	(0.0092)
Independent variables				
Resource efficiency eco-strategies (% firms)	0.8594	0.8969	0.8157	-0.0812***
	(0.3475)	(0.3040)	(0.3877)	(0.0065)
Water reduction	0.4408	0.4441	0.4369	-0.0072
	(0.4965)	(0.4969)	(0.4960)	(0.0093)
Energy reduction	0.6289	0.6584	0.5946	-0.0638***
	(0.4831)	(0.4742)	(0.4910)	(0.0090)
Predominant use of renewable energy	0.1293	0.1671	0.0852	-0.0818***
	(0.3355)	(0.3730)	(0.2792)	(0.0062)
Material reduction	0.5578	0.5865	0.5244	-0.0620***
	(0.4966)	(0.4925)	(0.4994)	(0.0093)
Waste reduction	0.5671	0.6317	0.4917	-0.1399***
	(0.4954)	(0.4823)	(0.4999)	(0.0092)
Sale of scrap to other firms	0.3071	0.3247	0.2866	-0.0380***
	(0.4613)	(0.4683)	(0.4522)	(0.0086)
Recycling	0.3782	0.4580	0.2851	-0.1728***
	(0.4849)	(0.4982)	(0.4515)	(0.0089)
Design of products that are easier to maintain,	0.2238	0.2644	0.1764	-0.0882***
repair, or reuse	(0.4168)	(0.4410)	(0.3812)	(0.0078)
Breadth of strategies (number of strategies)	3.2332	3.5350	2.8813	-0.6537***
	(2.1706)	(2.1431)	2.1484)	(0.0404)
Resource efficient investment (% firms)				
Less than 1% of turnover	0.4959	0.4792	0.5175	-0.0076
	(0.4522)	(0.4517)	(0.4528)	(0.0093)
1-5% of turnover	0.4008	0.4193	0.3769	-0.0423***
	(0.4900)	(0.4934)	(0.4846)	(0.0999)
6-10% of turnover	0.0696	0.0697	0.0695	-0.0001
	(0.2546)	(0.2547)	(0.2544)	(0.00519)
11-30% of turnover	0.0238	0.0233	0.0243	0.0009
	(0.1524)	(0.1511)	(0.1542)	(0.0031)
More than 30% of turnover	0.0096	0.0082	0.0114	0.0032
	(0.0977)	(0.0902)	(0.1065)	(0.0019)
Control variables				
Size (% firms)				
1-9 employees	0.4434	0.4392	0.4483	0.0091
	(0.4968)	(0.4963)	(0.4973)	(0.0093)
10-49 employees	0.3609	0.3650	0.3562	-0.00873
	(0.4803)	(0.4814)	(0.4789)	(0.0090)
50-249 employees	0.1955	0.1957	0.1953	-0.0004
	(0.3966)	(0.3968)	(0.3964)	(0.0074)
Young	0.0926	0.0817	0.1047	0.0229***
	(0.2895)	(0.2740)	(0.3062)	(0.0054)
Own technical expertise	0.4972	0.5160	0.4753	-0.0407***
	(0.5000)	(0.4997)	(0.4994)	(0.0094)
Own finance	0.5832	0.5647	0.6049	0.0402***
	(0.4930)	(0.4958)	(0.4889)	(0.0092)
External finance	0.1826	0.2362	0.1202	-0.1160***
	(0.3864)	(0.4248)	(0.3252)	(0.0071)
Greenness priority	0.3517	0.3668	0.3340	-0.0321***

	(0.4775)	(0.4819)	(0.4717)	(0.0089)
Business opportunity	0.2027	0.2239	0.1779	-0.0460***
	(0.4020)	(0.4169)	(0.3825)	(0.0075)
Sector dummies (% firms)				
Manufacturing	0.2258	0.2087	0.2457	0.0370***
	(0.4181)	(0.4064)	(0.4305)	(0.0078)
Retail	0.3195	0.3147	0.3251	0.1043
	(0.4663)	(0.4644)	(0.4684)	(0.0087)
Services	0.3195	0.3496	0.2844	-0.0652***
	(0.4663)	(0.4768)	(0.4511)	(0.0087)
Industry	0.1351	0.1269	0.1446	0.0177
	(0.3418)	(0.3329)	(0.3518)	(0.0064)
Observations	11,336	6,104	5,232	

Note: Standard deviation in brackets. Comparison of the two samples by the statistical t-test. *** Significant at 1%.
Source: Flash Eurobarometer Survey 426, European Commission.

4. EMPIRICAL STRATEGY

We estimate an ordered logit model, where we compare the impact of the various eco-innovation strategies on different exclusive categories of turnover growth: increased, unchanged and decreased (which is the base case).[25] The models for ordinal outcomes can be described in terms of a latent variable. The structural model is:

$$y^*_{i,c} = X_{i,c}\beta + \varepsilon_i \qquad \text{Eq.[1]}$$

where $y^*_{i,c}$ is the latent variable (annual turnover growth of firm i in country *c*), X, is a vector of explanatory and control variables and ε_i is the idiosyncratic error term. The latent variable can be divided into *M* ordinal categories, so the observed variable is:

$$y_{i,c} = j \text{ if } \alpha_j < y^*_{i,c} \leq \alpha_{j+1}, \text{ for } j = 1 \text{ } to \text{ } M$$

and the probabilities of observing $y^*_{i,c} = j$ are given by:

$$P(y_{i,c} = j|X_{i,c}) = F(\alpha_{j+1} - X_{i,c}\beta) - F(\alpha_j - X_{i,c}\beta)$$

where *F* denotes the logistic cumulative distribution function. The three categories for our growth variable $y^*$are: decreased (*j* = 1), unchanged (*j* = 2) and increased (*j* = 3).

To test our first hypothesis, we include a dummy variable indicating whether or not a firm is undertaking any eco-strategy to be more resource efficient (Eq. [2]). Then, following the argument that a distinction needs to be made between different typologies of eco-strategy to assess the effects of those innovations on firm growth, we specified Eq. [3]. Based on the question ‘‘What actions is your company undertaking to be more resource efficient?”, in Eq. [3] we include a vector of eight different types of eco-strategy: water reduction, energy reduction, using renewable energy, saving materials, minimizing waste,

[25] It is a limitation of our dependent variable that we do not have continuous data and therefore cannot use classic linear models.

selling scrap material to another company, recycling, and designing products that are easier to maintain, repair or use. To examine whether the intensity is more important than the adoption, we then introduce a dummy variable into Eq. [4] to account for the intensity of the eco-strategy investment.[26] This variable takes the value one whether the firm spends more than five percent of its yearly turnover on measures to improve resource efficiency.

$$Growth_{i,c} = eco - strategy_{i,c}\beta_1 + CL_{i,c}\beta_2 + \delta sector_{i,c} + \rho country_i + \varepsilon_i \qquad \text{Eq.[2]}$$

$$\begin{aligned} Growth_{i,c} = {} & water\ reduction_{i,c}\beta_1 + energy\ reduction_{i,c}\beta_2 + renewable\ energy_{i,c}\beta_3 \\ & + material\ reduction_{i,c}\beta_4 + waste\ reduction_{i,c}\beta_5 \\ & + selling\ scrap_{i,c}\beta_6 + recyling_{i,c}\beta_7 + product\ design_{i,c}\beta_8 + CL_{i,c}\beta_9 \\ & + \delta sector_{i,c} + \rho country_i + \varepsilon_i \end{aligned} \qquad \text{Eq.[3]}$$

$$Growth_{i,c} = high\_invesment_{i,c}\beta_1 + CL_{i,c}\beta_2 + \delta sector_{i,c} + \rho country_i + \varepsilon_i \qquad \text{Eq.[4]}$$

Moving on to the empirical test if breadth of eco-strategies is associated with positive firm performance, we estimate the models in Equations [5] - [6]. First, we introduce the breadth variable that refers to the number of eco-strategies implemented by each firm. Then, to identify any nonlinear relationship, if any, we also introduce the quadratic form of breadth.

$$Growth_{i,c} = breadth_{i,c}\beta_1 + CL_{i,c}\beta_2 + \delta sector_{i,c} + \rho country_i + \varepsilon_i \qquad \text{Eq.[5]}$$

$$Growth_{i,c} = breadth_{i,c}\beta_1 + breadth^2_{i,c}\beta_2 + CL_{i,c}\beta_3 + \delta sector_{i,c} + \rho country_i + \varepsilon_i \qquad \text{Eq.[6]}$$

To minimise any estimation bias due to an omitted variable, we have included in all the equations a series of control variables in line with previous work on the determinants of firm growth (for a review, see Coad (2009)), as well as being restricted by the variables available to us in our dataset. As regards the set of control variables (*CL*), to take into account relevant observable firm-level characteristics, we introduce the following variables: firm size –micro (*1-9 employees*), small (*10–49 employees*) and medium sized (*50–249 employees*) – age (*young*), the role of technological and management capabilities

[26] Unfortunately, we do not have continuous data for investment intensity. These data are collected through categorical values that are self-reported by firms on an interval scale. The questionnaire asks firms how much they invested to become more resource efficient in general, and so, the intensity is not available for each separate eco-strategy.

within the firm (*own technical expertise*) and, the importance of internal and external financial support respectively in implementing resource efficiency activities *(own finance and external finance).*

Then, as the different eco-strategy variables can be correlated with unobserved firm specific heterogeneity, we also control for firms' attitudes towards the environment. For instance, positive performance effects due to higher resource efficiency strategies could be a result of better management, especially eco-management. To prevent any potential omitted variable bias, we include two dummy variables that take into account the influence of firm eco-orientation by considering whether the environment is one of the top priorities *(greenness priority)* and whether the firm is aiming to create a competitive advantage or business opportunity by taking actions to be more resource efficient *(business opportunity)*. Finally, we include sector dummies (manufacturing, retail, services and industry), and country dummies.[27]

Due to the non-linear form of the ordered logit estimation the size of the coefficients should not be directly interpreted. The focus should be on the sign and significance of the estimates. Clustered standard errors by country are reported to avoid an underestimation of standard errors due to intra-group error correlation.

Before turning to the regression results, we first address potential concerns about the presence of multicollinearity. Table A.2 shows the correlations between the independent and control variables. The correlation coefficients and variance inflation factors raise no concerns regarding multicollinearity. The results of a collinearity diagnostic test on the regression models show that the mean variance inflation factor (VIF) values range between 2.41 and 3.10 (well below 10), thus, confirming the absence of multicollinearity problems in the dataset. The only noteworthy correlation is between the eight eco-strategies and breadth (from 0.37 to 0.70), which will be included in separate model specifications later on.

---

[27] Appendix 1 summarizes the list of variables and their definition, Appendix 2 shows the correlation matrix.

5. RESULTS

The results of the ordered logit model for the whole database and for both country groups considered in this study are displayed in Tables 4-6.[28] Five specifications have been estimated. Specification I shows the results when the eco-strategy variable makes no distinction between the nature of the eco-strategies. Specification II decomposes the eco-strategy variable into eight different resource-efficiency practices according to the Flash Eurobarometer Survey 426. Specification III considers the intensity of those eco-strategies. Finally, specifications IV and V incorporate the breadth of the eco-strategies and the quadratic form of breadth respectively to test whether firms with a greater breadth of eco-strategies experience better firm performance.

We find for all the countries involved that undertaking of an eco-strategy in general to be more resource efficient is associated with reduced growth in terms of turnover. When we split the sample by clusters, the eco-strategy coefficient remains negative, but is non-significant. At first sight our main finding would be the negative relationship between eco-innovation strategies and firm growth, meaning that it does not pay to be green. However, going a step further and distinguishing between different types of eco-strategy, we instead find clear confirmation that not all measures to improve resource efficiency have the same effect on growth, and therefore it would be best to decompose them.

Of the eight types of eco-strategy considered, only three have a significantly positive effect on firm performance. Using predominantly renewable energy (e.g. including own production through solar panels, etc.), recycling by reusing material or waste within the company, and designing products that are easier to maintain, repair, or reuse are eco-strategies that relate to positive firms' growth. However, firms that aim to reduce water or energy use experience a negative and strongly significant effect on firms' growth. The other eco-strategies under consideration show no significant effect on firm growth. In line with previous literature, this suggests that the effect of eco-strategies on firm performance varies depending on the specific sub-type of resource efficient strategy considered (Ghisetti and Rennings 2014; Doran and Ryan 2016). In general, these results suggest

[28] We must stress that the cross-sectional nature of the dataset we are using constitutes a limitation to the scope of the present analysis and only allows us to comment on correlations between variables rather than proper causations. In addition, the formulation of some questions does not allow an exact time structure to be identified.

that there is a need to consider the relationships of different eco-strategies in detail, since their effects on firm performance and especially firm growth are heterogeneous.

