



HAL
open science

Three essays on eco-innovation at the firm level: the French case

Yassine Guerroud

► **To cite this version:**

Yassine Guerroud. Three essays on eco-innovation at the firm level: the French case. Economics and Finance. Université Côte d'Azur, 2021. English. NNT : 2021COAZ0015 . tel-03406775

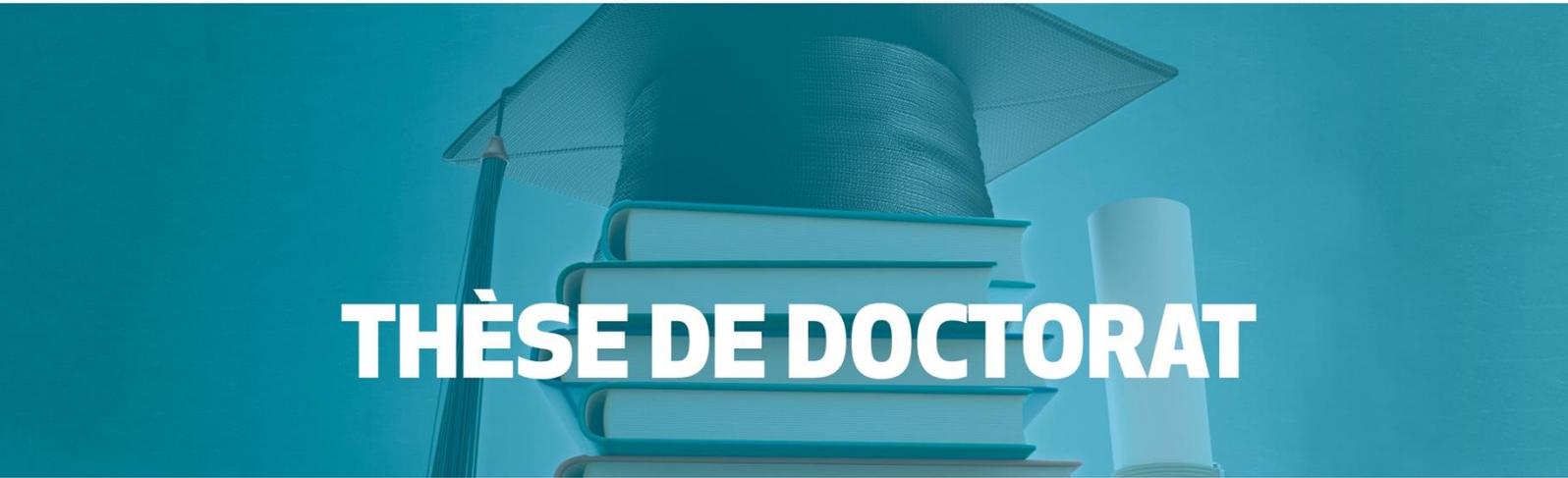
HAL Id: tel-03406775

<https://theses.hal.science/tel-03406775>

Submitted on 28 Oct 2021

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



THÈSE DE DOCTORAT

Trois essais sur l'éco-innovation au niveau
de l'entreprise : le cas français

Yassine GUERROUD

GREDEG

**Présentée en vue de l'obtention
du grade de docteur en sciences économiques
d'Université Côte d'Azur**

Dirigée par : Jackie KRAFFT, Directeur de
Recherche au CNRS (HDR)

Soutenue le : 07 / 10 / 2021

Devant le jury, composé de :

Jens HORBACH, Professeur (HDR), Université
des Sciences Appliquées, Augsburg,
Allemagne

Eva NIESTEN, Professeur, SKEMA Business
School, Paris, France

Michele PEZZONI, Maître de Conférences
(HDR), Université Côte d'Azur, France

Francesco QUATRARO, Professeur (HDR),
Université de Turin, Italie



DOCTORAL THESIS

Three essays on eco-innovation at
the firm level: the French case

Yassine GUERROUD

GREDEG

**Defense presented with the purpose of
obtaining a PhD in economics of the
Université Côte d'Azur**

PhD supervisor: Jackie KRAFFT, CNRS
Research Professor (*HDR*)

Date of the defense: 10 / 07 / 2021

Thesis committee:

Jens HORBACH, Professor (HDR), University
of Applied Sciences, Augsburg, Germany

Eva NIESTEN, Professor, SKEMA Business
School, Paris, France

Michele PEZZONI, Associate Professor (HDR),
Université Côte d'Azur, France

Francesco QUATRARO, Professor (HDR),
University of Torino, Italy

Trois essais sur l'éco-innovation au niveau de l'entreprise : le cas français

Jury :

Président du jury :

Francesco QUATRARO, Professeur (HDR), Université de Turin, Italie

Rapporteurs :

Jens HORBACH, Professeur (HDR), Université d'Augsbourg, Allemagne

Francesco QUATRARO, Professeur (HDR), Université de Turin, Italie

Examinateurs :

Eva NIESTEN, professeur, SKEMA Business School, Paris, France

Michele PEZZONI, Maître de Conférences (HDR), Université Côte d'Azur,
France

Directrice de la thèse :

Jackie KRAFFT, Directeur de recherche au CNRS (HDR), GREDEG, Sophia
Antipolis, France

Trois essais sur l'éco-innovation au niveau de l'entreprise : le cas français

L'idée longtemps soutenue dans la littérature était que le contexte réglementaire environnemental jouait un rôle négatif sur l'activité économique des entreprises et leur prospérité. À partir des années 1990, cette vision a commencé à changer avec l'idée que le conflit entre les performances économique et environnementale devrait être approché différemment. Plus concrètement, les décisions politiques et les efforts des chercheurs ont amorcé une nouvelle approche selon laquelle ni le cadre réglementaire ni la réduction de la pollution ne devaient se traduire en une pénalisation de l'activité économique. Selon ce contexte, les entreprises doivent introduire des innovations environnementales ou des éco-innovations qui, comme leur nom l'indique, sont des innovations avec des externalités négatives réduites sur l'environnement. L'objet de cette thèse s'inscrit dans ce contexte, et a pour objectif d'apporter des éléments d'analyse nouveaux à la littérature, d'approfondir l'analyse existante sur la question de l'éco-innovation au niveau de l'entreprise, et de mettre en lumière le contexte de la France.

Le premier chapitre de cette thèse représente une revue théorique et conceptuelle de la littérature sur l'éco-innovation. Elle est fondée sur plusieurs contributions dans le domaine, et a pour objectif de souligner l'impact de l'éco-innovation sur la performance de l'entreprise ainsi que les conséquences liées à son activité. Cette revue propose de structurer les effets de l'adoption de l'éco-innovation en les scindant en deux groupes : les effets internes et les effets externes. D'abord, les effets internes sont principalement liés à l'emploi et la capacité

de l'entreprise à en créer, ou à avoir un impact qualitatif par accroissement des qualifications. Ensuite, les effets externes concernent les relations que les entreprises développent entre elles sous la pression de la réglementation environnementale, via la modification de la chaîne de valeur, par exemple. Le but de ce chapitre est d'expliquer ces mécanismes en soulignant également d'autres aspects en rapport avec l'éco-innovation.

Le deuxième chapitre présente un cadre théorique et une étude empirique sur les déterminants de l'éco-innovation sur des données françaises. La littérature sur la question n'est pas très abondante, en particulier concernant la France, et la prise en compte des éco-innovations organisationnelles et de marketing est souvent ignorée. L'étude à travers ce chapitre vise à éclairer ces zones d'ombre. Les résultats montrent une grande importance de la réputation de l'entreprise pour l'introduction des quatre types d'éco-innovation, une importance de la réduction des coûts ainsi que l'implémentation de bonnes pratiques environnementales pour l'éco-organisation, et l'importance des aides gouvernementales et subventions ainsi que les contrats avec les clients pour l'éco-innovation de marketing.

Le troisième chapitre analyse la question de l'impact de l'éco-innovation sur la croissance de l'entreprise, en prenant en considération deux indicateurs de croissance : emploi et chiffre d'affaires, analysés sur données françaises. L'étude empirique vise à mesurer l'impact de l'introduction des différents types d'éco-innovation sur les deux indicateurs de croissance retenus. Suivant la littérature récente, des régressions par quantiles sont effectuées étant donné que la croissance des entreprises n'est ni homogène ni linéaire. Les résultats

montrent une relation positive et significative entre l'éco-innovation et la croissance du chiffre d'affaires du dernier quantile. Ces résultats ne sont pas vérifiés quant à la croissance de l'emploi. D'autres variables, principalement l'activité de brevetage, la recherche et développement et l'appartenance à un groupe d'entreprises, se révèlent être importantes pour la croissance des entreprises de l'échantillon, et ce quel que soit l'indicateur de croissance.

Codes JEL: L25, O30, Q50, Q51, Q55, Q56

Mots-clés: éco-innovation, environnement, déterminants, croissance de l'entreprise, CIS, emploi, chiffre d'affaires, hypothèse de Porter.

Three essays on eco-innovation at the firm level: the French case

The idea supported in the literature for a long time was that the regulatory framework had a negative impact on the activity of firms, as well as on their prosperity. Starting from the 1990s, this vision started to change progressively and was substituted by a new approach in which the conflict between economic and ecological performance should be approached differently. More concretely, political decisions and researchers' endeavours triggered this new approach according to which neither the regulatory framework nor the reduction of pollution should involve any economic activity harming. According to this context, firms should introduce environmental innovations or eco-innovations which are, as their name suggests, innovations with less environmental negative externalities. The content of this thesis sticks with this context and aims to bring in new elements to the debate, to deepen the extant analysis related to the questions of the introduction of eco-innovation at the firm level, as well as by highlighting the French context.

The first chapter of this thesis presents a theoretical and conceptual literature review on eco-innovation. This review is based on a bench of contributions in the field and aims to underline the impact of eco-innovation on firm performance, as well as the different consequences related to its activity. This review suggests that the effects of the introduction of eco-innovation can be decomposed into two separate categories: the internal effects and the external effects. First, internal effects are mainly related to employment and to the ability of firms to create more jobs, also including qualitative substitution effects based on improved

qualifications. Second, external effects are related to changes in relationships across firms while complying with the environmental regulation through the transformation of the supply chain. The objective of this chapter is to develop and explain these mechanisms alongside other aspects related to eco-innovation.

The second chapter includes a theoretical and an empirical analysis on the determinants of eco-innovation based on French data. Literature on the question is generally quite scarce, particularly regarding France, and almost inexistent concerning eco-organisational and eco-marketing innovations. The analysis along this chapter aims to emphasise these points, in a context marked by an increasing adoption of eco-organisational and eco-marketing innovations by firms. Results reveal a great importance of firm's reputation ahead of the introduction of all types of eco-innovation (product, process, organisation, and marketing), the importance of cost savings as well as the implementation of good environmental practices for the introduction of eco-organisational innovation, and the role of existing governmental aids and the contracts with customers for the introduction of eco-marketing innovation.

Finally, the third chapter deals with the question of the impact of eco-innovation on firm growth, considering two growth indicators: employment and turnover, and analysing French data. After the presentation of a literature review, the empirical analysis is developed to analyse the impact of the introduction of eco-innovation (with no distinction in types), on both growth indicators previously explained. Following the very recent literature, multiple quantile regressions are performed given the non-linearity and the heterogeneity of

firms' growth. Findings reveal a positive and significant relationship between eco-innovation and turnover growth of the top decile (10%) of the sample. Meanwhile, these results are not confirmed regarding eco-innovation and employment growth. Finally, other variables, namely patenting activity, research and development, and group ownership, are found to be important for firms' growth of the sample whatever the growth indicator used.

JEL codes: L25, O30, Q50, Q51, Q55, Q56

Key-words: eco-innovation, environment, determinants, firm growth, CIS, employment, turnover, Porter hypothesis.

Acknowledgements

First, I would like to thank my supervisor, Jackie KRAFFT, for the support, the help and the continuous follow-up since my master degree until this day. I would like to thank her for being available, for believing in me, for pushing me, and for giving me the opportunity to do something that I wanted to do, and this is something that I will never forget.

I would also like to thank the members of the thesis committee, Jens HORBACH, Eva NIESTEN, Michele PEZZONI, and Francesco QUATRARO, for having kindly accepted to evaluate my PhD dissertation.

My warmest thanks and thoughts go to my father for always being by my side no matter the distance separating us, for sacrificing his life to see my brothers and myself succeeding in our respective lives. I pay him this tribute and thank him for always believing in me, trusting and supporting me in the ups and downs, for teaching me to always be humble and straight towards myself and towards the others. I dedicate this work to him with all my love, admiration, and respect, hoping from the bottom of my heart that this makes him proud and honoured.

I would like to thank the colleagues who helped me through this work. My thoughts go to Cécile CEZANNE and Laurence SAGLIETTO

for the annual follow-up and advice, and Awatif BENKOURRAD, Michele PEZZONI, and Marco BAUDINO for the methodological advice and discussions.

My thoughts go to my dear brothers Mohammed and Youcef, as well as to my two sisters in law Nardjess and Jihane, to my two sweet nieces Rania and Lina, and to my dear aunts Fatima, Hassina, Khadidja, Mina, and Salima, as well as to my cousin Amina. Their love and consistent support and prayers had a significant impact on the whole process since I landed in France in 2015.

I would like to thank my friends who have always been here for me. My thoughts go to Amir, Djibril, Fatima, and Nasreddine, for the support and the advice they carried on giving to me, and all the ones who have contributed to this from near or from far, without forgetting the beloved ones who have joined another world.

My thoughts also go to every person I have shared good moments with in GREDEG, and to the ones I have shared the office with since January 2018; Alberto, Alexandre, Arnaud, Claire, Jeremy, Marie, and Sarah, in particular.

This work is for all of you.

*”...Si tu veux t’acheminer vers la
paix définitive, souris au destin qui
te frappe et ne frappe personne.”*

Omar Khayyâm

Contents

List of figures	xii
List of tables	xv
General introduction	1
1 The theoretical effects of the introduction of eco-innovation: a firm level survey	12
1.1 Introduction	13
1.2 Eco-innovation: Notions, measurement, and determinants	16
1.2.1 Browsing through definitions	16
1.2.2 Measurement and implementation	20
1.2.3 Determinants	23
1.3 Firm level effects: within and between firms' boundaries	30
1.3.1 Employment and jobs qualifications: the internal mechanism	30
1.3.2 The possible effects on supply chain: the external effect	43
1.4 Conclusion	46

2	What guides eco-innovation activities at the firm level? Empirical analysis based on the French community innovation survey	49
2.1	Introduction	50
2.2	Literature review and conceptual framework	53
2.3	Data and variables	60
2.3.1	Data and Community Innovation Survey	60
2.3.2	Definition of variables and descriptive statistics	61
2.4	Empirical analysis	67
2.4.1	Econometric estimation	67
2.4.2	Results	68
2.4.3	Eco-product and eco-process	71
2.4.4	Eco-organisation and eco-marketing	72
2.5	Marginal effects	73
2.6	Conclusion	76
3	Eco-innovation and French firms' growth: Empirical analysis based on the French community innovation survey	82
3.1	Introduction	83
3.2	Literature review and theoretical framework	85
3.3	Data	90
3.3.1	Community Innovation Survey	90
3.3.2	Description of dependent and independent variables	91
3.4	Empirical analysis	95

3.4.1	Research strategy and econometric estimation	95
3.4.2	Discussion of results	100
3.5	Conclusion	103
	General conclusion	106
	Bibliography	123
	Appendices	124
A.1	Summary statistics and correlations for variables used in chapter 2	125
A.2	Robustness checks related to the empirical analysis carried out in chapter 2	131
A.3	Summary statistics and correlations for variables used in chapter 3	147

List of Figures

1.1	Publications' evolution (source: Google Scholar)	17
1.2	Eco-innovation implementation process (source: Cheng and Shiu (2012))	23
1.3	Determinants of eco-innovation (source: Horbach et al. (2012)) . .	24
1.4	Eco-innovation effects on employment by categories of employment and by eco-innovation types.	42
3.1	Kernel Density estimate of "ln Turnover" growth	93
3.2	Kernel Density estimate of "ln Employment" growth	93

List of Tables

1.1	Main concepts definitions	17
1.2	Summary of literature related to determinants of eco-innovation .	27
1.3	Summary of studies on employment effects	36
2.1	Determinants of eco-product and eco-process innovations and suggested determinants of eco-organisational and eco-marketing innovations.	57
2.2	Distribution of the answers on firms that introduced environmental innovations (French CIS 2014). Question: "Which innovation with environmental benefits did your firm introduce between 2012 and 2014?"	62
2.3	Determinants of eco-innovation (French CIS 2014). Question: "What was the importance of each of the following factors ahead of the introduction of the innovation with environmental benefits chosen in the previous question?"	64
2.4	Determinants of eco-innovation from CIS 2014 and literature. . .	64

2.5	Marginal effects following the estimation of separate probit models for the four dependent variables (CIS 2014).	68
3.1	Eco-innovative firms among the sample (CIS 2014) "Was any eco-innovation type introduced in your firm during last three years?"	91
3.2	Mean of natural logs turnover and employment growth for each decile (CIS 2014).	93
3.3	Turnover growth determinants captured by " <i>LnTurnGrowth</i> " between 2014 and 2016.	97
3.4	Employment growth determinants captured by " <i>LnEmpGrowth</i> " between 2014 and 2016.	99
A.1.1	Summary statistics	125
A.1.2	Matrix of correlations between dependent variables.	129
A.1.3	Matrix of correlations between independent variables	129
A.1.4	Distribution of the answers on firms that introduced environmental innovations, before dropping observations with missing values.	130
A.1.5	Determinants of eco-innovation extracted from French CIS 2014, before dropping observations with missing values.	130
A.1.6	Correctly predicted probabilities according to the logit models. . .	130
A.2.1	Marginal effects following the estimation of separate logit models for the four dependent variables (CIS 2014). (High and average importance = 1, weak and no importance = 0)	131

A.2.2	Marginal effects following the estimation of separate logit models for the four dependent variables (CIS 2014). (high importance = 1 and other categories together = 0)	135
A.2.3	Coefficients resulting from the estimation of a multivariate probit model for the four dependent variables in one equation (CIS 2014).(high and average importance = 1, weak and no importance = 0)	139
A.2.4	Coefficients resulting from the estimation of a multivariate probit model for the four dependent variables in one equation (CIS 2014). (high importance = 1, other categories = 0)	143
A.3.1	Summary statistics	147
A.3.2	OLS regressions' coefficients.	152
A.3.3	Matrix of correlations among key independent variables	154

General introduction

The last decade of the twentieth century has known an important evolution in terms of economic thinking, particularly at the firm level, while taking into account the environmental regulation. For long, the focus was exclusively on economic activity and all environmental aspects were considered, such as costs, wastes, and taxes. Although each country had its own regulatory framework, this opposition between the economic sphere and the environmental sphere remained as a background of every practitioners, be they managers, entrepreneurs, investors or researchers. However, by the middle of 1990s one pioneer theoretical work could bring new insights in and propose a new analytical framework.

Porter and Van der Linde (1995) explained that a well-designed environmental regulatory framework would not necessarily harm production and economic activity, but could rather trigger a win-win situation. For these authors, firms complying with this regulatory framework would explore instead new methods and processes to produce while reducing the negative impact of production on environment, therefore reducing wastes and their related costs, and the use of energy and materials. The win-win situation lies in combining both economic and environmental performance together. In other words, producing and generating profit, while protecting environment, could go hand in hand.

Regulatory framework is not necessarily and solely based on policies, laws, restrictions, and taxes pulling firms' activity down and harming their production and slowing their performance. It is also about different subsidies and aids to help firms in making their transition to cleaner and greener modes of production. This is the new context that was brought by Porter and Van der Linde (1995).

Firms should rather cope with the existing environmental regulation and develop new production processes and practices aiming to issuing new green products, to explore new markets, and to gain in terms of competitiveness while reducing the negative environmental impact.

The key solution to this problem is to eco-innovate. Arundel and Kemp (2009) define in a very detailed way eco-innovation as being *"...a new concept of great importance to business and policy-makers. It is about innovations with lower environmental impact than relevant alternatives. The innovations may be technological or non-technological (organisational, institutional or marketing-based). Eco-innovations can be motivated by economic or environmental considerations. The former [eco-innovation] includes objectives to reduce resource, pollution control, or waste management costs, or to sell into the world market for eco-products."* This definition is considered until now one of the most complete given in the field. Eco-innovation appears to be very important for businesses as well as for the regulator. The definition also gives very important details about the objectives, the motivations and the types of eco-innovations. Indeed, eco-innovation can be guided by either environmental objectives (reduce all the forms of negative environmental impact), or by objectives related to the commercial activity of the firm, as it also covers the different types of innovation: product, process, organisation and marketing.

Yet, if innovation process is very complex to analyse, eco-innovation has another level of difficulty due to its novelty, and this is the focus of many researchers' endeavours. Researchers manifested an important and undoubtedly growing

interest to the question, analysing it from different angles (Green et al. (1994) , Rennings (2000) , Rennings and Zwick (2002) , Brunnermeier and Cohen (2003) , Rennings et al. (2004) , Chen et al. (2006) , Horbach (2008)). Studies of eco-innovation could comprise its definitions, dimensions, determinants and drivers, its implementation process, its types (product, process, organisation, and marketing), as well as the different possible impacts of its introduction at the firm level.

The introduction of eco-innovation at the firm level started to gain interest since the beginning of this century, as this interest was triggered by summits and conferences such as the Lisbon strategy in 2000 and Gothenburg priorities in 2003. The Lisbon Strategy is a ten-year project, between 2000 and 2010, aiming to develop a coordinated European approach in the fields of economic, employment and social policy (Rodriguez et al. (2010)), while Gothenburg priorities called for the implementation of sustainable economy mainly based on the facilitation of innovation, the protection and improvement of the environment, and the development of transnational synergies for sustainable growth areas.

These two groups of objectives deduced from both Lisbon strategy and Gothenburg objectives somehow shaped the literature in this new field and gave a direction to go forward, as a large number of academic contributions started tackling the problematic of employment growth and environment protection at the same time, in order to provide governments with recommendations and to develop the new body of literature related to this field.

The introduction of eco-innovation follows a process within the firm (Cheng and Shiu (2012)), and beyond this implementation process the issue since the beginning was to understand two main things. First, ahead of the whole implementation process of eco-innovation, efforts were made to know what guides and motivates it within the firm. In other words, the question was to know what do managers and decision-makers pay attention to within the boundaries of the firm, and what are the factors that influence their decision before introducing eco-innovation. Regarding this first issue, a bench of contributions saw the day and analyses popped up across almost all the developed countries significantly concerned by this question, progressively emanating as a result a global concern as well (Cleff and Rennings (1999) , Brunnermeier and Cohen (2003) , Horbach (2008) , Chen (2008) , Horbach et al. (2012) , Horbach et al. (2013) , Triguero et al. (2013) , Costantini et al. (2015) , Bossle et al. (2016) , del Río et al. (2016)). The second centre of interest is about the effects of eco-innovation at the firm level, here also several contributions emerged in order to investigate whether eco-innovation has a positive or negative impact on firm growth and performance, and whether it is favourable to the creation of more jobs positions. Also, in addition to the employment effect, some contributions tackled the impact of eco-innovation on the financial returns, captured by sales or turnover, for firms (Rennings and Zwick (2002) , Rennings et al. (2004) , Chen et al. (2006) , Horbach (2010) , Cainelli et al. (2011) , Gagliardi et al. (2016) , Ghisetti (2018) , Leoncini et al. (2019)). The exploration of how eco-innovation impacts both employment and turnover appears thus a timely issue, that requires further investigation.

This thesis dissertation has objectives to reach. The first objective is to present a literature review of eco-innovation at the firm level, that is structured in a way that it prepares the ground for the following related chapters. It also intends to go further in this way, by suggesting future research perspectives in the field. The second objective of the thesis is to analyse the French context which remains under-investigated, from two angles: on the one hand, better characterising the determinants of the introduction of eco-innovation at the level of French firms; on the other hand, detecting the eco-innovation impact of French firms growth. The third objective is to extend the current analyses on both determinants and firm growth by covering the four eco-innovation types, namely eco-product, eco-process, eco-organisation, and eco-marketing. The fourth objective is to contribute to the literature by exploring recent data on French firms and by benefiting from recent empirical approaches in the field.

