Technological Forecasting & Social Change 170 (2021) 120902

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

journal homepage: www.elsevier.com/locate/techfore

Drivers of eco-innovation in developing countries: the case of Chilean firms

Sara Fernández [a,*], Celia Torrecillas [b], Romilio Ernesto Labra [c]

[a] Department of Applied and Structural Economics and History, Universidad Complutense de Madrid, 289223, Pozuelo de Alarcón (Madrid), Spain
[b] Department of Applied and Structural Economics and History, Universidad Complutense de Madrid & Instituto Complutense de Estudios Internacionales (ICEI), 289223, Pozuelo de Alarcón (Madrid), Spain
[c] Chilean Agri-aquaculture Nutritional Genomics Center (CGNA) & University of Talca

ARTICLE INFO

Keywords:
eco-innovation
open innovation
drivers
developing countries
Chile

ABSTRACT

Despite the growing literature on the drivers of eco-innovation, few studies analyze it in developing countries. Therefore, to fill this gap, this paper aims to analyze the influence of different groups of drivers of eco-innovation (technology push, market pull and regulatory push-pull) on two types of eco-innovations: *Resources Efficiency and Sustainable Sensitiveness*, differentiating between varieties of innovation -product and process- and between the novelty degree- incremental and radical-. The empirical analysis is built using multivariate probit models and considering a sample of Chilean firms in the period 2009-2016. Results show a displacement of open innovation drivers when a developing country is analyzed; Collaboration with Partners, Alliances and Networks, along with the Non R&D Embedded are predominant technological push strategies in this analysis. Furthermore, Market factors would have a driving effect on eco-innovations, while the Public Support is weakly significant.

1. Introduction

In recent years, concern about the environmental impact of human activities has linked academia with economic and political interests. Globalization has generated trade expansion, growth and productivity gains, but it has also had a clear negative impact on the environment, jeopardizing sustainability. Therefore, environmental responsibility is becoming a priority for more economic actors. Consumers and entrepreneurs can be an example of this. On the one hand, an increasing number of consumers are willing to pay higher prices for products or services that have been generated in an environmentally friendly way. On the other hand, in the business field, since environmental awareness is driven by the possibility of gaining competitive advantages (Díaz-García et al., 2015), sustainability is key to improving financial results at the firm level (McDonagh and Prothero, 2014). All this, together with the need to achieve greater efficiency through innovation, makes firms decide on developing new products or processes that are environmentally friendly.

This concept of innovations generated in an eco-friendly way is what is known as "eco-innovation".

“The production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organisation (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives” (Kemp and Pearson, 2007: p.8).

A large part of the empirical literature on eco-innovation has focused on those factors that explain why firms carry out eco-innovations (del Río et al., 2017; Ghisetti et al., 2015; Horbach et al., 2012; Kesidou and Demirel, 2012; Triguero et al., 2013). In this sense, some studies have highlighted that innovations that reduce the negative impact on the environment can be motivated by other drivers than those that lead firms to carry out other types of innovations (Cainelli et al., 2015; Cuerva et al., 2014; Horbach, 2008). For instance, Cuerva et al. (2014) find that technology push factors (R&D, human capital, financial constraints and quality management systems), market pull (corporate social responsibility, product origin labels, changes in market demand and product differentiation) and regulatory push-pull (existence of public support) influence eco-innovations differently than non-environmental innovations.

However, despite the growing literature on the drivers of eco-innovation, as far as we know, few studies analyze those drivers in developing countries (Aloise and Macke, 2017; Bossle et al., 2016; Cai and Zhou, 2014; Chen et al., 2017; Sanni, 2018). It should be noted that globalization has meant that firms are competing with goods from other countries. In the case of firms in developing countries they will have to

* Corresponding author.
E-mail addresses: Sarafe21@ucm.es (S. Fernández), celiatorrecillas@ucm.es (C. Torrecillas), ernesto.labra@cgna.cl (R.E. Labra).

https://doi.org/10.1016/j.techfore.2021.120902
Received 17 November 2020; Received in revised form 20 May 2021; Accepted 22 May 2021
Available online 17 June 2021

compete not only with equals but also with firms from developed countries. Therefore, these firms need to develop innovations in order to gain competitive advantages and to be able to face the high competition. The binomial eco-innovation and competitiveness is of vital importance for most of these developing countries, which tend to have a reduced technological capacity that will affect not only innovations in general but also the development of eco-innovations. In this sense, the results obtained for a specific country cannot be extrapolated to the rest, since it is necessary to take into account the specific characteristics of each country such as the level of environmental awareness of its population (both consumers and entrepreneurs) or the development and features of its national innovation system (del Río et al., 2016). Therefore, since the drivers of eco-innovation may differ by country, there is a need for further empirical studies in each particular developing country.

This study fills this gap by studying determinants[1] of eco-innovation by firms in a developing country, Chile. Applying multivariate probit models, our main purpose is to identify the drivers of two different types of eco-innovations (*Resources Efficiency and Sustainable Sensitiveness*) distinguishing between product and process, and incremental and radical eco-innovators. We use the Chilean Innovation Survey in the period 2009-2016 for regions, and the Tenth Chilean Innovation Survey as a robustness check and for the sector analysis (period 2015-2016). This is a biannual survey that follows the general methodologies of the Community Innovation Survey -CIS- and Oslo Manual (OECD, 2005). Specifically, we are working with 4,396 observations in the main sample (dataset of regions), while in the robustness check (last wave of Chilean Innovation Survey), we work with a sample of 1,508 observations. With this analysis, we expect to increase our understanding about the drivers enhancing the adoption of eco-innovations in a country traditionally considered as developing.

The selection of this country is justified by two main arguments: *Laggard Technological Country* and *Green Country*. On the one hand, Chile is a laggard technological country with a large traditional economy based on commodities from natural resources (Bravo-Ortega et al., 2014; OECD, 2018). Chile has followed an innovation strategy based on human capital, R&D, facilities, and national and international knowledge networks, including cooperation and knowledge transferences (OCDE, 2018). However, the expenditure in R&D in this country is low (0.4 as percentage of GDP[2]), while the absorption of capabilities has continued to support the economic growth through the adoption of technologies from partners and markets (Bravo-Ortega et al., 2014; OECD, 2018). In this sense, literature indicates that this country has been adopted exogenous technologies due to the international trade and the spillover effect of Multinational Enterprises (Cimoli et al., 2006; Iizuka et al., 2016; Katz, 2001; Moreno-Brieva and Marín, 2019).

Regarding the region of Latin America and the Caribbean, Chile is the innovation leader. This country has recently been included in the list of High-Income Countries proposed by the World Bank and it is in the first position in innovation term according to the Global Innovation Index (Cornell University et al., 2020). Some countries of the region such as Peru, Ecuador and Colombia (0.1, 0.4 and 0.2 expenditure in R&D as a percentage of GDP, respectively) have followed similar paths of growth introducing innovations obtained from networks, partners, or alliances, and showing low values in R&D expenditure (Bravo-Ortega et al., 2014; Chavez and Meller, 2020; Meller and Yuri, 2020; OECD, 2018). However, other countries have showed traditionally higher level of R&D investment such as Brazil or Argentina (1.3 and 0.5 expenditure in R&D as a percentage of GDP, respectively). Nevertheless, those last countries cannot take off with this strategy (IDB, 2016).