Regarding the two country groups, the results for EU15 show that firms that undertake an energy reduction eco-strategy see a decrease in firm performance, whereas two resource efficiency practices – the use of renewable energies and the design of products that are easier to maintain, repair or reuse – seem to play a more important role in firm growth. As for the new member group, only one of the eight eco-strategies – the predominant use of renewable energy– exerts a positive and strongly significant effect on firms' growth. In addition, firms in these countries that implement water and energy reduction activities show the worst performance.

Other reasons for the negative relationship between eco-strategy in general and firm performance may be that firms might find it difficult to reap the returns on these resource-efficiency practices since they need time before they exert their full effects, or that the intensity of the strategies (which we do not observe in specifications I and II) is not sufficiently high to modify the production process or stimulate demand through environmental innovation dynamics. Regarding the latter, when we include investment in eco-strategies (specification III), it seems that greater investment in resource efficiency strategies triggers an improvement in overall firm performance. However, only a few firms in the sample invest intensely in eco-strategies and turn them out to be profitable in terms of firm growth. In contrast, when we split the analysis into EU15 and new members, the large amounts of money spent on resource efficiency strategies are only positive and significant for countries that have recently been incorporated into the EU project.

Regarding our third hypothesis, specifications IV and V examine the link between breadth of eco-strategies and firm performance. When breadth is introduced in specification IV a negative relationship is found, although this relationship is not significant. In specification V, however, when we also incorporate the quadratic term, the breadth variable becomes negative and significant and the quadratic term positive and significant, which suggests that the wider array of eco-strategies influences firm performance more than proportionality. The relationship between firm growth and eco-strategies is U-shaped, in line with the findings of Soltmann et al. (2015) using industry-level data. This implies that when the number of eco-strategies undertaken is low, this has a negative impact on firm performance. Conversely, when the number of eco-strategies is high, this triggers firm growth (see Appendix 3). However, again only a few firms in the sample undertake a large number of eco-strategies. These results are still robust when we split the sample into our two clusters of countries – the breadth variables and their quadratic forms have the same sign but are not significant.

As for the effects of control the variables employed in our econometric specification, the results reveal that firms that value either the environment as a core priority activity or resource efficient practices as a means of creating a competitive advantage show better firm performance. In particular we note that SMEs in the EU15 group rely more heavily on better eco-management than countries that have more recently joined the EU. In addition, having good own technical capabilities and expertise, and good access to financial resources (both internal and external) significantly helps European SMEs to improve their firm performance. Our results clearly confirm the conjecture that firm growth is different across country groups. External finance significantly increases firm growth in new member states, although, this variable seems not to be relevant for long-standing members of the EU. Own technical expertise and own financial resources also show a significant positive influence on growth in the EU15 countries. These results are in line with Hölzl (2009), finding that technological capabilities seem to be more important in high-growth SMEs in countries that are closer to the technological frontier.

As far as firm characteristics are concerned, age and size are found to be important determinants of a firm’s growth, with a large body of evidence showing that younger and smaller firms are more dynamic and thus more effective in spurring growth (Coad 2009; Navaretti, Castellani, and Pieri 2014). Regarding age, our results are in line with the previous literature, with young firms seeming to perform better. Firm size, meanwhile, is positively correlated to firm performance in both country groups in our sample.

Finally, the explanatory variables used in the ordered logit estimation confirm that sector and country factors have an impact on firm growth. Using the Wald test, we also examined the joint significance of the country dummies for the whole sample. The p-value of this test, which is equal to 0.000, allows us to reject the null hypothesis that the coefficients are jointly equal to 0. Indeed, this test shows the relevance of country specificities. Moreover, we obtain this result for all the specifications adopted in the paper.

Table 4
Ordered logit regression: whole sample

	(I)	(II)	(III)	(IV)	(V)
Eco-strategy	-0.171*				
	(0.0803)				
Types					
Water reduction		-0.171**			
		(0.0545)			
Energy reduction		-0.198***			
		(0.0484)			
Predominant use of renewable energy		0.221***			
		(0.0440)			
Material reduction		0.0155			
		(0.0468)			
Waste reduction		0.0228			
		(0.0410)			
Sale of scrap to other firms		-0.0108			
		(0.0525)			
Recycling		0.0810*			
		(0.0321)			
Design of products that are easier to maintain, repair, or reuse		0.148***			
		(0.0334)			
High investment			0.194**		
			(0.0680)		
Breadth				-0.0133	-0.116*
				(0.0150)	(0.0480)
Breadth^2					0.0143*
					(0.0057)
Control variables					
Size: ref. size 1_9					
size_10_49	0.525***	0.532***	0.522***	0.524***	0.525***
	(0.0444)	(0.0416)	(0.0440)	(0.0445)	(0.0440)
size_50_249	0.872***	0.887***	0.872***	0.874***	0.870***
	(0.0594)	(0.0574)	(0.0587)	(0.0601)	(0.0590)
Young	0.965***	0.962***	0.967***	0.965***	0.964***
	(0.0658)	(0.0673)	(0.0654)	(0.0662)	(0.0662)
Own technical expertise	0.0866*	0.0717*	0.0464	0.0645	0.0899*
	(0.0361)	(0.0320)	(0.0326)	(0.0333)	(0.0355)
Own finance	0.139**	0.135***	0.0824*	0.104**	0.146***
	(0.0439)	(0.0366)	(0.0375)	(0.0366)	(0.0429)
External finance	0.205***	0.198***	0.171**	0.192***	0.207***
	(0.0556)	(0.0574)	(0.0537)	(0.0582)	(0.0591)
Greenness priority	0.148***	0.146***	0.126***	0.141***	0.156***
	(0.0337)	(0.0354)	(0.0323)	(0.0362)	(0.0371)
Business opportunity	0.218***	0.199***	0.199***	0.213***	0.223***
	(0.0432)	(0.0468)	(0.0420)	(0.0453)	(0.0470)
Sector: ref. Industry					
Manufacturing	0.161*	0.178**	0.161*	0.163*	0.163*
	(0.0679)	(0.0686)	(0.0675)	(0.0683)	(0.0684)
Retail	0.192**	0.236***	0.202***	0.192**	0.194**
	(0.0605)	(0.0609)	(0.0605)	(0.0608)	(0.0603)
Services	0.300***	0.343***	0.308***	0.303***	0.304***
	(0.0651)	(0.0645)	(0.0652)	(0.0654)	(0.0655)
Constant cut1	-0.0982	-0.0524	-0.00637	-0.0301	-0.105
	(0.0845)	(0.0804)	(0.0799)	(0.0813)	(0.0861)
Constant cut2	1.355***	1.408***	1.447***	1.423***	1.349***
	(0.0801)	(0.0795)	(0.0813)	(0.0819)	(0.0829)
Wald test country dummies	10478***	20840***	8894***	9222***	9454***
Pseudo R^2	0.0447	0.0475	0.0449	0.0446	0.0445
Observations			11,336		

Clustered standard errors by country (28 clusters). *, ** and *** correspond to significance levels of 1%, 5% and 10%, respectively. Dependent variable: annual turnover growth (1) Decreased; (2) Remained unchanged, (3) Increased.

Table 5
Ordered logit regression: EU15 members

	(I)	(II)	(III)	(IV)	(V)
Eco-strategy	-0.158				
	(0.110)				
Types					
Water reduction		-0.0968			
		(0.0737)			
Energy reduction		-0.152**			
		(0.0537)			
Predominant use of renewable energy		0.166**			
		(0.0520)			
Material reduction		0.0177			
		(0.0583)			
Waste reduction		0.0349			
		(0.0529)			
Sale of scrap to other firms		-0.0162			
		(0.0734)			
Recycling		0.0908			
		(0.0500)			
Design of products that are easier to maintain, repair,		0.170***			
or reuse		(0.0341)	0.100		
High investment			(0.0956)		
				0.0095	-0.0905
Breadth				(0.0121)	(0.0611)
					0.0137
Breadth^2					(0.0078)
					(0.0057)
Control variables					
Size: ref. size 1_9					
size_10_49	0.546***	0.549***	0.546***	0.542***	0.543***
	(0.0655)	(0.0612)	(0.0654)	(0.0653)	(0.0649)
size_50_249	0.774***	0.783***	0.774***	0.770***	0.765***
	(0.0899)	(0.0824)	(0.0900)	(0.0900)	(0.0883)
Young	1.032***	1.037***	1.032***	1.033***	1.034***
	(0.0910)	(0.0921)	(0.0906)	(0.0901)	(0.0909)
Own technical expertise	0.134*	0.0960*	0.104*	0.0989	0.121*
	(0.0549)	(0.0478)	(0.0463)	(0.0506)	(0.0547)
Own finance	0.149*	0.124*	0.113*	0.107	0.137*
	(0.0624)	(0.0573)	(0.0543)	(0.0567)	(0.0648)
External finance	0.129	0.106	0.104	0.100	0.114
	(0.0690)	(0.0662)	(0.0682)	(0.0680)	(0.0688)
Greenness priority	0.184***	0.159***	0.166***	0.158***	0.168***
	(0.0336)	(0.0324)	(0.0342)	(0.0327)	(0.0327)
Business opportunity	0.207***	0.174**	0.192**	0.188**	0.198**
	(0.0602)	(0.0635)	(0.0588)	(0.0608)	(0.0623)
Sector: ref. Industry					
Manufacturing	0.148	0.154	0.149	0.146	0.147
	(0.101)	(0.0991)	(0.101)	(0.101)	(0.102)
Retail	0.240**	0.273***	0.247**	0.244**	0.250**
	(0.0785)	(0.0804)	(0.0792)	(0.0793)	(0.0780)
Services	0.362***	0.397***	0.370***	0.373***	0.376***
	(0.0818)	(0.0821)	(0.0806)	(0.0827)	(0.0817)
Constant cut1	-0.509***	-0.390***	-0.404***	-0.391***	-0.481***
	(0.126)	(0.114)	(0.115)	(0.114)	(0.113)
Constant cut2	0.922***	1.046***	1.027***	1.040***	0.950***
	(0.105)	(0.108)	(0.106)	(0.105)	(0.101)
Wald test country dummies	41910***	33690***	1.4e+05***	1.0e+05***	24925.20***
Pseudo R^2	0.0486	0.0504	0.0485	0.0484	0.0489
Observations			6,104		

Clustered standard errors by country (15 clusters). *, ** and *** correspond to significance levels of 1%, 5% and 10%, respectively. Dependent variable: annual turnover growth (1) Decreased; (2) Remained unchanged, (3) Increased.