In order to achieve these goals, this thesis dissertation is broken up into three chapters that are related by strong links in terms of reference literature, as well as chosen methods and results, making the dissertation a consistent piece.

The first chapter represents a theoretical and conceptual literature review of contributions on eco-innovation at the firm level. This question is explored from many angles and in several ways in the literature, and the chapter is, thus, intended to propose an ordered overview of the relevant literature. First, all the definitions of eco-innovation and other related concepts are presented and the connection between concepts and definitions are decomposed. This is followed by the implementation process, instruments of measurement of eco-innovation

and key determinants found in the literature. Then, a bench of contributions exclusively dealing with the different impacts of eco-innovation on firm activity and performance are considered, in view of better sorting the different effects, divided into internal ones (internal to the firm) and external ones (between different firms along the value or supply chain). The internal effects mainly concern what happens within the firm and comprise employment impacts as well as improvement in skills of introducing eco-innovation. The external effects are related to what happens to the eco-innovative firm externally, in terms of relationships with other firms. This includes the supply chain that becomes green by adopting eco-innovation (Beamon (1999)).

In sum, the first chapter addresses the following question:

What are the theoretical consequences of introducing eco-innovation on the firm's activity and performance?

In order to address this question several contributions related to economics and management literature, including older works and very recent ones are explored and analysed allowing a structured reading of key contributions in the field, as well as how literature has developed on the key mechanisms of internal and external effects. Furthermore and very concretely, the literature review nurtures the remainder of the dissertation, namely the two chapters related to the determinants of eco-innovation in France, and to the growth of French firms.

The second chapter deals with the determinants of eco-innovation. In fact, before introducing eco-innovation which follows an implementation process developed

by Cheng and Shiu (2012), several factors are taken into account before managers and decision-makers within firms decide to introduce a given eco-innovation type. This chapter tackles the determinants of eco-innovation by highlighting the French context which remains so far quite unknown.

The second chapter addresses the following question:

What are the determinants of the introduction of eco-innovation by French firms?

In order to answer this question, an important focus is made exclusively on literature related to determinants of eco-innovation since 1990s until recently, with the objective to underline what was done/not done in the field. In fact, some elements emerge from the literature review elaborated in the first chapter. On the one hand, distinction between eco-innovation types is not systematic, as it only includes eco-product and eco-process. Only in some occasions eco-organisational innovation is considered apart, and eco-marketing innovation is largely ignored. To fix this issue, this chapter proposes to investigate the determinants of the four types of eco-innovation: product, process, organisation and marketing. On the other hand, another point that comes out of the literature review is the country and the period of the study. This chapter tackles French data which were not exploited and analysed yet, although some studies include France among other countries in their analyses (Horbach et al. (2013) , Triguero et al. (2013)). Data for this chapter stem from the community innovation survey (CIS) wave conducted in 2014 for the three previous years: 2012, 2013 and 2014.

The third chapter deals with the question of the impact of introducing eco-innovation on firm growth. Beyond the implementation process and what drives the introduction of eco-innovation, the focus on the impact of eco-innovation is also a key issue to be investigated, as many scholars and policy-makers are questioning the positive role that eco-innovation might have on employment growth and skills dynamics.

The third chapter addresses the following question:

What is the impact nature of the introduction of eco-innovation on firm growth?

In order to answer this question, a literature review focused on the contributions dealing with eco-innovation impacts at the firm level is carried out. Then, an empirical analysis based on two community innovation survey waves (2014 and 2016) is implemented. Very often, most studies explain employment growth by eco-innovation, and few have embedded more than one indicator in their analyses (Cainelli et al. (2011)). Therefore, in this chapter the analysis investigates two different growth indicators: employment growth and turnover growth, with the objective to close a first gap in literature. Furthermore, a more detailed setting is provided through the empirical evidence, it is admitted that quantile firms may differ from average firms. Another contribution of this chapter is investigating the impact of eco-innovation whatever its type: product, process, organisation and marketing, since few is said about the eco-innovation types considered in studies.

Through the different theoretical, conceptual and empirical analyses of the three main questions of this dissertation, the aim is to contribute to the literature and to close the gaps identified in it. Providing the literature review on the relationship between eco-innovation and firm in general allows to redefine the transmission channels by which eco-innovation affects firm activity with a distinction between internal and external effects. By providing evidence on French data another objective is to highlight the much unknown French context and to contribute to the literature. In addition to the latter gap, performing an empirical analysis on the determinants of eco-innovation contributes to the literature related to this question as it remains quite scarce. The fact of not neglecting any eco-innovation type helps to propose a complete and original analysis of the determinants of eco-innovation. By proposing an empirical analysis of the impact of eco-innovation on firm growth using two growth indicators: employment and turnover, also intends to give a more complete analysis of the nature of eco-innovation impacts. From a methodological perspective, the second chapter comprises an empirical analysis based on the study of the probability to introduce one eco-innovation type or another, thus probit models are estimated in the main analysis, and logit models in addition to multivariate probit models are estimated as robustness checks. For the third chapter, performing quantile regressions is a modern method applied by researchers when dealing with firm growth (Coad and Rao (2008) , Segarra and Teruel (2014) , Colombelli et al. (2019)), thus two distinct quantile regression models are performed to accurately investigate the impacts on each quantile of the distribution of firms considering both growth indicators, in addition to two

ordinary least square (OLS) models estimated for the robustness checks.

All in all, this thesis dissertation is intended to provide a consistent contribution through three distinct essays on how eco-innovation can be conceived, can drive and impact the advanced economies, by focusing on the firm level. It aims to be conceived as a one step ahead in the large, still in exploration phase literature of the environmental innovation.

Chapter 1

The theoretical effects of the introduction of eco-innovation: a firm level survey

1.1 Introduction

The study of eco-innovation has known a large interest, especially in the context of a growing concern for the preservation of environment, together with the willingness to respond to pressures of environmental regulation. This context creates incentives for firms to produce, generate and introduce green technologies to switch from standard innovations to environmentally-friendly innovations. This transition, according to Porter and Van der Linde (1995), can lead to a win-win situation, as spreading technologies to improve environmental performance will produce knowledge spillover that positively affects competitiveness for firms through innovation, with expected long-run benefits such as creating new economic opportunities and improving environmental benefits.

In the meantime, the underlying incompatibility between economic and environmental performance leads to recurrent discussions of the Porter hypothesis. Among recent key contributions, Horbach (2010) endorses Porter hypothesis and suggests that political support for environmental innovations activities is key to emission reductions and can improve the competitiveness of firms, which is also expected to lead to positive employment effects. Alternatively, Cainelli et al. (2011) do not find Porter-like effects in the short run and suggest that the analysis should be more appropriately focused on the medium-long run. Horbach et al. (2012) complement the argument by advancing that firms are not always able to detect eco-innovation potential due to their inexperience in dealing with environmental issues, in a context of incomplete information. They suggest

Environmental Management Systems (EMS) as an eco-organisational innovation, which would make firms able to deal with these issues in a comprehensive, systematic, planned and documented way, in view of decreasing uncertainty. Triguero et al. (2013) add to the latter the role of organisational issues and suggest that governments must establish an environmental regulation to encourage firms to develop eco-organisational innovations. Costantini et al. (2015) highlight the important role of public policies in affecting both demand and supply sides through environmental policies and subsidies to R&D as an important driver to create favourable context for eco-innovation, in line with Porter hypothesis.

In sum, recent discussions on Porter hypothesis do not necessarily end up by rejecting it. It is rather seen as a framework leading to suggestions for further findings and evidence, and one of the recent options of the literature in view of disentangling how and when the Porter hypothesis holds and when it does not, is to put a more important focus on the potential effects at the firm level. Although this granular theoretical investigation on eco-innovation at the firm level looks promising, contributions in the field still are scarce. Recently, Barbieri et al. (2016) highlight the most relevant directions in which the literature has developed and suggest that there is ample room for discussion on the effects of environmental innovation on firms' activity and performance. The present chapter is intending to go further in this way, by suggesting further research perspectives based on a large literature review of eco-innovation at the firm level.

In this perspective, the aim is to better define the effects of the introduction of eco-innovation at the firm level by distinguishing between internal and external

changes that firms experience in their activities and structures when introducing environmentally-friendly innovations. First, as an internal change within firms' boundaries, employment reallocation and the emergence of the substitution mechanism between unskilled and high-skilled jobs seem to be one of the most important consequences of the introduction of eco-innovation. Still internally, firms can experience some jobs losses. Second, an external change occurs from one firm to another, as considering the environmental regulation progressively turns supply chains to become green or greener (Beamon (1999)). The effects of the introduction of eco-innovation operate, thus, both within firms but also between firms in a cooperation/collaboration perspective.

In view of providing a deeper comprehension of these mechanisms, first detailed review of definitions of eco-innovation, instruments of measurement and determinants is carried out in Section 2. Then, relevant and critical contributions that explore eco-innovation at the firm level are discussed in Section 3. Main findings on employment growth are explored with the presentation of different methodologies, with a deeper investigation on eco-innovation effects in terms of employment reallocation, jobs qualifications and skills within the firm. The impacts of the introduction of eco-innovation are also analysed beyond firms' boundaries, as green supply chain (GSC) affects the cooperation/collaboration between firms introducing green technologies in both upstream and downstream levels. In a final step, the chapter draws conclusions in Section 4 on how this can shape future research perspectives in the field.

1.2 Eco-innovation: Notions, measurement, and determinants

The literature uses several notions to deal with eco-innovation. There are also different ways to measure and implement eco-innovation, and a variety of determinants identified and taken into account in view of introducing eco-innovation. This section provides some guidelines that can be useful for readers that are not familiar with the topic.

1.2.1 Browsing through definitions

Eco-innovation as a concept started to be used by economists at the beginning of 1990s. For several years, its importance and interest have been growing, both in practice and at the academic level. This concept coexists with three other ones: “green innovation”, “environmental innovation” and “sustainable innovation” (Schiederig et al. (2012)).

For instance, in order to highlight the growing interest that this field has known and particularly since 2000, using Google Scholar (Figure 1.1), the evolution of each concept in the academic world between 1990-2017 can be visualised. Numbers of publications that separately contain “Eco-innovation”, “Environmental Innovation”, “Green Innovation”, and “Sustainable Innovation” in their respective titles are illustrated.

The following table 1.1 sums up the different definitions, identifying the main aspects of each concept.

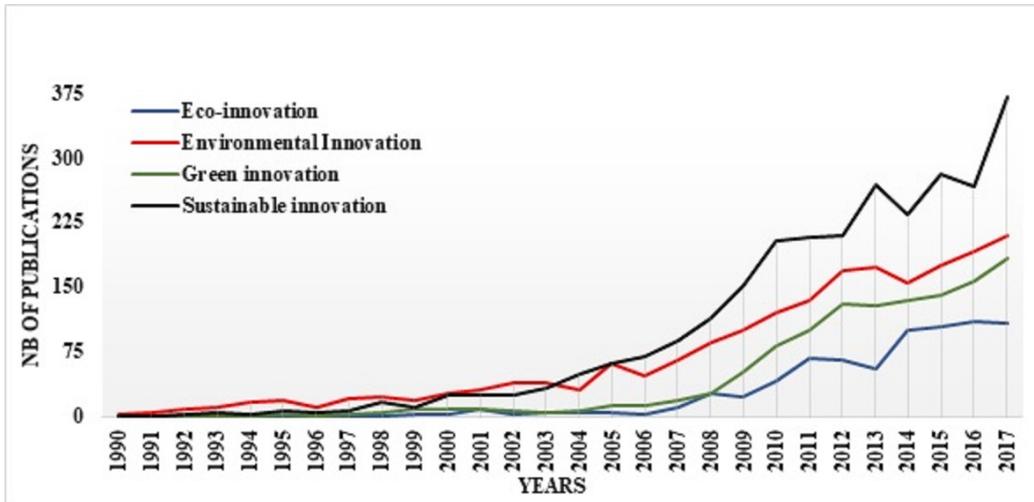


Figure 1.1: Publications' evolution (source: Google Scholar)

Table 1.1: Main concepts definitions

Concepts	Authors	Main aspects
Green innovation	Driessen and Hillebrand (2002)	- Innovation aiming to improve environmental benefits.
	Chen et al. (2006)	- Innovation involved in energy-saving, pollution prevention, waste recycling and green products and processes design.

Environmental innovation	Oltra and Saint Jean (2009)	- Innovations of new or modified products and processes aiming to benefit the environmental sustainability.
Sustainable innovation	Dresner (2008)	- The integration of people well-being in the economic development.
Eco-innovation	Rennings (2000)	- Innovations aiming to reduce the environmental impact and contribute to environmental sustainability.
	Kemp and Pearson (2008)	- Reduction of environmental risk, pollution and other negative impacts of resources use, compared to alternatives, throughout product life cycle.

Reid and Miedzinski (2008)	- Creation of competitive goods and services and quality of life to all people with minimal use of natural resources.
Andersen (2008)	- Close relation with competitiveness with a focus on the integration degree of environmental issues into the economic process.
OECD (2009) and OECD (2011)	- Creation and implementation of new or significantly improved products, services and process which, with or without intent, lead to environmental improvements. It can also be identified by its favourable impact on environment.

	Arundel and Kemp (2009)	- Important for both business and policy-makers, it is an innovation with lower environmental impact by reducing resources use, controlling pollution and limiting the waste of management costs.
--	-------------------------	---

Table 1.1 illustrates that, except for the sustainable innovation in which a social dimension is included, all definitions examine close topics and deal with similar subjects. This observation is consistent with Schiederig et al. (2012) who show minor differences among the different definitions, and is also in line with Gagliardi et al. (2016) who stress that “*environment-related innovation is also called eco-innovation or green innovation*”. Several definitions are used in literature, but it can be considered that all the concepts defined above can be used almost interchangeably in the literature, although Türkeli and Kemp (2018) find that environmental innovation is more influenced by policy compared to eco-innovation.

1.2.2 Measurement and implementation

Arundel and Kemp (2009) are the first authors offering instruments on how to measure eco-innovation by using four categories of instruments allowing to

measure it at the firm level. Drawing from the literature on economics of science and innovation, they suggest to consider i) input measures: all resources put into a process in order to achieve an eco-innovation, including research and development (R&D) expenditures, R&D personal staff, and innovation expenditures; ii) intermediate output measures: number and type of scientific publications and patents in green fields; iii) direct output measures: number of innovations and all data on sales of new products in green sectors; and finally iv) indirect impact measures: derived from aggregate data to estimate changes in resource efficiency and productivity. A complementary approach is proposed by Buttol et al. (2012), based on the common distinction product versus process innovations. Eco-product innovation includes any kind of improvement which considers both environmental and technological characteristics of products and leading to reduce the negative impact on environment, while eco-process innovation aims to improve production processes or delivery methods.

In addition to eco-innovation measurement, its implementation process also appears as a key milestone for the analysis and to its introduction at the firm level. It involves the consideration of organisational aspects alongside technological ones. Chen (2008) introduces the concept of “green core competences” and defines them as “*The collective learning and capabilities about green innovation and environmental management*”. He finds that this concept is essential in understanding firm ability to develop both green product and process innovations. Cheng and Shiu (2012) further identify three different key dimensions: eco-organisation implementation, eco-process implementation

and eco-product implementation, in line with Triguero et al. (2013). First, the implementation of eco-organisational innovation refers to the commitment of firms' managers and shareholders to implement eco-innovation management. It does not reduce environmental impact directly but facilitates the introduction of eco-process and eco-product innovations. It mainly includes eco-training programs, eco-product design programs and eco-learning techniques (Arundel and Kemp (2009)). It thus regroups a wide range of efforts and decisions made within the firm that can result in eco-innovation. Second, the implementation of eco-process innovation refers to the introduction of production processes that generates a reduced environmental impact, such as material recycling. It can be introduced in different production stages as long as it reduces the negative environmental impact and saves costs as a result. An eco-process innovation can take the form of additive solutions to existing process in order to reduce the negative impact on environment or can be integrated in production processes through substitution of inputs. Finally, the implementation of eco-product innovation refers to the development of new eco-products or the environmental improvement of existing ones, as the main environmental impact of many products comes from their use. The implementation of eco-product innovation mainly focuses on a product life cycle in order to reduce the environmental impact.

Eco-innovation implementation process is presented below (Figure 1.2). It demonstrates that the firm performance is pulled by the implementation of eco-innovation based on its three dimensions; organisational, process and product. These three dimensions are the components of the introduction process of

eco-innovation, and they have to be carried out in a step-by-step perspective.

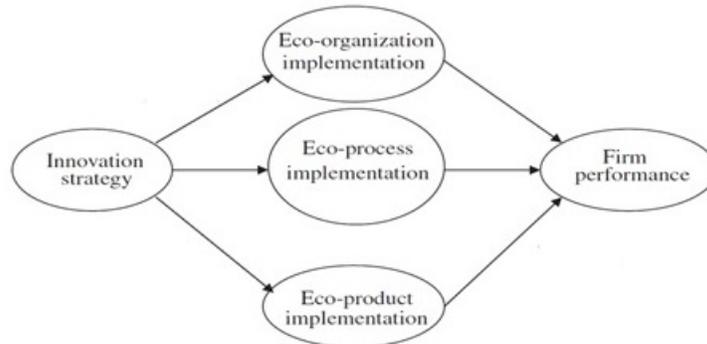


Figure 1.2: Eco-innovation implementation process (source: Cheng and Shiu (2012))

1.2.3 Determinants

The determinants or drivers¹ of eco-innovation describe all factors that influence the firm decision ahead of the introduction of eco-innovation. Recently, a lot of research has been carried out to identify them, especially through empirical methods. Horbach et al. (2012) identified four main separated groups of determinants for the introduction of eco-innovation, targeting different environmental impact areas. The four groups of determinants are related to regulatory framework, market, technology and firm specific factors (Figure 1.3).

Environmental regulation takes the form of actions which aim to reduce pollution, toxic emissions and all forms of wastes. It thus affects firm competitiveness as it is directly linked with its activity. Environmental regulation has been identified as

¹“Determinants” is conventional, but Bossle et al. (2016) also talk about drivers of eco-innovation.

being a very important determinant for the introduction of eco-innovation, and has an effect known as the “regulatory push/pull effect” (Horbach et al. (2012)). In addition, the decision to introduce eco-organisational innovation mainly emerges from environmental regulation or voluntary environmental initiatives such as Environmental Management Systems (EMS).

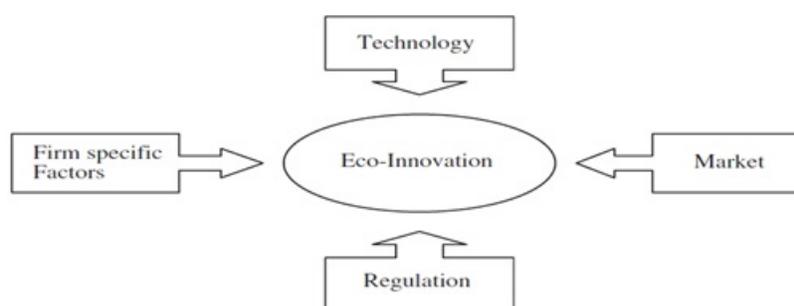


Figure 1.3: Determinants of eco-innovation (source: Horbach et al. (2012))

As an early contribution, Green et al. (1994) study through a survey on 800 UK manufacturing firms how they were innovating in technologies in response to environmental pressures, seeking to identify factors stimulating UK firms to innovate in more environmentally-friendly products and processes, and to investigate changes in R&D to facilitate such innovations. The main three factors for eco-product innovation are: the existing environmental regulation, the anticipated environmental regulation, and prospects to expand the market share of new “green” products. Alternatively, for eco-process innovation, the main three factors are: the existing environmental regulation, the anticipated environmental regulation, and cost-savings through a better use of materials and energy. Cleff and Rennings (1999) confirm that environmentally-friendly process innovation is

more influenced by regulation, while there is a significant influence from strategic market goals on environmentally-related products innovation. Then, Rennings and Zwick (2002) stress that environmental aspects in the innovation process of a firm are dominated by economic factors or by restrictions due to regulation.

Another strand of literature focusing on the maturity of regulation can explain the difference between end-of-pipe technologies and recycling measures. Brunnermeier and Cohen (2003) in a study on the response of US manufacturing firms to changes in pollution abatement expenditures and regulatory pressures, find that environmental innovations captured by successful green patent applications increases with the rise of pollution abatement expenditures. However, they do not find a significant effect of regulatory enforcement on the incentives to innovate. del Río González (2005) identifies regulation and corporate image as the main drivers for introducing cleaner technologies, in a survey on Spanish pulp and paper industry sector. Popp (2006) in a study based on patent data from USA, Japan and Germany, find that companies innovation decisions are mainly driven by national regulation. Frondel et al. (2007) and Arimura et al. (2007) find that policy stringency is an important driving force for eco-innovation. Horbach (2008) finds that environmental regulation, environmental management tools and general organisational changes encourage eco-innovation. Khanna et al. (2009) distinguish between existing and anticipated regulation, as they contribute to the creation of incentives inside the firm to adopt pollution prevention techniques. Kammerer (2009) finds that both customer benefits and environmental regulation have a significant impact on environmental product

innovation. More recently, Horbach et al. (2012) find that firms draw a big attention to expected environmental regulation for all environmental product innovations. Triguero et al. (2013), in a study on 27 European countries, find that existing environmental regulation has a positive impact on eco-product and eco-organisational innovations, while expected environmental regulation has no effect on the decision to eco-innovate at the firm level in Europe.

Apart from environmental regulation, the other determinants are designed as having an impact, although weaker (Rehfeld et al. (2007)). Kammerer (2009) finds that customer benefits play an important role in eco-innovation as eco-product innovation provides an added-value to the customer. Triguero et al. (2013) find that the supply-side factors represent a more important driver for environmental processes and organisational innovations than for environmental product innovations. Finally, Cañón-de Francia et al. (2007) stress that the availability of greater technical knowledge within a company moderates its vulnerability in facing new environmental regulations.

More recently, Costantini et al. (2015) find, in a study carried out on biofuels sector, that technological capabilities and environmental regulation accelerate innovative activities in the sector. They suggest that both demand-pull and technology-push factors are found to be important determinants for innovation in the same sector. del Río et al. (2016) highlight the distinction between eco-process and eco-product innovation while investigating the determinants of eco-innovation, as these two eco-innovation types are not likely to be affected by the same factors. Eco-process innovation is introduced in order to reduce

energy and resource costs and to comply with environmental regulation. Whereas, eco-product innovation is mainly driven by demand factors, opportunities in environmental markets and social influences. Table 1.2 summarizes the main conclusions related to determinants of the explored literature.

Table 1.2: Summary of literature related to determinants of eco-innovation

Authors and year	Journal	Main findings and most important determinants of eco-innovation
Green et al. (1994)	Futures	- Regulation, cost savings and prospect of new market shares.
Cleff and Rennings (1999)	European Environment	- Regulation and market goals.
Brunnermeier and Cohen (2003)	Journal of Environmental Economics and Management	- positive relationship between pollution abatement expenditures and successful green patents applications.
del Río González (2005)	Business Strategy and the Environment	- Regulation and corporate image are the most important eco-innovation drivers.

Popp (2006)	Journal of Environmental Economics and Management	- National regulation mainly drives eco-innovation.
Cañón-de Francia et al. (2007)	Environmental and Resource Economics	- Technical knowledge moderates within a firm moderates its vulnerability in facing environmental regulation.
Fronzel et al. (2007)	Business Strategy and the Environment	- Policy stringency is an important force for eco-innovation.
Rehfeld et al. (2007)	Ecological Economics	- Technology-push and market-pull.
Horbach (2008)	Research Policy	- Environmental regulation, technological capabilities and organisational changes encourage eco-innovation.
Kammerer (2009)	Ecological Economics	- Environmental regulation and customer benefits significantly affect eco-innovation activities.

Khanna et al. (2009)	Environmental Resource Economics	- Environmental regulation creates incentives to adopt pollution prevention techniques.
Triguero et al. (2013)	Ecological Economics	- Existing environmental regulation has a positive impact on eco-innovative activities. No observed effect from future regulation.
Costantini et al. (2015)	Research Policy	- Environmental policies and subsidies to R&D create a favourable context for eco-innovation.