On the other hand, we could classify Chile as a “Green country” considering several arguments. Firstly, the ecological sustainability indicator ranked Chile in the position 52 over 131 countries and, analyzing the sub-index of the environmental performance indicator, Chile is in the best position comparing to the rest of Latin American and the Caribbean countries: Argentina, Brazil, Colombia, Costa Rica and Ecuador (Cornell University et al., 2020). Secondly, the weight of green industrial sector over GDP is high, being agri-food the most important in term of employment and export (Álvarez et al., 2010). Finally, Chile is an outstanding case of high economic performance in the last three decades. This economic performance has been based on raw materials, mainly mining and silvo-agriculture (Katz, 2020; Solinamo, 2017). Therefore, in Chile we can check the binomial of laggard innovation country and eco-friendly and environmental concern country.

The main contributions of this work are threefold. First, using a representative sample of Chilean firms, this paper analyses a still unexplored developing country regarding eco-innovation fields. Secondly, we attempt to examine the effect of different drivers on two variety of eco-innovations closely related and not mutually exclusive (*Resources Efficiency* and *Sustainable Sensitiveness*) distinguishing between product and process, and incremental and radical eco-innovators. Finally, we study whether the factors traditionally considered as determinants of eco-innovations in developed countries behave similarly in developing countries, contributing to the development of a framework of eco-innovation drivers in countries no leader technologically.

The paper is organized as follows. The next section presents the theoretical framework as well as the development of hypotheses. The third section describes the data and some descriptive statistics and introduces the econometric methodology. The fourth section explains the main results. The final section draws the main conclusions from the analysis.

2. Drivers of Eco-Innovation: Developed vs Developing countries

The analysis of the drivers of environmental innovations has mostly focused on developed countries such as Germany (Horbach, 2008; Horbach et al., 2012; Ketata et al., 2014), France (Li Ying et al., 2018; Mothe et al., 2018) or Spain (del Río et al., 2017; Jové-Llopis and Segarra-Blasco, 2018; Marzucchi and Montresor, 2017). Since the results of country-specific studies cannot be generalized, there is a need for more research that analyses the drivers of environmentally friendly innovations in middle-income or developing countries (del Río et al., 2016). However, as far as we know, few empirical studies examine the determinants of eco-innovations in emerging or developing countries (Aloise and Macke, 2017; Bossle et al., 2016; Cai and Zhou, 2014; Chen et al., 2017; Sanni, 2018). In this regard, Cai and Zhou (2014) and Bossle et al., (2016) distinguish between internal and external factors as determinants of eco-innovations. For instance, using survey data of 1, 266 Chinese manufacturing firms, Cai and Zhou (2014) finds that demand factors and the regulatory framework have a positive effect on the development of eco-innovations, highlighting the role of internal drivers as a link between external drivers and integrative capability. In the same way and also for China, Chen et al. (2017) show the positive influence of technology, market demand and environmental regulation on the development of eco-innovations. On the other hand, by considering 521 manufacturing firms in Nigeria, Sanni (2018) shows that formal sources of knowledge, ground breaking arranging strategies and meeting regulations are important drivers of environmental innovation. Likewise, Aloise and Macke (2017), focusing on the case of Manaus Free Trade Zone in Brazil, find environmental legislation as well as use of environmentally friendly suppliers foster eco-innovations. Previous studies show the importance, but still limited, of eco-innovation drivers in developing countries.

The pioneer study of Horbach (2008) identified three main groups of drivers of eco-innovation: *technology push, market pull and regulatory push*

[1] This paper assumes that drivers, factors and determinants are conceptually similar, i.e. they are considered as synonyms.

[2] The top countries according to the Global Innovation Index 2020 (Switzerland, Sweden and United States of America) has approx. 3.3 of expenditure in R&D as a percentage of the GDP). Chile is the last country in R&D Investment of the OECD.

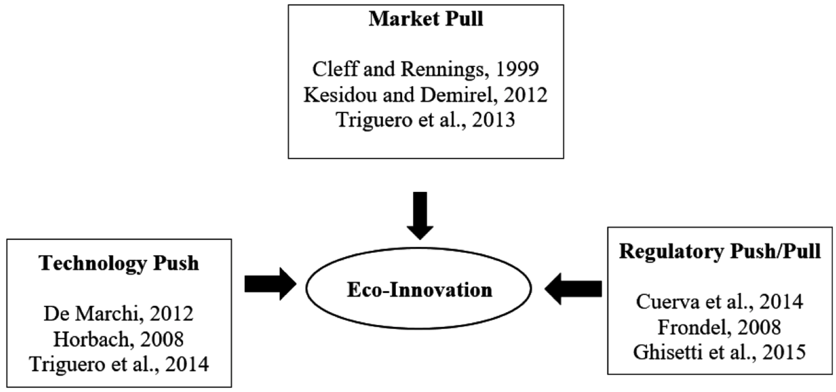

Figure 1. Drivers of eco-innovation in developed countries

and pull. In this regard, firm's resources and capabilities facilitate the development of knowledge base to implement eco-innovations (Segarra-Oña et al., 2013; Triguero et al., 2014). Nevertheless, not only the firm's resources and capabilities must be taken into account, technological cooperation agreements (De Marchi, 2012) with different partners (Sáez-Martínez et al., 2014) must also be considered within *technology push* effect.

Secondly, the growing demand for environmentally friendly products and services has been highlighted as a *market pull factor* (Kesidou and Demirel, 2012; Triguero et al., 2013). In this sense, although consumers seem willing to pay higher prices for environmentally friendly products (McDonagh and Prothero, 2014), it should be noted that some consumers may not be able to pay for such goods (del Río et al., 2017; Rennings, 2000).

Finally, *regulatory framework* has also been considered as an eco-innovation driver. Its importance has been recently increased due to the pressure from international institutions to achieve economic growth that does not endanger the environment. All of the above has affected the development of certain policies in countries around the world. One example of such international pressure is the well-known United Nations Sustainable Development Goals (UNSDGs). Achieving these goals requires countries to develop a new regulatory framework that includes more and better environmental policies. In this sense, the literature establishes that regulatory framework can be an important driver of eco-innovation, since the potential benefits of using more efficient processes with less environmental impact are greater than the costs of fines for non-compliance with environmental regulations. In this respect, firms meet the established regulatory framework, improving their competitive advantages. This double "win-win" situation favored by the environmental regulation is known as Porter Hypothesis (Porter and Van der Linde, 1995). This hypothesis has been confirmed by several studies, highlighting, among others, those of Ashford and Hall (2011), Cuerva et al. (2014) and Frondel et al. (2008).

As per the previous literature background, this study analyses the drivers of different types of eco-innovation considering their object and degree of novelty in a developing country such as Chile. Therefore, our main aim is to demonstrate whether the three groups of factors *technology push, market pull and regulatory push and pull* that are traditionally considered to be determinants of eco-innovation in developed countries could also be found in a developing country in the region of Latin America and the Caribbean. The connection with the three group of factors and the main references supporting it can be found in Figure 1.

Following this way of reasoning, in the following lines, we describe *technology push, market pull, and regulatory push and pull* factors comparing developed and developing countries. These arguments will allow us the development of our hypotheses.

2.1. Technology Push Factors

Technology push factors consider the influence of the internal knowledge base as crucial for the development of eco-innovations. Therefore, eco-innovations will depend highly on the internal technological resources and capabilities of the firms. To develop these technological capabilities, literature has noted the importance of investment in R&D (Cainelli et al., 2015; Horbach, 2008; Horbach et al., 2012). In this sense, firms that are able to enhance their capabilities through investments in R&D are more likely to make environmentally friendly innovations (Horbach, 2008; Jové-Llopis and Segarra-Blasco, 2018).