Table 6
Ordered logit regression: new EU members

	(I)	(II)	(III)	(IV)	(V)
Eco-strategy	-0.170				
	(0.117)				
Types					
Water reduction		-0.271***			
		(0.0744)			
Energy reduction		-0.236**			
		(0.0799)			
Predominant use of renewable energy		0.323***			
		(0.0763)			
Material reduction		0.0111			
		(0.0777)			
Waste reduction		0.00940			
		(0.0614)			
Sale of scrap to other firms		-0.00211			
		(0.0789)			
Recycling		0.0501			
		(0.0378)			
Design of products that are easier to maintain, repair, or reuse		0.110			
		(0.0680)			
High investment			0.305**		
			(0.0929)		
Breadth				-0.0433	-0.140*
				(0.0292)	(0.0708)
Breadth^2					0.0136
					(0.0079)
Control variables					
Size: ref. size 1_9					
size_10_49	0.499***	0.514***	0.491***	0.507***	0.507***
	(0.0620)	(0.0557)	(0.0598)	(0.0625)	(0.0613)
size_50_249	0.968***	0.997***	0.968***	0.991***	0.986***
	(0.0726)	(0.0752)	(0.0705)	(0.0735)	(0.0718)
Young	0.911***	0.898***	0.916***	0.912***	0.910***
	(0.0860)	(0.0892)	(0.0846)	(0.0884)	(0.0876)
Own technical expertise	0.0307	0.0495	-0.0171	0.0300	0.0566
	(0.0386)	(0.0415)	(0.0416)	(0.0412)	(0.0394)
Own finance	0.125*	0.163***	0.0471	0.117**	0.166***
	(0.0581)	(0.0418)	(0.0488)	(0.0443)	(0.0473)
External finance	0.358***	0.381***	0.314***	0.367***	0.383***
	(0.0827)	(0.0874)	(0.0758)	(0.0901)	(0.0927)
Greenness priority	0.0975	0.124	0.0752	0.116	0.133
	(0.0599)	(0.0678)	(0.0536)	(0.0691)	(0.0726)
Business opportunity	0.232***	0.235**	0.208***	0.250***	0.258***
	(0.0613)	(0.0729)	(0.0597)	(0.0713)	(0.0737)
Sector: ref. Industry					
Manufacturing	0.499***	0.514***	0.491***	0.507***	0.507***
	(0.0620)	(0.0557)	(0.0598)	(0.0625)	(0.0613)
Retail	0.968***	0.997***	0.968***	0.991***	0.986***
	(0.0726)	(0.0752)	(0.0705)	(0.0735)	(0.0718)
Services	0.911***	0.898***	0.916***	0.912***	0.910***
	(0.0860)	(0.0892)	(0.0846)	(0.0884)	(0.0876)
Constant cut1	-0.202	-0.159	-0.125	-0.174	-0.229
	(0.107)	(0.0924)	(0.0958)	(0.0935)	(0.117)
Constant cut2	1.281***	1.335***	1.359***	1.309***	1.255***
	(0.113)	(0.102)	(0.112)	(0.107)	(0.119)
Wald test country dummies	3656***	35196***	5345***	9303***	9685***
Pseudo R^2	0.0409	0.0457	0.0415	0.0413	0.0417
Observations			5,232		

Clustered standard errors by country (13 clusters). *, ** and *** correspond to significance levels of 1%, 5% and 10%, respectively. Dependent variable: annual turnover growth (1) Decreased; (2) Remained unchanged, (3) Increased.

Table 7
Summary of the above discussion

Hypothesis	Variables within the econometric analysis	Results		
		Whole sample	**EU 15 members**	**New EU members**
H1: The economic effects of eco-strategies on firm growth patterns are heterogeneous and conditioned by the type of eco-strategy considered.	Eco-strategy	-	0	0
	Water reduction	--	0	---
	Energy reduction	---	--	--
	Renewable energy	+++	++	+++
	Material reduction	0	0	0
	Waste reduction	0	0	0
	Sale of scrap	0	0	0
	Recycling	+	0	0
	Product design	+++	+++	0
H2: The intensity of investments in eco-strategies triggers better firm performance.	High investment	+++	0	++
H3: Firms with a greater breadth of eco-strategies experience better firm.	Breadth	-	0	-
	Breadth^2	+	0	0

The table extracts the result of Table 4–6 in terms of significance and sign for the relationship of eco-strategies and firm performance in terms of sales growth. +++, ++, + indicate positive significance on a 1%, 5% and 10% level, respectively. ---, --, - indicate negative significance on a 1%, 5% and 10% level, respectively, 0 means no significant effect.

5.1 Additional analyses and robustness check

In this section, the robustness of the ordered logit model (OLM) estimates is tested. A critical assumption of the OLM is that it requires the distance between each category to be equivalent (proportional odds assumption). It also requires the number of categories not be too large and for there to be sufficient variation in each category. Since an ordinal dependent model might violate the proportionality assumption, the estimation requires models that avoid the assumption of equality in the distance between categories (Long and Freese 2006). To test whether this assumption is violated in our sample we used the Brant test (Brant 1990) in each model specification. Unsurprisingly, the test shows that our models violate the parallel-lines assumption, partly due to the inclusion of the many country dummy variables. If we focus on our independent and control variables, there are few occasions when the parallel regression assumption is violated. The test statistics indicate that the assumption is violated for the following variables: business opportunity, size (50-249 employees), and manufacturing and retail sectors.[29]

[29] See Appendix 4 for further details.

Therefore, as a robustness check for the ordered logit model and as the literature suggests we provide additional estimates. First, we dichotomize the outcome variable (increased v. unchanged or decreased firm growth) and use a binary logistics regression. We, then also report a model that does not assume proportionality (generalized ordered logit model).[30]

In essence the results from both models, the logit and the generalized ordered, convey the same story. Not all eco-strategies have the same impact on firm growth across SMEs in the EU28, and the intensity and breadth of the eco-strategies are relevant regarding firm growth.[31] In short, we can rely on the results from the standard ordered logit model as presented above.

In addition, to test the robustness of the estimations we perform two more regressions.[32] First, we run an ordered probit only for manufacturing firms given their innovation potential and environmental pressure. Second, because of the heterogeneity of the EU15 country group, we split the cluster into core countries and Mediterranean countries in order to better understand the differences between the two. The results are in accordance with the current results displayed above.

6. CONCLUSIONS

The aim of this chapter was to shed light on how eco-innovation strategies impact on SME growth across European countries. Previous empirical studies on the relationship between eco-strategies and firm performance have often been based on relatively small samples and are usually confined to a single country. Our study expands this stream of research by using an extensive dataset covering a large sample of SMEs in 28 European countries. In addition, we classify the EU28 countries into two clusters. This distinction between EU15 and new EU members (the group of states that joined from 2004 onwards) allows us to better understand the differences between the two groups of countries.

---

[30] The generalized ordered logit model is less restrictive than the ordered logit model, which assumes proportional odds among the categories of the dependent variable, but is still more parsimonious and interpretable than non-ordinal methods, such as multinomial logistic regression. See Appendix 4. Methodology and robustness check results for further details.

[31] See Table A.4.2 and A.4.3 for further details.

[32] See Table A.4.4, A.4.5 and A.4.6 for further details.

Through the application of an ordered logistic model our empirical results suggest that there is a need to distinguish between different eco-strategies and, in line with previous literature, draw attention to the fact that the correct question is not whether ‘it pays to be eco’, but rather ‘when’ and ‘for whom’ it pays to be eco. Firm growth varies greatly according to eco-strategies, and thus, not all eco-strategies are positively related to better performance, at least not in the short term. It would appear that in a European SME context, certain measures in eco-strategies can result in a win-win situation for both the firm and society, while others result in a better environmental situation at the expense of firm performance in terms of growth. In particular we find that European firms using renewable energies perform better. Undertaking eco-strategies aimed at recycling or designing products that are easier to maintain, repair or reuse also increases firm growth in EU15. However, those firms that aim to reduce water or energy pollution seem to show a negative correlation with firm growth. Consequently, our results also shed light on the idea that the analysis and classification of different types of eco-strategies does matter.

Furthermore, our results indicate that higher investment in eco-strategies improves firm growth, particularly in the new member states that joined the EU from 2004 onwards. In other words, it seems important to be eco-efficient, but it must also happen in a big way. Finally, we observe a U-shaped relationship between eco-strategies and firm growth, meaning that a greater breadth of eco-strategies is associated with better firm performance. However, few SMEs are able to either invest large amounts or undertake large numbers of eco-strategies.

At the same time, we also observe that the conjecture of firm growth is different across country groups. Valuing the environment as a core activity of the firm is more important for EU15 members, whereas new EU members seem to rely more on external finance for growth.

To sum up, our empirical evidence suggests both a negative and a positive relationship between eco-strategies and firm performance that depends, on the one hand, on the types of eco-strategy, and on the other, on the level and intensity of those eco-strategies. Hence the association between eco-strategies and firm performance may be more complex than simply positive, negative or neutral. This would suggest that the theoretical framework should encompass, at the same time, both perspectives: a positive and negative relationship between eco-strategies and firm performance.

In terms of implications, we find that most European SMEs do undertake eco-strategies but at a low investment intensity. Since the impact of eco-strategies is negative when investment intensity is not taken into account, this suggests that there is room for policy interventions aimed at raising awareness among SMEs of the advantages of making a minimum level of investment in eco-strategies. The eco-strategies whereby European firms add value vary slightly across different countries. Policy-makers should therefore consider the economic and technological specifications of each group of EU countries so as to choose the best possible instruments for increasing investments in eco-strategies. Furthermore, a greater breadth of eco-strategies is associated with better firm performance, and therefore managers should evaluate not only the benefit of each particular eco-strategy, but also the possible synergies and interactions between different strategies.

REFERENCES

Albertini, E. (2013). Does Environmental Management Improve Financial Performance? A Meta-Analytical Review. *Organization & Environment*, *26*(4), 431–457. doi:10.1177/1086026613510301

Ambec, S., Cohen, M. A., Elgie, S., & Lanoie, P. (2013). The Porter Hypothesis at 20: Can Environmental Regulation Enhance Innovation and Competitiveness? *Review of Environmental Economics and Policy*, *7*(1), 2–22. doi:10.1093/reep/res016

Ambec, S., & Lanoie, P. (2008). Does it pay to be green? A systematic overview. *Academy of Management Perspectives*, *22*(4), 45–62. doi: 10.5465/AMP.2008.35590353

Antonioli, D., Borghesi, S., & Mazzanti, M. (2016). Are regional systems greening the economy? Local spillovers, green innovations and firms' economic performances. *Economics of Innovation and New Technology*, *25*(7), 692–713. doi:10.1080/10438599.2015.1127557

Aragón-Correa, J. A., Hurtado-Torres, N., Sharma, S., & García-Morales, V. J. (2008). Environmental strategy and performance in small firms: A resource-based perspective. *Journal of Environmental Management*, *86*(1), 88–103. doi:10.1016/j.jenvman.2006.11.022

Barbieri, N., Ghisetti, C., Gilli, M., Marin, G., & Nicolli, F. (2016). A Survey of the Literature on Environmental Innovation Based on Main Path Analysis. *Journal of Economic Surveys*, *30*(3), 596–623. doi:10.1111/joes.12149

Beltrán-Esteve, M., & Picazo-Tadeo, A. J. (2017). Assessing environmental performance in the European Union: Eco-innovation versus catching-up. *Energy Policy*, *104*(February), 240–252. doi:10.1016/j.enpol.2017.01.054

Bossle, M. B., Dutra de Barcellos, M., Vieira, L. M., & Sauvée, L. (2016). The drivers for adoption of eco-innovation. *Journal of Cleaner Production*, *113*, 861–872. doi:10.1016/j.jclepro.2015.11.033

Brant, R. (1990). Assessing Proportionality in the Proportional Odds Model for Ordinal Logistic Regression. *Biometrics*, *46*(4), 1171–1178.

Cainelli, G., De Marchi, V., & Grandinetti, R. (2015). Does the development of environmental innovation require different resources? Evidence from Spanish manufacturing firms. *Journal of Cleaner Production*, *94*, 211–220. doi:10.1016/j.jclepro.2015.02.008

Cainelli, G., Mazzanti, M., & Zoboli, R. (2011). Environmentally oriented innovative strategies and firm performance in services. Micro-evidence from Italy. *International Review of Applied Economics*, *25*(1), 61–85. doi:10.1080/02692170903426146

Carrillo-Hermosilla, J., Del Río, P., & Könnölä, T. (2009). *Eco-Innovation. When Sustainability and Competitiveness Shake Hands*. London: Palgrave Macmillan. doi:10.1057/9780230244856

Coad, A. (2009). *The Growth of Firms: a Survey of Theories and Empirical Evidence*. Cheltenham, UK: Edward Elgar.

Cohen, M. A., & Tubb, A. (2017). *The Impact of Environmental Regulation on Firm and Country Competitiveness: A Meta-Analysis of the Porter Hypothesis*. doi:http://dx.doi.org/10.2139/ssrn.2692919

Colombelli, A., Krafft, J., & Quatraro, F. (2015). *Eco-innovation and firm growth: Do green gazelles run faster? Microeconometric evidence from a sample of European firms*. *GREDED Working paper Series* (Vol. 12).

Crepon, B., Duguet, E., & Mairesse, J. (1998). Research, Innovation And Productivity: An Econometric Analysis At The Firm Level. *Economics of Innovation and New Technology*, *7*(2), 115–158. doi:10.1080/10438599800000031

Cuerva, M. C., Triguero, Á., & Córcoles, D. (2014). Drivers of green and non-green innovation: empirical evidence in Low-Tech SMEs. *Journal of Cleaner Production*, *68*, 104–113. doi:10.1016/j.jclepro.2013.10.049

Davidescu, A. A. M., Vass Paul, A. M., Gogonea, R. M., & Zaharia, M. (2015).