There is a consensus about determinants of eco-innovation in the literature, namely regulatory push/pull, technology-push, market-pull (demand-side) and firm specific factors (supply-side), but environmental regulation is considered as being the most important determinant of eco-innovation. That said, more research by countries is left to be carried out.

1.3 Firm level effects: within and between firms' boundaries

This section theoretically deals with the effects of the introduction of eco-innovation at the firm level, by highlighting the main mechanisms to explain each effect. Two distinct but linked categories of effects are spotted in literature: first, an internal effect on employment and on the production process within the firm. Second, an external effect occurring between firms in the transition from non-green to green supply chains.

1.3.1 Employment and jobs qualifications: the internal mechanism

The debate about eco-innovation effects on employment reallocation and the new emerging skills and qualifications has known an increasing attention since studies of eco-innovation at the firm level started to be carried out. First, it appears in the literature that introducing environmentally-friendly innovations affects firm's organisation in terms of employment. Second, it is found that eco-innovation has a direct effect on firm behaviour, through inputs modification in terms of employment, quality of staff and educational level of each employee.

A bench of recent studies focuses on the relationship between eco-innovation and firm growth, the latter being empirically captured by employment growth (Rennings and Zwick (2002) , Rennings et al. (2004) , Cainelli et al. (2011)

, Leoncini et al. (2019)), sales growth (Colombelli et al. (2019)), productivity growth, turnover (Cainelli et al. (2011), and added-value (Daunfeldt et al. (2010)) as dependent or explained variables. Patents, stocks of knowledge, pace of growth, size, location and age of the firm are usually used as explanatory or independent variables (Cainelli et al. (2011) , Leoncini et al. (2019) , Colombelli et al. (2019)). Employment growth appears as being a robust growth indicator for firms, as financial returns generated by large firms can be reinvested in creating new jobs positions and introducing new technologies including green jobs and green technologies. That said, productivity growth and turnover are also important performance indicators of the firm, as they give a view on its activity respectively captured by its output average per employee and by the turnover generated by sales. Regarding explanatory variables, green patents are widely used to characterize eco-innovations, as they represent the output of an innovation and a robust indicator explaining the growth pace of a firm. When talking about stocks of knowledge or sharing knowledge in open-innovations modes, spillover and proximity between research institutions (universities and laboratories) and firms are important indicators explaining firm performance (Audretsch and Vivarelli (1996) , Ghisetti et al. (2015)).

Rennings and Zwick (2002), based on a survey of 1500 firms from five European countries which have introduced eco-innovations, find that both product and services innovations create more jobs than process innovations, and employment impacts differ depending on eco-innovation goal. If eco-innovation is motivated by cost-savings, it tends to reduce employment, whereas if it is motivated

by market shares, the effect in this case depends on whether firm strategy is successful or not. Thus, the impact can be positive or negative depending on the initial conditions. This is consistent with findings by Horbach et al. (2012), which show that when environmental goals motivate innovation, a positive employment impact can be expected. Environmental innovation is motivated by cost-savings, this can cause a negative impact on employment as the firm will reduce its inputs in terms of labour. Rennings and Zwick (2002) also find that environmental innovations have a small but positive net effect on employment, and that a shift from end-of-pipe technologies to cleaner production could be beneficial for the environment while creating jobs in the same time. Cainelli et al. (2011) in a study on a sample of approximately 800 Italian services firms between 1995-1998², using the three growth indicators: employment, turnover and productivity as dependent variables, find an overall negative impact of the introduction of eco-innovation on firm growth in the short run. It is found that there is a negative link between environmental motivations and employment growth in large firms, a consistent result with the ones found by Evans (1987a) and Evans (1987b). A negative result is observed on the link between eco-innovation strategies and turnover. It involves either a short-medium effect balanced by benefits due to added-value shift, or a real negative impact, contingent on the period of observation where environmental strategies were not at the heart of management policies. These findings are associated with a non-significant or

²According to these authors, services firms are less exploited in the literature, as data for manufacturing firms are more available, also these firms seem to be more interesting as they are directly linked to the environmental issues through industry and polluting emissions.

even a negative effect on labour productivity. These results can be explained by a set of factors, such as non-mature markets³, very early movers requiring time to capture the benefits of such innovative strategies, and the weakness of related service branches.

Horbach and Rennings (2013), based on the German CIS conduction in 2009, study the effects of environmental technologies on different environmental innovation fields. They find that for innovative firms there is an overall more dynamic employment development. The introduction of cleaner technologies in the innovation process within the firm generates more employment, while end-of-pipe technologies innovations negatively affect employment.

Gagliardi et al. (2016) perform a patent-based study on 4500 Italian manufacturing firms, on the relation between environment-related innovations and jobs creation. They test whether green innovation measured by environment-related patents has a positive impact on long-run employment growth. They find that, despite the higher costs of new green technologies, there is a positive and significant impact of green innovation on employment growth: green technologies can provide firms with extra returns, that can be reinvested to yield employment growth. This effect is found to be substantially bigger than the one of standard innovations. Leoncini et al. (2019) in a study on approximately 5500 manufacturing Italian firms, investigate the relationship between green and non-green technologies and firm growth, using the age of the firm as an explanatory variable and focusing on

³Eco-innovation strategies started to be introduced into firms' activities during this period, when markets were not mature.

employment growth. The age of the firm has a double effect on firm growth. First, it has an important role in determining the potential growth of the firm. Second, it is a moderating factor for the impact of innovative activities on firm growth (Audretsch et al. (2014)) and on employment growth particularly (Coad et al. (2016)). Leoncini et al. (2019) find that there is a positive and significant effect of green technologies on growth, greater than the one of non-green technologies. They also find that the age of the firm moderates the growth effects of green technologies of fast-growing firms. In other words, this moderation effect is positive, as the most experienced firms grow in a strong pace, while younger firms grow slowly. These findings are consistent with those explained before by del R o et al. (2016). In fact, the latter illustrate that firm size has a positive effect on the eco-innovative behaviour of firms due to a set of reasons: a higher visibility for larger firms, more important financial and human resources, the existence of R&D department, the difficulty of smaller firms in facing the complexity of environmental innovations and the investments needed to switch to green technologies⁴. del R o et al. (2016) find that the eco-innovative behaviour for small firms is influenced by the lack of internal capabilities (unskilled employees), as well as low access to information and subsidies. Regarding firm age, they state that it has a double-edged sword effect, meaning that the older the firm, the greater the accumulation of internal capabilities, which will positively influence eco-innovative firms. That said, in most studies, eco-innovation is analysed in

⁴This is not the case for all countries. In fact, some governments (i.e. Germany) provide increasing subsidies in order to accelerate the transition to green technologies.

general while only few research works distinguish end-of-pipe technologies from cleaner production (Horbach et al. (2012). According to Frondel et al. (2007), end-of-pipe technologies restrain pollution emissions by implementing add-on measures in the production process. Thus, they are greening the extant production process but cannot be considered as completely green. Alternatively, cleaner production consists in the reduction of the resource use and/or pollution at the source, by using cleaner technologies and production methods.

From this background, the most relevant contributions show that employment growth is the most commonly used indicator to measure firm performance in the literature. Findings vary depending on studies hypotheses, frameworks, samples, countries and periods of studies. However, a large range of contributions converge to conclude that adopting sustainable practices under environmental regulation pressures can make eco-innovative firms more competitive and thus more profitable, compared to their non eco-innovative counterparts. Table 1.3 below summarizes the selected studies dealing with employment effects, and illustrates the used approaches, authors and their main findings and conclusions.

Table 1.3: Summary of studies on employment effects

Authors and year	Journal	Period of study	Data	Model(s)	Main finding(s)
Rennings and Zwick (2002)	International Journal of Innovation Management	2000	IMPRESS 1500 telephone surveys	Logit model and factor analysis	- Eco-product innovations create more jobs than eco-process innovations. - The impacts vary depending on the goal of innovations.
Rennings et al. (2004)	Business Strategy and the Environment	2000	IMPRESS 1500 telephone surveys	Multinomial logit model and logit models	- Positive effect of environmental innovation (product and service) on net employment increase.

Horbach (2010)	Journal of Economics and Statistics	2004 and 2005	Establishment Panel of the Institute for Employment Research (IAB Nuremberg)	Discrete choice analysis	<ul style="list-style-type: none"> - If it is an end-of-pipe innovation, it has a negative impact on the probability to create new jobs. As it is labour saving. - Environmental innovation activities have a significant and positive influence on employment development and jobs creation.
-------------------	--	------------------	--	--------------------------------	---

Cainelli et al. (2011)	International Review of Applied Economics	1993-1995 and 1995-1998	Community Innovation Survey (CIS) and System of the Enterprise Account (SEA)	Gibrat-like empirical model, probit model	- Negative link between environmental innovations and both employment and turnover growth, and a negative or non-significant effect on labour productivity.
Horbach and Rennings (2013)	Journal of Cleaner Production	2009	CIS 2009 wave	Endogenous switching model	- Innovative firms in general are characterized by more dynamic employment development. - Those introducing cleaner technologies are more competitive.

Gagliardi et al. (2016)	Industrial and Corporate Change	2001-2008	AIDA database of Bureau van Dijk and EPO	OLS	- Positive effects on demand employment. - Positive impact of green innovation on long-run job creation. Bigger effect than the one of other innovations.
Leoncini et al. (2019)	Small Business Economics	2000-2008	AIDA database of Bureau van Dijk ASIA database of ISTAT, PATSTAT	Longitudinal fixed effects quantile models	- Positive effect of green technologies on employment growth, greater than the one of non-green technologies.

Pfeiffer and Rennings (2001) find that there is a net job creation by making the transition from end-of-pipe technologies to cleaner production. Also, a positive bias is detected for skilled and high-skilled labour, whereas demand for unskilled

labour decreases. End-of-pipe technologies are associated with job losses, while innovations in cleaner production have a positive impact on employment (Cainelli et al. (2011). Caroli and Van Reenen (2001) predicted that environmentally oriented innovations lead to a skills bias effect. By exploiting a survey on EU on the diversification of employment effects, Rennings et al. (2001) conclude that process and product innovations increase the probability of higher stock of labour, whereas process innovations and end-of-pipe technologies have a negative effect on employment, and they also confirm the skills bias. Horbach (2008) finds that technological capabilities measured by the share of high-skilled employees encourage the introduction of environmental product innovations. Cainelli et al. (2011) find a negative and significant impact of eco-innovation strategies, especially in large firms, on employment growth, and can be distinguished by job categories. Indeed, the net negative effects of both environmental product and process innovation strategies on unskilled labour force (administration) can lead to their destruction to create high-skilled positions (R&D).

Most environmental strategies thus seem to be characterized by a reduction in the unskilled employment and a shift in terms of qualified and high-qualified staff. Pfeiffer and Rennings (1999) examine both positive and negative effects of eco-innovation on employment dynamics. On the one hand, job losses can derive from a shift in productivity linked to a use of new technologies, resulting in lesser workforce involved in the production process, as less labour will be necessary to produce the same output. On the other hand, new jobs can emerge from the higher actual competitiveness generated by higher cost efficiency and/or potential higher

market added-value, which is particularly associated with eco-product innovation. These conclusions are consistent with the finding that eco-process innovation is associated with job losses, while product innovation (and eco-product) is associated with new, high-skilled jobs creation. Pfeiffer and Rennings (2001) find that recycling measures and environmental management systems have a positive effect on employment and upgrading in skills.

More recently, Consoli et al. (2016) highlight that the literature has addressed environmental regulation on a set of dimensions such as innovation, firm performance and employment effects, but has neglected issues related to the occupations that make up “green jobs”, and whether and how they differ from non-green ones. They carry out an empirical analysis on the “green employment”, which is a very recent concept that has not been used very often in the literature. The study is based on cross-sectional data from the United States for 2011 and 2012. As a starting point, they aim at finding the characteristics, contents, and the main differences between green jobs and non-green jobs in terms of skills and human capital after transition to greener forms of production, consumption and distribution. They find that green jobs use more intensively high-level skills compared to non-green jobs. In sum, the high-skilled workers in eco-innovative firms are green workers, and as revealed from previous studies (Pfeiffer and Rennings (2001) , Horbach (2010) , Cainelli et al. (2011)), green production generates a net jobs creation and high skills as a main result. Figure 1.4 summarizes the literature identifying eco-process innovation tending to destroy jobs, and eco-product innovation more likely to create jobs. This effect on job

development is coupled with a replacement effect in terms of skills: there will be more demand on high-skilled jobs and a decrease in unskilled jobs.

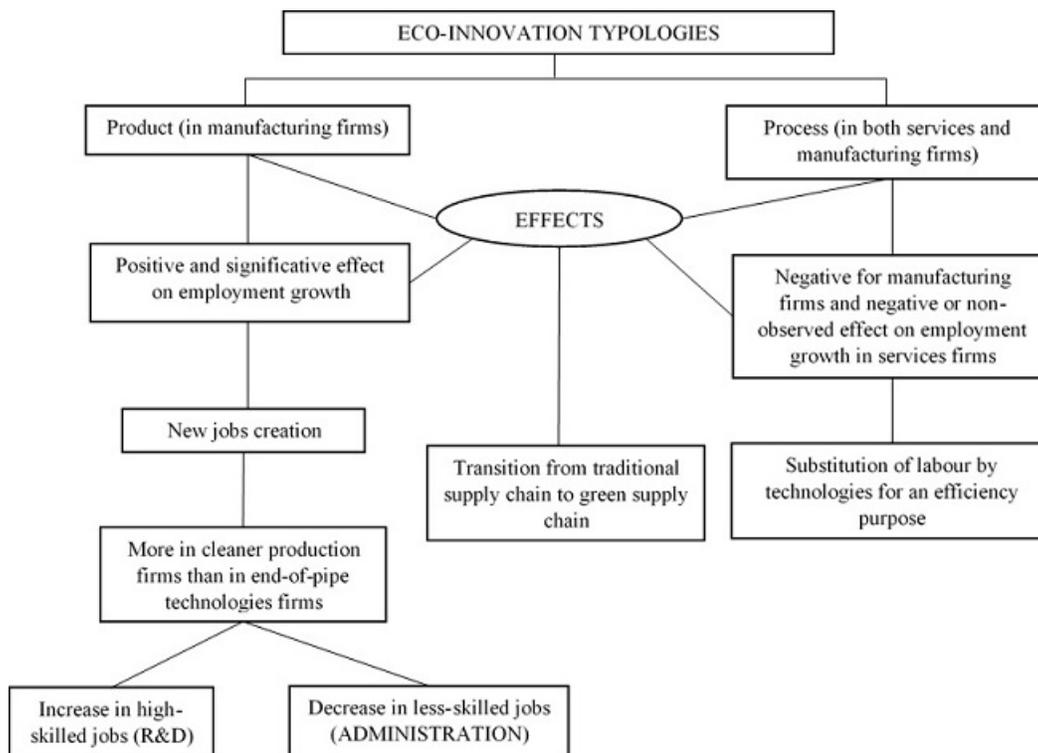


Figure 1.4: Eco-innovation effects on employment by categories of employment and by eco-innovation types.

From what precedes, the main effects of adopting eco-innovation can be better delineated, since it is found that it has an overall positive effect on firm growth for manufacturing firms, and a negative or unobserved effect for services firms, with a positive skills bias. The effects of eco-innovation on employment may be the most important ones, not only on employment but on the whole firm performance, since employment is a robust performance indicator. For services firms, it is found that eco-innovation has a negative or non-observed positive impact on employment

growth. Whilst for manufacturing firms, eco-innovation has a positive impact on employment growth for large firms, and negative for small firms. A positive skills bias is observed, as unskilled jobs are substituted by high-skilled jobs. In fact, eco-innovation strategies are known to be complex and more knowledge intensive, compared to standard innovations, so they require high-skilled workers. Also, for an efficiency purpose, services firms tend to replace workforce and labour by technologies.

1.3.2 The possible effects on supply chain: the external effect

Apart from internal effects within firms, eco-innovation also has an impact on the relationship between firms in a supplier-customer perspective. In order to generate environmental benefits at every stage of production and due to the awareness of the environmental risks and the willingness to comply with environmental regulation, sustainable practices through the whole supply chain are adopted. Eco-innovation, not only makes the production process and final product changing within the firm, but also affects the relationship between firms in both upstream and downstream levels in a vertical integration/specialization perspective. By considering the vertical relationship between firms, not only green or cleaner technologies can be transmitted, but also knowledge spillover can be used through improvements in machines, the inputs purchased from suppliers, and those related to interactions between suppliers and customers.

While traditional supply chain is defined as “*an integrated manufacturing process by which raw materials are converted into final products, then delivered to customer*”, “green” supply chain (GSC) is defined as being an extension of the traditional supply chain (Beamon (1999)). This extension occurs by considering the present and future environmental effects of processes and products and is motivated and driven in order to comply with the environmental regulation, using a set of practices. The latter, according to Vachon and Klassen (2006), are related to environmental issues and performance and they encompass all the activities related to the prevention from pollution and the limitation of wastes, and include the “recovery operations”: recycle, reuse and re-manufacture. This undoubtedly involves potential implications on the dynamics of employment and skills.

Chiou et al. (2011) in a study carried out on Taiwanese firms, find that “greening the supplier” through green innovation generates significant benefits to the environmental performance, and a competitive advantage for the firm. In the same vein, Grekova et al. (2016) in a study on Dutch industrial sector, explore the potential of environmental collaboration between suppliers and customers in order to induce environmentally sustainable improvements to internal processes to deal with external sustainability and to contribute to business performance. In environmental collaboration, supply chain partners optimize the use of each other resources and exploit learning and knowledge sharing opportunities to enhance environmental sustainability. They find that environmental collaboration between suppliers can improve the performance of firm processors directly, whereas the environmental collaboration with customers indirectly influences firm

performance, by stimulating it to permanently implement sustainable process improvements that subsequently bring cost-savings and market gains.

Diffusing green technologies along the supply chain within and between firms is highlighted in the literature, but empirically, quantitative studies are scarce (Costantini et al. (2017)). The latter study the effects of introducing and diffusing green technologies along the supply chain and inter-sectoral linkages on environmental performance. They find, first, that both corporate and policy governance strategies should specifically address the goal of maximizing environmental benefits by introducing clean technologies along the supply chain, as corporate sustainability depends on internal capabilities but also on environmental gains along the supply chain. Thus, to achieve higher environmental performance there should be an effective governance of the sustainable supply chain. Second, these strategies should be coordinated in order to save costs related to the reduction of environmental risks. The results found by Costantini et al. (2017) clearly have implications for firm and policy choices regarding the governance system of the supply chain, both within the firm and between firms. Last, Colombelli et al. (2019) show that there are inducement mechanisms stimulating the introduction of green technologies and increasing the derived demand for technologies produced by upstream firms supplying eco-innovations.

Given the different findings reviewed above, some scenarios may be possible linking internal and external effects. The common assumption that eco-product innovation stimulates jobs creation, while eco-process innovations destroy

redundant tasks might be supported by the effect of coexistence of different GSC whether they are eco-product innovation oriented or eco-process innovation oriented. To go further on these inter-sectoral linkages and collaboration between vertically related firms, it is acknowledged that eco-product innovation and eco-process innovation are linked across the industry life cycle and evolve over time. Both are developed within and beyond the firm boundaries, through the implementation of sustainable practices in different types of GSC, whether they are product-oriented or process-oriented that may coexist.

In reference with Katz (1989), Perry (1989) and Langlois and Robertson (1995) on vertical integration/specialisation strategies, end-of-pipe technologies as process innovation are expected to be more characterized by vertical specialization along the GSC. In this context, either job stagnation or job decline should be observed. Cleaner technologies should be characterized with a higher degree of vertical integration in the early stage of the introduction of eco-innovation, while stronger vertical specialization should be observed in a later stage of development. Over time, as competition raises and vertical specialization is becoming predominant, job creation through the development of green jobs should be observed, with high skills replacing low skills at a later stage of development.

1.4 Conclusion

The objective of this chapter was to theoretically analyse the relation between eco-innovation and firm activity and performance, in reference with Porter-like

framework. Along this review, we could identify some mechanisms through which eco-innovation affects firm activity and performance, and which represent interesting fields of investigation and further research subjects. From what was presented along this chapter, these mechanisms can be divided into two main categories: internal effects and external effects.

For the first category, eco-innovation has a direct effect on employment within the firm, effects vary between services and manufacturing firms, and depend on size, age of the firm, and pace of growth. There is also a skills bias for high-skilled jobs, as when a firm adopts eco-innovation, high-skilled employees with strong educational background need to be recruited in order to develop green innovations. A “virtuous circle” creating sustainable growth and generating economic prosperity within the firm is thus documented in the literature related eco-innovation.

The second category of effects has emerged in the literature since eco-innovative firms cannot be considered in isolation, but rather as embedded into inter-sectoral linkages and vertical collaborations with other firms. Characteristics and properties of these inter-firm effects still need to be better explored, not only because it conditions the way and pace at which eco-innovation is introduced by firms, but also because it can have indirect effects on the job creation and upgrading in skills that eco-product is expected to generate, as well as on the job stagnation/decline and removal of redundant tasks that is likely to emerge in the case of eco-process innovation.

This chapter had the ambition of clarifying these interesting questions and based on the review of literature and presentation of key recent results, could eventually provide a basis for further research in the field.

Chapter 2

**What guides eco-innovation
activities at the firm level?**

**Empirical analysis based on the
French community innovation
survey**

2.1 Introduction

Since eco-innovation has become a focus of environmental policies and innovation strategies, its introduction at the firm level has been documented in recent studies, especially focusing on the motivation behind it (Cheng and Shiu (2012)). The study of the determinants of eco-innovation has known an increasing interest since the study of eco-innovation was triggered during 1990s. An important range of results and findings have already been concluded, although the impact of eco-innovation on firm performance still is not consensual (Ghisetti (2018)).

Recent contributions suggest groups of key determinants that drive eco-innovation activities, namely i) regulatory factors such as existing environmental regulation and public aids, ii) demand pull aspects like existing and anticipated demand in the market and new market shares, iii) technology pull/push such as research and development and cooperation with universities and research institutions, and iv) firm specific characteristics such as the implementation of environmental procedures and good practices, and the improvement of firm's reputation (Green et al. (1994) , Cleff and Rennings (1999) , Rennings and Zwick (2002) , del Río González (2005) , Popp (2006) , Arimura et al. (2007) , Frondel et al. (2007) , Horbach (2008) , Horbach et al. (2012) , Horbach et al. (2013) , Bossle et al. (2016)). In the same way as generic (or standard) innovations in a Schumpeterian framework, now eco-innovation is known to cover different types such as eco-product and eco-process innovations, but also eco-organisational, and eco-marketing innovations. Yet, very few is known on

how the introduction of these different types of eco-innovation is affected by different determinants and factors surrounding the activity of the firm. Horbach (2008) finds that the improvement of technological capabilities, environmental regulation and environmental management systems (EMS) trigger and encourage the introduction of eco-innovation as a whole, but Horbach et al. (2012) find that environmental regulation is important for eco-product innovations only, and this is in line with earlier findings (Green et al. (1994) , Cleff and Rennings (1999) , Rennings and Zwick (2002) , Brunnermeier and Cohen (2003) , del Río González (2005) , Popp (2006)). However, it can be found that some studies do not match with these common findings. For instance, Triguero et al. (2013) find that cooperation with scientific institutions triggers a high activity in all types of eco-innovation, and they also find that market shares have a significant impact on eco-product, while cost savings are solely important for eco-process innovations. But, they do not find a significant incentive of regulation and public aids on the decision to eco-innovate. In addition, Bossle et al. (2016) make a distinction between internal and external drivers for a firm to fully adopt an eco-innovation; regulation, efficiency, EMS, technology and cooperation, seem to be the most important drivers.

Over the last twenty years there has been a political willingness to protect the environment and particularly in France. According to a report (Caudron et al. (2014))¹, the French government spent 47.5 billion euros for the protection of environment in 2012. Expenditures for used water were constant, but expenditures

¹By the commission of accounts and environmental economy.

for soil and water sanitation and for noise control were increasing, while expenditures for radioactive wastes reached 680 million euros.