There are a large number of studies showing the positive influence of investments in R&D on eco-innovations, mainly in developed countries (Cainelli et al., 2015; Horbach et al., 2012; Horbach et al., 2016). The results are in the same vein when the studies distinguish by type of eco-innovation (del Río et al., 2017; Horbach, 2016; Jové-Llopis and Segarra-Blasco, 2018; Marzzuchi and Montresor, 2017; Triguero et al., 2018).

However, there is no evidence of the relationship between R&D intensity and eco-innovation for developing countries. For the particular case of Chile, some empirical works have studied the influence of R&D on general[3] innovations. However, the results show that higher investments in R&D do not produce a greater propensity to innovate (Álvarez et al., 2010; Benavente, 2006). This might be due to the fact that developing countries often have an excessively fragmented Innovation System. In fact, Chile is the third country with the lowest spending on R&D as a percentage of GDP in the OECD (OECD, 2020)[4]. Therefore, although R&D investments are relevant to improve internal innovation capabilities, Chilean firms cannot have enough internal resources for the development of eco-innovations, having to use other strategies such as external R&D, collaborations or R&D acquisitions to cover this deficit.

More specifically Benavente (2006), pointed out that innovation output in Chile will be based on other inputs such as the diffusion of technology through national or international collaborations (cooperation), the introduction of new inputs developed overseas (external R&D) and the purchasing of new machinery (embodied technology), instead of the traditional input of R&D expenditure.

Thus, taking into account the specific characteristics of the firms analyzed, we hypothesize that:

Hypothesis 1. *(H1): R&D intensity is not a driver of eco-innovations in*

[3] We call general innovations to product and process innovation. OECD (2005)

[4] The most recent data published by the OECD is from 2018 (provisional data) and ranks Colombia, Mexico and Chile as the three countries with the lowest spending on R&D as a percentage of GDP.

Chilean firms.

Similar to investment in R&D, human resources have been considered essential for the development of technological capabilities within the firm. In this sense, literature has pointed out firms that invest more in training are more likely to achieve eco-innovations (Cainelli et al., 2015; Green et al., 1994; Ketata et al., 2014). In fact, this relevance is also analyzed in studies for developing countries. De Jesús Pacheco et al. (2018), in a study about Brazilian SMEs where they conduct several interviews, found that human capital is one of the internal variables that influence the development of eco-innovations. Specifically, the authors show that an improvement in human resources would minimize the effects of existing barriers to eco-innovations.

However, human resources seem to have different importance depending on the type of innovation. Triguero et al. (2018) show a positive effect of training on process and incremental eco-innovations aimed at reducing environmental damage, as well as process eco-innovations related to energy efficiency for a sample of food and beverage firms in Spain. The results for developing countries are similar. Sanni (2018), in a study for Nigerian manufacturing firms, finds that staff training is an important factor in the development of process eco-innovations, while for product, it is not significant. Thus, following previous findings, we hypothesize that:

Hypothesis 2. *(H2): Training is more associated with process and incremental eco-innovations than with product and radical eco-innovations in Chilean firms.*

The acquisition of machinery or software has also been considered an important driver of innovation as it allows the improvement of technological capabilities without the need of direct investment in R&D. In addition, the application of new machinery or software complement external knowledge (Hervas-Oliver et al., 2011). Empirical studies have shown that the acquisition of these technologies is a more relevant factor for the development of eco-innovations than for general innovations (Cainelli et al., 2015; Horbach et al., 2012). Distinguishing by types of eco-innovations, different European analyses have shown how the acquisition of machinery or software should be considered a positive determinant of energy and material eco-innovations (Marzzuchi and Montresor, 2017; Triguero et al., 2018).

Regarding developing countries, Sanni (2018), in his study for Nigeria, finds that the acquisition of software and hardware is a key factor in eco-innovations. The author justifies this result by pointing out that firms in developing countries are not very intensive in internal R&D investments (R&D intensity) and solve this deficiency with other forms of R&D. In fact, Navarro et al. (2010) point out that in many Latin American and the Caribbean economies, innovations are based mainly on imitation and technology transfer such as the acquisition of machinery and equipment. Therefore, taking into account the previous studies, we believe that this lack of investment in internal R&D for eco-innovation could be compensated with other forms of R&D such as the acquisition of machinery or software.

Finally, for the particular analysis of Chile, Benavente (2006) found that the acquisitions of new machinery are a crucial for the generation of innovation in this country.

As per the previous arguments, we hypothesize:

Hypothesis 3. *(H3): The acquisition of embodied technology increases all types of eco-innovation in Chilean firms.*

Nowadays, innovation is not only determined by investments in R&D or embedded technology, especially in sectors with low technological content. Other types of internal knowledge that are not embedded into the technology such as marketing or distribution expenditures should be analyzed for the innovation success. In this sense, only a few eco-innovation studies have taken into account expenditure in activities aimed to introduce improved products or services in the market and the related expenditure on procedures and technical preparations for implementation (Horbach et al., 2012; Marzzuchi and Montresor, 2017; Triguero et al., 2018).

Regarding the studies of developing countries, we have not found arguments examining the effects of non-R&D disembodied activities over innovations. However, these activities can be considered particularly relevant in these countries where investment in R&D is in many cases prohibitive due to high financial and human capital costs (Navarro et al., 2010). In fact, non-R&D disembodied activities could complement the low levels of R&D that these countries pointed out, in order to reach successful eco-innovations. Therefore, given non-R&D activities are also essential for successful innovations, especially in low-tech sectors, and taking into account the characteristics of Chilean economy and its firms, we hypothesize that:

Hypothesis 4. *(H4): Non-R&D disembodied activities increase all types of eco-innovation in Chilean firms.*

External R&D can improve a firm's absorption capacity as well as enhances its innovative performance by complementing the internal knowledge base. However, the empirical results are inconclusive. Some studies indicate that external R&D is more important in the development of eco-innovations than in general innovations (Cainelli et al., 2015; Jové-Llopis and Segarra-Blasco, 2018; Mothe et al., 2018). On the one hand, while Cainelli et al. (2015) show a greater influence of external R&D on process eco-innovations, Mothe et al. (2018) show it for product. On the other hand, other authors have not found relevance of external firm R&D in the development of eco-innovations (Li-Ying et al., 2018; Triguero et al., 2018). In the context of developing countries, it is known that firms are not intensive in R&D investments and thus, those companies need to fill that gap of internal capabilities with other types of actions, being external R&D an alternative. Indeed, de Jesús Pacheco et al. (2018) conducts a survey of Brazilian SMEs whose results show that external R&D is a fundamental factor for the development of eco-innovations. Based on these results and the profiles of the analyzed firms, we hypothesize that:

Hypothesis 5. *(H5): External R&D is more linked to product and radical eco-innovations than to process and incremental eco-innovations in Chilean firms.*

Collaboration with different knowledge sources (e.g. customers, suppliers, competitors, universities) also helps to complement the firm's internal knowledge base by increasing its possibilities of succeeding in innovation. Therefore, the use of external sources of knowledge has also been considered as a base factor for the development of eco-innovations in Europe (Ketata et al., 2014 for Germany; Li-Ying et al., 2018 and Mothe et al., 2018 for France; Ghisetti et al., 2015 and Triguero et al., 2013 for several European countries). For instance, Mothe et al. (2018) carries out a study using the French CIS in which they analyze the influence of information sources on product and process eco-innovation. The results show how the variety of information sources affect both product and process eco-innovations, although the effect seems greater for eco-products.