Evaluating Romanian eco-innovation performances in European context. *Sustainability*, *7*(9), 12723–12757. doi:10.3390/su70912723

De Marchi, V. (2012). Environmental innovation and R&D cooperation: Empirical evidence from Spanish manufacturing firms. *Research Policy*, *41*(3), 614–623. doi:10.1016/j.respol.2011.10.002

Del Río, P., Peñasco, C., & Romero-Jordán, D. (2015). Distinctive Features of Environmental Innovators: An Econometric Analysis. *Business Strategy and the Environment*, *24*(6), 361–385. doi:10.1002/bse.1822

Del Río, P., Peñasco, C., & Romero-Jordán, D. (2016). What drives eco-innovators? A critical review of the empirical literature based on econometric methods. *Journal of Cleaner Production*, *112*(4), 2158–2170. doi:10.1016/j.jclepro.2015.09.009

Demirel, P., & Kesidou, E. (2011). Stimulating different types of eco-innovation in the UK: Government policies and firm motivations. *Ecological Economics*, *70*(8), 1546–1557. doi:10.1016/j.ecolecon.2011.03.019

Díaz-García, C., González-Moreno, Á., & Sáez-Martínez, F. J. (2015). Eco-innovation: insights from a literature review. *Innovation: Management, Policy & Practice*, *17*(1), 6–23. doi:10.1080/14479338.2015.1011060

Dixon-Fowler, H. R., Slater, D. J., Johnson, J. L., Ellstrand, A. E., & Romi, A. M. (2013). Beyond “Does it Pay to be Green?” A Meta-Analysis of Moderators of the CEP–CFP Relationship. *Journal of Business Ethics*, *112*(2), 353–366. doi:10.1007/s10551-012-1268-8

Doran, J., & Ryan, G. (2012). Regulation and firm perception, eco-innovation and firm performance. *European Journal of Innovation Management*, *15*(4), 421–441. doi:10.1108/14601061211272367

Doran, J., & Ryan, G. (2016). The Importance of the Diverse Drivers and Types of Environmental Innovation for Firm Performance. *Business Strategy and the Environment*, *25*(2), 102–119. doi:10.1002/bse.1860

Earnhart, D., & Lizal, L. (2007). Effect of Pollution Control on Corporate Financial Performance in a Transition Economy. *European Environment Journal*, *266*(17), 247–266. doi:10.1002/eet

Elsayed, K., & Paton, D. (2005). The impact of environmental performance on firm performance: Static and dynamic panel data evidence. *Structural Change and Economic Dynamics*, *16*(3), 395–412. doi:10.1016/j.strueco.2004.04.004

Esty, D. C., & Winston, A. S. (2009). *Green to gold: how smart companies use* *environmental strategy to innovate, create value, and build competitive advantage*. Wiley: New Jersey.

European Commission. (2010). *A strategy for smart, sustainable and inclusive growth*. Brussels.

European Commission. (2011). *EU environment policy supporting jobs and growth*. Luxembourg.

Frondel, M., Horbach, J., & Rennings, K. (2007). End-of-pipe or cleaner production? An empirical comparison of environmental innovation decisions across OECD countries. *Business Strategy and the Environment*, *16*(8), 571–584. doi:10.1002/BSE.496

Gagliardi, L., Marin, G., Miriello, C., D., G., H., H. B., & D., H. (2016). The greener the better? Job creation effects of environmentally-friendly technological change. *Industrial and Corporate Change*, *25*(5), 779–807. doi:10.1093/icc/dtv054

Ghisetti, C., Mancinelli, S., Mazzanti, M., & Zoli, M. (2016). Financial barriers and environmental innovations: evidence from EU manufacturing firms. *Climate Policy*, *3062*(December), 1–17. doi:10.1080/14693062.2016.1242057

Ghisetti, C., & Rennings, K. (2014). Environmental innovations and profitability: how does it pay to be green? An empirical analysis on the German innovation survey. *Journal of Cleaner Production*, *75*, 106–117. doi:10.1016/j.jclepro.2014.03.097

Hart, S. L., & Dowell, G. (2011). A Natural-Resource-Based View of the Firm: Fifteen Years After. *Journal of Management*, *37*(5), 1464–1479. doi:10.1177/0149206310390219

Hojnik, J., & Ruzzier, M. (2015). What drives eco-innovation? A review of an emerging literature. *Environmental Innovation and Societal Transitions*, *19*, 31–41. doi:10.1016/j.eist.2015.09.006

Hojnik, J., & Ruzzier, M. (2016). The driving forces of process eco-innovation and its impact on performance: Insights from Slovenia. *Journal of Cleaner Production*, *133*, 812–825. doi:10.1016/j.jclepro.2016.06.002

Hölzl, W. (2009). Is the R&D behaviour of fast-growing SMEs different? Evidence from CIS III data for 16 countries. *Small Business Economics*, *33*(1), 59–75. doi:10.1007/s11187-009-9182-x

Hoogendoorn, B., Guerra, D., & van der Zwan, P. (2015). What drives environmental practices of SMEs? *Small Business Economics*, *44*(4), 759–781. doi:10.1007/s11187-014-9618-9

Horbach, J. (2008). Determinants of environmental innovation—New evidence from German panel data sources. *Research Policy*, *37*(1), 163–173. doi:10.1016/j.respol.2007.08.006

Horbach, J. (2016). Empirical determinants of eco-innovation in European countries using the community innovation survey. *Environmental Innovation and Societal Transitions*, *19*, 1–14. doi:10.1016/j.eist.2015.09.005

Horbach, J., Oltra, V., & Belin, J. (2013). Determinants and Specificities of Eco-Innovations Compared to Other Innovations—An Econometric Analysis for the French and German Industry Based on the Community Innovation Survey. *Industry & Innovation*, *20*(6), 523–543. doi:10.1080/13662716.2013.833375

Horbach, J., & Rennings, K. (2013). Environmental innovation and employment dynamics in different technology fields – an analysis based on the German Community Innovation Survey 2009. *Journal of Cleaner Production*, *57*, 158–165. doi:10.1016/j.jclepro.2013.05.034

Horváthová, E. (2010). Does environmental performance affect financial performance? A meta-analysis. *Ecological Economics*, *70*(1), 52–59. doi:10.1016/j.ecolecon.2010.04.004

Horváthová, E. (2012). The impact of environmental performance on firm performance: Short-term costs and long-term benefits? *Ecological Economics*, *84*, 91–97. doi:10.1016/j.ecolecon.2012.10.001

Jaffe, A. B., & Palmer, K. (1997). Environmental Regulation and Innovation: A Panel Data Study. *Review of Economics and Statistics*, *79*(4), 610–619. doi: 10.1162/003465397557196

Jo, J. H., Roh, T. W., Kim, S., Youn, Y. C., Park, M. S., Han, K. J., & Jang, E. K. (2015). Eco-Innovation for sustainability: Evidence from 49 countries in Asia and Europe. *Sustainability*, *7*(12), 16820–16835. doi:10.3390/su71215849

Kemp, R., & Pearson, P. (2007). *Final report MEI project about measuring eco-innovation*. UNU-MERIT, Maastricht. https://www.oecd.org/env/consumption-innovation/43960830.pdf

Kunapatarawong, R., & Martínez-Ros, E. (2016). Towards green growth: How does green innovation affect employment? *Research Policy*, *45*(6), 1218–1232. doi:10.1016/j.respol.2016.03.013

Lanoie, P., Laurent-Lucchetti, J., Johnstone, N., & Ambec, S. (2011). Environmental Policy, Innovation and Performance: New Insights on the Porter Hypothesis. *Journal* *of Economics & Management Strategy*, *20*(3), 803–842. doi:10.1111/j.1530-9134.2011.00301.x

Lee, K.-H., & Min, B. (2015). Green R&D for eco-innovation and its impact on carbon emissions and firm performance. *Journal of Cleaner Production*, *108*, 534–542. doi:10.1016/j.jclepro.2015.05.114

Leeuwen, G. van, & Mohnen, P. (2017). Revisiting the Porter Hypothesis: an emperical analysis of green innovation for the Netherlands. *Economics of Innovation and New Technology*, *26*(1–2), 63–77. doi:10.1080/10438599.2016.1202521

Leiponen, A., & Helfat, C. E. (2010). Innovation objectives, knowledge sources, and the benefits of breadth. *Strategic Management Journal*, *31*(2), 224–236. doi:10.1002/smj.807

Long, J. S., & Freese, J. (2006). *Regression models for categorical dependent variables using Stata*. StataCorp LP.

Marin, G. (2014). Do eco-innovations harm productivity growth through crowding out? Results of an extended CDM model for Italy. *Research Policy*, *43*(2), 301–317. doi:10.1016/j.respol.2013.10.015

Marin, G., & Lotti, F. (2017). Productivity effects of eco-innovations using data on eco-patents. *Industrial and Corporate Change*, *26*(1), 125–148. doi:10.1093/icc/dtw014

Marin, G., Marzucchi, A., & Zoboli, R. (2015). SMEs and barriers to Eco-innovation in the EU: exploring different firm profiles. *Journal of Evolutionary Economics*, *25*(3), 671–705. doi:10.1007/s00191-015-0407-7

Miroshnychenko, I., Barontini, R., & Testa, F. (2017). Green practices and financial performance: A global outlook. *Journal of Cleaner Production*, *147*, 340–351. doi:10.1016/j.jclepro.2017.01.058

Navaretti, G. B., Castellani, D., & Pieri, F. (2014). Age and firm growth: evidence from three European countries. *Small Business Economics*, *43*(4), 823–837. doi:10.1007/s11187-014-9564-6

Palmer, K., Oates, W. E., & Portney, P. R. (1995). Tightening Environmental Standards: The Benefit-Cost or the No-Cost Paradigm? *Journal of Economic Perspectives*, *9*(4), 119–132. doi:10.1257/jep.9.4.119

Porter, M. E. (1985). *Competitive advantage: creating and sustaining superior performance*. New York: Free Press.

Porter, M. E. (1991). America's Green Strategy. *Scientific American*, *264*(4), 168. doi:10.1038/scientificamerican0491-168

Porter, M. E., & Linde, C. van der. (1995). Toward a New Conception of the Environment-Competitiveness Relationship. *Journal of Economic Perspectives*, *9*(4), 97–118. doi:10.1257/jep.9.4.97

Przychodzen, J., & Przychodzen, W. (2015). Relationships between eco-innovation and financial performance - Evidence from publicly traded companies in Poland and Hungary. *Journal of Cleaner Production*, *90*, 253–263. doi:10.1016/j.jclepro.2014.11.034

Quintana-García, C., & Benavides-Velasco, C. A. (2008). Innovative competence, exploration and exploitation: The influence of technological diversification. *Research Policy*, *37*(3), 492–507. doi:10.1016/j.respol.2007.12.002

Rennings, K. (2000). Redefining innovation —eco-innovation research and the contribution from ecological economics. *Ecological Economics*, *32*(2), 319–332. doi:10.1016/S0921-8009(99)00112-3

Rexhäuser, S., & Rammer, C. (2014). Environmental Innovations and Firm Profitability: Unmasking the Porter Hypothesis. *Environmental and Resource Economics*, *57*(1), 145–167. doi:10.1007/s10640-013-9671-x

Riillo, C. A. F. (2017). Beyond the question “Does it pay to be green?”: How much green? and when? *Journal of Cleaner Production*, *141*, 626–640. doi:10.1016/j.jclepro.2016.09.039

Ryszko, A. (2016). Proactive environmental strategy, technological eco-innovation and firm performance-case of Poland. *Sustainability*, *8*(2), 156. doi:10.3390/su8020156

Sharma, S., & Vredenburg, H. (1998). Proactive corporate environmental strategy and the development of competitively valuable organizational capabilities. *Strategic Management Journal*, *19*(8), 729–753. doi:10.1002/(SICI)1097-0266(199808)19:8<729::AID-SMJ967>3.0.CO;2-4

Soltmann, C., Stucki, T., & Woerter, M. (2015). The Impact of Environmentally Friendly Innovations on Value Added. *Environmental and Resource Economics*, *62*(3), 457–479. doi:10.1007/s10640-014-9824-6

Tavassoli, S., & Karlsson, C. (2016). Innovation strategies and firm performance: Simple or complex strategies? *Economics of Innovation and New Technology*, *25*(7), 631–650. doi:10.1080/10438599.2015.1108109

Triguero, Á., Moreno-Mondéjar, L., & Davia, M. A. (2013). Drivers of different types of eco-innovation in European SMEs. *Ecological Economics*, *92*, 25–33. doi:10.1016/j.ecolecon.2013.04.009

Triguero, Á., Moreno-Mondéjar, L., & Davia, M. A. (2015). Eco-innovation by small and medium-sized firms in Europe: from end-of-pipe to cleaner technologies. *Innovation: Management, Policy & Practice*, *17*(1), 24–40. doi:10.1080/14479338.2015.1011059

Trumpp, C., & Guenther, T. (2017). Too Little or too much? Exploring U-shaped Relationships between Corporate Environmental Performance and Corporate Financial Performance. *Business Strategy and the Environment*, *26*(1), 49–68. doi:10.1002/bse.1900

Wagner, M., Phu, N. Van, Azomahou, T., & Wehrmeyer, W. (2002). The relationship between the environmental and economic performance of firms: an empirical analysis of the European paper industry. *Corporate social responsibility and Environmental Management*, *146*(9), 133–146. doi:10.1002/csr.22

Walley, N., & Whitehead, B. (1994). It's not easy being green. *Harvard Business Review*, *72*, 46–52.