Nonetheless, studies on the determinants of eco-innovation activities in France are still scarce and, to the best of our knowledge, questions related to these determinants by eco-innovation types were not raised so far, despite the fact that studies on innovation based on French CIS waves were carried out (Lhuillery and Pfister (2009) , Colombelli et al. (2013)).

The main objective of this chapter is to analyse the determinants guiding firms to introduce eco-innovation, and by extending the analysis to four types of eco-innovation; product, process, organisation and marketing.

Data stem from the French Community Innovation Survey (CIS) which was conducted in 2014, and which includes several questions regarding the determinants of the introduction of eco-innovation within French firms between 2012 and 2014. It is the most recent wave until today dealing with environmental innovations, and providing data allowing to analyse the four types of eco-innovation altogether.

The remainder of the chapter is organised as follows; Section 2 draws a literature review of recent contributions on the determinants of eco-innovation at the firm level, and it draws the conceptual framework. Section 3 includes the presentation of data and variables, Section 4 develops the econometric approach and the presentation of results (with further robustness checks in the appendix). Section 5

generates broad discussions of results of key variables, followed by conclusions, limits, and research perspectives in Section 6.

2.2 Literature review and conceptual framework

Arundel and Kemp (2009) have contributed to qualify what an eco-innovation is and how it can be measured. Based on an in depth exploration of the Oslo Manual which is largely inspired by the work of Schumpeter. The originality of this definition lies in the fact that it does not neglect any innovation type, and beyond the importance of product and process innovations, organisation and marketing are also considered. Furthermore, it complies with the Schumpeterian vision, as it distinguishes between the four types of eco-innovation and it provides an extension from standard to environmental innovation by considering its four types.

Eco-product innovation refers to the development of new eco-products or the improvement of environmental impact of the existing products, since the environmental impact results from their use, eco-product innovation, thus, focuses on the lifecycle (Cheng and Shiu (2012)) of the product, and eco-process is related to additive solutions to existing production processes in order to reduce the negative impact on environment, or can be integrated in production processes through the substitution of inputs.

Eco-organisational innovation refers to the commitment of firms' managers and shareholders, through decisions made among and with firms in a context of

cooperation, to introduce innovations that reduce the negative environmental impact in the future. It does not reduce the environmental impact immediately but facilitates the introduction of eco-process innovations (Cheng and Shiu (2012)). Eco-organisational innovation is related to training, introducing new tasks, and implementing new practices including environmental management systems (EMS). EMS represent a set of tools and procedures used within the firm in order to detect the environmental risks of production and to reduce wastes, with the objective of converging towards environmental benefits. EMS are indeed considered as one of the most important eco-organisational innovations, as they are introduced by firms' managers. Similarly to this eco-innovation type, literature on the determinants of eco-marketing innovation is also not very well-known, and more importantly, the definition of eco-marketing innovation is not yet clear. Sarkar (2012) states that eco-(or green) marketing refers to " *The presentation or advertising of products with eco-concerns... It can be applied to consumer or industrial goods, and even services*". Thus, eco-marketing innovation encompasses several aspects such as the modification of a product, its packaging, presentation, pricing, promotion logistics, and its delivery modes to customers, with the objective to limit the environmental impact. It is noteworthy to mention that in this eco-innovation type particularly, it is expected that the relationship between firm and customers is very important that it can push firms to innovate in how a product is presented and delivered. One example on eco-marketing innovation could be different advertisements and promotions of products with green concerns (electrical cars, goods based on recycled materials

etc...) and how they are presented in such a way to clearly communicate, beyond their novelty and newness, the environmental concerns which they encompass.

Green et al. (1994) seeking to identify the factors stimulating a sample of 800 UK manufacturing firms to innovate in environmentally-friendly innovations, find that existing and anticipated environmental regulations and prospects to exploit new market shares for green products, are the main drivers of eco-product innovation. For eco-process, the main determinants are existing and anticipated environmental regulations and cost savings through a better use of energy and materials. Cleff and Rennings (1999) find in a study based on the Mannheim Innovation Panel survey conducted in 1996, that strategic market goals influence eco-product innovations, while eco-process innovations are determined by regulation. Frondel et al. (2007) find in a study based on a OECD survey, that cleaner production by modifying the production process² is guided by cost savings and environmental management systems (EMS). Horbach (2008), by presenting the determinants of environmental innovation based on German data, finds that the improvement of knowledge capital by research and development triggers environmental innovations, in addition to environmental regulation, organisational changes and environmental management systems (EMS). Horbach et al. (2012) present the determinants of eco-innovation by type of environmental impact areas, based on the German CIS conducted in 2009. They find that current and expected government regulation is particularly important for different toxic

²Through the use of cleaner technologies as inputs, that consist in the reduction of resource use and/or pollution at the source.

emissions reduction. Whereas cost savings are found to be more important for reducing energy and material use. Triguero et al. (2013) find that entrepreneurs giving importance to cooperation with research institutions (and laboratories) and willing to offer more green products to satisfy the increase in demand, are more active in all types of eco-innovations. Supply-side factors seem to be more important drivers for process and organisational eco-innovations than for eco-product. Market share is a significant driver for eco-product and eco-organisational innovations, while cost savings are only important for eco-process innovations. Existing regulation has an important impact on eco-product and eco-organisational innovations, while expected regulation and other forms of government aids do not seem to have a significant influence on the decision to eco-innovate.

The study of eco-innovation at the firm level was also carried out by looking at the location of the firm. Horbach (2014) analyses the motivation of adopting eco-innovation compared to other innovations based on the location of the firm, and by including several regional variables such as poverty, unemployment, GDP *per capita*, the level of education, and finds that eco-innovation is more likely to be guided by regional proximity to research centres and universities, and that it requires a high qualification.

From what precedes, it can be seen that in the economic literature, on the one hand there is a consensus on a set of determinants driving the introduction of eco-innovation at the firm level, by focusing essentially on the distinction between eco-product innovation and eco-process innovation. On the other hand,

most of these studies neglect the distinction between eco-organisational and eco-marketing innovations.

As explained throughout this review, not only the distinction between eco-product and eco-process needs to be considered, but also eco-organisation and eco-marketing require a further investigation, in order to precisely analyse the determinants of the introduction of each eco-innovation type.

Table 2.1: Determinants of eco-product and eco-process innovations and suggested determinants of eco-organisational and eco-marketing innovations.

Eco-product	Eco-process	Eco-organisation	Eco-marketing
- Environmental regulation	- Environmental regulation	- Environmental regulation	- Previous contracts with customers
- Cooperation	- Cooperation	- Cost savings	- The improvement of firm's reputation
- Market shares	- Research and development	- The improvement of firm's reputation	
- Cooperation with research institutions	- Environmental management systems (EMS)		

Table 2.1 summarizes the determinants that are already stated in the literature and that comply with the common distinction between eco-product and eco-process innovations carried out in most of contributions. For the introduction of both of these two eco-innovation types, environmental regulation and cooperation are suggested to be important determinants. By complying with environmental regulation, firms modify their production processes in order to issue eco-products.

This may also be affected by cooperation, whether it is with universities, partners, competitors or customers. Cooperation seems to be important as it helps firms to adjust their production processes and, thus, their products by lining up with other firms and in order to satisfy customers' requirements, in addition to market shares. According to Arundel and Kemp (2009), the objective is also to sell in a market of eco-products and to earn financial returns. Furthermore, for the introduction of eco-process innovation, both research and development and environmental management systems are suggested to be important. In fact, research and development expenditures are put in place by firms in order to innovate. This innovation may happen through the improvement of production processes by adopting sustainable practices, with the purpose of limiting wastes and to save money in the long run. Implementing a new production process or improving the existing one results from the decision to reduce the environmental impact of firm's production, which explains the suggestion of the possible influence of environmental management systems on the introduction of an eco-process innovation.

Table 2.1 also suggests some determinants that are expected to be important for eco-organisational and eco-marketing innovations, since still few is known on these two eco-innovation types.

Since eco-organisational innovation is guided by the decisions made by firms' managers (Cheng and Shiu (2012)), its introduction is suggested to be mainly guided by the firm's reputation, because when firms' managers make the decision to introduce eco-innovation, they can consider some factors that seem to be

important to them, such as complying with environmental regulation and caring about the image of the firm. Cost savings are known to be an important determinant for the introduction of eco-process innovation in several studies, but no empirical evidence has found, until now, whether it is the same case for the introduction of eco-organisational innovation. However, in this study cost savings are suggested to be important for the introduction of eco-organisational innovation. Since this determinant is important for the reduction of costs related to production process, firms may be likely to allocate an importance to this determinant before making the decision to introduce an eco-process innovation later. Cost savings can affect the way in which the set of organisational practices are put in place in view of detecting environmental risks of production and reducing wastes. This decision is considered as an eco-organisational innovation. In a similar way, environmental regulation can shape the way in which training, the development of new tasks within the firm as well as new organisational practices are operated.

As long as marketing innovation is basically affected by market conditions, market-pull determinants are generally expected to influence the firm's decision to introduce an eco-marketing innovation. Among these determinants, contracts with customers as a determinant leading to commercial transaction, is suggested to have an influence on the decision to introduce an eco-marketing innovation. Contracts with customers will involve in all the activities described in eco-marketing innovation definition, while distribution and logistics are probably the most important ones. In addition to that, a firm introducing an eco-marketing

innovation might be aware and careful of its image towards its customers, as presenting or advertising products with eco-concerns might attract additional demand.

2.3 Data and variables

2.3.1 Data and Community Innovation Survey

Data mainly stem from the French Community Innovation Survey (CIS) conducted in 2014. It includes data related to the previous three years. CIS is conducted since 1992 and takes the form of a questionnaire for manufacturing and services firms, in order to collect their managers' opinions and feelings regarding several subjects, mainly related to their innovation activities. CIS includes several modules, but the following analysis mainly focuses on the one related to eco-innovations³, their determinants, and the environmental impact of innovation activities. That said, other datasets (FARE⁴ 2014, ANTIPOL⁵ 2012, 2013 & 2014, and DADS⁶ 2014) which are all provided by the National Institute of Statistics and Economic Studies (Institut National de la Statistique et des études économiques (INSEE)), were merged with the CIS 2014, in order to complete the missing values related to variables.

³Until now, this CIS wave is the most recent one dealing with environmental innovations.

⁴Fichier approché des résultats d'ESANE : élaboration des statistiques annuelles d'entreprises.

⁵Enquête sur les investissements dans l'industrie pour protéger l'environnement.

⁶Déclaration annuelle des données sociales.

2.3.2 Definition of variables and descriptive statistics

With reference to the definition included in CIS 2014, a firm is considered as eco-innovative if it has introduced at least one eco-innovation type during previous three years⁷. The sample was initially composed of 18109 observations, and since the analysis deals with the determinants of eco-innovation, it is restrained to the 5089 firms whose respondents answered the question related to the eco-innovation type(s) introduced between 2012 and 2014. Due to missing values in the two research and development variables: internal R&D (*IntR&D*), and external R&D (*ExtR&D*) which are important variables of interest in the analysis, 1103 observations were dropped to keep 3986 observations as a final sub-sample to which the analysis is restrained⁸.

According to the definition included in the CIS 2014: *"An innovation with environmental benefits is defined as the introduction of a good, a service, a process, an organisational approach or a marketing that are significantly improved and that can generate an environmental benefit, compared to alternatives. The environmental benefit can be the main objective of the innovation or can result from an innovation targeting other objectives. The environmental benefits can be generated within the firm or during the use or the consumption of a good or a service by the final user, which can be a consumer, a firm or a government."* It is noteworthy that the latter definition matches perfectly

⁷The last three years before the CIS results are released.

⁸Table A.1.4 and table A.1.5 in appendix show the distribution of the answers to the two key questions of the analysis (cf. table 2.2 and table 2.3) before dropping observations.

with the one given by Arundel and Kemp (2009), as it makes the distinction between the four eco-innovation types.

The goal of the empirical analysis is to analyse and emphasise the most relevant determinants of activities related to each eco-innovation type: eco-product, eco-process, eco-organisation, and eco-marketing. As shown below (Table 2.2), respondents answered the question on which type of eco-innovation was introduced within their firms between 2012 and 2014. The answers are binary (YES = 1, NO = 0), and a negative (NO) answer to each type of innovation does not necessarily mean that the considered firm is not eco-innovative, but it might mean that it is eco-innovative at least⁹ in one of the three remained eco-innovation types. The empirical analysis is based and restrained to the differences among the four eco-innovation types. Thus, only the sub-sample of the respondents to the question related to eco-innovation type(s) is considered.

Table 2.2: Distribution of the answers on firms that introduced environmental innovations (French CIS 2014). Question: "Which innovation with environmental benefits did your firm introduce between 2012 and 2014?"

Eco-innovation types	In% of eco-innovative firms		Number of firms
	YES	NO	
Eco-product	40,37%	59,63%	3986
Eco-process	47,27%	52,73%	3986
Eco-organisation	32,89%	67,11%	3986
Eco-marketing	10,06%	89,94%	3986

Among the respondents, 40,37% declared that they have introduced an eco-product innovation, 47,27% have introduced an eco-process, while 32,89%

⁹It is possible that one firm introduced more than one innovation type during the considered period.

an eco-organisational innovation, and 10,06% an eco-marketing innovation. That said, on the one hand, these responses represent the four dependent variables included in the econometric analysis. On the other hand, table 2.3 represents the distribution of the answers to the nine key-determinants from the questionnaire. Immediately after answering the question on the type of eco-innovation that was introduced within the firm, respondents rated the importance of each of the nine determinants (included in one question) that influenced their decision to introduce the eco-innovation type chosen in the previous question. This evaluation makes determinants categorical variables (No importance = 4, weak importance = 3, average importance = 2, and high importance = 1). Results in the table 2.3 and numbers of firms are obtained by keeping only the "weak", "average" and "high" importance answers for each key determinant. These answers represent the nine independent variables of interest used in the econometric analysis, to explain the dependent variables related to each eco-innovation type.

Beside the dependent and independent variables presented in tables 2.2 and 2.3, other variables of control are included in the empirical analysis. These variables such as research and development, regional funding and size (in terms of number of employees) are not necessarily known as directly determining the introduction of eco-innovations, but they may have an impact, as they are known to affect innovation activities in general.

Table 2.3: Determinants of eco-innovation (French CIS 2014). Question: "What was the importance of each of the following factors ahead of the introduction of the innovation with environmental benefits chosen in the previous question?"

Eco-innovations (all types) introduced in response to:	In % of firms with at least weak importance of each determinant	Number of firms
Existing environmental regulation	85,73% (3417)	3986
Existing environmental taxes, charges and fees	76,07% (3032)	3986
Anticipated environmental regulation and taxes	78,20% (3117)	3986
Governmental aids and subsidies	63,70% (2539)	3986
Existing or anticipated demand on environmental innovations	75,44% (3007)	3986
Improvement of the firm's reputation	89,56% (3570)	3986
Implementation of good environmental practices	87,81% (3500)	3986
High energy, material and water costs	85,20% (3396)	3986
The need to respond to previous contracts	45,79% (1825)	3986

Table 2.4 summarizes the variables of interest, other variables that affect innovations in general and environmental innovations, and control variables. They are sorted by groups of determinants with respect to what was previously presented in literature.

Table 2.4: Determinants of eco-innovation from CIS 2014 and literature.

Eco-innovation determinants' categories	Eco-innovation determinants for the empirical analysis and control variables ¹⁰	Variables' labels
Policy measures	- Existing environmental regulation	<i>ExistEnvReg</i>

¹⁰Detailed descriptions are in table A.1.1

	- Existing environmental taxes, charges and other fees	<i>ExistEnvTaxFees</i>
	- Anticipated environmental regulation and taxes	<i>AntEnvReg</i>
	- Existing government aids and subsidies	<i>ExistGovAids</i>
Technology-push	- Innovation intensity	<i>ExistAntDem</i>
	- Internal R&D	<i>IntR&D</i>
	- External R&D	<i>ExtR&D</i>
	- Patenting activity	<i>PatentApp</i>
	- Cooperation with universities	<i>CoopUni</i>
	- Cooperation with research organisms	<i>CoopReasOrg</i>
Market-pull	- Existing and anticipated demand on env. innovations	<i>ExistAntDem</i>
	- The need to respond to previous contracts	<i>PrevContracts</i>
	- High energy, material and water costs	<i>CostSavings</i>
	- Cooperation with competitors	<i>CoopComp</i>
Firm specific factors	- Improvement of the firm's reputation	<i>FirmRep</i>
	- Implementation of good environmental practices	<i>ImpEnvPract</i>

Based on the existing literature, the empirical analysis includes the nine key independent variables extracted from the CIS eco-innovation module and developed previously, but it also includes other variables, by looking at the determinants presented in several contributions. Table 2.4 summarizes the most important variables included in the analysis¹¹.

Innovation intensity is captured by the innovation efforts made by firms whatever the type of innovation (Horbach et al. (2012)), as well as research and development and patenting activity (Popp (2006) , Horbach et al. (2013) , Costantini et al. (2015)). Cooperation with universities and research institutions was highlighted in several contributions as an important factor triggering R&D and subsequently innovation activities (Audretsch and Vivarelli (1996) , Bigliardi et al. (2012) , Ghisetti et al. (2015)) and technological performance for firms. Cooperation with research institutions including universities and laboratories was also highlighted by Triguero et al. (2013) as an important driver for eco-innovation. Cooperation with competitors was also revealed in several studies as being an important determinant, as well as firm size (Horbach (2008) , Horbach et al. (2012)).

Furthermore, an increasing body of literature includes location and regional variables (Barbieri et al. (2020) , Corradini (2019) , Horbach (2014)) in order to capture their influence on firm performance and other related phenomena. In the empirical analysis throughout this chapter, in addition to control variables,

¹¹Table A.1.1 provides details on other control and dummy variables.

regional dummies are also included in order to control for the location of all of the firms included in the sample.

2.4 Empirical analysis

2.4.1 Econometric estimation

In order to analyse the determinants of eco-innovation activities by considering its four types, it is needed to estimate the probability to introduce an eco-innovation in response to the determinants summarised in table 2.4, in addition to other variables that influence the decision of the firm to (eco) innovate. Given the specificity of the binary outcome of the four dependent variables, and assuming a normal distribution, a probit model for each dependent variable is estimated according to the general rule of computation of a probability as follows:

$$Pr(EcoInnovation_t = 1) = F(\beta_o + \beta_1 ExistEnvReg + \beta_2 ExistEnvTaxFees + \beta_3 AntEnvReg + \beta_4 ExistGovAids + \beta_5 ExistAntDem + \beta_6 FirmRep + \beta_7 ImpEnvPract + \beta_8 CostSavings + \beta_9 PrevContracts) + V_c Controls + V_d Dummies$$

Where t refers to each eco-innovation type: product, process, organisation and marketing.

V_c is a vector of coefficients that multiply each one of the control variables included in a given model. And V_d is a vector of coefficients that multiply each one of the dummy variables: size, region and sectors included in a given model.

All the models have in common the same set of key determinants, in addition to sets of control variables and dummy variables that differ from a model to another. This is due to multicollinearity among independent variables and/or endogeneity issues among dependent and independent variables.

2.4.2 Results

In a first step, among the nine variables of interest, the most important ones are presented, for eco-product and eco-process innovations, as several results are already obtained. Then, the results related to eco-organisational and eco-marketing innovations are presented afterwards.

Table 2.5: Marginal effects following the estimation of separate probit models for the four dependent variables (CIS 2014).

	(1) EcoProduct	(2) EcoProcess	(3) EcOrg	(4) EcoMarketing
ExistEnvReg	0.00494 (0.26)	0.0457* (2.25)	-0.0167 (-0.84)	-0.0187 (-1.42)
ExistEnvTaxFees	-0.0239 (-1.36)	0.0197 (1.05)	0.0610*** (3.42)	0.0111 (0.94)
AntEnvReg	-0.00862 (-0.48)	0.00559 (0.29)	0.0332 (1.77)	0.00872 (0.71)
ExistGovAids	-0.00817 (-0.49)	0.0156 (0.88)	-0.0162 (-0.96)	0.0238* (2.23)
ExistAntDem	0.159***	0.0177	-0.0311	0.0142

	(10.68)	(1.06)	(-1.94)	(1.36)
FirmRep	0.0436*	0.00341	0.0815***	0.0470***
	(2.33)	(0.17)	(4.18)	(3.35)
ImpEnvPract	0.00643	0.0525**	0.0515**	0.0189
	(0.36)	(2.75)	(2.78)	(1.49)
CostSavings	-0.0429**	0.0907***	0.0882***	-0.00348
	(-2.70)	(5.38)	(5.35)	(-0.32)
PrevContracts	-0.0190	-0.0192	0.0266	0.0238*
	(-1.09)	(-1.03)	(1.52)	(2.16)
EMS	0.0279	0.0920***	-	0.0176
	(1.72)	(5.39)		(1.63)
PatentApp	0.128***	-0.000743	-0.0532*	-0.000863
	(6.89)	(-0.04)	(-2.54)	(-0.06)
IntR&D	0.124***	0.0423*	-0.0302	0.0329**
	(6.37)	(2.11)	(-1.60)	(2.69)
ExtR&D	0.0447**	0.0370*	0.0317	0.0180
	(2.90)	(2.21)	(1.96)	(1.74)
CoopUniv	0.0359	0.0457	0.0622**	0.0179
	(1.66)	(1.91)	(2.66)	(1.23)
CoopReasOrg	-0.00869	0.0124	-0.0691**	0.00298
	(-0.38)	(0.49)	(-2.76)	(0.19)
CoopComp	0.0102	0.0143	0.0631**	0.00316
	(0.44)	(0.55)	(2.61)	(0.21)

FunLocRegion	-0.00221	0.0338	0.0537*	0.00354
	(-0.10)	(1.40)	(2.35)	(0.24)
FunNatOrg	0.0204	0.00246	-0.0000574	-0.0180
	(1.01)	(0.11)	(-0.00)	(-1.26)
FunEU	0.00320	0.0806**	0.0307	0.0291
	(0.12)	(2.64)	(1.07)	(1.63)
ResTxCred	0.0522**	0.0314	-0.0937***	-0.00707
	(2.92)	(1.61)	(-5.03)	(-0.58)
InnOrg	-0.0440**	0.147***	-	0.0598***
	(-2.82)	(9.00)		(5.36)
InnoMkt	0.115***	-0.000111	0.150***	-
	(7.67)	(-0.01)	(10.34)	
EnvSpe	0.0843***	0.0377	0.00174	-0.00664
	(3.44)	(1.44)	(0.07)	(-0.39)
EnviStaff	-0.0240	-0.00327	0.0199	-0.0243
	(-0.98)	(-0.13)	(0.78)	(-1.41)
Age	YES	YES	YES	YES
Size dummies	YES	YES	YES	YES
Sector dummies	YES	YES	YES	YES
Regional dummies	YES	YES	YES	YES
<i>N</i>	3986	3986	3986	3986
<i>R</i> ²	0.1934	0.1273	0.1149	0.1595

t statistics in parentheses.

*, **, *** respectively denote significance at the $p < 0.05$, $p < 0.01$, $p < 0.001$ level.

(-) means that the variable is not included in the model, for perfect prediction.

Sector and size dummies' marginal effects are not reported in the table.

Only eco-innovative firms are considered.

2.4.3 Eco-product and eco-process

On the one hand, existing and anticipated demand (*ExistAntDem*), as well as the improvement of firm's reputation (*FirmRep*) are significant and positively correlated with the probability to introduce an eco-product innovation. Cost savings (*CostSavings*) are, according to the estimation results less likely to encourage the introduction of an eco-product innovation. One important fact with this regard, is that the introduction of an eco-product innovation does not seem to be guided by policy measures, captured by different regulations, but more by market behaviour and firm specific factors, captured by the improvement of firm's reputation (*FirmRep*). This result is in line with the one found by del Río González (2005), but the majority of previous findings did not highlight this determinant as being important for the introduction of any eco-innovation type.

On the other hand, existing environmental regulation (*ExistEnvReg*) as well as cost savings (*CostSavings*) and the implementation of good environmental practices (*ImpEnvPract*) are more likely to encourage the introduction of eco-process innovation. Cost savings (*CostSavings*) are known to be very important for the introduction of eco-process innovation (Green et al. (1994)

, Frondel et al. (2007)). Since firms are willing, through the introduction of environmentally-friendly processes or the improvement of existing ones, to reduce costs related to charges and fees put in place by government, alongside the costs related to different wastes. This may be an argument why cost savings are more likely to encourage the introduction of eco-process innovation rather than eco-product innovation.