In developing countries, the studies are introducing similar results (Cai and Zhou, 2014; Sanni, 2018). Specifically, Cai and Zhou (2014) conducts a survey of Chinese firms whose results suggest a positive relationship between eco-innovation and the more efficient external networks, while Sanni (2018) finds formal sources of knowledge more important than informal sources to eco-innovate in Nigerian firms. For the specific case of Chile, Benavente (2006) highlights the importance of external knowledge "inputs developed overseas" in the generation of innovations.

Therefore, following the previous empirical evidence:

Hypothesis 6. *(H6): The influence of the external knowledge breadth is positive for all types of eco-innovation in Chilean firms.*

The firms' internal knowledge base can also be complemented through technological cooperation agreements. Many studies have

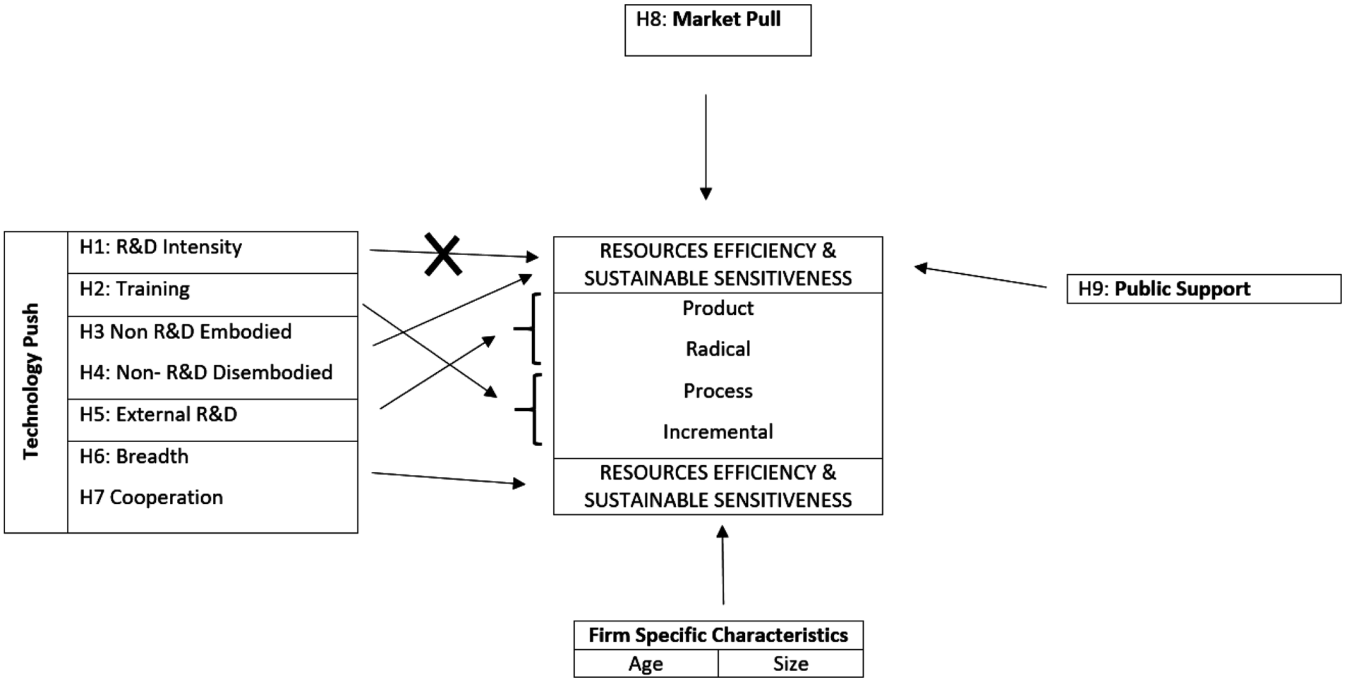

Figure 2. Research strategy for Chile

shown that cooperating in R&D can be a relevant instrument for the successful development of eco-innovations (De Marchi, 2012; Ghisetti et al., 2015; Horbach, 2008; Li Ying et al., 2018). When it is distinguished by type of eco-innovation, the results are not so clear. While del Río et al. (2017) and Mothe et al. (2018) find a positive influence of R&D cooperation for both product and process eco-innovations, Jové-Llopis and Segarra-Blasco (2018) does not find it to be a determinant of eco-innovation. Marzucchi and Montresor (2017) only obtain a positive and significant result for process eco-innovations (energy and material efficiency).

The use of cooperation agreements in developing countries may be even more important due to the increased number of enterprises with insufficient resources for the development of eco-innovations. In fact, the lack of R&D cooperation agreements in developing countries has been identified as an important barrier to the implementation of eco-innovations (Aloise and Macke, 2017; de Jesús Pacheco et al., 2018). Therefore, since eco-innovating requires the use of new and complex technologies, entering into cooperation agreements will facilitate access to the external knowledge necessary to develop eco-innovations in developing countries. Given these premises, we suppose:

Hypothesis 7. *(H7): Technological collaborative agreements (cooperation) increase all types of eco-innovation in Chilean firms.*

2.2. Market Pull Factors

The literature on eco-innovation also includes market-pull factors as determinants of eco-innovation (Horbach, 2008; Kesidou and Demirel, 2012; Triguero et al., 2013). Studies show that growing environmental awareness on the part of consumers increases the demand for environmental products. Some authors have found that market factors are especially relevant in the development of product eco-innovations (Cleff and Rennings, 1999; Mothe et al., 2018; Triguero et al., 2013).

Recently, several empirical studies have found no influence of market factors, such as entering new markets or increasing market share (del Río et al., 2017; Jové-Llopis and Segarra-Blasco, 2018). These results have been attributed to two factors. Firstly, a possible low level of environmental awareness in the country to which the firms belong (del Río et al., 2017; Jové-Llopis and Segarra-Blasco, 2018). Secondly, the high cost of products with environmental attributes, which makes some consumers unable or unwilling to pay (del Río et al., 2017; Jové Llopis and Segarra-Blasco, 2018; Rennings, 2000).

Focusing on developing countries, authors also consider that the implementation of eco-innovations and the increase on market share are closely related (de Jesús Pacheco et al., 2018). However, results are still not clear. On the one hand, similarly that in developed countries studies, Sanni (2018) finds as significant determinants satisfying consumer demand and dealing with competitors in implementing eco-innovations in manufacturing industries. Chen et al., (2017), which show a positive influence of market demand on eco-innovation in China, have also supported the previous argument. On the other hand, Aloise and Macke (2017), in a study about Brazilian firms in the Manaus Free Trade Zone where they conduct several interviews, find that market factors are not considered as determinants of eco-innovations. These authors note that this result may be due to the profile of the firms operating in the area. They point out that when firms belong to multinationals, local firms do not aim to analyze market expectations, environmental awareness and preferences for environmental products, they simply focus on producing what the matrix decides.

Regarding Chile, market-pull factors such as consumer' likes or other demand elements have been a key factor for the generation of innovation in Chile (Benavente, 2006) and taking into account the previous results, the following hypothesis is as follows:

Hypothesis 8. *(H8): Market factors enhance all types of eco-innovation in Chilean firms.*

2.3. Regulatory Push-Pull Factors

The last set of eco-innovation factors are the so-called regulatory push and pull factors. In terms of regulatory push-pull factors, most studies have focused on two key aspects: the pressure exerted by environmental regulations and the role of public support.