Williams, R. (2006). Generalized ordered logit/partial proportional odds models for ordinal dependent variables. *Stata Journal*, *6*(1), 58–82. doi:st0097

APPENDIX

Appendix 1. Variable definitions

Table A.1

Variable definitions

Dependent variables	
Turnover growth	Categorical variable which takes the value 1 = firm turnover decrease; 2 = firm turnover unchanged; and 3 = firm turnover increased
Independent variables	
Eco-strategies	8 dummy variables which take the value 1 if the firm states to undertake the following actions to be more resource efficient; 0 if not Water reduction Energy reduction Predominant use of renewable energy Material reduction Waste reduction Sale of scrap to other firms Recycling Design of products that are easier to maintain, repair, or reuse Breadth: number of eco-strategies undertaken by the firm (range from 0 to 8) High investment: Dummy variable which takes the value 1 if the firm investment in eco-strategies is higher than 5% of annual turnover; 0 if not
Control variables	
Size	Categorical variable 1–9 employees 9–49 employees 50–249 employees
Young	Dummy variable that takes a value equal to 1 if firm is less than 6-year-old; 0 if not
Own technical expertise	Dummy variable that takes a value equal to 1 if firm reports internal technical expertise to implement resource efficiency practices; 0 if not
Own finance	Dummy variable that takes a value equal to 1 if firm reports self-finance resource efficiency measures; 0 if not
External finance	Dummy variable that takes a value equal to 1 if firm reports external support to implement resource efficiency practices; 0 if not
Greenness priority	Dummy variable which takes the value 1 if firm reports that the environment is a core priority for the firm, going beyond regulatory requirements; 0 if not
Business opportunity	Dummy variable that takes a value equal to 1 if firm considers the creation of a competitive advantage or business opportunity as a main reason to implement resource efficiency practices; 0 if not
Sector	Sector-specific dummy variables. This indicates the main activity of the company: manufacturing, retail, services and industry

Appendix 2. Correlation matrix

Table A.2
Correlation matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	1.00																						
2	0.48*	1.00																					
3	0.13*	0.17*	1.00																				
4	0.39*	0.42*	0.13*	1.00																			
5	0.39*	0.40*	0.17*	0.42*	1.00																		
6	0.18*	0.19*	0.10*	0.23*	0.26*	1.00																	
7	0.20*	0.20*	0.14*	0.23*	0.29*	0.19*	1.00																
8	0.17*	0.19*	0.14*	0.25*	0.23*	0.18*	0.21*	1.00															
9	0.07*	0.09*	0.09*	0.07*	0.06*	0.05*	0.06*	0.09*	1.00														
10	0.65*	0.67*	0.37*	0.68*	0.70*	0.50*	0.54*	0.49*	0.12*	1.00													
11	-0.06*	-0.13*	-0.06*	-0.08*	-0.09*	-0.20*	-0.06*	-0.05*	-0.02*	-0.16*	1.00												
12	0.01	0.04*	0.01	0.01	0.02*	0.07*	0.02*	0.01*	0.012	0.04*	-0.67*	1.00											
13	0.07*	0.10*	0.05*	0.08*	0.09*	0.16*	0.04*	0.04*	0.015	0.14*	-0.44*	-0.37*	1.00										
14	-0.02*	-0.05*	-0.02*	-0.02*	-0.03*	-0.04*	-0.01	-0.02*	-0.01	-0.04*	0.10*	-0.04*	-0.07*	1.00									
15	0.18*	0.27*	0.07*	0.27*	0.26*	0.15*	0.17*	0.19*	0.07*	0.34*	-0.07*	0.01*	0.06*	-0.03*	1.00								
16	0.24*	0.31*	0.07*	0.27*	0.25*	0.17*	0.17*	0.12*	0.08*	0.35*	-0.08*	0.02*	0.07*	-0.02*	0.15*	1.00							
17	0.11*	0.14*	0.11*	0.12*	0.15*	0.13*	0.10*	0.08*	0.07*	0.20*	-0.12*	0.02*	0.11*	-0.01	0.01*	-0.02*	1.00						
18	0.21*	0.24*	0.13*	0.20*	0.25*	0.11*	0.21*	0.11*	0.04*	0.32*	-0.06*	0.01	0.06*	-0.01	0.16*	0.17*	0.06*	1.00					
19	0.10*	0.15*	0.07*	0.18*	0.14*	0.14*	0.10*	0.15*	0.06*	0.22*	-0.10*	0.02*	0.08*	-0.01	0.15*	0.11*	0.09*	-0.02*	1.00				
20	-0.02*	-0.04*	0.03*	0.02*	0.02	0.03*	-0.01	0.02*	0.03*	0.01	-0.02*	0.03*	-0.01	0.03*	0.04*	-0.01	0.01	0.01	0.05	1.00			
21	0.05*	0.06*	0.01	0.11*	0.10*	0.20*	0.06*	0.12*	0.04*	0.15*	-0.15*	0.02*	0.16*	-0.04*	0.10*	0.09*	0.04*	0.01	0.08*	-0.21*	1.00		
22	0.05	-0.01	-0.04*	-0.08*	-0.03*	-0.03*	-0.01	-0.06*	-0.07*	-0.05*	0.11*	-0.03*	-0.10*	-0.03	-0.07*	-0.02*	-0.04*	-0.01	-0.04*	-0.27*	-0.37*	1.00	
23	-0.03*	-0.01	-0.01	-0.03*	-0.05*	-0.17*	-0.04*	-0.06*	0.01	-0.09*	0.03*	-0.01	-0.02*	0.01*	-0.04*	-0.05*	0.01	-0.01	-0.03*	-0.27*	-0.37*	-0.46*	1.00

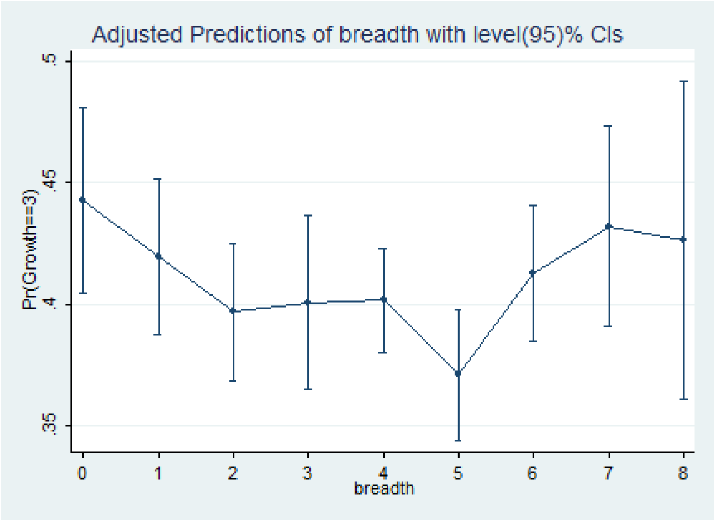
*Significant at 5%.

1. Water reduction; 2. Energy reduction; 3. Predominant use of renewable energy; 4. Material reduction; 5. Waste reduction; 6.Sale of scrap to other firms; 7.Recycling; 8.Design of products that are easier to maintain, repair, or reuse; 9.High investment in eco-strategy; 10. Breadth; 11. Size: 1-9 employees; 12. Size 10-49 employees; 13. Size 50-249 employees; 14. Young; 15. Own technical expertise; 16. Own finance; 17. External finance; 18. Greenness priority; 19. Business opportunity; 20. Industry; 21. Manufacturing; 22.Retail; 23.Services.

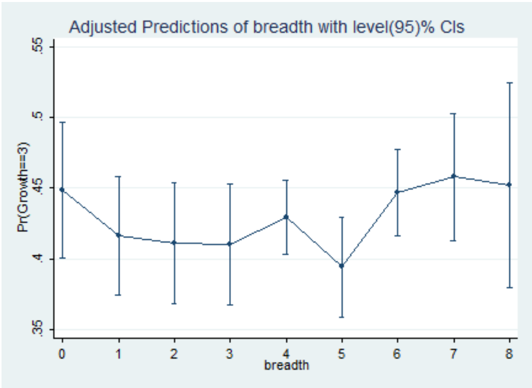
Appendix 3. Predicted probabilities

Figure A.3.1

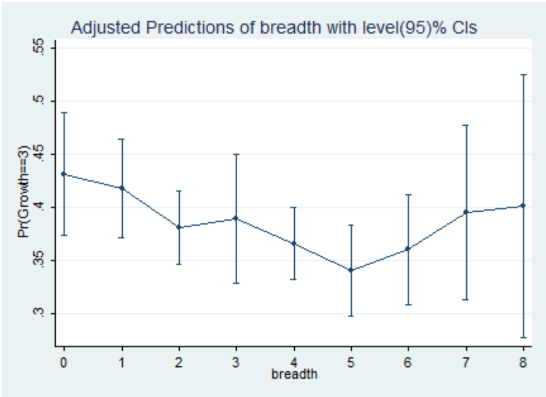
Adjusted predictions



EU28



EU15



EU OTHERS

Source: own elaboration.

Appendix 4. Robustness checks

Ordered logit models are used when the dependent variable has three or more categories and is ordinal. The results are relatively straightforward, intuitive and easy to interpret. However, to apply such a model one condition should be satisfied. This is known in the literature as proportionality odds or the parallel-lines assumption, meaning that the distance between each category is equivalent. A key problem with the parallel-lines model is that its assumptions are often violated. Applying the Brant test, we may check whether any variable of our model violates the parallel-lines assumption, as well as testing of the assumption for each variable separately (Table A.4.1).

When this assumption is violated the literature proposes different alternative models to estimate. One option is dichotomize the outcome and use binary logistic regression, (Table A.4.2).

The second empirical strategy is use a model that does not assume proportionality (ologit2), see (Williams 2006) for a further discussion of this methodology. We have estimated a generalized ordinal logistic model which deploys the user-designed command gologit2 in STATA by R. Williams.[1] Following Williams (2006). The model can be written addressing the logistic nature of the relationship between explanatory variables (*X*) and the dependent variable (*Y*):

$$P(Y_{i,c} > j) = g(X\beta_j) = \frac{\exp(\alpha_j + X_{i,c}\beta_j)}{1 + \{\exp(\alpha_j + X_{i,c}\beta_j)\}}, \qquad j = 1\ to\ M \qquad \text{Eq.[1]}$$

where *Y* is the categorical variable for firm growth rate of sales, which ranges from 1 to 3 (M being the number of categories of the ordinal dependent variable, that is 3.) X_i is a vector of explanatory variables, which include eco-innovation strategies as well as other control variables. β_j are the relevant coefficients, which, unlike what happens in standard ordered logit models (where the parallel-lines assumption is accepted), may differ across categories of *Y*.

From the above expression, it can be determined that the probabilities that *Y* will take on each of the values 1, …, *M* are given by:

---

[1] gologit2 estimates generalized ordered logit models for ordinal dependent variables. A major strength of gologit2 is that it can also estimate three special cases of the generalized model: the proportional odds/parallel lines model, the partial proportional odds model, and the logistic regression model.

$$
\begin{aligned}
P(Y_i = 1) &= 1 - g(X_i\beta_1) \\
P(Y_i = j) &= g\left(X_i\beta_{j-1}\right) - g\left(X_i\beta_j\right) \qquad j = 2,\ldots,M-1 \qquad \text{Eq.[2]} \\
P(Y_i = M) &= g(X_i\beta_{M-1})
\end{aligned}
$$

When M is greater than 2 the generalized ordered model is equivalent to a series of binary logistic regressions where categories of the dependent variable are combined (Williams 2006): e.g., since M= 3, then for J = 1 the category is contrasted with categories 2, and 3, for J = 2 the contrast is between categories 1 and 2 versus 3.