2.4.4 Eco-organisation and eco-marketing

Results show that existing environmental taxes and fees (*ExistEnvTaxFees*), cost savings (*CostSavings*), and the implementation of good environmental practices (*ImpEnvPract*) are important determinants for the introduction of eco-organisational innovation. Whereas for the introduction of eco-marketing innovation, results underline the importance of the existing governmental aids (*ExistGovAids*) and previous contracts with costumers (*PrevContracts*).

Among the nine key determinants, findings do not show any eventual positive effect of the anticipated environmental regulation (*AntEnvReg*) (Triguero et al. (2013)) on the probability of introducing any of these two eco-innovation types. Whereas for the improvement of firm's reputation (*FirmRep*), according to the findings, this determinant seems to be important in guiding the introduction of both these eco-innovation types, which is, to the best of our knowledge, a finding that was not mentioned previously in literature.

2.5 Marginal effects

In what follows, the importance of key determinants and control variables for the probability to introduce an eco-innovation is discussed with further details.

a- Key determinants

The previous subsection includes only, among the key determinants, the most important ones guiding the introduction of each eco-innovation type. In this subsection, marginal effects are presented in order to understand how determinants affect different probabilities of introducing different eco-innovation types, according to the findings (see table 2.5).

According to the findings, eco-product innovation is more likely to be guided by the existing and anticipated demand in the market (*ExistAntDem*) (Green et al. (1994) and the improvement of firm's reputation (*FirmRep*). The increase in these two independent variables (increasing from 0 to 1) increases the probability to introduce an eco-product innovation respectively by 16 percentage point and 4 percentage point.

The improvement of firm's reputation (*FirmRep*) is also an important determinant guiding the introduction of eco-organisational and eco-marketing innovations, as its increase rises the two probabilities related to the introduction of both eco-innovation types by respectively 8 and 5 percentage point.

The introduction of an eco-process innovation is, according to the findings, guided by the existing environmental regulation (*ExistEnvReg*) (Cleff and

Rennings (1999)), by the implementation of good environmental practices (*ImpEnvPract*), and by cost savings (*CostSavings*) (Frondel et al. (2007), their increase according to the findings rises the probability to introduce an eco-process innovation by respectively 4, 5 and 9 percentage point.

Concerning the introduction of eco-organisational innovation, in addition to the improvement of firm's reputation (*FirmRep*) explained previously, the introduction of this eco-innovation type is guided by the existing environmental charges and fees (*ExistEnvTaxFees*), the implementation of good environmental practices (*ImpEnvPract*), and by cost savings (*CostSavings*). An increase in the existing environmental charges and fees (*ExistEnvTaxFees*) increases the probability of introducing an eco-organisational innovation by 6 percentage point. Then, the increase in the implementation of good environmental practices (*ImpEnvPract*) increases the probability of introducing this eco-innovation type by 5 percentage point, and finally, the increase in cost savings (*CostSavings*) increases the probability to adopt an eco-organisational innovation by 8 percentage point.

Regarding eco-marketing innovation, in addition to the improvement of firm's reputation (*FirmRep*), the existing governmental aids (*ExistGovAids*) and previous contracts with customers (*PrevContracts*) guide the introduction of this type of eco-innovation, as an increase in these two determinants increases the probability of introducing this eco-innovation type by 2 percentage point each.

b- Other control variables

Among the control variables included in the analysis, according to the findings, environmental management systems (*EMS*) seem to be important for the introduction of eco-process innovation. Accordingly, the increase in this independent variable increases the probability to introduce an eco-process innovation by 9 percentage point. Patenting activity (*PatentApp*), captured by at least one patent application during the three previous years, increases the probability of introducing an eco-product innovation by 13 percentage point. Innovation efforts, approached by doing internal and external R&D (*IntR&D* and *ExtR&D*) guide the introduction of eco-product innovation, their increase rises the probability of introducing this eco-innovation type by respectively 12 and 4 percentage point. *IntR&D* is also an important driver guiding the introduction of eco-marketing innovation, where its increase rises the probability of introducing this eco-innovation type by 3 percentage point. Whereas *ExtR&D* is important for the introduction of eco-process innovation, as its increase rises the probability of introducing this eco-innovation type by 4 percentage point.

Another important result is related to cooperation with universities (*CoopUniv*) and with competitors (*CoopComp*). The increase in these two variables rises the probability of introducing an eco-organisational innovation by 6 percentage point for each determinant. Having access to local and regional funding (*FunLocRegion*) increases the probability of introducing this eco-innovation type by 5 percentage point, and European funding (*FunEu*) increases the probability to introduce an eco-process innovation by 8 percentage point. Having

access to research tax credit (*ResTxCred*) and having an environmental specialist employee within the firm (*EnvSpe*) are also important drivers of introducing an eco-product innovation, their increase rises the probability of introducing this eco-innovation type by respectively 5 and 8 percentage point. This result, in addition to the improvement of firm's reputation (*Firmrep*), may reveal that innovations efforts are oriented towards product innovations rather than process. As a summary of the main determinants of each eco-innovation type, eco-product innovation, according the findings, is more likely guided by market, technology and firm specific factors. Eco-process is guided by regulatory framework, technology (not with the same extent as for eco-product innovation) and firm specific factors. Whereas for eco-organisational innovation, it seems to be guided by regulatory framework and firm specific factors. In addition to these two categories of determinants, eco-marketing is also guided by technology aspects.

2.6 Conclusion

Through this chapter, the objective was to investigate the determinants of eco-innovation at the firm level. Based on the French Community Innovation Survey conducted in 2014 for the period 2012-2014, the empirical analysis aimed to highlight the determinants of eco-innovation by types of innovation. In fact, according to the Schumpeterian framework which was adapted from standard innovation to the context of eco-innovation, its four types: eco-product, eco-process, eco-organisation and eco-marketing were considered throughout the

empirical analysis. These eco-innovation types with binary outcomes represented the dependent variables for each model included in the empirical analysis, in order to provide a detailed analysis and to precisely emphasise, among the set of nine key determinants, the most important ones for the introduction of each eco-innovation type.

With a focus on the nine key determinants of eco-innovation, findings have shown that cost savings and existing environmental regulation are both important for the introduction of eco-process innovation. These findings are in line with a large range of contributions in the field (Green et al. (1994) , Frondel et al. (2007) , Horbach et al. (2012) and Triguero et al. (2013)). In addition to that, the implementation of good environmental practices also matters, and this is a result not previously documented in the literature. An other new important finding is the improvement of firm's reputation, found to be important for the introduction of eco-product innovation. In fact, results reveal that French firms allocate a great importance to their reputation, which leads them to introduce an eco-product innovation. Since this eco-innovation type cares about the lifecycle of the product and about the environmental impact resulting from its use, this plays an important role regarding the image that a firm has, particularly for its customers. Another determinant that seems to be important for the introduction of eco-product innovation is the existing and anticipated demand in the market. Customers' behaviour, according to findings, plays an important role in the orientation of firms' decisions. In the same way as the improvement of firm's reputation, the demand on environmental products from customers guides firms

to the introduction of eco-product innovation in order to satisfy this demand.

Regarding the two types of eco-innovation that were not covered by literature, namely eco-organisational and eco-marketing innovations, results show that the improvement of firm's reputation is important as well. For eco-organisational innovation, this determinant, together with the implementation of good environmental practices, seem to be important as by making decisions to introduce any eco-innovation type firms' managers consider a set of factors and tend to implement new environmental practices. As eco-organisational innovation represents a set of decisions made within the firm, managers would tend to avoid any kind of additional charges and fees related to environmental aftermaths, which explains the importance of existing environmental taxes and fees, in addition to cost savings for the introduction of this eco-innovation type. Same as for eco-organisational innovation, as eco-marketing innovation represents the step after an eco-product is issued, selling into a market of green products (Arundel and Kemp (2009)) requires internal and external factors including pricing, packaging, logistics and distribution methods, which are related to marketing, as these factors and the way a firm acts towards its customers contribute and reflect its image. In addition to the improvement of firm's reputation, previous contracts with customers, unsurprisingly, represents an important determinant for the introduction of eco-marketing innovation, because the relationship between a firm and its customers is a focus of any marketing policy within the firm in order to satisfy the requirements of customers.

Cooperation with universities and with competitors reveals being important for

the introduction of eco-organisational innovation. This finding highlights the importance of cooperation as a whole and when firms are constantly opened to improve themselves. According to the findings, governmental funding does not show any impact on the probability of introducing any eco-innovation type, this shows that more public efforts should be made for to better support firms in making their transition from standard to green innovations. This issue of governmental expenditures and aids together with public funding for the protection of environment was highlighted in the report on environmental economy (Caudron et al. (2014)). The report shows the importance of such a factor in triggering the protection of environment, through research and development (both internally and externally) in order to yield cooperation with universities and competitors, to encourage innovation activities, to introduce more eco-innovations and to accelerate the introduction process. Regarding the firm's age, size, sector of activity and region where implemented, no impact was revealed by the findings, showing that the introduction of eco-innovation, whatever its type, is not restricted only to one type of firms.

Furthermore, some limits are revealed and some points can be improved. The first issue may be the data themselves, as it is known that many survey results are biased by default (Mairesse and Mohnen (2010)), because several respondents may not give the most accurate answers that precisely reflect the actual situation of their firms. Yet, data exploited through this research are the most recent stemming from CIS and dealing with environmental issues. To this one can be added the heterogeneity problem due to cross-sectional data. The third limit is the missing

values, as more than 1000 observations were dropped. Another limit can be the non-availability of some variables, which could eventually affect the results or the significance of some marginal effects.

An important point, which is not strictly a limit but deserves some more details is how independent variables were transformed from categorical to binary ¹². Despite the fact that some studies tackled EMS as eco-organisational innovation, findings related to eco-organisation in addition to eco-marketing innovations remain novel to literature compared to the range of existing studies. It is, thus, recommended that more research should be carried out in this direction. Exploiting new data, approaching variables differently, and/or providing findings based on different countries and regions to establish a possible comparison, would be an interesting perspective. This recommendation is motivated by the importance of eco-organisational innovation, as highlighted in literature (Cheng and Shiu (2012)) is the first eco-innovation type introduced within the firm, and the most important for the eco-innovation implementation process, but whose determinants remain unexplored. This recommendation is also motivated by the importance of eco-marketing innovation, as it represents the final step after an eco-product is issued and which represents the bridge between the final eco-product and the customer. Providing an analysis based on the only sub-sample of eco-innovative firms was a choice among others. In fact, this question can

¹²The choice that was made is that those variables were transformed such as weak and no importance were equivalent to zero (0) and average and high importance equivalent to one (1). Further tests with different classifications are provided in appendix (tables A.2.1, A.2.2, A.2.3, and A.2.4)

be tackled in different ways, for example by comparing the determinants of eco-innovation through a dummy variable versus other innovators.

Chapter 3

Eco-innovation and French firms' growth: Empirical analysis based on the French community innovation survey

3.1 Introduction

From the 1990s, the importance of the protection of environment started to be concretely inserted in the core of policy. Summits and long-run plans such as the Lisbon strategy (2000) consisted in putting in place a ten-year plan (2000-2010). The Göteborg priorities (2003) launched sustainable development and the promotion of environmental innovation as an engine for economic prosperity combined with environmental protection. Since then, the study of the impact of eco-innovation on firm growth started to gain interest both in economic and management literature.

Firm growth is captured in the literature by several indicators. Even though employment growth remains the most important growth indicator and the most commonly used (Leoncini et al. (2019)), turnover growth capturing the financial returns of firm activity, together with productivity growth, are also important indicators that are used in literature (Cainelli et al. (2011) , Colombelli et al. (2019)). Most of studies use employment growth as a dependent variable (Rennings and Zwick (2002) , Rennings et al. (2004) , Cainelli et al. (2011) , Leoncini et al. (2019)), given that policy-makers are concerned by reducing the unemployment rate (Storey (1994)), and that it is considered as a robust indicator on firm growth as well as its economic activity and performance. Yet, several studies have used turnover growth as an alternative or second dependent variable in empirical analyses, as it captures revenues of the firm that are generated by its commercial activity and sales. Others include both indicators in order to capture

the impact of eco-innovation. In view of understanding whether eco-innovation is positively correlated or not with both employment and turnover growth, they tend to be considered together (Cainelli et al. (2011)). These indicators representing the dependent variables in the empirical analyses are usually explained by a variety of independent variables, such as research and development, patenting activity, and cooperation.

Even though the impact of eco-innovation on firm growth was addressed, still its nature is not consensual. In fact Horváthová (2010) in a review chapter, finds that 35% of empirical studies detect a positive relationship between environmental and financial performance, i.e. between the environmental innovation and financial returns measured by sales and turnover. He finds that 10% of empirical studies find a negative relationship, and 19% a non-significant relationship. Several studies have already addressed the impact of eco-innovation among countries (Rennings and Zwick (2002) , Rennings et al. (2004) , Ghisetti (2018)), but economic literature has not tackled the issue at the firm level to a significant level, and much is still unknown. Exploring the issue at the firm level could bring in new results on how eco-innovation affects firm growth for a population of average firms, but also could shed a light on the different patterns of firm growth using quantiles. As such, the ambiguities of measuring the impact at an average level could possibly be removed by getting deeper into quantile firms.

The objective of this research is to contribute to the literature by exploring the French context and using both French CIS waves conducted in 2014 and 2016, which have not been used in previous studies in the field yet. The analysis is

embedded in a Porter-like framework (Porter and Van der Linde (1995)) according to which the introduction of eco-innovation resulting from regulatory pressures is supposed to generate a shift in firm performance, and to enhance firm growth in terms of employment and gains in terms of competitiveness captured by new market shares, as well as in terms of turnover growth due to the increasing commercial activity of the firm.

The remainder of this chapter is articulated as follows: Section 2 includes a literature review and draws the theoretical framework that will structure the work. Section 3 explores the data on French firms used in this work, based on CIS waves conducted in 2014 and 2016. Section 4 presents the empirical analysis, with a review of the research strategy and the econometric estimation. Section 5 discusses the results and Section 6 concludes.

3.2 Literature review and theoretical framework

During the last thirty years the study of the introduction of environmental innovation raised an increasing interest and questions in relation with its effects at the firm level. Since then, the literature has devoted much interest on the issue of the determinants of introducing eco-innovation, and the role of firm growth has been better characterized in recent contributions.

The effects of introducing eco-innovation at the firm level can be distinguished by its types (product, process, organisation, and marketing) (Horváthová (2010) , Ghisetti (2018)), and can also be distinguished by the growth indicator that is

affected by the introduction of eco-innovation. In this regard, two separate effects are spotted in a large part of the literature. The first effect is related to turnover which represents firm revenues resulting from sales, as turnover growth gives an important indication of the commercial activity of the firm. The second one concerns employment growth which represents an important economic indicator of the firm activity. The analyses below mainly consist in analysing the eventual impacts on competitiveness, employment and turnover growth of the firm.

As a pioneer contribution in this research field, Porter and Van der Linde (1995) state that a well-designed regulatory framework could help firms to make transition from standard to green innovations. This incentive could give the possibility for firms to exploit new markets and to be more competitive. This gain in terms of competitiveness captures the economic prosperity and performance of the firm, meaning that environmental regulation does not necessarily harm production and industry, but in contrary, adopting eco-innovation to comply with the imposed regulation would rather satisfy both economic and environmental performance. Since then, most of studies tackled the relationship between eco-innovation and firm performance in a so-called Porter-like framework.

Rennings and Zwick (2002) in a study on 1500 eco-innovative firms across five European countries, find that product innovation creates more jobs compared to process innovation, and that employment impact differs depending on the goal of eco-innovation. Indeed, eco-innovation may have various motivations and objectives, which were explicitly stated in the definition given later by Arundel and Kemp (2009), "...*Eco-innovation can be motivated by economic or*

environmental considerations. The former[Eco-innovation] includes objectives to reduce resource, pollution control, or waste management costs, or to sell into a market for eco-products.”. Rennings et al. (2004) in a study on 1500 eco-innovative firms, find a positive effect of product environmental innovation on net employment increase, and a decrease in terms of employment in the case of end-of-pipe innovations, as they are related to process and are subsequently labour saving. This finding was confirmed later by Horbach and Rennings (2013), in a study based on the German CIS wave conducted in 2009, stating that eco-innovations dominated by end-or-pipe technologies have a negative impact on employment. Horbach (2010) in a study on German data, finds a positive and significant impact of environmental innovation activities on employment development and jobs creation. Horbach et al. (2012) also find that adopting an environmental innovation helps expecting a positive employment impact. Cainelli et al. (2011) in a study on 800 Italian services firms, find a negative impact of eco-innovation on firm growth in terms of both employment and turnover, in the short run. These findings are consistent with the ones found by Evans (1987a) and Evans (1987b). These findings are explained by the fact that dematerialization process through the introduction of new technologies for an efficiency purpose is related to job losses in the short run. In addition, when technologies are environmentally-friendly they tend to create a substitution mechanism between unskilled and high-skilled jobs. Horbach and Rennings (2013) also find that there is an overall employment dynamics for firms that innovate, and that firms introducing cleaner technologies in the production process

have more employment. Gagliardi et al. (2016) in a study on 4500 Italian firms, find that despite the high cost of green technologies, there is a positive and significant impact of eco-innovation on jobs creation and employment growth. Whereas in a more recent contribution, based on 18 EU countries, Ghisetti (2018) does not find a significant impact of greener production choices on the economic performance. Leoncini et al. (2019) in a study on 5500 Italian manufacturing firms, find that there is a positive and significant effect of green technologies on firm growth, captured by employment growth, greater than the effect of non-green technologies. They use the employment growth as growth indicator, and find in addition that mature firms are more likely to grow in a strong pace with a net jobs creation. They argue that these firms have enough financial returns to reinvest in green technologies.

One important fact is that employment growth is the most commonly used indicator for firm performance in the literature. In fact, this indicator is used because of the importance of employment in the economic analysis and at the policy level. The importance of employment growth comes from the fact that it reflects not only the economic prosperity at the firm level but also at a macro level. As stated by Arundel and Kemp (2009), eco-innovation also comprises the objective of selling into markets for eco-products and this implies that the commercial activity of the eco-innovative firm, in addition to its employment dynamic, is also an important indicator reflecting its performance. Indeed, eco-innovating may result in new goods and services, and may help firms to exploit new markets or by expanding their actual market shares. This can also

trigger important gains in terms of competitiveness and a shift in terms of sales and financial returns.

The present research takes into account these arguments and aims to contribute to the literature by addressing the issue of the correlation nature between eco-innovation and both growth indicators. The aim is to close some of the following identified gaps as well. First, the French context remains unknown¹, so this first issue is addressed by exploiting French and recent data. Another contribution of this research is applying quantile regressions to investigate turnover and employment growth by quantiles within the distribution. Since the analysis is carried out in a Porter-like framework, positive relationship between eco-innovation and both growth indicators is only hypothetical. Same goes for the positive relationship between market shares and turnover growth, and research and development and both growth indicators. These hypothetical positive relationship natures and effects are due to the bench of studies whose findings revealed negative or non-significant impacts of eco-innovation on firm growth and performance, and thus did not validate the Porter-like framework (Cainelli et al. (2011) , Ghisetti (2018)), which theoretically suggests the existence of a positive impact between eco-innovation and firm's performance and activity, captured by turnover and employment. Last, the literature often characterizes average effects on firm growth which might not capture the diverse effects observed across quantiles. Digging into firm level data and accessing different types of firm growth

¹Several studies are already carried out on different European countries at once including France (see Horbach et al. (2013) and Colombelli et al. (2019))

might generate new information on how eco-innovation operates at the firm and quantile level.

3.3 Data

3.3.1 Community Innovation Survey

Data mainly stem from the French CIS waves that were respectively conducted in 2014 and 2016, merged with FARE databases from 2014 and 2016 in order to complete the missing values related to two key variables for each year: the number of employees and the turnover amount, to calculate growth indicators. Both CIS and both FARE databases are released by the National Institute of Statistics and Economic Studies (Institut National de la Statistique et des études économiques (INSEE)).

The French CIS wave of 2014 includes a module on eco-innovation with a filter question allowing to spot, among the respondents, which firms are eco-innovative and which are not. Table 3.1 illustrates the proportions of the eco-innovative and the non-eco-innovative firms among the whole sample, as well as the question that was asked in the CIS about the introduction of an eco-innovation during the previous last three years². The analysis is restrained only to the sub-sample composed of these respondents. The four eco-innovation types: product, process, organisation and marketing are considered, and one variable

²Between 2012 and 2014.

capturing eco-innovation is created. The variable *EcoInnovation* which is the independent variable of interest in the empirical analysis, takes the value 1 if a random respondent says that one eco-innovation type at least was introduced during the considered period, and takes the value 0 otherwise.

Table 3.1: Eco-innovative firms among the sample (CIS 2014) "Was any eco-innovation type introduced in your firm during last three years?"

All eco-innovation types	In % of respondents		Number of firms
	YES	NO	
<i>EcoInnovation</i>	77.58%	22.42%	3840

3.3.2 Description of dependent and independent variables

The objective of the empirical analysis is to investigate the impact of the introduction of eco-innovation by French manufacturing and services firms on both turnover and employment growth, between 2014 and 2016³.

In order to create both growth indicators which represent the dependent variables, natural logs (ln) for both turnover and employment growth are calculated. For the turnover growth indicator, which represents the first dependent variable in the econometric estimation, two key variables are needed: the amount of turnover for each firm in 2014 and the one in 2016. Turnover growth indicator is presented as follows:

$$\ln_turn_growth = \ln\left(\frac{turn2016 - turn2014}{turn2014}\right) \approx \ln(turn2016) - \ln(turn2014)$$

³The 2014 CIS wave is the most recent one including a module on eco-innovation. The 2016 CIS wave is not the most recent one, the one that was conducted in 2018 is, but the merge between it and the 2014 wave resulted in a very small number of firms compared to the merge between both 2014 and 2016 waves.

Where \ln_turn_growth is the natural logarithm of turnover growth between 2014 and 2016, $turn2016$ and $turn2014$ are respectively the amounts of turnover in 2016 and 2014, and finally $\ln(turn2016)$ and $\ln(turn2014)$ are their respective natural logarithms.

Same as for turnover growth indicator, in order to calculate the employment growth indicator, the second dependent variable included in the empirical analysis, two key variables are needed; the number of employees for each firm in 2014 and the one in 2016. Employment growth indicator is presented as follows:

$$\ln_emp_growth = \ln\left(\frac{emp2016 - emp2014}{emp2014}\right) \approx \ln(emp2016) - \ln(emp2014)$$

Where \ln_emp_growth is the natural logarithm of employment growth between 2014 and 2016, $emp2016$ is the number of employees in 2016 and $emp2014$ is the number of employees in 2014, and $\ln(emp2016)$ and $\ln(emp2014)$ are their respective natural logarithms.

That said, the importance of the French CIS 2014 comes from the fact that, in addition to the variables allowing to calculate both growth indicators, it also encompasses the independent variables that are included in the same analysis. Although *EcoInnovation* remains the independent variable of interest, other variables capturing research and development activity, patenting activity, sectors of activity and geographical location, as well as the age of the firm are needed.

The main sample of the CIS 2014 database encompasses 18109 observations, among them respondents from 5089 firms have answered questions whether they

were eco-innovative or not. Due to missing values in the variables based on which both growth indicators are calculated⁴, the number of observations was reduced to 4877. Since several important independent variables have missing values the sample was reduced to 3840, as the final number of observations on which the analysis is proceeded.

Table 3.2: Mean of natural logs turnover and employment growth for each decile (CIS 2014).