Overall, empirical studies have shown that regulation is an important driver of eco-innovations in Europe, confirming Porter's hypothesis (Horbach et al., 2012; Kesidou and Demirel, 2012; del Río et al., 2017). Despite this widespread positive influence of regulation on the implementation of eco-innovations, it should be borne in mind that in countries where the environmental regulatory framework is less developed, the results could be different. Not only the regulatory framework itself must be taken into account, but also the type of firms operating in these countries and how regulations may affect them (Aloise and Macke, 2017). However, although evidence in such countries is still scarce, results seem to be following the same direction as in more developed countries as part of globalization influence. Horbach (2016) finds that regulations have a greater effect on the introduction of eco-innovations in Eastern European countries. For instance, Cai and Zhou (2014) for China and Sanni (2018) for Nigeria find a positive effect of regulations on eco-innovation.

As part of the regulatory push and pull factors, the literature has also analyzed the importance of subsidies as a determinant of eco-innovation. However, empirical studies are not yet conclusive. While some studies show a positive influence of subsidies on the development of eco-innovations (Horbach, 2008; Marzzuchi and Montresor, 2018), in other public grants seem to be non-significant (Jové-Llopis and Segarra-Blasco, 2018; Mothe et al., 2018). In relation to the influence of subsidies in developing countries, the Horbach's study (2016) should be noted, which shows a greater importance of this variable in Eastern European countries due to the lower financial performance.

Therefore, taking into account the previous literature, as well as, the characteristics of the country and the firms studied, we propose that:

Hypothesis 9. *(H9): Public support*[5] *enhances all types of eco-innovation in Chilean firms.*

According to the previous arguments, Figure 2 provides a graphic representation of our research strategy for this study. We distinguish two different types of eco-innovation in order to check if there are differences between the factors that explain eco-innovations. *Resources-efficiency eco-innovations* include those changes in product or process that means a decrease in the use of inputs (materials and energy). In a similar way, *Sustainable-sensitiveness eco-innovations* include those changes in product or process that reduce environmental damage of the firm. In addition, the different eco-innovation drivers have been grouped according to the classification presented in Figure 1 of the theoretical framework. Finally, the characteristics of the company, such as age or size, will also be considered as control variables.

3. Empirical analysis

For testing our set of hypotheses proposed above we use four Chilean Innovation Surveys (from the Seventh to the Tenth Chilean Innovation Survey). This dataset follows the methodology of the Community Innovation Survey (CIS) and Oslo Manual (OECD, 2005) collecting variables regarding the innovation and the R&D expenditure of the Chilean firms. For our main objective of capturing the eco-innovation and its drivers, this is the best dataset for testing Chilean firms.

The Chilean Innovation Survey is published by Chilean regions and by sectors. They are a different collection of data. For the main analysis we use the dataset of regions for the last four innovation surveys and, for the robustness check of sectors, we use the data of the last innovation survey.

Our original sample (by region) was composed by 19,762 observations obtained by four Chilean Innovation Survey, over the period 2009-2016 (biannual data)[6]. Unfortunately, we had not access to the identification of the firms over the years. We have considered all the sector of the economy (agriculture, manufacturing and service). However, due to the missing data of the survey, we work with a sample size of approx. 4,396 observations. We have to highlight that we have had to join all the surveys during the different years. The different surveys have introduced changes in the methodology and questions that have been carefully incorporated. In fact, there are some difficulties for connecting different years of the innovation surveys as it has been previously pointed out by Álvarez et al., (2011) or Bravo-Ortega et al. (2014). However, there is not a continuity in the firms that participate in the different surveys and therefore, we could not identify the individuals for applying other more sophisticated techniques, such as Panel data.

The robustness check of analysis by sector has been done with the Tenth Innovation Survey. This sample is composed by 5,879 observations. However, due to the missing data of the sample, we work with approx. 1,508 observations. The survey classifies sectors by agriculture, manufacturing, and services[7]. The sectorial classification of the Chilean Survey can be found in Table 1.A in the appendix.

We use two innovation aspects for the definition of the "innovation" part of our eco-innovation **dependent variables:** the *type of innovation and the degree of novelty of the innovations*. In this sense, we use four innovation variables: product, process, incremental and radical innovation. These variables take a value of 1 if firms manifested any type of innovation (product, process, incremental or radical), and 0 otherwise. The identification of these variables in the survey is collected in Table 2.A in the appendix called list of variables.

For the definition of the "eco" part of our eco-innovation dependent variables, we use two dummies of the importance of environmental aspect of the innovation purpose (we consider just importance 4 -high- and 3 -medium-). In particular, we collect the material efficiency and energy use (*Resources Efficiency*) and the environmental damage reduction and health and safety improvement (*Sustainable Sensitiveness*).

Finally, we interact the "innovation" and the "eco" variables developing eight dependent variables: prod -*Resources Efficiency*, prod -*Sustainable Sensitiveness*, proc -*Resources Efficiency*, proc -*Sustainable Sensitiveness*, incre -*Resources Efficiency*, incre-*Sustainable Sensitiveness*, rad -*Resources Efficiency* and rad -*Sustainable Sensitiveness*. Where, prod, proc, incre and rad (*Resources Efficiency*), collect changes in product and process innovation that involve a decrease in consumption of inputs (material and energy consumption). On the other hand, prod, proc, incre and rad (*Sustainable Sensitiveness*), pointed out the changes in product and process innovation that involves a reduction of the environmental impact or health and security improvement.

As **independent variables** we introduce some eco-innovation drivers following the previous literature. These drivers are divided in three blocks: 1) Technological push: firms' resources and capabilities and external acquisitions or collaborations, 2) Market pull, and 3) Regulatory push/pull factors -Public Support-.

Regarding the Technological Push factors -firm's resources and capabilities-, we use the following five variables. The first one collects the *R&D intensity* as a % of R&D over sales (in thousands of Chilean pesos). The second variable collects the training for employees for the introduction of new or improved process and product over employees (*R&D Form*). Variable number three tries to capture the embedded non-R&D based knowledge, considering the acquisition of machinery, equipment and software for the production of innovation over employees (*Non R&D embed*). The fourth variable is a proxy of the expenditure for the introduction of the innovation in the market including the installation of new equipment, the market prospecting and advertising, the installation of new equipment for innovation and the design for innovation, over employees (*Non R&D Dissembodied*). We have developed an index of the three Non R&D Dissembodied variables as a result of the average of all of them. Finally, we introduce the % of external R&D over sales in thousands of Chilean pesos (*External R&D*).

The external acquisition/collaborations of technological push factor refers to those variables that allude to collaboration with partners,

[5] We are aware that the regulatory framework affecting eco-innovations includes different types of regulations and subsidies. However, this article has only been able to consider funding due to the limitations of the available data.

[6] Our survey includes the Seventh, Eighth, Ninth and Tenth Innovation Survey collected in 2011, 2013, 2015 and 2017.

[7] There are more firms classified in the service sector.

Table 1
Number of eco-innovative firms

Type of Eco-innovative firms	Number of firms	%
Eco-innovators	1129	25.68
Prod&Proc- *Resources Efficiency*	295	26.13
Prod&Proc- *Sustainable Sensitiveness*	834	73.87

* these percentages have been calculated with the clean dataset and the total observations are equal to 4396
Source: own elaboration based on the four Chilean Innovation Survey

alliances and networks. We introduce two variables in this section: *Breadth* and *Coop. Breadth* is building following Triguero et al. (2018). Chilean Innovation Survey consider 10 sources of knowledge: 1) internal sources, 2) suppliers, 3) customer, 4) competitors, 5) consultants, laboratories and private research centers, 6) universities, 7) public research organism, 8) conferences and expositions, 9) research journal, and 10) professional or industrial associations. Each of these sources is coded as binary variables (1 and 0 otherwise). Finally, the resulting, *Breadth,* will be in a range from 0 to 10. Our second variable is *Coop* which refers to cooperative innovation pointed out by the active participation of other companies or non-commercial institutes (universities, research institutes, others). This is a dummy variable that takes values 1 if there is cooperation, and 0 otherwise.