The results should be interpreted as follows: the first panel contrasts category 1 (decrease in firm's annual turnover) with categories 2 and 3 (remained unchanged and increased); the second panel contrasts categories 1 and 2 (decrease and remained unchanged) with category 3 (increased). Positive coefficients indicate that when the explanatory variables take value 1 (given that they are all dummies) the firm is more likely to be in a higher category of *Y* than the current – reference – one, whereas negative coefficients indicate that, when the explanatory variable takes the value 1, there will be an increase the likelihood of being in the current (or a lower) category (Williams 2006).

Table A.4.1
Brant test of parallel regression assumption

	Chi2	p>chi2	df	Chi2	p>chi2	df	Chi2	p>chi2	df
All	217.72	0.000	42	226.30	0.000	50	218.79	0.000	43
Eco-strategies	0.12	0.724	1						
Water reduction				1.45	0.229	1			
Energy reduction				0.25	0.618	1			
Renewable energy				1.45	0.228	1			
Material reduction				1.07	0.301	1			
Waste reduction				0.64	0.425	1			
Sale scrap				1.32	0.251	1			
Recycling				0.21	0.647	1			
Design of products				3.63	0.057	1			
High investment				0.08	0.782	1			
Breadth							0.93	0.334	1
$Breadth^2$							0.66	0.417	1
Size 10-49 employee	2.30	0.129	1	1.80	0.180	1	2.20	0.138	1
Size 50-249 employee	7.62	0.006	1	6.02	0.014	1	7.39	0.007	1
Young	1.37	0.243	1	1.27	0.259	1	1.34	0.247	1
Own technical	0.12	0.729	1	0.14	0.712	1	0.30	0.584	1
Own finance	0.01	0.904	1	0.00	0.992	1	0.01	0.911	1
Greenness priority	0.42	0.519	1	0.63	0.428	1	0.62	0.429	1
Business opportunity	7.79	0.005	1	7.57	0.006	1	7.25	0.007	1
Manufacturing	5.22	0.022	1	5.10	0.024	1	4.98	0.026	1
Retail	7.72	0.005	1	7.43	0.006	1	7.65	0.006	1
Services	1.29	0.255	1	1.33	0.249	1	1.28	0.257	1
BE	1.09	0.297	1	1.50	0.220	1	1.08	0.300	1
NE	0.13	0.719	1	0.00	0.947	1	0.14	0.711	1
DE	20.62	0.000	1	21.64	0.000	1	20.45	0.000	1
IT	2.74	0.098	1	3.23	0.072	1	2.52	0.112	1
LU	0.58	0.446	1	0.41	0.523	1	0.60	0.439	1
DK	0.60	0.440	1	0.77	0.379	1	0.59	0.444	1
IE	3.30	0.069	1	2.95	0.086	1	3.26	0.071	1
GB	3.33	0.068	1	3.66	0.056	1	3.42	0.064	1
GR	11.78	0.001	1	11.11	0.001	1	12.23	0.000	1
ES	2.43	0.119	1	2.31	0.129	1	2.54	0.111	1
PT	0.81	0.368	1	1.11	0.293	1	0.81	0.368	1
FI	4.21	0.040	1	5.07	0.024	1	4.11	0.043	1
SE	2.33	0.127	1	3.10	0.079	1	2.30	0.129	1
AT	11.31	0.001	1	12.61	0.000	1	11.31	0.001	1
CY	1.17	0.280	1	0.93	0.335	1	1.24	0.265	1
CZ	11.11	0.001	1	11.78	0.001	1	11.04	0.001	1
EE	2.40	0.121	1	2.53	0.112	1	2.06	0.152	1
HU	0.53	0.466	1	0.70	0.404	1	0.49	0.486	1
LV	0.89	0.344	1	0.67	0.414	1	0.95	0.329	1
LT	1.04	0.308	1	0.85	0.356	1	1.15	0.284	1
MT	0.06	0.810	1	0.11	0.743	1	0.06	0.809	1
PL	5.15	0.023	1	5.77	0.016	1	5.02	0.025	1
SK	5.84	0.016	1	6.19	0.013	1	5.87	0.015	1
SI	2.00	0.158	1	2.35	0.126	1	1.82	0.178	1
BG	1.60	0.206	1	1.81	0.178	1	1.45	0.229	1
RO	4.19	0.041	1	4.08	0.043	1	4.43	0.035	1
CR	0.05	0.824	1	0.02	0.893	1	0.06	0.804	1

A significant test statistic provides evidence that the parallel regression assumption has been violated.

Table A.4.2
Logit regression: whole sample

	(I)	(II)	(III)	(IV)	(V)
Eco-strategy	-0.148				
	(0.0805)				
Types					
Water reduction		-0.192**			
		(0.0592)			
Energy reduction		-0.182**			
		(0.0562)			
Predominant use of renewable energy		0.255***			
		(0.0441)			
Material reduction		0.0401			
		(0.0499)			
Waste reduction		0.0368			
		(0.0439)			
Sale of scrap to other firms		0.00973			
		(0.0577)			
Recycling		0.0733*			
		(0.0352)			
Design of products that are easier to maintain, repair, or reuse		0.109**			
		(0.0363)			
High investment			0.176*		
			(0.0734)		
Breadth				-0.00823	-0.0967*
				(0.0146)	(0.0469)
Breadth^2					0.0122*
					(0.00576)
Control variables					
Size: ref. size 1_9					
size_10_49	0.569***	0.574***	0.565***	0.567***	0.568***
	(0.0537)	(0.0513)	(0.0533)	(0.0536)	(0.0535)
size_50_249	0.941***	0.952***	0.940***	0.941***	0.939***
	(0.0641)	(0.0627)	(0.0635)	(0.0652)	(0.0643)
Young	0.952***	0.948***	0.954***	0.953***	0.952***
	(0.0766)	(0.0777)	(0.0763)	(0.0768)	(0.0770)
Own technical expertise	0.0873	0.0740	0.0543	0.0669	0.0873*
	(0.0455)	(0.0425)	(0.0433)	(0.0442)	(0.0441)
Own finance	0.144**	0.138***	0.0966*	0.112**	0.147**
	(0.0514)	(0.0415)	(0.0450)	(0.0422)	(0.0474)
External finance	0.197**	0.186**	0.168**	0.184**	0.196**
	(0.0644)	(0.0651)	(0.0626)	(0.0655)	(0.0663)
Greenness priority	0.137***	0.131**	0.117**	0.128**	0.140**
	(0.0405)	(0.0437)	(0.0387)	(0.0432)	(0.0443)
Business opportunity	0.279***	0.262***	0.262***	0.273***	0.280***
	(0.0446)	(0.0504)	(0.0444)	(0.0484)	(0.0495)
Sector: ref. Industry					
Manufacturing	0.237**	0.253***	0.238**	0.239**	0.239**
	(0.0737)	(0.0751)	(0.0731)	(0.0735)	(0.0737)
Retail	0.293***	0.338***	0.304***	0.293***	0.295***
	(0.0804)	(0.0811)	(0.0799)	(0.0806)	(0.0801)
Services	0.350***	0.394***	0.359***	0.353***	0.354***
	(0.0811)	(0.0806)	(0.0809)	(0.0815)	(0.0813)
Constant	-1.440***	-1.485***	-1.521***	-1.504***	-1.438***
	(0.0974)	(0.0991)	(0.0991)	(0.100)	(0.101)
Country dummies	YES	YES	YES	YES	YES
pseudo R^2	0.0620	0.0657	0.0622	0.0618	0.0623
Observations			11,336		

Clustered standard errors by country (28 clusters). *, ** and *** correspond to significance levels of 1%, 5% and 10%, respectively. Dependent variable: annual turnover growth (1) Increased; (0) Remained unchanged or decreased.

Table A.4.3
Gologit2 regression: whole sample

	(I)		(II)		(III)		(IV)		(V)	
	Panel 1	**Panel 2**	**Panel 1**	**Panel 2**	**Panel 1**	**Panel 2**	**Panel 1**	**Panel 2**	**Panel 1**	**Panel 2**
Eco-strategy	-0.192	-0.158*								
	(0.103)	(0.0775)								
Types										
Water reduction			-0.140*	-0.192***						
			(0.0625)	(0.0571)						
Energy reduction			-0.215***	-0.190***						
			(0.0632)	(0.0544)						
Predominant use of renewable			0.175*	0.254***						
			(0.0698)	(0.0429)						
Material reduction			-0.0149	0.0387						
			(0.0625)	(0.0486)						
Waste reduction			0.00165	0.0358						
			(0.0510)	(0.0434)						
Sale of scrap to other firms			-0.0695	0.0188						
			(0.0609)	(0.0574)						
Recycling			0.108*	0.0690						
			(0.0448)	(0.0355)						
Design of products			0.213***	0.111**						
			(0.0453)	(0.0379)						
High investment					0.199**	0.191*				
					(0.0766)	(0.0749)				
Breadth							-0.0191	-0.00906	-0.136*	-0.103*
							(0.0178)	(0.0147)	(0.0579)	(0.0461)
Breadth^2									0.0164*	0.0130*
									(0.0068)	(0.0055)
Control variables										
Size: ref. size 1_9										
size_10_49	0.489***	0.563***	0.502***	0.566***	0.486***	0.560***	0.489***	0.561***	0.489***	0.562***
	(0.0435)	(0.0536)	(0.0399)	(0.0514)	(0.0433)	(0.0532)	(0.0437)	(0.0536)	(0.0428)	(0.0533)
size_50_249	0.764***	0.933***	0.789***	0.942***	0.764***	0.933***	0.769***	0.933***	0.764***	0.930***
	(0.0665)	(0.0642)	(0.0631)	(0.0625)	(0.0662)	(0.0636)	(0.0663)	(0.0652)	(0.0659)	(0.0642)
Young	1.050***	0.946***	1.039***	0.947***	1.053***	0.949***	1.051***	0.947***	1.050***	0.946***
	(0.0966)	(0.0755)	(0.0984)	(0.0766)	(0.0968)	(0.0751)	(0.0972)	(0.0758)	(0.0962)	(0.0760)
Own technical expertise	0.0946*	0.0914*	0.0820*	0.0761	0.0481	0.0553	0.0728	0.0690	0.103*	0.0915*
	(0.0427)	(0.0449)	(0.0391)	(0.0408)	(0.0339)	(0.0429)	(0.0374)	(0.0429)	(0.0444)	(0.0432)
Own finance	0.125*	0.145**	0.124**	0.139***	0.0611	0.0935*	0.0900*	0.110**	0.137**	0.148**
	(0.0501)	(0.0501)	(0.0437)	(0.0422)	(0.0378)	(0.0444)	(0.0412)	(0.0428)	(0.0506)	(0.0478)
External finance	0.223***	0.206**	0.217***	0.196**	0.183**	0.174**	0.210***	0.192**	0.228***	0.204**
	(0.0611)	(0.0633)	(0.0612)	(0.0645)	(0.0557)	(0.0622)	(0.0623)	(0.0650)	(0.0648)	(0.0656)
Greenness priority	0.161***	0.138***	0.163***	0.133**	0.137***	0.118**	0.157***	0.129**	0.173***	0.142**
	(0.0372)	(0.0405)	(0.0399)	(0.0433)	(0.0354)	(0.0391)	(0.0397)	(0.0432)	(0.0414)	(0.0440)
Business opportunity	0.115*	0.276***	0.0967	0.256***	0.0926	0.257***	0.113*	0.268***	0.123*	0.277***
	(0.0571)	(0.0442)	(0.0588)	(0.0500)	(0.0537)	(0.0443)	(0.0562)	(0.0482)	(0.0583)	(0.0494)
Sector: ref. Industry										
Manufacturing	0.0835	0.228**	0.105	0.245***	0.0833	0.229**	0.0864	0.230**	0.0892	0.230**
	(0.0875)	(0.0715)	(0.0887)	(0.0732)	(0.0874)	(0.0710)	(0.0878)	(0.0716)	(0.0882)	(0.0716)
Retail	0.113	0.266***	0.159*	0.311***	0.124	0.278***	0.112	0.266**	0.117	0.269***
	(0.0663)	(0.0809)	(0.0666)	(0.0814)	(0.0668)	(0.0803)	(0.0669)	(0.0809)	(0.0667)	(0.0805)
Services	0.272***	0.337***	0.313***	0.381***	0.285***	0.346***	0.274***	0.339***	0.277***	0.341***
	(0.0628)	(0.0812)	(0.0647)	(0.0811)	(0.0634)	(0.0813)	(0.0635)	(0.0816)	(0.0638)	(0.0815)
Constant	0.150	-1.412***	0.0991	-1.463***	0.0502	-1.499***	0.0810	-1.479***	0.162*	-1.411***
	(0.0815)	(0.0927)	(0.0740)	(0.0954)	(0.0761)	(0.0956)	(0.0780)	(0.0962)	(0.0801)	(0.0978)
Pseudo R^2	0.0532	0.0532	0.0564	0.0564	0.0568	0.0568	0.0530	0.0530	0.0535	0.0535
Observations					11,336					

Clustered standard errors by country (28 clusters). *, ** and *** correspond to significance levels of 1%, 5% and 10%, respectively. Country dummies are included.