Deciles	Turnover growth rate (%)	Employment growth rate (%)
1	-1.12	-0.68
2	-0.18	-0.11
3	-0.08	-0.02
4	-0.02	0.04
5	0.02	0.11
6	0.07	0.27
7	0.12	0.87
8	0.21	1.93
9	0.53	3.83
Total sample	-0.05	0.69

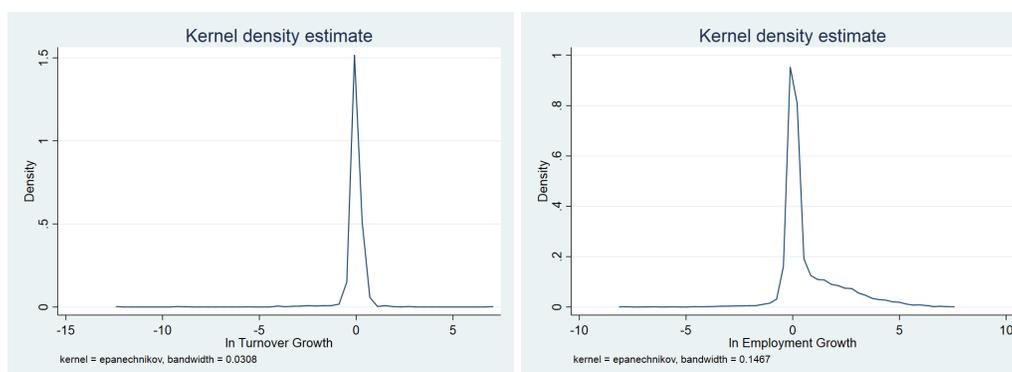


Figure 3.1: Kernel Density estimate of "ln Turnover" growth
 Figure 3.2: Kernel Density estimate of "ln Employment" growth

⁴Without finding any other databases to complete them.

Both growth indicators represent the dependent variables included in the empirical analysis. Figure 3.1, and Figure 3.2 illustrate the distribution of both growth indicators. Table 3.2 illustrates the average growth rates of both dependent variables for each decile among the sample, and what can be noticed is that employment growth pace is faster than the one for turnover. Firms grow faster in terms of employment than in terms of sales and financial returns. Another fact is that overall employment growth mean is positive whereas turnover growth mean is negative. Since these values are presented in terms of natural logarithms, thus the average growth of turnover is greater than the one of employment.

Since the objective of the empirical analysis is to investigate how and whether eco-innovation affects both turnover and employment growth of French eco-innovative firms, and as explained previously the independent variables included in the analysis capture different aspects (See Table A.3.1 for detailed descriptive statistics related to independent variables) that can influence firm performance. With this regard, in addition to the variable capturing firms doing or not eco-innovation (*EcoInnovation*), other variables are also included in the analysis. The regulatory framework (Rennings and Zwick (2002) , Rennings et al. (2004)) is captured by the existing environmental regulation (*ExistEnvReg*), existing environmental aids (*ExistGovAids*), and cost savings (*CostSavings*). Research and development is captured by both internal (*IntR&D*) and external (*ExtR&D*) (Segarra and Teruel (2014)). Patenting activity (*PatentApp*) captured means that a firm either has made at least one application during the last three years (between 2012 and 2014) or not. Other independent variables related

to cooperation are included in the analysis (Rennings et al. (2004)), respectively cooperation with universities (*CoopUniv*), cooperation with research organisms (*CoopResOrg*) as well as cooperation with competitors (*CoopComp*). besides the independent variables, dummies are also included in the analysis to capture different aspects related to the firm. These dummies encompass firm size in both years 2014 and 2016 (Rennings and Zwick (2002) , Rennings et al. (2004) , Horbach (2010) , Cainelli et al. (2011) , Horbach and Rennings (2013) , Segarra and Teruel (2014)), firm age (Horbach (2010) , Horbach and Rennings (2013) , Leoncini et al. (2019)), activity sector (Horbach (2010) , Cainelli et al. (2011) , Horbach and Rennings (2013)), and regions where firms are located (Horbach (2010) , Horbach and Rennings (2013)).

3.4 Empirical analysis

3.4.1 Research strategy and econometric estimation

Since growth rates do not evolve linearly, standard Ordinary Least Squares (OLS) regression⁵ does not reflect the real nature of the relationship between independent variables, particularly the one capturing eco-innovation, and the dependent variables. Since both growth indicators' distributions are heterogeneous, and in order to understand the real effect of eco-innovation on both of them, performing quantile regression is the appropriate method to analyse the impact of eco-innovation and other independent and control variables on the growth of each

⁵OLS coefficients for both dependent variables are reported in Table A.3.2 in appendix.

quantile across the sample. On the one hand, this type of regression considers the relationship between independent variables and conditional quantiles of the dependent variables, and thus provides accurate and a more comprehensive picture on how turnover and employment growth of the first (25%) of observations are influenced by different factors compared to the last quartile (75%) or the last decile (90%) for instance. Instead of considering only the median of variables, this regression will be customized for the chosen quantiles. On the other hand, and building up upon previous studies and research, quantile regression approach is regularly employed in recent studies on firm growth (Coad and Rao (2008) , Kesidou and Demirel (2012), Horbach and Rammer (2020)). This regression model is also known as simultaneous quantile regression as it performs parallel and multiple regressions for the chosen quantiles, each one considered to be linear. To this end, the following model for each growth indicator is estimated:

$$GrowthIndicator_i = \beta_1 EcoInnovation + \beta_2 V_e Explanatory + \beta_3 V_c Controls + \beta_4 V_d Dummies$$

Where $GrowthIndicator_i$ is $LnTurnGrowth$ and $LnEmpGrowth$ in two separate models, for which quantiles 25, 50, 75, 90, 95, and 99 are reported (see tables 3.3 and 3.4). Both growth indicators are explained by the same bench of explanatory variables, controls and dummies with one exception. In fact, one difference is the introduction of two variables: $EnvSpe$ (having an environmental specialist in the firm) and $EnvStaff$ (having an environmental staff in the firm) in the explanatory variables explaining the relationship between $EcoInnovation$ and turnover growth ($LnTurnGrowth$), without including them

in the explanatory variables explaining the relationship between *EcoInnovation* and employment growth (*LnEmpGrowth*), in order to avoid endogeneity problems. This reduces anyway the number of observations in the second regression compared to the first one (see table A.3.1 for descriptive statistics related to the two variables in question). β_1 , β_2 , β_3 , and β_4 are the coefficients to be estimated related to respectively; eco-innovation, explanatory variables, control variables, and dummies. V_e , V_c , and V_d respectively denote vectors of explanatory variables, control variables, and dummies.

Table 3.3: Turnover growth determinants captured by "*LnTurnGrowth*" between 2014 and 2016.

	q25	q50	q75	q90	q95	q99
EcoInnovation	-0.00115 (-0.11)	0.000534 (0.08)	0.0106 (0.93)	0.0331* (2.22)	0.044 (1.55)	0.0491 (0.60)
IntR&D	-0.0240 (-1.91)	-0.00353 (-0.46)	-0.00423 (-0.34)	-0.00641 (-0.36)	-0.0296 (-0.91)	-0.189 (-1.61)
ExtR&D	-0.0170 (-1.34)	-0.00932 (-1.06)	-0.00448 (-0.44)	0.00534 (0.35)	-0.00162 (-0.06)	0.198* (2.23)
PatentApp	-0.0178 (-1.28)	0.0216* (2.25)	0.00894 (0.67)	0.0456 (1.95)	0.0675 (1.84)	0.0428 (0.41)
CoopUniv	0.0181 (1.02)	0.00653 (0.66)	0.0242 (1.58)	0.0391 (1.53)	0.0746* (2.12)	0.0764 (0.55)
CoopResOrg	-0.0183 (-1.01)	-0.0185 (-1.05)	-0.0186 (-1.21)	-0.0501 (-1.75)	-0.0755 (-1.79)	-0.0904 (-0.77)

CoopComp	-0.0154	-0.00889	0.0144	0.0395	0.0297	-0.0884
	(-0.85)	(-0.68)	(0.83)	(1.40)	(0.69)	(-1.02)
Gp	-0.00963	-0.00703	-0.0177	0.00684	0.00336	-0.0771
	(-0.81)	(-0.75)	(-1.62)	(0.41)	(0.11)	(-1.15)
NewMktShare	0.0294*	0.00753	0.00178	-0.0144	-0.00259	-0.0574
	(2.46)	(0.93)	(0.16)	(-0.77)	(-0.10)	(-0.64)
ExistEnvReg	-0.0124	-0.00583	-0.00589	-0.0342*	-0.0104	-0.169
	(-1.16)	(-1.09)	(-0.54)	(-2.07)	(-0.37)	(-1.69)
ExistGovAids	0.0299**	0.0107	0.00817	0.0141	0.00258	-0.0630
	(2.69)	(1.44)	(0.71)	(0.82)	(0.08)	(-0.82)
CostSavings	-0.00249	0.00320	-0.00359	-0.00458	-0.00977	0.0778
	(-0.26)	(0.37)	(-0.32)	(-0.28)	(-0.36)	(0.84)
EnvSpe	-0.0169	-0.00672	-0.00681	0.00446	0.0390	0.0889
	(-1.08)	(-0.64)	(-0.43)	(0.14)	(0.87)	(0.68)
EnviStaff	-0.00611	-0.0169	0.00223	-0.00266	-0.0350	-0.144
	(-0.43)	(-1.68)	(0.13)	(-0.09)	(-0.72)	(-1.19)
Age	YES	YES	YES	YES	YES	YES
Size dummies (2014)	YES	YES	YES	YES	YES	YES
Size dummies (2016)	YES	YES	YES	YES	YES	YES
Region dummies	YES	YES	YES	YES	YES	YES
Sector dummies	YES	YES	YES	YES	YES	YES
<i>N</i>	3819	3819	3819	3819	3819	3819

R^2	0.0319	0.0190	0.0270	0.0498	0.0663	0.1403
-------	--------	--------	--------	--------	--------	--------

Table 3.4: Employment growth determinants captured by "*LnEmpGrowth*" between 2014 and 2016.

	q25	q50	q75	q90	q95	q99
EcoInnovation	-0.00853 (-0.69)	0.00768 (0.66)	0.0436 (1.59)	0.0648 (0.95)	0.0667 (0.71)	0.161 (1.13)
IntR&D	0.0202 (1.39)	0.0283* (2.04)	0.0142 (0.47)	-0.00624 (-0.09)	0.103 (0.98)	0.0304 (0.22)
ExtR&D	-0.00163 (-0.13)	-0.00361 (-0.32)	0.00767 (0.31)	-0.00853 (-0.13)	-0.0220 (-0.25)	0.168 (1.31)
PatentApp	0.0259 (1.66)	0.0189 (1.48)	0.0297 (0.83)	0.0948 (0.96)	0.302** (2.60)	0.425** (2.81)
CoopUniv	0.0129 (0.75)	0.0177 (1.05)	0.0447 (0.87)	-0.0270 (-0.27)	-0.00319 (-0.03)	0.217 (0.97)
CoopResOrg	-0.0140 (-0.69)	0.0114 (0.49)	0.118* (2.08)	0.268* (2.21)	0.156 (1.02)	0.0827 (0.36)
CoopComp	0.000197 (0.01)	-0.00768 (-0.36)	-0.106* (-2.19)	0.0125 (0.11)	-0.00484 (-0.04)	-0.283 (-1.64)
Gp	0.00118 (0.11)	0.0167 (1.55)	0.0945*** (3.60)	0.609*** (6.56)	0.708*** (6.38)	0.769*** (5.10)
NewMktShare	0.00508 (0.46)	0.0112 (0.88)	0.0285 (0.99)	0.00560 (0.08)	-0.0704 (-0.88)	-0.284* (-2.52)
ExistEnvReg	-0.00228	0.00790	-0.0145	0.0761	0.156	-0.00572

	(-0.21)	(0.62)	(-0.56)	(1.09)	(1.64)	(-0.03)
ExistGovAids	0.0230	0.0143	0.000841	0.0108	0.0163	-0.0597
	(1.86)	(1.25)	(0.03)	(0.16)	(0.18)	(-0.46)
CostSavings	-0.0190	-0.0252*	-0.0188	-0.0478	0.104	0.134
	(-1.57)	(-2.18)	(-0.32)	(-0.74)	(1.21)	(1.07)
Age	YES	YES	YES	YES	YES	YES
Size dummies (2014)	YES	YES	YES	YES	YES	YES
Size dummies (2016)	YES	YES	YES	YES	YES	YES
Region dummies	YES	YES	YES	YES	YES	YES
Sector dummies	YES	YES	YES	YES	YES	YES
<i>N</i>	3837	3837	3837	3837	3837	3837
<i>R</i> ²	0.3513	0.4612	0.5631	0.5629	0.5666	0.5898

t statistics in parentheses

*, **, and *** respectively denote significance at $p < 0.05$, $p < 0.01$, $p < 0.001$

Sector, size, and regional dummies' coefficients are not reported in the table.

Only respondents to the question (cf. table 1.1) are considered.

3.4.2 Discussion of results

Tables 3.3 and 3.4 illustrate quantile regression coefficients' related to quantiles 25, 50, 75, 90, 95, and 99 for both growth indicators: turnover growth (*LnTurnGrowth*) and employment growth (*LnEmpGrowth*). Results show a positive relationship between eco-innovation and turnover growth at 90% (or for

the 10% of firms among the sample with the highest growth rates). Although this positive relationship is not verified across all the distribution through the different quantiles reported in the analysis, this finding remains very important as it is consistent and related with literature on high-growth firms (Coad and Rao (2008) , Segarra and Teruel (2014)) illustrating the positive relationship between innovation and firm growth of the fastest firms among a distribution, and between eco-innovation and firm growth for the same category of firms (Colombelli et al. (2019)). Still regarding this finding, for the remaining quantiles (0.25, 0.50, and 0.75), eco-innovation does not seem to explain the turnover growth of French firms in this analysis. In addition to eco-innovation for this category of firms, the top 1% of firms with the highest turnover growth doing external research and development (*ExtR&D*) experience a significant and positive relationship between the latter and the former, as doing external research and development (*ExtR&D*) would, according to the findings, increase the turnover growth by nearly 20%. In fact, research and development efforts in general are known to trigger eco-innovation (Horbach (2008)) and to generate a shift in terms of sales, and in this analysis the distinction is made between internal (*IntR&D*) and external (*ExtR&D*) research and development to investigate the impact of both of them on both growth indicators⁶. It is noteworthy that findings do not really show whether this positive relationship is due to doing research and development in the green the field or in the non-green field, since the sample encompasses

⁶A variable explaining research and development efforts in general did not provide significant results. The distinction between both research and development categories helps to investigate respective possible impacts accurately and separately.

both eco-innovative and non-eco-innovative firms (which responded the question in table 3.1). It is also noticeable that there could be a virtuous circle between both research and development and turnover growth, as financial returns help firms to reinject funds into further research-oriented activities, allowing them in turn to generate more innovations and therefore increasing sales. Regarding patenting activity (*PatentApp*), findings show that a firm which has made at least one patent application during the mentioned period would experience a positive and significant impact on turnover growth for top half of firms in the distribution. In fact, patenting inventions and innovations offers firms a protection and therefore a monopoly which may increase their financial returns for a certain period of time. Still, it is not known through data whether these patents are green or non-green. Cooperation with universities (*CoopUniv*) is found to having a positive and significant impact on turnover growth for the top 5% growing firms. This finding also seems to be important as cooperation with universities and research laboratories may enhance more innovations and therefore leads to the mechanism explained previously.

Regarding the relationship between eco-innovation and employment growth, findings illustrated in table 3.4 do not show any significance between this key variable (*EcoInnovation*) and the second growth indicator (*LnEmpGrowth*) considered in this analysis. That said, internal research and development (*IntR&D*) is found to have a positive and significant relationship with employment growth for the higher 50% of firms among the distribution. This may be explained by the fact of increasing internal research and development

activities which requires further workers and opens new positions within the firm. Same as for turnover growth, patenting activity (*PatentApp*) capturing patent application between 2012 and 2014, is significantly and positively related to employment growth for the top 5% and 1% firms with the highest employment growth among the distribution. This finding can be explained by the financial returns generated by the protection offered by the patent and which implies an increasing productivity and so further recruitment of new employees. Concerning the cooperation with research organisms (*CoopResOrg*), findings show a positive and significant relationship with employment growth at 0.75 and 0.90. Cooperation with research organisms and research activities may then trigger new job opportunities for firms given the increasing new and updated tasks. Last but not least, one very important finding reveals that firms belonging to a group of firms experience an increasing job dynamics and a creation of new jobs, almost across the whole sample. This finding is important because it shows that firms which are not isolated in the market may have more opportunities to create new jobs and to experience a net employment growth.

3.5 Conclusion

The content of this chapter was to investigate the relationship between eco-innovation and firm growth. Since firm growth can be approached through sales (turnover in this analysis) and employment, both are considered and investigated in this analysis. Both indicators were calculated based on their

respective natural logarithms (\ln). Findings show a positive and significant relationship between eco-innovation and the 10% of firms with the highest growth rates. This finding is consistent with high-growth firms literature, meaning that high-growth French eco-innovative firms, according to the findings, experience a turnover growth triggered by a shift in sales. On the contrary, no impact was observed from eco-innovation on employment growth across the distribution. Other important findings are also to be underlined. First, the importance of external research and development and its impact on turnover growth for the "fastest" 1% of firms. Second, the role of patenting activity for both growth indicators. Third, the importance of belonging to a group of firms on employment growth.

The result detecting a positive and significant relationship between the high-growth firms and eco-innovation based on this French firms sample, gives material to explore the issue in future studies, as the literature is quite limited in the field at the moment.

Regarding the caveats of this research, it is acknowledged that the positive impact of the explanatory variables, other than *EcoInnovation*, on both growth indicators does not detect whether it is due to eco-innovation or to other factors. For instance, when external research and development has a positive and significant relationship with turnover growth, this does not mean that this relationship is triggered by introducing eco-innovation, since this analysis is not only restrained to those eco-innovative firms (*EcoInnovation* = 1), but to all those who replied to the question whether an eco-innovation was introduced or

not between 2012 and 2014, i.e. across the sample 77.5% of eco-innovative firms, and 22.5% of not eco-innovative.

Apart from these caveats, the chapter shows that more research should be carried out on French data, as how firms eco-innovate and with what impacts is still scarce in this country. Also, the chapter contributes to show that research should be carried out in order to investigate the importance of jobs creation by high-growth eco-innovative firms, compared to their non eco-innovative counterparts.

General conclusion

The objective of this thesis dissertation was to analyse eco-innovation at the firm level with a focus on the French context that remains until now unexplored and unknown. For so doing, this dissertation was divided into three chapters starting with a theoretical and conceptual literature review on the relation between eco-innovation and firm growth, following with an identification of the drivers of eco-innovation including all types of innovation (product, process, organisation and marketing), and ending up with an investigation on the impact of eco-innovation on firm growth.

The first chapter aimed to address the main aspects surrounding this concept to better prepare the ground for the following chapters, starting from definitions, addressing measurement instruments, dimensions and eco-innovation types as well as determinants, but also impacts decomposed into internal and external ones. Although employment appears to focus the most important internal effects of introducing eco-innovation, still the nature of this effect is not consensual in the different contributions, and there is an employment dynamics based on new occupations, tasks and skills that eco-innovative firm experience to be documented further. Another important effect is the transformation of the traditional supply chain into the green supply chain (GSC) as far as firms are willing to comply with the environmental regulation, with possible coexistence of both GSC eco-product innovation oriented and GSC eco-process innovation oriented with possibly important jobs implications. The main contributions of this chapter was to define and explain the mechanisms through which eco-innovation affects firm activity, structure, and performance.

The second chapter tackled the determinants of eco-innovation, analysing French data related to services and manufacturing firms that took part in the community innovation survey (CIS) conducted in 2014 which covered the period including the three years before. CIS 2014 is the last one until today dealing with eco-innovation activity and environmental innovation efforts by French firms, since the waves that were conducted afterwards did not include the eco-innovation module. Based on separate probit model estimations for different dependent variables capturing the four types of eco-innovation: eco-product, eco-process, eco-organisation, and eco-marketing innovations, the probability of introducing an eco-innovation is estimated depending on the importance awarded to different determinants. Other important explanatory variables capturing innovation activities such as R&D, patenting activity, or cooperation aspects with different actors are also included. Two important findings can be mentioned, the main and most important one lying in the importance of firm's reputation ahead of the introduction of eco-innovation whatever its type. The second one is related to the introduction of eco-marketing innovation that was not documented in literature until now: contracts with customers, in addition to firm's reputation, is an important determinant for the introduction of this eco-innovation type. To the best of our knowledge, these two findings are novel to literature as this chapter was able not to ignore any eco-innovation type. Alongside these mentioned contributions of this chapter, focusing on the French context could hopefully represent an important step towards a new understanding of the determinants of eco-innovation.

Finally, the third chapter was dedicated to the study of the impact of eco-innovation whatever its type, on firm growth. Two growth indicators, employment and turnover, were embedded in the empirical analysis of this chapter. Exploring French data related to two CIS waves conducted in 2014 and 2016, separate quantile regressions were ran in order to explain both growth indicators, following recent contributions in the field of firm growth (Coad et al. (2014) , Segarra and Teruel (2014)). The main finding is a positive and significant relation between eco-innovation and the top decile of the sample corresponding to the fastest growing firms. This result, although not observed across the whole sample, remains important and represents the major contribution of this chapter although the relation is not valid for employment growth. Several contributions are already carried out whose findings are presented in the literature, this unobserved impact remains normal since not all the contributions have come up with the same positive and significant relation between eco-innovation and firm growth. Last, other variables, i.e. patenting activity, research and development, and group ownership are important for firm growth whatever the growth indicator used.

Regarding the limits of this work, they are mainly related to data and econometric approaches. Although in the second chapter probit and logit models are estimated, respectively for the main analysis and robustness checks, data stemming from surveys are to be considered biased by default since answers are always declarative and some can be considered as subjective (Mairesse and Mohnen

(2010)). Same goes for the third chapter, where data stem from CIS waves of 2014 and 2016, and where both growth indicators are calculated based on amounts (for turnover) and numbers of employees, but the independent variables depend on the answers given by respondents. The third chapter did not cover issues related to tasks and qualifications either, and this is also another limit in relation with data which did not allow such an investigation. Concerning the approaches and methodology, the findings throughout both second and third chapters result from the methodologies and estimations presented previously, other approaches and different methodologies and hypotheses may lead to different results.

Regarding the perspectives for future research that this work may offer, it still holds that eco-innovation at the firm level needs to be investigated further. Although several contributions dealing with number of aspects related to it are already presented, but this field is still relatively new. Employment effects including jobs reallocation, skills making up jobs, and different qualifications within eco-innovative firms still require further and deeper research, especially in a cross-country perspective. Furthermore, it is acknowledged that although supply chain and green supply chain concepts are tackled in both management and economic literature, they still need to be more and better documented, particularly the green supply chain that is linked to the introduction of eco-innovation. These are some of the possible research perspectives related to the mechanisms defined in the first chapter. Furthermore, since the French case remains unknown and barely explored, more investigation needs to be carried out given the open field that it actually represents. Determinants of eco-innovation, the impact of the

latter on firm growth as well as French high-growth firms as a whole and the eco-innovative ones among them need deeper investigation, and as the results of this thesis reveal that there is still room to go further in this direction. In a similar way, green jobs and the green supply chain remain unexplored in France and literature is too scarce. Since these two concepts are directly related to internal and external effects of eco-innovation at the firm level, more attention should be given them. These lines of research will certainly structure the research agenda for future studies, and it is also part of this work to identify a way to contribute to it in a shorter or longer term.

Bibliography

Andersen, M. M. (2008). Eco-innovation–towards a taxonomy and a theory. In *25th celebration DRUID conference*.

Arimura, T., Hibiki, A., and Johnstone, N. (2007). An empirical study of environmental r&d: what encourages facilities to be environmentally innovative. *Environmental policy and corporate behaviour*, pages 142–173.

Arundel, A. and Kemp, R. (2009). Measuring eco-innovation. *UNU-MERIT working paper series. Maastricht, The Netherlands, 2009-017*.

Audretsch, D. B., Coad, A., and Segarra, A. (2014). Firm growth and innovation. *Small business economics*, 43(4):743–749.

Audretsch, D. B. and Vivarelli, M. (1996). Firms size and r&d spillovers: Evidence from italy. *Small Business Economics*, 8(3):249–258.