The factors related to the market demand are proxied by using two dummies variables M*arket penetration* and *Extend product range.* The first one*,* points out firm's importance of the introduction of the innovation in the market (1 if there are high or medium importance, and 0 otherwise). The second one refers to the expansion of the goods and services (this variable takes the value of 1 if there are high or medium importance, and 0 otherwise). We have developed and index following the methodology of the *Breadth* variable. Therefore, our resulting variable *Market index* will be in a range from 0 to 2.

The regulatory push and pull framework is captured by Public Support. This variable is composed by a dummy variable of all the solicitation and concession of funding by all the institutes that the survey collects: CORFO, CONICYT, FIA, ICM, FIP, PROCHILE, and others. The resulting variable *Public Support* takes 1, if there is solicitation and concession of funding, and 0 otherwise.

We introduce two control variables of Age and Size in the model. Age is the difference between our last year in our analysis (2016) and the constitution of the firms. We have introduced Age2 in order to deal with the non-linear trend of this variable. Size corresponds to the number of employees.

Finally, we include time dummies in the main analysis following Triguero et al. (2018), and sector dummies in the robustness check. The sector variables are divided in agriculture, manufacturing and services according to the sector classification of the Chilean Innovation Survey following Jové-Llopis and Segarra-Blasco (2020) and Moreno-Mondéjar et al. (2020).

The list with the definition of the variables (Table 2.A), the table of the basic descriptive statistics (Table 3.A), the table of the correlation (Table 4.A) and the table with the VIF test (Table 5.A) are included in the Appendix section. The tests satisfy the econometric requirements. We have not found correlation between our independent variables (all the values are lower than 0.60) and our analysis is not showing heteroscedasticity: the VIF test show values lower than 10.

Data shows as the different type of eco-innovation are included in the Chilean firms. The eco innovative firms are the 25.7% of the total sample being the 26.13% eco innovative firms in *Resources Efficiency* and the 73.9% eco innovative firms in *Sustainable Sensitiveness*. Therefore, we have more firms reporting product and process-*Sustainable Sensitiveness* (see Table 1).

As Table 2 shows, firms are more Process oriented and therefore, we have found more eco-innovator firms (*Resources Efficiency* and *Sustainable Sensitiveness*) in process innovation than in product innovation. In addition, regarding the degree of novelty, incremental eco-innovators are higher than radical eco-innovators for both type of eco-innovations (*Resources Efficiency* and *Sustainable Sensitiveness*). Therefore, for our analysis eco-innovators are more process and incremental oriented. This result is similar to those finding by Triguero et al. (2018).

Considering the evolution of the eco-innovative firms in the different years included in our dataset, we could mention that there is a positive evolution of eco-innovators in Chilean firms, finding the highest value in the Tenth Innovation Survey (2015-2016) (Figure 3). Dividing the analysis by type of eco-innovators, all the data decrease from the Eighth to the Ninth Innovation Survey (2011-2014), showing again an increase in the Tenth Survey. Regarding the type of innovation, for all the years, product and process eco-innovators collect more than 50% of the eco innovative activities. Focusing on the degree of novelty, radical eco-innovators show for all the years the lowest values.

Regarding the analysis by sector, the 24.31% of the firms included in the Tenth Chilean Innovation Survey are eco innovative firms. Comparing the different sectors, results show as services and manufacturing are the most eco innovative sectors in process, product, incremental and radical eco-innovation. On the contrary, agriculture shows the lower values of eco-innovators firms. In this analysis also the percentage of eco innovative firms in *Sustainable Sensitiveness* is higher than in *Resources Efficiency.* These results are like those found by Jové-Llopis and Segarra-Blasco, (2020). Table 3 collects the distribution of eco innovation according to the sectors: agriculture, manufacturing, and services.

Regarding methodology used, multivariate probit models have been implemented for testing our working hypothesis. This methodology has various advantages among others as biprobit or probit analyses. This

Table 2
Type of eco-innovators

Types of Eco-innovators		
Product Innovators	**Firms**	**% observations**
Prod- *Resources Efficiency*	123	2.80
Prod- *Sustainable Sensitiveness*	363	8.26
Process Innovators	**Firms**	**% observations**
Proc- *Resources Efficiency*	172	3.91
Proc- *Sustainable Sensitiveness*	471	10.71
Product and Process Innovators	**Firms**	**% observations**
Incre- *Resources Efficiency*	182	4.14
Incre- *Sustainable Sensitiveness*	508	11.56
Rad- *Resources Efficiency*	44	1.01
Rad- *Sustainable Sensitiveness*	188	4.28

* these percentages have been calculated with the clean dataset and the total observations are equal to 4396
Source: own elaboration based on the four Chilean Innovation Survey