Table A.4.4
Ordered logit: manufacturing firms (whole sample)

	(I)	(II)	(III)	(IV)	(VI)
Eco-strategy	-0.730***				
	(0.161)				
Types					
Water reduction		-0.224*			
		(0.0939)			
Energy reduction		-0.473***			
		(0.092)			
Predominant use of renewable energy		0.214			
		(0.133)			
Material reduction		0.0558			
		(0.0929)			
Waste reduction		0.0412			
		(0.0811)			
Sale of scrap to other firms		-0.0949			
		(0.0706)			
Recycling		0.0586			
		(0.0522)			
Design of products that are easier to maintain, repair, or reuse		0.152			
		(0.0847)			
High investment			0.217		
			(0.119)		
Breadth				-0.0543**	-0.225***
				(0.0187)	(0.0586)
Breadth^2					0.0222**
					(0.00763)
Control variables					
Size: ref. size 1_9					
size_10_49	0.486***	0.527***	0.471***	0.489***	0.492***
	(0.102)	(0.101)	(0.105)	(0.101)	(0.0993)
size_50_249	0.851***	0.921***	0.830***	0.860***	0.860***
	(0.138)	(0.132)	(0.137)	(0.131)	(0.130)
Young	0.893***	0.868***	0.864***	0.863***	0.864***
	(0.141)	(0.145)	(0.138)	(0.143)	(0.144)
Own technical expertise	0.178	0.158	0.0698	0.120	0.159
	(0.0909)	(0.0844)	(0.0858)	(0.0874)	(0.0888)
Own finance	0.336**	0.263*	0.184	0.247*	0.298**
	(0.109)	(0.102)	(0.106)	(0.108)	(0.110)
External finance	0.312***	0.303**	0.249*	0.304**	0.303**
	(0.0945)	(0.0930)	(0.0979)	(0.0931)	(0.0931)
Greenness priority	0.187	0.193*	0.143	0.178	0.198*
	(0.0975)	(0.0977)	(0.0935)	(0.0957)	(0.0989)
Business opportunity	0.260**	0.252**	0.224**	0.266**	0.272**
	(0.0803)	(0.0848)	(0.0830)	(0.0854)	(0.0837)
Constant cut1	-0.473***	-0.195	-0.0163	-0.105	-0.267*
	(0.129)	(0.126)	(0.112)	(0.124)	(0.110)
Constant cut2	0.938***	1.229***	1.389***	1.302***	1.142***
	(0.127)	(0.121)	(0.105)	(0.118)	(0.107)
Country dummies	YES	YES	YES	YES	YES
Observations			2,560		

Clustered standard errors by country (18 clusters). *, ** and *** correspond to significance levels of 1%, 5% and 10%, respectively. Dependent variable: annual turnover growth (1) Decreased; (2) Remained unchanged, (3) Increased.

Table A.4.5
Ordered logit regression: Core countries

	(I)	(II)	(III)	(IV)	(VI)
Eco-strategy	-0.195				
	(0.134)				
Types					
Water reduction		-0.131			
		(0.0737)			
Energy reduction		-0.144*			
		(0.0690)			
Predominant use of renewable energy		0.204***			
		(0.0530)			
Material reduction		0.0455			
		(0.0790)			
Waste reduction		0.0591			
		(0.0775)			
Sale of scrap to other firms		-0.0729			
		(0.0853)			
Recycling		0.0264			
		(0.0540)			
Design of products that are easier to maintain, repair, or reuse		0.182***			
		(0.0292)			
High investment			0.0541		
			(0.132)		
Breadth				0.00524	-0.0955
				(0.0138)	(0.0757)
Breadth^2					0.0136
					(0.0101)
Control variables					
Size: ref. size 1_9					
size_10_49	0.539***	0.549***	0.538***	0.535***	0.537***
	(0.0902)	(0.0846)	(0.0904)	(0.0899)	(0.0898)
size_50_249	0.641***	0.660***	0.639***	0.636***	0.635***
	(0.0875)	(0.0782)	(0.0863)	(0.0873)	(0.0864)
Young	1.051***	1.055***	1.050***	1.051***	1.052***
	(0.0789)	(0.0797)	(0.0786)	(0.0789)	(0.0801)
Own technical expertise	0.140*	0.0978	0.111	0.107	0.124*
	(0.0598)	(0.0551)	(0.0572)	(0.0580)	(0.0588)
Own finance	0.141*	0.116*	0.105	0.102	0.130*
	(0.0607)	(0.0539)	(0.0542)	(0.0527)	(0.0621)
External finance	0.138	0.114	0.112	0.110	0.120
	(0.0918)	(0.0881)	(0.0910)	(0.0909)	(0.0915)
Greenness priority	0.147***	0.123**	0.126**	0.122**	0.132***
	(0.0383)	(0.0379)	(0.0406)	(0.0373)	(0.0376)
Business opportunity	0.186**	0.150*	0.170*	0.169*	0.179*
	(0.0721)	(0.0752)	(0.0705)	(0.0719)	(0.0736)
Sector: ref. Industry					
Manufacturing	0.0107	0.0230	0.0114	0.0103	0.00867
	(0.119)	(0.118)	(0.119)	(0.119)	(0.118)
Retail	0.190	0.221*	0.192	0.191	0.199
	(0.107)	(0.110)	(0.108)	(0.109)	(0.107)
Services	0.331**	0.356**	0.341**	0.343**	0.345**
	(0.113)	(0.115)	(0.112)	(0.115)	(0.114)
Constant cut1	-0.706***	-0.563***	-0.574***	-0.566***	-0.664***
	(0.133)	(0.122)	(0.113)	(0.116)	(0.120)
Constant cut2	0.826***	0.975***	0.958***	0.965***	0.869***
	(0.150)	(0.143)	(0.131)	(0.139)	(0.140)
Country dummies	YES	YES	YES	YES	YES
Pseudo R^2	0.0398	0.0421	0.0396	0.0395	0.0400
N	4,353	4,353	4,353	4,353	4,353

Clustered standard errors by country (4 clusters). *, ** and *** correspond to significance levels of 1%, 5% and 10%, respectively. Dependent variable: annual turnover growth (1) Decreased; (2) Remained unchanged, (3) Increased.
Core countries: Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Luxembourg, Sweden, the Netherlands, the United Kingdom.

Table A.4.6
Ordered logit regression: Mediterranean countries

	(I)	(II)	(III)	(IV)	(VI)
Eco-strategy	-0.143				
	(0.213)				
Types					
Water reduction		-0.0219			
		(0.204)			
Energy reduction		-0.165*			
		(0.0803)			
Predominant use of renewable energy		0.0383			
		(0.131)			
Material reduction		-0.0670			
		(0.0628)			
Waste reduction		-0.0333			
		(0.0509)			
Sale of scrap to other firms		0.152			
		(0.130)			
Recycling		0.239***			
		(0.0716)			
Design of products that are easier to maintain, repair, or reuse		0.132			
		(0.108)			
High investment			0.221		
			(0.120)		
Breadth				0.0156	-0.110
				(0.0281)	(0.0981)
Breadth^2					0.0175
					(0.00949)
Control variables					
Size: ref. size 1_9					
size_10_49	0.578***	0.557***	0.578***	0.574***	0.571***
	(0.0792)	(0.0711)	(0.0754)	(0.0803)	(0.0778)
size_50_249	1.091***	1.078***	1.095***	1.086***	1.074***
	(0.0936)	(0.0830)	(0.0963)	(0.0974)	(0.0918)
Young	0.947**	0.946**	0.957**	0.948**	0.950**
	(0.301)	(0.306)	(0.304)	(0.296)	(0.297)
Own technical expertise	0.141	0.107	0.0982	0.0954	0.140
	(0.147)	(0.111)	(0.0998)	(0.125)	(0.146)
Own finance	0.171	0.131	0.122	0.114	0.159
	(0.183)	(0.161)	(0.145)	(0.170)	(0.188)
External finance	0.124	0.0939	0.0832	0.0851	0.118*
	(0.0687)	(0.0552)	(0.0613)	(0.0531)	(0.0592)
Greenness priority	0.290***	0.233***	0.280***	0.257***	0.271***
	(0.0738)	(0.0578)	(0.0744)	(0.0717)	(0.0676)
Business opportunity	0.297**	0.261**	0.278**	0.272**	0.280**
	(0.0966)	(0.0994)	(0.0920)	(0.103)	(0.105)
Sector: ref. Industry					
Manufacturing	0.437***	0.431***	0.441***	0.434***	0.437***
	(0.0499)	(0.0567)	(0.0530)	(0.0587)	(0.0618)
Retail	0.402***	0.432***	0.416***	0.411***	0.410***
	(0.0284)	(0.0287)	(0.0249)	(0.0217)	(0.0254)
Services	0.448***	0.493***	0.454***	0.456***	0.463***
	(0.0877)	(0.0732)	(0.0862)	(0.0843)	(0.0786)
Constant cut1	0.372*	0.491***	0.459*	0.485***	0.419***
	(0.149)	(0.134)	(0.187)	(0.142)	(0.126)
Constant cut2	1.597***	1.723***	1.685***	1.710***	1.646***
	(0.0471)	(0.0927)	(0.181)	(0.110)	(0.0580)
Country dummies	YES	YES	YES	YES	YES
Pseudo R^2	0.0404	0.0432	0.0407	0.0403	0.0410
Observations			1,751		

Clustered standard errors by country (4 clusters). *, ** and *** correspond to significance levels of 1%, 5% and 10%, respectively. Dependent variable: annual turnover growth (1) Decreased; (2) Remained unchanged, (3) Increased.
Mediterranean countries: Italian, Greece, Spain and Portugal.

CHAPTER 5

CONCLUSIONS

1. SUMMARY AND CONCLUDING REMARKS

This doctoral thesis consists of three different empirical essays on the determinants and effects of innovation strategies at firm level. The relevance of science and innovation as key factors that can help European countries to move towards smart, sustainable, inclusive growth economies have been recognised by the EU's long-term Strategy: "Horizon 2020" (European Commission 2011c). The importance of this topic has been revived by the recent major economic global crisis especially between SMEs as the backbone of Europe's economy (European Commission 2010b). In this concluding chapter, we briefly discuss the main findings, derive the policy implications that emerge from them, and suggest directions for future research.

Within the innovation literature, analyses of the determinants of innovation success are legion, especially those investigating the nature of R&D activities. The first contribution, Chapter 2, titled *"What is the role of innovation strategies? Evidence from Spanish firms"* proposed an original strategic perspective on the topic starting from the motivations that drive a firm to engage in innovation activities. We took a broad view on the long-term relationship between innovation strategies and innovation success. A typical firm is unable to undertake in all possible choice of innovation activities because of scarce resources. Decisions made at this point constitute the innovation strategies of the firm, the choice of a firm's long-term goals and resource allocation for the achievement of those goals. We investigate these in the first study of the present thesis by empirically testing which strategy has the greatest odds of improving innovation performance, and whether there is a fit between the innovation strategy pursued and innovation output measured in terms of product and process innovations.

First, based on a principal component analysis a distinction between absence, mixed, or oriented strategy towards quality, production, cost and environment is made. Then, considering the longitudinal structure of the PITEC data source, a random effect probit model is used to examine the impact of these strategies. The evidence for Spanish firms suggests that a good innovation strategy can help firms to guide the innovation process and to achieve a durable competitive advantage in dynamics environments. Consequently, the main barrier to innovation success is the absence of a well-articulated innovation strategy among firms.