Barbieri, N., Ghisetti, C., Gilli, M., Marin, G., and Nicolli, F. (2016). A survey of the literature on environmental innovation based on main path analysis. *Journal of Economic Surveys*, 30(3):596–623.

- Barbieri, N., Marzucchi, A., and Rizzo, U. (2020). Knowledge sources and impacts on subsequent inventions: Do green technologies differ from non-green ones? *Research Policy*, 49(2):103901.
- Beamon, B. M. (1999). Designing the green supply chain. *Logistics information management*.
- Bigliardi, B., Bertolini, M., Doran, J., and Ryan, G. (2012). Regulation and firm perception, eco-innovation and firm performance. *European Journal of Innovation Management*.
- Bossle, M. B., de Barcellos, M. D., Vieira, L. M., and Sauvée, L. (2016). The drivers for adoption of eco-innovation. *Journal of Cleaner Production*, 113:861–872.
- Brunnermeier, S. B. and Cohen, M. A. (2003). Determinants of environmental innovation in us manufacturing industries. *Journal of environmental economics and management*, 45(2):278–293.
- Buttol, P., Buonamici, R., Naldesi, L., Rinaldi, C., Zamagni, A., and Masoni, P. (2012). Integrating services and tools in an ict platform to support eco-innovation in smes. *Clean Technologies and Environmental Policy*, 14(2):211–221.
- Cainelli, G., Mazzanti, M., and 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.

- Cañón-de Francia, J., Garcés-Ayerbe, C., and Ramírez-Alesón, M. (2007). Are more innovative firms less vulnerable to new environmental regulation? *Environmental and Resource Economics*, 36(3):295–311.
- Caroli, E. and Van Reenen, J. (2001). Skill-biased organizational change? evidence from a panel of british and french establishments. *The Quarterly Journal of Economics*, 116(4):1449–1492.
- Caudron, C., Diel, O., Louis, H., Margontier, S., Pasquier, I., and Randriambololona, C. (2014). L'économie de l'environnement en 2012.
- Chen, Y.-S. (2008). The driver of green innovation and green image–green core competence. *Journal of business ethics*, 81(3):531–543.
- Chen, Y.-S., Lai, S.-B., and Wen, C.-T. (2006). The influence of green innovation performance on corporate advantage in taiwan. *Journal of business ethics*, 67(4):331–339.
- Cheng, C. C. and Shiu, E. C. (2012). Validation of a proposed instrument for measuring eco-innovation: An implementation perspective. *Technovation*, 32(6):329–344.
- Chiou, T.-Y., Chan, H. K., Lettice, F., and Chung, S. H. (2011). The influence of greening the suppliers and green innovation on environmental performance and competitive advantage in taiwan. *Transportation Research Part E: Logistics and Transportation Review*, 47(6):822–836.

- Cleff, T. and Rennings, K. (1999). Determinants of environmental product and process innovation. *European environment*, 9(5):191–201.
- Coad, A., Daunfeldt, S.-O., Hözl, W., Johansson, D., and Nightingale, P. (2014). High-growth firms: introduction to the special section. *Industrial and Corporate Change*, 23(1):91–112.
- Coad, A. and Rao, R. (2008). Innovation and firm growth in high-tech sectors: A quantile regression approach. *Research policy*, 37(4):633–648.
- Coad, A., Segarra, A., and Teruel, M. (2016). Innovation and firm growth: Does firm age play a role? *Research policy*, 45(2):387–400.
- Colombelli, A., Haned, N., and Le Bas, C. (2013). On firm growth and innovation: Some new empirical perspectives using french cis (1992–2004). *Structural Change and Economic Dynamics*, 26:14–26.
- Colombelli, A., Krafft, J., and Quatraro, F. (2019). Firms' growth, green gazelles and eco-innovation: evidence from a sample of european firms. *Small Business Economics*, pages 1–18.
- Consoli, D., Marin, G., Marzucchi, A., and Vona, F. (2016). Do green jobs differ from non-green jobs in terms of skills and human capital? *Research Policy*, 45(5):1046–1060.
- Corradini, C. (2019). Location determinants of green technological entry: evidence from european regions. *Small Business Economics*, 52(4):845–858.

- Costantini, V., Crespi, F., Marin, G., and Paglialunga, E. (2017). Eco-innovation, sustainable supply chains and environmental performance in european industries. *Journal of cleaner production*, 155:141–154.
- Costantini, V., Crespi, F., Martini, C., and Pennacchio, L. (2015). Demand-pull and technology-push public support for eco-innovation: The case of the biofuels sector. *Research Policy*, 44(3):577–595.
- Daunfeldt, S.-O., Elert, N., Johansson, D., et al. (2010). The economic contribution of high-growth firms: Do definitions matter. *Ratio working papers*, 151:1–20.
- del Río, P., Peñasco, C., and Romero-Jordán, D. (2016). What drives eco-innovators? a critical review of the empirical literature based on econometric methods. *Journal of Cleaner Production*, 112:2158–2170.
- del Río González, P. (2005). Analysing the factors influencing clean technology adoption: a study of the spanish pulp and paper industry. *Business strategy and the environment*, 14(1):20–37.
- Dresner, S. (2008). *The principles of sustainability*. Earthscan.
- Driessen, P. H. and Hillebrand, B. (2002). Adoption and diffusion of green innovations. *Marketing for sustainability: towards transactional policy-making*, pages 343–355.
- Evans, D. S. (1987a). The relationship between firm growth, size, and

- age: Estimates for 100 manufacturing industries. *The journal of industrial economics*, pages 567–581.
- Evans, D. S. (1987b). Tests of alternative theories of firm growth. *journal of political economy*, 95(4):657–674.
- Fronzel, M., J., and 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.
- Gagliardi, L., Marin, G., and Miriello, C. (2016). The greener the better? job creation effects of environmentally-friendly technological change. *Industrial and Corporate Change*, 25(5):779–807.
- Ghisetti, C. (2018). On the economic returns of eco-innovation: Where do we stand? In *New Developments in Eco-Innovation Research*, pages 55–79. Springer.
- Ghisetti, C., Marzucchi, A., and Montessor, S. (2015). The open eco-innovation mode. an empirical investigation of eleven european countries. *Research Policy*, 44(5):1080–1093.
- Green, K., McMeekin, A., and Irwin, A. (1994). Technological trajectories and r&d for environmental innovation in uk firms. *Futures*, 26(10):1047–1059.
- Grekova, K., Calantone, R. J., Bremmers, H. J., Trienekens, J. H., and Omta, S. (2016). How environmental collaboration with suppliers and

- customers influences firm performance: evidence from dutch food and beverage processors. *Journal of cleaner production*, 112:1861–1871.
- Horbach, J. (2008). Determinants of environmental innovation—new evidence from german panel data sources. *Research policy*, 37(1):163–173.
- Horbach, J. (2010). The impact of innovation activities on employment in the environmental sector—empirical results for germany at the firm level. *Jahrbücher für Nationalökonomie und Statistik*, 230(4):403–419.
- Horbach, J. (2014). Do eco-innovations need specific regional characteristics? an econometric analysis for germany. *Review of Regional Research*, 34(1):23–38.
- Horbach, J., Oltra, V., and 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 and Innovation*, 20(6):523–543.
- Horbach, J. and Rammer, C. (2020). Circular economy innovations, growth and employment at the firm level: Empirical evidence from germany. *Journal of Industrial Ecology*, 24(3):615–625.
- Horbach, J., Rammer, C., and Rennings, K. (2012). Determinants of eco-innovations by type of environmental impact—the role of regulatory push/pull, technology push and market pull. *Ecological economics*, 78:112–122.

- Horbach, J. and 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.
- Horváthová, E. (2010). Does environmental performance affect financial performance? a meta-analysis. *Ecological economics*, 70(1):52–59.
- Kammerer, D. (2009). The effects of customer benefit and regulation on environmental product innovation.: Empirical evidence from appliance manufacturers in germany. *Ecological Economics*, 68(8-9):2285–2295.
- Katz, M. L. (1989). *Vertical contractual relations*, volume 1, chapter 11, pages 655–721. Elsevier Science Publishers.
- Kemp, R. and Pearson, P. (2008). Mei project about measuring eco-innovation, final report. *Maastricht. In.*
- Kesidou, E. and Demirel, P. (2012). On the drivers of eco-innovations: Empirical evidence from the uk. *Research Policy*, 41(5):862–870.
- Khanna, M., Deltas, G., and Harrington, D. R. (2009). Adoption of pollution prevention techniques: the role of management systems and regulatory pressures. *Environmental and Resource Economics*, 44(1):85–106.
- Langlois, R. and Robertson, P. (1995). *Firms, Markets, and economic change: a dynamic theory of business institutions.*

- Leoncini, R., Marzucchi, A., Montresor, S., Rentocchini, F., and Rizzo, U. (2019). 'better late than never': the interplay between green technology and age for firm growth. *Small Business Economics*, 52(4):891–904.
- Lhuillery, S. and Pfister, E. (2009). R&d cooperation and failures in innovation projects: Empirical evidence from french cis data. *Research policy*, 38(1):45–57.
- Mairesse, J. and Mohnen, P. (2010). Using innovation surveys for econometric analysis. In *Handbook of the Economics of Innovation*, volume 2, pages 1129–1155. Elsevier.
- OECD (2009). *Eco-innovation in industry: enabling green growth*. OECD.
- OECD (2011). *Better policies to support eco-innovation*. Organisation for Economic Co-operation and Development.
- Oltra, V. and Saint Jean, M. (2009). Sectoral systems of environmental innovation: an application to the french automotive industry. *Technological Forecasting and Social Change*, 76(4):567–583.
- Perry, M. (1989). *Vertical Integration: Determinants and Effects*, volume 1, chapter 4, pages 183–255. Elsevier Science Publishers.
- Pfeiffer, F. and Rennings, K. (1999). Employment impacts of cleaner production. *Mannheim: Centre for European Economic Research (ZEW). Discussion paper*, (46).

- Pfeiffer, F. and Rennings, K. (2001). Employment impacts of cleaner production—evidence from a German study using case studies and surveys. *Business strategy and the environment*, 10(3):161–175.
- Popp, D. (2006). International innovation and diffusion of air pollution control technologies: the effects of NO_x and SO₂ regulation in the US, Japan, and Germany. *Journal of Environmental Economics and Management*, 51(1):46–71.
- Porter, M. E. and Van der Linde, C. (1995). Toward a new conception of the environment-competitiveness relationship. *Journal of economic perspectives*, 9(4):97–118.
- Rehfeld, K.-M., Rennings, K., and Ziegler, A. (2007). Integrated product policy and environmental product innovations: An empirical analysis. *Ecological economics*, 61(1):91–100.
- Reid, A. and Miedzinski, M. (2008). Eco-innovation. *Final report for sectoral innovation watch. Europe Innova. Technopolis group.*
- Rennings, K. (2000). Redefining innovation—eco-innovation research and the contribution from ecological economics. *Ecological economics*, 32(2):319–332.
- Rennings, K., Ziegler, A., and Zwick, T. (2001). Employment changes in environmentally innovative firms.
- Rennings, K., Ziegler, A., and Zwick, T. (2004). The effect of environmental

- innovations on employment changes: an econometric analysis. *Business strategy and the environment*, 13(6):374–387.
- Rennings, K. and Zwick, T. (2002). Employment impact of cleaner production on the firm level: Empirical evidence from a survey in five european countries. *International Journal of Innovation Management*, 6(03):319–342.
- Rodriguez, R., Warmerdam, J., and Triomphe, C. E. (2010). The lisbon strategy 2000-2010. an analysis and evaluation of methods used and results achieved. study for the european parliament.
- Sarkar, A. (2012). Green branding and eco-innovations for evolving a sustainable green marketing strategy. *Asia-Pacific Journal of Management Research and Innovation*, 8(1):39–58.
- Schiederig, T., Tietze, F., and Herstatt, C. (2012). Green innovation in technology and innovation management—an exploratory literature review. *R&d Management*, 42(2):180–192.
- Segarra, A. and Teruel, M. (2014). High-growth firms and innovation: an empirical analysis for spanish firms. *Small Business Economics*, 43(4):805–821.
- Storey, D. (1994). Understanding the small business sector london: International thomson business press.
- Triguero, A., Moreno-Mondéjar, L., and Davia, M. A. (2013). Drivers of different types of eco-innovation in european smes. *Ecological economics*, 92:25–33.

Türkeli, S. and Kemp, R. (2018). Changing patterns in eco-innovation research: A bibliometric analysis. In *New Developments in Eco-Innovation Research*, pages 13–54. Springer.

Vachon, S. and Klassen, R. D. (2006). Extending green practices across the supply chain: the impact of upstream and downstream integration. *International Journal of Operations & Production Management*, 26(7):795–821.

Appendices

A.1 Summary statistics and correlations for variables used in chapter 2

Table A.1.1: Summary statistics

	Description	Mean	St.Dev
Dependent variables			
EcoProduct	Eco-product innovation (1 = Yes, 0 = No)	.4	.49
EcoProcess	Eco-process innovation (1 = Yes, 0 = No)	.47	.5
EcOrg	Eco-organisational innovation (1 = Yes, 0 = No)	.33	.47
EcoMarketing	Eco-marketing innovation (1 = Yes, 0 = No)	.1	.3
Independent variables			
ExistEnvReg	Existing environmental regulation (1 = High and average importance, 0 = weak and no importance)	.71	.45
ExistEnvTaxFees	Existing environmental taxes, charges and other fees (1 = High and average importance, 0 = weak and no importance)	.47	.5
AntEnvReg	Anticipated environmental regulation and taxes (1 = High and average importance, 0 = weak and no importance)	.54	.5

ExistGovAids	Existing government aids, subsidies and other financial incentives (1 = High and average importance, 0 = weak and no importance)	.3	.46
ExistAntDem	Existing and anticipated demand on environmental innovation in the market (1 = High and average importance, 0 = weak and no importance)	.52	.5
FirmRep	Improvement of firm's reputation (1 = High and average importance, 0 = weak and no importance)	.75	.43
ImpEnvPract	Implementation of good environmental practices (1 = High and average importance, 0 = weak and no importance)	.7	.46
CostSavings	High costs of energy, water and materials (1 = High and average importance, 0 = weak and or importance)	.65	.48
PrevContracts	The need to answer to previous contracts (1 = High and average importance, 0 = weak and no importance)	.26	.44
Controls			
EMS	Environmental management systems (1 = Yes, 0 = No)	.55	.5
Coop	Cooperation (1 = Yes, 0 = No)	.52	.5
PatentApp	Patent application during last three years (1 = Yes, 0 = No)	.26	.44
IntR&D	Internal research & development (1 = Yes, 0 = No)	.71	.45

ExtR&D	External research & development (1 = Yes, 0 = No)	.44	.5
CoopUniv	Cooperation with universities (1 = Yes, 0 = No)	.23	.42
CoopReasOrg	Cooperation with R&D organisms (1 = Yes, 0 = No)	.17	.38
CoopComp	Cooperation with competitors (1 = Yes, 0 = No)	.11	.32
FunLocRegion	Local and regional funding (1 = Yes, 0 = No)	.15	.35
FunNatOrg	Governmental funding (1 = Yes, 0 = No)	.21	.41
FunEU	European funding (1 = Yes, 0 = No)	.1	.3
ResTxCred	Research tax credit (1 = Yes, 0 = No)	.46	.5
InnOrg	Organisational innovation (1 = Yes, 0 = No)	.68	.47
InnoMkt	Marketing innovations (1 = Yes, 0 = No)	.55	.5
ReductUse	Reduction of material use (1 = Yes, 0 = No)	.39	.78
EcoWater	Reduction of water use (1 = Yes, 0 = No)	.27	.86
ConsReduct	Reduction of energy consumption (1 = Yes, 0 = No)	.48	.71
CarbonReduct	Reduction of CO2 emissions (1 = Yes, 0 = No)	.35	.81
AirPollReduct	Reduction of air, water and soil pollution, reduction of noise (1 = Yes, 0 = No)	.33	.82
PollSub	Replacement of dangerous substances (1 = Yes, 0 = No)	.4	.77
EnergSub	Replacement of fossils with renewable energies (1 = Yes, 0 = No)	.13	.91
Recycling	Recycling of wastes and water (1 = Yes, 0 = No)	.53	.68
EnvSpe	One employee at least is specialist in environment (1 = Yes, 0 = No)	.26	.44

EnviStaff	Environmental staff (1 = Yes, 0 = No)	.15	.36
Age	2014 - year of foundation	31.02	23.31
Size dummies			
Size1	Number of employees ≤ 9	.09	.28
Size2	$10 \leq$ Number of employees ≤ 249	.67	.47
Size3	$250 \leq$ Number of employees ≤ 4999	.24	.42
Size4	Number of employees ≥ 5000	.01	.07
Sector dummies			
Sec1-sec10	Agriculture, forests exploitation and fishing	.1	.07
Sec11-sec20	Extractions, food, tobacco, textile, clothes, shoes, wood	.21	.13
Sec21-sec30	Paper, nuclear, chemical, plastics, mineral products, metallurgy, metalwork, equipments, machines and multimedia machines industries	.18	.12
Sec31-sec40	Electronics, Tv and radio, medical instruments, other transport materials, furniture manufacturing, recovery, cars industry, electricity	.26	.14
Sec41-sec50	Water distribution, construction, car trade and fixing	.08	.08
Sec51-sec60	Wholesale trade, retail trade, hotels and restaurants, land transportation	.14	.11

Sec61-sec67	Maritime transport, air transport, auxiliary transport services, telecommunication, finance, insurance, insurance and finance auxiliaries, real estate, renting and hiring, IT activities, research and development, services to firms, public administration, education	.03	.04
-------------	--	-----	-----

Table A.1.2: Matrix of correlations between dependent variables.

Variables	(1)	(2)	(3)	(4)
(1) EcoProduct	1.000			
(2) EcoProcess	0.107	1.000		
(3) EcOrg	-0.087	0.149	1.000	
(4) EcoMarketing	0.114	0.094	0.204	1.000

Table A.1.3: Matrix of correlations between independent variables

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) ExistEnvReg	1.000								
(2) ExistEnvTaxFees	0.454	1.000							
(3) AntEnvReg	0.530	0.557	1.000						
(4) ExistGovAids	0.245	0.298	0.300	1.000					
(5) ExistAntDem	0.237	0.167	0.248	0.267	1.000				
(6) FirmRep	0.233	0.185	0.230	0.150	0.328	1.000			
(7) ImpEnvPract	0.305	0.226	0.279	0.159	0.285	0.462	1.000		
(8) CostSavings	0.233	0.305	0.263	0.229	0.188	0.211	0.255	1.000	
(9) PrevContracts	0.177	0.144	0.173	0.167	0.229	0.178	0.201	0.120	1.000

Table A.1.4: Distribution of the answers on firms that introduced environmental innovations, before dropping observations with missing values.

Eco-innovation types	In% of eco-innovative firms		Number of firms
	YES	NO	
Eco-product	31,62%	68,38%	5089
Eco-process	37,02%	62,98%	5089
Eco-organisation	33,74%	66,26%	5089
Eco-marketing	9,59%	90,41%	5089

Table A.1.5: Determinants of eco-innovation extracted from French CIS 2014, before dropping observations with missing values.

Eco-innovations (all types) introduced in response to:	In % of firms with eco-innovations with at least weak importance of each determinant	Number of firms
Exist. env. reg.	85,09%(4330)	5089
Exist. env. taxes, charges and fees	75,69% (3852)	5089
Anticip. env. reg. and taxes	77,4% (3939)	5089
Gov. aids and subsidies	62,84% (3198)	5089
Exist. or anticip. dem. on env. inno	73,49% (3740)	5089
Improv. of the firm's reputation	88,7% (4514)	5089
Impl. of good env. practices	87,6% (4458)	5089
High energy, material and water costs	84,71% (4311)	5089
The need to respond to previous contr.	47,14% (2399)	5089

Table A.1.6: Correctly predicted probabilities according to the logit models.

Eco-product	Eco-process	Eco-organisation	Eco-marketing
72.55%	66.66%	71.12%	89.74%

A.2 Robustness checks related to the empirical analysis carried out in chapter 2

In order to confirm the results obtained and presented in table ?? are correct and robust given the data and variables included in the empirical analysis, a separate logit model, assuming a logistic distribution for the four dependent variables is estimated following the rule hereafter:

$$Pr(Y = 1) = \frac{\exp(x'\beta)}{1 + \exp(x'\beta)}$$

This probability rule can be more explicitly written in order to explicitly show the equation including the variables of interest, controls and dummies, as follows:

$$Pr(EcoInnovation_t = 1) = G(\beta_o + \beta_1 ExistEnvReg + \beta_2 ExistEnvTaxFees + \beta_3 AntEnvReg + \beta_4 ExistGovAids + \beta_5 ExistAntDem + \beta_6 FirmRep + \beta_7 ImpEnvPract + \beta_8 CostSavings + \beta_9 PrevContracts) + V_c Controls + V_d Dummies$$

Table A.2.1: Marginal effects following the estimation of separate logit models for the four dependent variables (CIS 2014). (High and average importance = 1, weak and no importance = 0)

	(1)	(2)	(3)	(4)
	EcoProduct	EcoProcess	EcOrg	EcoMarketing
ExistEnvReg	0.00473 (0.25)	0.0451* (2.21)	-0.0187 (-0.93)	-0.0181 (-1.36)
ExistEnvTaxFees	-0.0232	0.0198	0.0599***	0.0108

	(-1.32)	(1.06)	(3.36)	(0.90)
AntEnvReg	-0.0105	0.00513	0.0350	0.00754
	(-0.58)	(0.26)	(1.86)	(0.60)
ExistGovAids	-0.0101	0.0168	-0.0170	0.0231*
	(-0.61)	(0.96)	(-1.00)	(2.16)
ExistAntDem	0.159***	0.0182	-0.0312	0.0143
	(10.69)	(1.09)	(-1.94)	(1.36)
FirmRep	0.0441*	0.00270	0.0843***	0.0523***
	(2.34)	(0.13)	(4.25)	(3.44)
ImpEnvPract	0.00691	0.0513**	0.0523**	0.0213
	(0.38)	(2.68)	(2.79)	(1.60)
CostSavings	-0.0434**	0.0908***	0.0902***	-0.00142
	(-2.71)	(5.40)	(5.45)	(-0.13)
PrevContracts	-0.0181	-0.0198	0.0261	0.0218*
	(-1.05)	(-1.06)	(1.51)	(2.00)
EMS	0.0276	0.0909***	-	0.0171
	(1.70)	(5.37)		(1.58)
PatentApp	0.126***	-0.00149	-0.0558**	-0.00449
	(6.88)	(-0.07)	(-2.64)	(-0.33)
IntR&D	0.123***	0.0441*	-0.0294	0.0295*
	(6.30)	(2.20)	(-1.57)	(2.39)
ExtR&D	0.0430**	0.0379*	0.0314	0.0207*
	(2.80)	(2.28)	(1.94)	(1.98)

CoopUniv	0.0358 (1.67)	0.0438 (1.85)	0.0626** (2.68)	0.0179 (1.23)
CoopReasOrg	-0.00793 (-0.35)	0.0135 (0.53)	-0.0698** (-2.77)	0.000772 (0.05)
CoopComp	0.00963 (0.41)	0.0128 (0.50)	0.0635** (2.67)	0.000918 (0.06)
FunLocRegion	-0.00372 (-0.17)	0.0352 (1.47)	0.0534* (2.34)	0.00325 (0.22)
FunNatOrg	0.0203 (1.01)	0.000767 (0.03)	-0.000907 (-0.04)	-0.0146 (-1.02)
FunEU	0.00443 (0.16)	0.0791** (2.60)	0.0331 (1.16)	0.0298 (1.67)
ResTxCred	0.0525** (2.96)	0.0318 (1.64)	-0.0921*** (-4.90)	-0.00639 (-0.52)
InnOrg	-0.0453** (-2.89)	0.148*** (9.02)	-	0.0601*** (5.11)
InnoMkt	0.116*** (7.70)	0.0000551 (0.00)	0.152*** (10.47)	-
EnvSpe	0.0841*** (3.43)	0.0375 (1.44)	0.00348 (0.14)	-0.00188 (-0.11)
EnviStaff	-0.0254 (-1.04)	-0.00288 (-0.11)	0.0192 (0.75)	-0.0246 (-1.38)
Age	YES	YES	YES	YES

Size dummies	YES	YES	YES	YES
Sector dummies	YES	YES	YES	YES
Regional dummies	YES	YES	YES	YES
N	3986	3986	3986	3986
R^2	0.1926	0.1274	0.1155	0.1594

t statistics in parentheses.