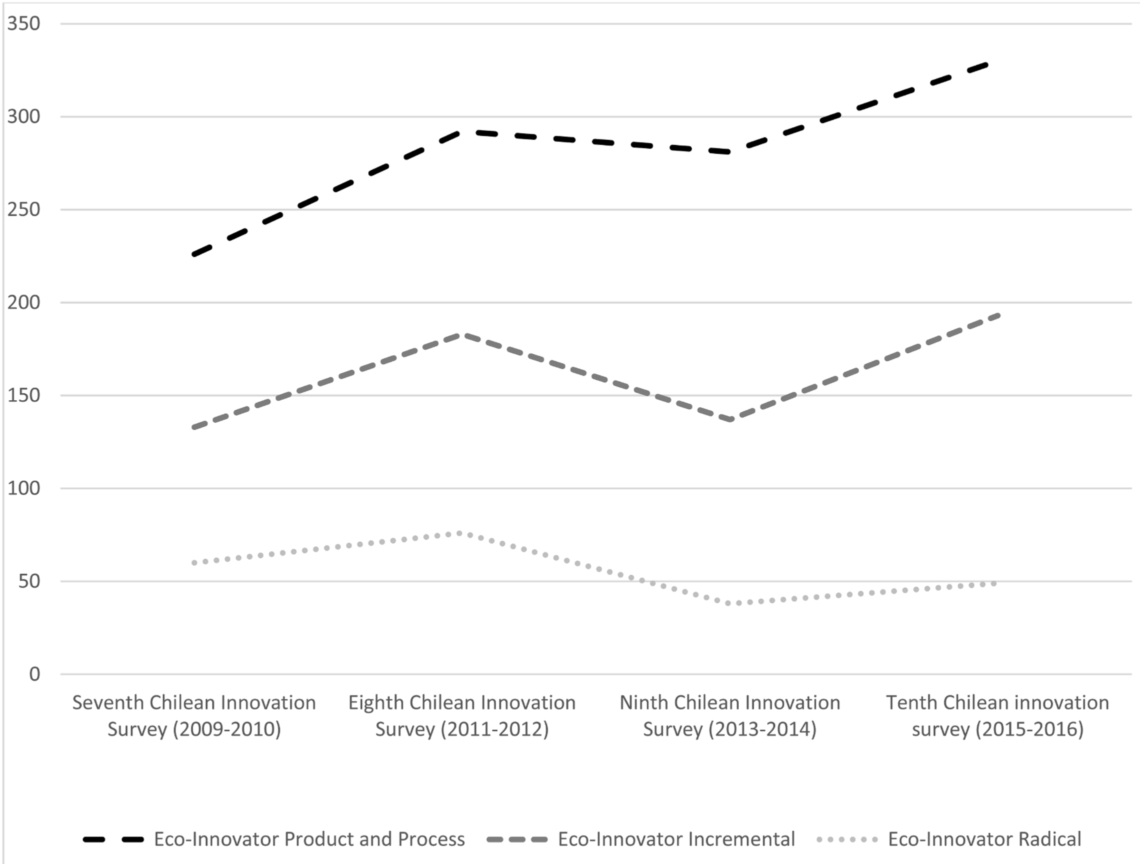

Figure 3. Number of firms distinguishing by type of Eco-Innovators

method allows us to test simultaneously estimation for the different types of innovation in firms considered in our analysis (product, process, incremental and radical innovation) and for two eco-innovation strategies: *Resources Efficiency* and *Sustainable Sensitiveness*. Moreover, this method enable us to detect simultaneously the variables that could affect the different innovation strategies and the substitution or complementarities between the different alternatives (this information is reported by the error terms). The Multivariate Probit model (PMV) is the natural extension of the univariate probit model, in which the errors have a standard multivariate normal distribution, some index variables intervene as endogenous and present various forms of simultaneity and causality (Vargas, 2003). For the application of this methodology, we follow Cappellari and Jenkins (2003; 2006).

The model of our types of innovations (Product, Process, Incremental and Radical) is based in two variables: *Resources Efficiency* and *Sustainable Sensitiveness*

Table 3
Eco-innovators by type and sector

Eco-innovators	Agriculture	Manufacturing	Services
Resources efficiency Prod&Proc	86	124	480
	9.98%	9.86%	12.78%
Sustainable Sensitiveness Prod&Proc	89	128	522
	10.32%	10.17%	13.89%
Resources efficiency Incremental	54	70	282
	6.26%	5.56%	7.51%
Sustainable Sensitiveness Incremental	61	73	319
	7.08%	5.80%	8.49%
Resources efficiency Radical	16	27	73
	1.86%	2.15%	1.94%
Sustainable Sensitiveness Radical	10	27	75
	1.16%	2.15%	2.00%

Source: own elaboration based on the Tenth Chilean Innovation Survey

$$\begin{cases} PROD = 1 \text{ and } 0 \text{ otherwise} \\ PROC = 1 \text{ and } 0 \text{ otherwise} \\ INCRE = 1 \text{ and } 0 \text{ otherwise} \\ RAD = 1 \text{ and } 0 \text{ otherwise} \end{cases} \begin{cases} Resources\ Efficiency\ ^{*}_{m} = \theta_m + \varphi_m X_m + \varepsilon_m,\ m = 1, \ldots, M\ (1) \\ Sustainable\ Sensitiveness^{*}_{m} = \theta_m + \varphi_m X_m + \varepsilon_m,\ m = 1,\ \ldots,\ M\ (2) \end{cases}$$

Where, PROD and PROC refers to product and process innovation and INCRE and RAD appoint incremental and radical innovations. And,

Resources Efficiency$_m$ =1 if *Resources Efficiency*$_m$* = > 0 and 0 otherwise;

Sustainable Sensitiveness$_m$ =1 if *Sustainable Sensitiveness*$_m$* = > 0 and 0 otherwise;

The error terms ε_m are distributed as a multivariate normal, with zero mean and variance-covariance matrix V, where V takes value 1 on the leading diagonal, and correlations $\rho_{jk} = \rho_{kj}$ are the off-diagonal elements (Cappellari and Jenkins, 2006). The model allows us the calculation of ρ_{21}.

4. Results

Table 4 shows the results of the multivariate probit model for *Resources Efficiency* and *Sustainable Sensitiveness* in product and process, incremental and radical innovation, respectively. Our main findings highlight the influence of technology push and market pull factors in developing eco-innovations, while Public Support does not appear to be so significant. Nevertheless, several differences are found when distinguishing by type of eco-innovation, according to both the nature of the eco-innovation and its degree of novelty.

Regarding firms' knowledge resources and capabilities, results show that R&D is not a determining factor in the development of eco-innovations in Chilean firms, since this variable is not significant in any of the estimations. These findings are consistent with previous literature on innovation in this country, which notes that higher investments in R&D do not generate a greater propensity to innovate (Benavente, 2006). Regarding eco-innovation, as far as we know, there are no studies that consider the intensity of R&D as a determinant of eco-innovations in developing countries. However, this result is in contract to pioneers eco-innovation studies for developed countries (Cainelli et al., 2015; Horbach et al., 2012; Horbach et al., 2016). This finding can have several explanations. From the perspective of resources, investments in R&D involve high costs (both financial and human) and in many cases firms located in developing countries cannot afford them (Crespi and Zuniga, 2011; Navarro et al., 2010). On the other hand, from the perspective of the capabilities of the companies belonging to these countries, as Crespi and Zuniga point out (2011, p.273): "*the roles of imitation and technology acquisition are more important than R&D and innovation as preconditions for learning and catching up*". Therefore, our results confirm the H1 pointing out that although investments in R&D are important to improve and strengthen the firm's internal capabilities, firms in developing countries such as Chile may have difficulties in accessing the necessary resources for these investments, having to choose between directly acquiring the technology or seeking collaborative agreements. In fact, it is possible that these needs, together with certain characteristics of these countries (political instability, excessively fragmented innovation systems, etc.), lead these companies not to contemplate invest on R&D.

Considering human resources as specific firm's capabilities and knowledge resources, Hypothesis 2 proposed that the training of R&D personnel was more associated with process and incremental eco-innovations. However, the results show that this variable is not significant for any type of eco-innovations. Therefore, our H2 is rejected. R&D Formation could complement the low levels of direct R&D investments to reach successful eco-innovations. Nevertheless, the costs that firms have to face in terms of human capital can be very high (Navarro et al., 2010). Therefore, given that these firms have scarce resources for investments in R&D, the resources to defray the costs of innovation training programs will also be scarce, allocating their investment efforts to the direct purchase of R&D or the acquisition of machinery with the technology already incorporated. In fact, this circumstance has been shown in previous literature from developing countries, indicating that when firms are not very intensive in direct R&D investments, they base their innovations on imitation or technology transfer (Navarro et al., 2010; Sanni, 2018).

According to our findings, embodied technology (Non R&D Embedded) promotes all types of product eco-innovation and process and incremental eco-innovations related to *Resources Efficiency*. However, we have not found a significant effect on radical eco-innovations. Therefore, these results confirm partially H3, claiming that the acquisition of embodied technology is an important driver of different types of eco-innovations. These findings are in line with those obtained by Marzucchi and Montresor (2017) who pointed out that the embedded technology in new machinery, software and hardware is positively associated with a greater probability of adopting energy and material eco-innovations. Nevertheless, it should be emphasized that although

Table 4
Estimation results: Product, Process, Incremental and Radical *Resources Efficiency and Sustainable Sensitiveness*