Our findings confirm that, at least in Spain, the determinants of innovation success differ between the different types of strategies undertaken and between manufacturing and services firms. Those that are able to design mixed innovation strategies have a greater probability of being a product successful innovative firm, while it decreases the probability of innovation in processes suggesting that managing multiple innovation objectives is challenging and Spanish firms have not the capacity to benefit from these strategies in terms of process success. The results also show that there is a good fit between the strategies pursued by each firm and the innovation output obtained; quality strategy orientation is positively related to product innovation success, whereas product, cost and eco strategies are positively related to process innovation success.

The results from our representative sample show that Spanish innovative firms can be grouped into three clusters: a first group of firms that do not have an explicit strategy (and consequently are the worst-performing); a second a group of firms that pursue some objectives in the innovative field and want to innovate, but do have insufficient capacity to focus their innovation and, finally, a group of firms that have a capacity to design one or more oriented innovation strategies and which experience greater innovation success. Our sectoral analysis shows that service firms face more problems in defining their innovation strategies than do than manufacturing firms. In particular, service firms present a higher percentage of mixed or, no strategy, and their oriented strategies show a lower impact on firm success than for manufacturing firms.

These findings have relevant policy-making implications. The results indicate that firms follow different paths in their innovation processes, and have different innovation goals and motivations when implementing their innovation activities. Therefore, it seems appropriate that the differences found here should be considered in the design of policies to encourage internal reflection within firms as the first step towards increasing their innovation success. In this sense, public policies should bear in mind the requirements of the sectors and firms being targeted. The effectiveness of such policies, especially in the case of service firms, could be enhanced if complemented with policies that encourage their absorptive capacity to combine resources, people, ideas and knowledge to meet long term goals.

The green economy became a pillar of major European and international strategies mainly because of the continuing deterioration of the natural environment, most visible in terms of climate change and ecosystem degradation.[1] An eco-innovation strategy is a key instrument towards a green economy, and is at the centre of the current European agenda. Consequently, we move on to investigating strategies to reduce environmental impacts, specifically by identifying some significant lacunae in the literature, and attempting to fill them. Specifically, in Chapter 3 we examine the drivers of an eco-innovation orientation (all those element that push or pull firms' decisions to orientate their innovation to be green) and, in Chapter 4, continue by analysing the implications (the economic consequences in terms of gains or losses that the adoption of eco-strategies creates for firms).

In Chapter 3, title "*What spurs the decision to undertake eco-motivations? A panel data analysis of Spanish service and manufacturing firms"*, it emerged that eco-innovations share some similarities with general innovations but, for reasons considered in some depth (double externality problem), they also differ substantially in the drivers that foster their adoption. In general, these differences justify our analysis of the drivers of eco-innovation strategy, as the literature concentrates on the determinants of general innovations, leaving an important gap which our work addresses.

Furthermore, because of the higher environmental impact of manufacturing, most eco-innovation studies have been focused on the role played by these sectors. But the structural shift of economies towards services cannot be taken for granted to lead to substantial changes in the transition toward green EU economies. Services firms place lower direct pressures on natural resources than do manufacturing firms but, if we add in the indirect effects summed over entire supply-chain value, this total pressure might in

[1] Most notably within the Europe 2020 strategy adopted in 2010 by the EU to drive sustainable growth.

fact be considerable higher. In addition, services are generally considered less innovative than manufacturing, and this is especially relevant in the context of green innovation.

Very little of the literature on eco-innovation incorporates both sectoral and temporal dimensions. Here, we make a significant contribution by investigating the similarities and differences between service and manufacturing firms over the period 2008–2014. Using a large panel of Spanish firms, we examine long-term relationships between variables, and study persistence in eco-innovation over time. Our identification of the main factors activating and hindering decisions to eco-innovate over time and in differentiated sectors, should help policy-makers design appropriate and effective instruments to stimulate these determinants, or overcome these barriers.

Our empirical evidence suggests that manufacturing has a higher orientation toward the environment than do services and that the drivers affecting the eco-innovative orientation of firms are quite similar. Nevertheless, some differences were found, and these might be explained by the distinctions between the groups. We have outlined the importance of regulatory stimulus to eco-innovation for both service and manufacturing firms, but have also stressed that sectors diverge in the magnitude of their regulatory pressure. In addition, the results indicate that local and EU subsidies have significantly greater effects only in service firms.

In both sectors, we find true persistence in eco-motivation at the firm level. Having accounted for the impact of observed and unobserved firm characteristics, the results suggest that firms follow a path of eco-strategy over time in the sense that the decision to undertake eco-innovations in a period enhances the probability of being eco-oriented in subsequent periods. Indeed, these results suggest a significant state dependence effect for eco-strategy, even if different the types of motivations are considered separately.

The results also underline the fact a firm's profile, including parameters such as its size, is key when it comes to designing eco-innovation strategies for manufacturing firms. In contrast, market factors are not found to be distinctive drivers for eco-innovative firms either in the service or manufacturing sectors.

These results are of considerable interest for public policy attempting to promote an eco-orientation among Spanish firms. Since eco-innovations are characterized by the double externality problem, public policy retains a relevant role. Traditional environmental policy, in terms of existing regulations, is effective in the Spanish context in driving eco-innovation orientation in all the sectors, whereas local and EU grants are significant triggers only in the services sectors. Hence, public policies should also reward eco-oriented firms in the form of tax incentives, grants or subsidies since they face a high level of uncertainty, novelty and some specific financial difficulties. Since eco-orientation is persistent then stimulating policy measures, such as government regulations or support, would be expected to have sustained effects, because not only do they affect current eco-orientation strategy, but they are also likely to induce a sustained green strategy. We note that eco-innovations have both environmental and innovation externalities and that this poses a complex challenge for policy makers, since support requires a coordinated approach, one that integrates innovation, research and environmental policy. In this sense, the promotion of eco-innovation requires a balanced strategy that combines different policy tools.

Finally, in Chapter 4, "*Eco-strategies and firm growth in European SMEs: when does it pay to be green?*", we assess the economic consequences of adopting resource efficient practices to be greener. On the one hand, the need for eco-strategies is continuously increasing. However, the primary incentive for an individual firm to invest in green strategies is that they are profitable (in which case, further policy interventions would be unnecessary). This motivated our firm level analysis, where the main research question was to understand, not only whether or not it generally pays to be green, but also in which cases, and for whom, it is worthwhile to be green.

Although the relationship between eco-innovation strategies and firm performance has been empirically examined for more than two decades, the literature has not arrived at a consensus. This prompted us to undertake a broad study to investigate the effects of eco-strategies on the sales growth of firms. We used an extensive sample of SMEs, located across 28 European countries, and broken down into EU15 and new members. We not only differentiated between typologies of resource efficiency practices, but also considered the intensity and the breadth of the eco-practices implemented.

The empirical results confirm that firm growth varies greatly according to the eco-strategy implemented and thus, at least in the short term, not all eco-strategies are positively related to better performance. In a European SME context, certain eco-strategy measures can result in a win-win situation for both the firm and society, while others are better for the environment, but at the expense of the firm's growth. We find that European firms using renewable energies perform better. Undertaking eco-strategies aimed at recycling or designing products that are easier to maintain, repair, or reuse, increases growth in EU15 firms. In contrast, aiming to reduce water or energy pollution, seems to show a negative correlation with a firm's growth. The primary broad implication is that a proper differentiation of eco-strategies is required to establish the competitiveness effects associated with their adoption. Consequently, these results also suggest that the analysis and classification of different types of eco-strategy matters.

The empirical results also indicate that high investment in eco-strategies improves a firm's growth, particularly in new members that joined the EU from 2004 onwards. We also found a U-shaped relationship between eco-strategies and firm growth, indicating that a greater breadth of eco-strategies is associated with better firm performance. However, few European SMEs are able to either invest heavily or undertake multiple eco-strategies and, for most firms, an increasing level of green practices negatively affects performance because they fail to reach the breakeven threshold. This suggests that there is room for policy interventions aimed at raising awareness among SMEs of the advantages of making a minimum level of investment in eco-strategies, or in considering the possible positive synergies and interactions between different eco-practices.

Clearly, green innovations are needed in the drive towards a sustainable economy. But our results indicate that it is not always profitable for European SMEs to be green and that there is a need to identify which are the winning strategies. Policy makers should carefully consider which typologies of eco-strategies they are wishing to stimulate, as these generate heterogeneous results and vary slightly across different countries. Policy-makers should therefore consider the economic and technological specifications of each group of EU countries to remove barriers to resource efficiency practices and to inform, educate, and persuade firms about what they can do to respond to alleviate global environmental challenges. Fostering the adoption of resource efficiency practices by firms might be a good policy target, one which could contribute to improving both the environment and a firm's performance.

2. FUTURE RESEARCH

When evaluating the empirical exercises conducted in this thesis, one must be aware of their limitations. In recent years, the qualitative and quantitative improvements of the information available in the European Community Innovation Survey, coordinated by Eurostat and managed by the respective statistical institutes, has enabled new and more ambitious research. Working with PITEC, we were able to address some issues related to firm behaviour, persistence, endogeneity problems, and potential bias in relation to sample selection. In addition, having access to datasets other European dataset such as the Flash Eurobarometer Survey that include parameters such as country, sector and firm size has enriched this thesis. Despite the access to more robust data sources, the empirical research limitations cannot be ignored. The combination of our positive results and these limitations, helps point towards future extensions that are important for a better understanding of the determinants and the effects of green economy innovation strategies. We now consider these for each of the studies we undertook.

In Chapter 2, the definition of innovation success was limited to technological innovation product and process innovation. But the complexity of the concept of firm level innovation success implies that there is a need to find alternative methods of capturing such successes and benefits. Also, we focused on the firm level without linking innovation strategy to any specific innovation project of the firm—clearly, not all projects had the same impact or equal success for the firm but, due to the restrictions in the available data, in our work all innovation projects were aggregated. We hope that enhanced data sources will make this important disaggregation possible at some future time. Finally, our research focused on firm innovation success in the Spanish context, its extension to other geographical area would help provide more general empirical evidence and might lead a broader understanding of success factors. This, in turn, might improve the adaptation of policies to the instrinsic geo-characteristics of the region or country in question.

In Chapter 3, there are limitations in the dataset analysed. Although PITEC is a valuable data source, and one that has been previously used in analyses of eco-innovation in Spain, it was not specifically established to analyse environmental innovation, and consequently variables of interest to us, such as market demand for green products or different environmental policy instruments, are not reported. Also, is based on self-reported data with the consequent intrinsic risk of bias. Ideally, we would have exploited hard data in our study, but such databases are simply not available. As in other empirical studies using PITEC data, it was not possible to capture actual eco-strategy adoption; we could only select firms that self-reported a wish to reduce environmental impacts or energy consumption. Our results must, of course, be interpreted accordingly. This dataset allowed us to examine the specific case of Spanish firms. The empirical literature, however, suggests that similarities and differences may have a significant geo-political component, such us Nordic or Central European countries versus Mediterranean ones. This is only to be expected, since the institutional context (including environmental regulation, environmental awareness of the consumers, and the national system of innovation) differs across countries. The extension of this research to cross-country analyses would better help to understand the specificities of each country and to design better policies aiming at increasing eco-innovations. We finally note that there is significant heterogeneity among services and that further research is required to disentangle the strengths and weaknesses of specific service sectors. Trade and Transportation are commonly considered to have significant environmental impacts, but this is much too broad a classification to guide policy.

In Chapter 4, the database only allows us to identify the existence of a specific eco-strategies and the intensity of all strategies in general (through categorical values on an interval scale), but we cannot capture individual eco-strategy intensities. We have seen that sometimes carrying out an eco-strategy is not enough; a high level of intensity is also necessary. This suggests that developing more sophisticated proxies of eco-strategies is potential avenue for future research. On the methodological front, our cross-section analysis could be further extended by incorporating temporal dynamics in the analysis as data becomes available. The use of panel data would still correct for any remaining unobserved heterogeneity or omited variables issues. Finally, because of data limitation, we analysed firm performance using a single measure, and in a categorical dimension. In addition to growth performance, future research may extend the findings using other measures. In an ideal world, one would exploit balance sheet data on profitability rather than self-reported measures, but statistical offices understandable anonymization procedures currently prohibit this. Another important extension of this chapter would be to investigate the economic effects of eco-strategies, not only for firms, but for society as a whole, by looking at measures of productivity or employment instead of firm growth.