*, **, *** respectively denote significance at the $p < 0.05$, $p < 0.01$, $p < 0.001$ level.

(-) means that the variable is not included in the model, for perfect prediction.

Sector and size dummies' marginal effects are not reported in the table.

Only eco-innovative firms are considered.

Table A.2.1 includes marginal effects resulting from a separate logit model regressions for each of the four dependent variables of the empirical analysis. By considering the same transformation of independent variables from categorical to binary such that high and average importance take value 1, and weak and no importance categories take value 0. Results are almost the same as the ones provided by the probit estimation.

In the following table (A.2.2), marginal effects resulting from a separate logit model regressions for each of the four dependent variables are presented, but with a different transformation of the categorical independent variables into binary, such that high importance category takes value 1 and others categories take the value 0.

Table A.2.2: Marginal effects following the estimation of separate logit models for the four dependent variables (CIS 2014). (high importance = 1 and other categories together = 0)

	(1)	(2)	(3)	(4)
	EcoProduct	EcoProcess	EcOrg	EcoMarketing
ExistEnvReg	0.00592 (0.36)	0.0451* (2.58)	0.0200 (1.17)	-0.00481 (-0.44)
ExistEnvTaxFees	0.0634** (-2.88)	0.00823 (0.35)	0.0379 (1.75)	0.0197 (1.49)
AntEnvReg	0.0263 (1.32)	0.0105 (0.50)	0.0243 (1.21)	0.0258* (2.06)
ExistGovAids	0.0115 (0.48)	0.0210 (0.81)	0.0189 (0.78)	0.000136 (0.01)
ExistAntDem	0.132*** (7.99)	0.0151 (0.81)	-0.0280 (-1.56)	0.0157 (1.46)
FirmRep	0.0822*** (5.10)	0.0319 (1.86)	0.0469** (2.86)	0.0583*** (5.39)
ImpEnvPract	-0.0382* (-2.25)	0.0278 (1.56)	0.0316 (1.87)	-0.00590 (-0.55)
CostSavings	-0.0179 (-1.15)	0.102*** (6.33)	0.0800*** (5.16)	-0.0186 (-1.81)
PrevContracts	0.0327 (1.41)	0.0171 (0.68)	0.0536* (2.31)	0.0130 (0.90)

EMS	0.0339*	0.0926***	-	0.0191
	(2.09)	(5.48)		(1.77)
PatentApp	0.128***	-0.00162	-0.0581**	-0.00787
	(7.03)	(-0.08)	(-2.73)	(-0.58)
IntR&D	0.131***	0.0434*	-0.0315	0.0307*
	(6.68)	(2.17)	(-1.67)	(2.51)
ExtR&D	0.0422**	0.0381*	0.0339*	0.0184
	(2.74)	(2.29)	(2.08)	(1.76)
CoopUniv	0.0389	0.0447	0.0605**	0.0175
	(1.81)	(1.89)	(2.58)	(1.20)
CoopReasOrg	-0.00221	0.0159	-0.0714**	0.00521
	(-0.10)	(0.63)	(-2.81)	(0.34)
CoopComp	0.00314	0.0108	0.0709**	0.000102
	(0.13)	(0.42)	(2.96)	(0.01)
FunLocRegion	-0.0133	0.0410	0.0615**	0.00596
	(-0.59)	(1.71)	(2.68)	(0.40)
FunNatOrg	0.0213	-0.000819	-0.00630	-0.0119
	(1.06)	(-0.04)	(-0.29)	(-0.83)
FunEU	0.00188	0.0729*	0.0283	0.0289
	(0.07)	(2.40)	(0.98)	(1.62)
ResTxCred	0.0500**	0.0281	-0.0992***	-0.00599
	(2.82)	(1.45)	(-5.25)	(-0.49)
InnOrg	-0.0459**	0.147***	-	0.0602***

	(-2.91)	(8.95)	(5.11)	
InnoMkt	0.114***	-0.00157	0.155***	-
	(7.59)	(-0.10)	(10.60)	
EnvSpe	0.0836***	0.0403	0.00729	-0.00287
	(3.41)	(1.55)	(0.28)	(-0.17)
EnviStaff	-0.0318	-0.00414	0.0198	-0.0223
	(-1.30)	(-0.16)	(0.76)	(-1.25)
Age	YES	YES	YES	YES
Size dummies	YES	YES	YES	YES
Sector dummies	YES	YES	YES	YES
Regional dummies	YES	YES	YES	YES
<i>N</i>	3986	3986	3986	3986
<i>R</i> ²	0.1892	0.1273	0.1045	0.1593

t statistics in parentheses.

*, **, *** respectively denote significance at the $p < 0.05$, $p < 0.01$, $p < 0.001$ level.

(-) means that the variable is not included in the model, for perfect prediction.

Sector and size dummies' marginal effects are not reported in the table.

Only eco-innovative firms are considered.

Table A.2.2 includes the marginal effects resulting from the estimation of separate logit models for the four dependent variables with respect to the classification explained previously. Here also, results show the same consistence of the ones initially found and checked through table A.2.1.

In order to investigate further robustness of the findings, multivariate probit model regressions are ran in two steps following, respectively, the two classifications of the transformation of the categorical variables into binary (see tables A.2.3 and A.2.4). This type of model is estimated when dependent variables are binary and almost explained by the same set of independent variables. It is estimated in order to eliminate the eventual biases due to collinearity among independent variables.

The model takes the form of a set of equations as follows:

$$1 - EcoProduct = F(\beta_o + \beta_1 ExistEnvReg + \beta_2 ExistEnvTaxFees + \beta_3 AntEnvReg + \beta_4 ExistGovAids + \beta_5 ExistAntDem + \beta_6 FirmRep + \beta_7 ImpEnvPract + \beta_8 CostSavings + \beta_9 PrevContracts) + V_{c1}Controls + V_{d1}Dummies$$

$$2 - EcoPrc = L(\beta_o + \beta_1 ExistEnvReg + \beta_2 ExistEnvTaxFees + \beta_3 AntEnvReg + \beta_4 ExistGovAids + \beta_5 ExistAntDem + \beta_6 FirmRep + \beta_7 ImpEnvPract + \beta_8 CostSavings + \beta_9 PrevContracts)V_{c2}Controls + V_{d2}Dummies$$

$$3 - EcOrg = H(\beta_o + \beta_1 ExistEnvReg + \beta_2 ExistEnvTaxFees + \beta_3 AntEnvReg + \beta_4 ExistGovAids + \beta_5 ExistAntDem + \beta_6 FirmRep + \beta_7 ImpEnvPract + \beta_8 CostSavings + \beta_9 PrevContracts) + V_{c3}Controls + V_{d3}Dummies$$

$$4 - EcoMkt = K(\beta_o + \beta_1 ExistEnvReg + \beta_2 ExistEnvTaxFees + \beta_3 AntEnvReg + \beta_4 ExistGovAids + \beta_5 ExistAntDem + \beta_6 FirmRep + \beta_7 ImpEnvPract + \beta_8 CostSavings + \beta_9 PrevContracts) + V_{c4}Controls + V_{d4}Dummies$$

The key independent variables do not change in each model, but among controls and dummies variables change, for the controls because of collinearity, and for dummies particularly in sectors and regions.

Table A.2.3: Coefficients resulting from the estimation of a multivariate probit model for the four dependent variables in one equation (CIS 2014).(high and average importance = 1, weak and no importance = 0)

	(1)	(2)	(3)	(4)
	EcoProduct	EcoProcess	EcOrg	EcoMarketing
ExistEnvReg	0.0263 (0.44)	0.126* (2.21)	-0.0661 (-1.10)	-0.142 (-1.76)
ExistEnvTaxFees	-0.0951 (-1.74)	0.0670 (1.27)	0.186*** (3.43)	0.162* (2.27)
AntEnvReg	-0.0167 (-0.29)	0.00612 (0.11)	0.101 (1.76)	0.0311 (0.41)
ExistGovAids	-0.0565 (-1.10)	0.0489 (0.98)	-0.0600 (-1.17)	0.123 (1.89)
ExistAntDem	0.539*** (11.09)	0.0328 (0.70)	-0.0899 (-1.84)	0.0626 (0.98)
FirmRep	0.122* (2.06)	0.0320 (0.57)	0.267*** (4.46)	0.347*** (4.01)
ImpEnvPract	0.0115 (0.20)	0.144** (2.67)	0.161** (2.84)	0.135 (1.73)
CostSavings	-0.121* (-2.42)	0.266*** (5.32)	0.237*** (4.74)	-0.00636 (-0.13)

	(-2.45)	(5.60)	(4.77)	(-0.10)
PrevContracts	0.00216	-0.0334	0.107*	0.0414
	(0.04)	(-0.66)	(2.10)	(0.64)
EMS	0.137**	0.329***	-	0.125
	(2.79)	(7.02)		(1.95)
PatentApp	0.494***	-0.0422	-0.198**	-0.0787
	(8.53)	(-0.73)	(-3.19)	(-0.99)
IntR&D	0.338***	0.165**	-0.107	0.0728
	(5.81)	(3.04)	(-1.95)	(1.01)
ExtR&D	0.156**	0.116*	0.103*	0.147*
	(3.23)	(2.44)	(2.09)	(2.31)
CoopUniv	0.0906	0.154*	0.203**	0.137
	(1.33)	(2.28)	(2.86)	(1.54)
CoopReasOrg	-0.0398	0.0341	-0.207**	0.0218
	(-0.56)	(0.48)	(-2.73)	(0.23)
CoopComp	0.0582	0.0489	0.249***	0.0790
	(0.79)	(0.67)	(3.38)	(0.86)
FunLocRegion	-0.0484	0.0942	0.137*	0.0345
	(-0.69)	(1.39)	(2.00)	(0.38)
FunNatOrg	0.0671	0.00253	-0.00164	-0.174*
	(1.06)	(0.04)	(-0.03)	(-1.99)
FunEU	0.0747	0.250**	0.0801	0.111
	(0.88)	(2.91)	(0.93)	(1.02)

ResTxCred	0.181*** (3.34)	0.0747 (1.40)	-0.284*** (-5.11)	-0.150* (-2.07)
InnOrg	-0.0372 (-0.70)	0.362*** (6.93)	-	0.222** (2.91)
InnoMkt	0.229*** (4.76)	-0.0479 (-1.04)	0.421*** (9.10)	-
EnvSpe	0.171* (2.51)	0.145* (2.19)	-0.104 (-1.54)	-0.129 (-1.43)
EnviStaff	-0.109 (-1.44)	-0.000271 (-0.00)	0.0388 (0.50)	-0.211* (-1.99)
Age	YES	YES	YES	YES
Size dummies	YES	YES	YES	YES
Sector dummies	YES	YES	YES	YES
Regional dummies	YES	YES	YES	YES
_cons	-1.305*** (-16.35)	-1.216*** (-15.84)	-1.069*** (-14.44)	-2.024*** (-17.53)
atrho21				
_cons		0.0332 (1.27)		
atrho31				
_cons		-0.132*** (-4.42)		
atrho41				

_cons	0.165*** (4.47)
atrho32	
_cons	0.0909** (3.15)
atrho42	
_cons	0.134*** (3.75)
atrho43	
_cons	0.181*** (4.56)
<i>N</i>	3986

t statistics in parentheses.

*, **, *** respectively denote significance at the $p < 0.05$, $p < 0.01$, $p < 0.001$ level.

Only eco-innovative firms are considered.

Table A.2.3 includes the coefficients with their significance levels resulting from the estimation of a multivariate probit model with the four dependent variables and their independent variables. Results seem to be consistent. In the following table (A.2.4), coefficients with their significance levels resulting from the estimation of a multivariate probit model for the four dependent variables are presented. The only change is related to the transformation of categorical variables, in this case high importance take value 1 and other categories take value 0.

Table A.2.4: Coefficients resulting from the estimation of a multivariate probit model for the four dependent variables in one equation (CIS 2014). (high importance = 1, other categories = 0)

	(1)	(2)	(3)	(4)
	EcoProduct	EcoProcess	EcOrg	EcoMarketing
ExistEnvReg	0.0252 (0.49)	0.150** (3.03)	0.0713 (1.40)	-0.0461 (-0.68)
ExistEnvTaxFees	-0.192** (-2.81)	0.0187 (0.28)	0.0893 (1.36)	0.207* (2.51)
AntEnvReg	0.0903 (1.45)	0.00580 (0.10)	0.0688 (1.12)	0.130 (1.66)
ExistGovAids	0.0732 (0.99)	0.0617 (0.85)	0.0201 (0.28)	-0.00674 (-0.07)
ExistAntDem	0.462*** (8.67)	0.0293 (0.56)	-0.0821 (-1.52)	0.0786 (1.17)
FirmRep	0.210*** (4.16)	0.108* (2.21)	0.178*** (3.57)	0.366*** (5.62)
ImpEnvPract	-0.102 (-1.94)	0.0729 (1.45)	0.0936 (1.83)	0.00963 (0.15)
CostSavings	-0.0648 (-1.35)	0.299*** (6.51)	0.222*** (4.74)	-0.0846 (-1.35)
PrevContracts	0.161* (2.31)	0.0752 (1.09)	0.191** (2.80)	-0.0249 (-0.29)

EMS	0.152** (3.12)	0.330*** (7.04)	-	0.132* (2.05)
PatentApp	0.507*** (8.79)	-0.0393 (-0.68)	-0.204*** (-3.31)	-0.0937 (-1.17)
IntR&D	0.359*** (6.21)	0.162** (3.00)	-0.117* (-2.15)	0.0574 (0.80)
ExtR&D	0.150** (3.10)	0.117* (2.47)	0.106* (2.15)	0.145* (2.28)
CoopUniv	0.0964 (1.42)	0.156* (2.30)	0.203** (2.88)	0.127 (1.43)
CoopReasOrg	-0.0204 (-0.29)	0.0372 (0.52)	-0.207** (-2.75)	0.0397 (0.42)
CoopComp	0.0324 (0.44)	0.0398 (0.54)	0.264*** (3.60)	0.0904 (0.99)
FunLocRegion	-0.0755 (-1.09)	0.121 (1.78)	0.164* (2.40)	0.0581 (0.64)
FunNatOrg	0.0625 (0.99)	-0.0106 (-0.17)	-0.0263 (-0.41)	-0.167 (-1.91)
FunEU	0.0531 (0.62)	0.233** (2.71)	0.0590 (0.69)	0.121 (1.10)
ResTxCred	0.175** (3.24)	0.0638 (1.20)	-0.303*** (-5.49)	-0.157* (-2.17)
InnOrg	-0.0420	0.355***	-	0.200**

	(-0.79)	(6.82)		(2.62)
InnoMkt	0.234***	-0.0495	0.425***	-
	(4.89)	(-1.08)	(9.22)	
EnvSpe	0.177**	0.173**	-0.0753	-0.119
	(2.62)	(2.64)	(-1.13)	(-1.32)
EnviStaff	-0.128	0.00198	0.0380	-0.198
	(-1.70)	(0.03)	(0.49)	(-1.86)
Age	YES	YES	YES	YES
Size dummies	YES	YES	YES	YES
Sector dummies	YES	YES	YES	YES
Regional dummies	YES	YES	YES	YES
_cons	-1.239***	-1.037***	-0.784***	-1.779***
	(-17.93)	(-15.65)	(-13.27)	(-18.94)
atrho21				
_cons		0.0274		
		(1.05)		
atrho31				
_cons		-0.137***		
		(-4.60)		
atrho41				
_cons		0.153***		
		(4.13)		
atrho32				

_cons	0.0938** (3.27)
atrho42	
_cons	0.139*** (3.89)
atrho43	
_cons	0.202*** (5.06)
<i>N</i>	3986

t statistics in parentheses.

*, **, *** respectively denote significance at the $p < 0.05$, $p < 0.01$, $p < 0.001$ level.

Only eco-innovative firms are considered.

A.3 Summary statistics and correlations for variables used in chapter 3

Table A.3.1: Summary statistics

	Description	N	Mean	St.Dev
Dependent variables				
LnTurnGrowth	Difference between both natural logs of turnover values between 2014 and 2016 (Min = -12.36, Max = 7.03)	3840	-.05	.75
LnEmpGrowth	Difference between both natural logs of the number of employees between 2014 and 2016 (Min = -7.97, Max = 7.41)	3837	.69	1.4
Independent variables and controls				
EcoInnovation	If any of the four eco-innovation types introduced between 2012 and 2014 (1 = Yes, 0 = No)	3840	.78	.42
IntR&D	Internal research and development (1 = Yes , 0 = No)	3840	.71	.45

ExtR&D	External research and development (1 = Yes , 0 = No)	3840	.44	.5
PatentApp	Patent application between 2012 and 2014 (1 = Yes, 0 = No)	3840	.26	.44
CoopUniv	Cooperation with universities (1 = Yes, 0 = No)	3840	.23	.42
CoopResOrg	Cooperation with R&D organisms (1 = Yes, 0 = No)	3840	.17	.38
CoopComp	Cooperation with competitors (1 = Yes, 0 = No)	3840	.11	.31
Gp	Firm belonging to a group of firms (1 = Yes, 0 = No)	3840	.66	.47
NewMktShare	New market shares exploited during the last three years (between 2012 and 2014) (1 = Yes, 0 = No)	3840	.46	.5
ExistEnvReg	Existing environmental regulation (1 = High and average importance, 0 = weak and no importance)	3840	.71	.45
ExistGovAids	Existing government aids, subsidies and other - nancial incentives (1 = High and average importance, 0 = weak and no importance)	3840	.3	.46
CostSavings	High costs of energy, water and materials (1 = High and average importance, 0 = weak and or importance)	3840	.65	.48

EnvSpe	At least one employee is specialist in environment (1 = Yes, 0 = No)	3819	.26	.44
EnviStaff	Environmental staff (1 = Yes, 0 = No)	3819	.16	.36
LnAge	Natural log of the age of the firm (2014 - year of foundation) (Min = .69, Max = 4.75)	3840	3.26	.7
Size dummies				
2014:				
Size1	Number of employees ≤ 9	3840	.08	.27
Size2	$10 \leq$ Number of employees ≤ 249	3840	.68	.47
Size3	$250 \leq$ Number of employees ≤ 4999	3840	.23	.42
Size4	Number of employees ≥ 5000	3840	.01	.07
2016:				
Size1	Number of employees ≤ 9	3840	.03	.18
Size2	$10 \leq$ Number of employees ≤ 249	3840	.56	.5
Size3	$250 \leq$ Number of employees ≤ 4999	3840	.39	.49
Size4	Number of employees ≥ 5000	3840	.02	.12
Sector dummies				
Sec1	Includes: Agriculture, forests exploitation and fishing	3840	.1	.3
Sec2	Includes: Extractions, food, tobacco, textile, clothes, shoes, wood	3840	.22	.41

Sec3	Includes: Paper, nuclear, chemical, plastics, mineral products, metallurgy, metalwork, equipments, machines and multimedia machines industries	3840	.19	.39
Sec4	Includes: Electronics, Tv and radio, medical instruments, other transport materials, furniture manufacturing, recovery, cars industry, electricity	3840	.27	.44
Sec5	Includes: Water distribution, construction, car trade and fixing	3840	.08	.27
Sec6	Includes: Wholesale trade, retail trade, hotels and restaurants, land transportation	3840	.13	.33
Sec7	Includes: Maritime transport, air transport, auxiliary transport services, telecommunication, finance, insurance, insurance and finance auxiliaries, real estate, renting and hiring, IT activities, research and development, services to firms, public administration, education	3840	.02	.15
Regional dummies:				
NUTS2				
1970-2015				

Reg1	Guadeloupe	3840	0	.03
Reg2	Martinique	3840	0	.04
Reg3	Guyane	3840	0	.05
Reg4	La Réunion	3840	0	.07
Reg5	Île-de-France	3840	.28	.45
Reg6	Champagne-Ardenne	3840	.02	.13
Reg7	Picardie	3840	.03	.16
Reg8	Haute-Normandie	3840	.02	.14
Reg9	Centre	3840	.03	.18
Reg10	Basse-Normandie	3840	.02	.13
Reg11	Bourgogne	3840	.02	.15
Reg12	Nord-Pas-de-Calais	3840	.05	.22
Reg13	Lorraine	3840	.03	.16
Reg14	Alsace	3840	.03	.18
Reg15	Franche-Comté	3840	.02	.13
Reg16	Pays de la Loire	3840	.06	.24
Reg17	Bretagne	3840	.05	.22
Reg18	Poitou-Charentes	3840	.02	.15
Reg19	Aquitaine	3840	.04	.2
Reg20	Midi-Pyrénées	3840	.04	.21
Reg21	Limousin	3840	.01	.08
Reg22	Rhône-Alpes	3840	.13	.33
Reg23	Auvergne	3840	.02	.14

Reg24	Languedoc-Roussillon	3840	.02	.14
Reg25	Provence-Alpes-Côte-D'Azur	3840	.05	.22
Reg26	Corse	3840	.16	0.04

Table A.3.2: OLS regressions' coefficients.

	(1)	(2)
	Turnover (<i>LnTurnGrowth</i>)	Employment (<i>LnEmpGrowth</i>)
EcoInnovation	-0.0413 (-1.37)	0.0206 (0.69)
IntR&D	-0.0523 (-1.65)	0.0322 (1.02)
ExtR&D	-0.0170 (-0.62)	-0.00596 (-0.22)
PatentApp	0.00252 (0.07)	0.0924** (2.73)
CoopUniv	-0.00245 (-0.06)	0.0104 (0.27)
CoopResOrg	-0.0578 (-1.42)	0.0924* (2.27)
CoopComp	-0.0187 (-0.44)	-0.0572 (-1.37)
Gp	-0.0597* (-2.08)	0.122*** (4.33)

NewMktShare	0.0497 (1.78)	-0.0129 (-0.46)
ExistEnvReg	-0.00679 (-0.24)	0.0188 (0.67)
ExistGovAids	-0.00188 (-0.07)	0.0208 (0.76)
CostSavings	-0.0221 (-0.82)	-0.0240 (-0.89)
EnvSpe	-0.0483 (-1.15)	-
EnviStaff	-0.0143 (-0.34)	-
LnAge	YES	YES
Size dummies (2014)	YES	YES
Size dummies (2016)	YES	YES
Region dummies	YES	YES
Sector dummies	YES	YES
<i>N</i>	3819	3837
<i>R</i> ²	0.052	0.728

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

- means that the variable is not included in the model.

Table A.3.3: Matrix of correlations among key independent variables

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) LnTurnGrowth	1.000												
(2) LnEmpGrowth	0.1051	1.000											
(3) EcoInnovation	-0.234	0.0535	1.000										
(4) IntR&D	-0.0098	0.0755	0.1396	1.000									
(5) ExtR&D	-0.0176	0.0977	0.1455	0.3243	1.000								
(6) PatentApp	0.0075	0.1392	0.1444	0.3514	0.3194	1.000							
(7) CoopUniv	-0.0134	0.131060	0.1418	0.3025	0.3887	.4272	1.000						
(8) CoopResOrg	-0.0277	0.1232	0.1064	0.2482	0.3365	0.3370	0.5894	1.000					
(9) CoopComp	-0.0151	0.0701	0.0820	0.1734	0.2002	0.2177	0.3777	0.3444	1.000				
(10) Gp	-0.0189	0.1979	0.1360	0.1692	0.2066	0.2072	0.2028	0.1476	0.0852	1.000			
(11) ExistEnvReg	-0.0103	0.0686	0.1130	0.0591	0.1131	0.0903	0.1025	0.1024	0.0574	0.1133	1.000		
(12) ExistGovAids	-0.0044	0.0319	0.0506	0.0621	0.0544	0.0520	0.1056	0.1266	0.0609	0.0278	0.2425	1.000	
(13) CostSavings	-0.0211	0.0167	0.1096	0.0360	0.0562	0.0175	0.0808	0.0740	0.0432	0.0724	0.2370	0.2383	1.000