	Product		Process		Incremental		Radical	
	Resources Efficiency	Sustainable Sensitiveness	Resources Efficiency	Sustainable Sensitiveness	Resources Efficiency	Sustainable Sensitiveness	Resources Efficiency	Sustainable Sensitiveness
R&D Intensity	-0.213	0.025	-0.281	-0.220	-0.827	-0.018	0.007	0.017
	(0.272)	(0.043)	(0.512)	(0.474)	(1.292)	(0.052)	(0.087)	(0.079)
R&D Formation	-0.003	-0.002	-0.000	-0.000	-0.001	-0.001	-0.000	-0.000
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Non R&D Embeded	0.000**	0.000*	0.000**	0.000	0.000**	0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Non R&D Dissem	-0.000	-0.000	-0.000	-0.001	-0.000	-0.001	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)
External R&D	-0.000	-0.000	-0.000	-0.000	-0.001	-0.001	-0.000	-0.000
	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)
Breadth	0.100***	0.088***	0.051*	0.037	0.075**	0.059**	0.041	0.069*
	(0.031)	(0.0029)	(0.029)	(0.028)	(0.029)	(0.028)	(0.048)	(0.042)
Coop	0.239*	0.148	0.267*	0.246*	0.122	0.106	0.604**	0.296
	(0.170)	(0.167)	(0.160)	(0.151)	(0.163)	(0.156)	(0.242)	(0.232)
Market index	-0.102	-0.085	0.169**	0.164**	0.183**	0.124*	-0.104	-0.015
	(0.092)	(0.086)	(0.076)	(0.071)	(0.077)	(0.073)	(0.134)	(0.114)
Public Support	0.155	0.205	0.018	0.063	0.060	0.050	0.062	0.408*
	(0.211)	(0.204)	(0.213)	(0.206)	(0.219)	(0.213)	(0.312)	(0.241)
Age2	0.045	0.095**	0.054	0.035	0.032	0.073*	0.171**	0.174***
	(0.045)	(0.042)	(0.043)	(0.040)	(0.042)	(0.040)	(0.071)	(0.062)
Size	-0.000	0.000	-0.000	0.000	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
_cons	-2.353***	-2.552***	-2.217***	-2.015***	-2.139***	-2.253***	-3.497***	-3.518***
	(0.286)	(0.274)	(0.270)	(0.249)	(0.268)	(0.254)	(0.469)	(0.425)
Time Dummies	YES		YES		YES		YES	
/atrho21	1.403***		1.190***		1.085***		1.726***	
	(0.120)		(0.091)		(0.091)		(0.215)	
log likelihood	-264.18343		-349.92236		-350.94413		-106.11839	
Observations	970		972		972		970	

Standard errors in parentheses. Time dummies included except the first one.
note: *** p<0.01, ** p<0.05, * p<0.1

the acquisition of machinery with embodied technology or software is more related to *Resources Efficiency* eco-innovations, a positive influence on product eco-innovations related to *Sustainable Sensitiveness* is found[8]. Taking the above argument into account, in a developing country such as Chile, where investments in R&D are scarce, the acquisition of machinery with embodied technology, software or hardware is crucial in the development of eco-innovations. Specifically, these acquisitions will favor the implementation of product, process and incremental eco-innovations related both to efficiency in the use of resources (*Resources Efficiency*) and product eco-innovations aimed at reducing the environmental impact directly (*Sustainable Sensitiveness)*.

Contrary to our expectation, our results do not show a positive relationship between the development of eco-innovations and the spending on activities to introduce improved products or services on the market, as well as on procedures and technical preparations for the implementation of eco-innovations (H4-Non R&D Disembodied). There is no evidence analyzing this type of activity as a possible determinant of eco-innovations in developing countries. Although it had been considered that Non-R&D disembodied activities could complement the lack of R&D investments in developing countries (Navarro et al., 2010) and thus, it can positively influence the development of eco-innovations, our results show that the expenditure made by Chilean firms in these types of activities do not increase the probability of obtaining any eco-innovations. Therefore, we reject our hypothesis 4.

In addition, firms can also improve their internal knowledge base through the purchase of patents or licenses in order to enhance absorptive capacity of the firm and innovative performance (Cassiman and Veugelers, 2006). However, our results point out that External R&D does not increase the firm propensity to develop eco-innovations. Considerable previous literature showed External R&D as an important driver of eco-innovation. However, other studies carried out at European level did not find this variable to be significant for any type of eco-innovation (de Marchi, 2012; Li-Ying et al., 2018; Triguero et al., 2018), being our results in line with them. In this sense, empirical evidence is not clear, and in this case External R&D appears not significant for the period analyzed. Therefore, in view of the aforementioned, we are not able confirm H5.

Regarding the effect of Collaboration, Networks and Alliances on eco-innovation, we hypothesized (H6) that the influence of the external knowledge Breadth is positive for all types of eco-innovation. This positive and significant effect is found for all types of eco-innovations, with the exception of process eco-innovations related to *Sustainable Sensitiveness* and radical eco-innovations associated with *Resources Efficiency*. In line with previous studies for developing countries (Cai and Zhou, 2014; Sanni, 2018), we found that the variety in the use of information sources influences the propensity to eco-innovate. However, in our knowledge there are no analyses for this type of countries distinguishing a wide variety of eco-innovations. Therefore, since H6 is demonstrated, we can affirm that in countries such as Chile with fragmented innovation systems and where risk aversion may be higher, using a large number of knowledge sources will only increase the probability of product eco-innovations, since this type of innovation can have the greatest benefit for firms.

Additionally, formal Cooperation agreements have been considered as drivers of eco-innovations. Our findings show that this influence is positive and significant for the development of product, process and radical eco-innovations aimed to reduce resources (coeff. 0.239, coeff. 0.267 and coeff. 0.604 respectively) and for process eco-innovations related to *Sustainable Sensitiveness* (coeff. 0.246). Therefore, the results on hypothesis 7 are partially confirmed. This finding is supported by the empirical literature. In this regard, Marzucchi and Montresor (2017) demonstrated that Cooperation positively influences just process eco-innovations while del Río et al. (2017) and Mothe et al. (2018) obtained a positive influence for product and process eco-innovations.

Table 5
Summary of hypotheses results

Hypotheses	Result	Observations
H1: R&D intensity is not a driver of eco-innovations in Chilean firms.	Supported	
H2: Training is more associated with process and incremental eco-innovations than with product and radical eco-innovations in Chilean firms.	Not supported	
H3: The acquisition of embodied technology increases all types of eco-innovation in Chilean firms.	Partially Supported	Supported for all types of product eco-innovations and process and incremental eco-innovations related to *Resources Efficiency*.
H4: Non-R&D disembodied activities increase all types of eco-innovation in Chilean firms.	Not supported	
H5: External R&D is more linked to product and radical eco-innovations than to process and incremental eco-innovations in Chilean firms.	Not supported	
H6: The influence of the external knowledge breadth is positive for all types of eco-innovation in Chilean firms.	Supported	With the exception only of Process-*Sustainable Sensitiveness* and Radical-*Resources Efficiency*.
H7: Technological collaborative agreements increase all types of eco-innovation in Chilean firms.	Partially Supported	Support for all types of process eco-innovations and product and radical *Resources Efficiency* eco-innovations.
H8: Market factors enhance all types of eco-innovation in Chilean firms.	Partially Supported	With the exception only of Product and Radical eco-innovations.
H9: Public Support enhances all types of eco-innovation in Chilean firms.	Weakly Supported	Confirmed only for radical eco-innovations associated with *Sustainable Sensitiveness*.

To analyze the influence of Market factors, an index that summarize both the importance of market penetration and the importance of extending the range of products, has been used (*Market index*). Our results show a positive influence of this index on process (coeff. 0.169, coeff. 0.164) and incremental eco-innovations (coeff. 0.183, coeff. 0.124), for *Resources-Efficiency* or *Sustainable Sensitiveness*. Therefore, since we only found evidence for process and incremental eco innovations, H8 can only be partially confirmed. Market factors also have a positive influence on the development of eco-innovations in developing countries. However, unlike the results obtained in the previous literature (Sanni, 2018), these market factors can only be considered drivers of process and incremental eco-innovations in Chile. This result may be due to the characteristics of the country analyzed, as eco-products have a higher price which makes its population or their international markets may be unwilling to pay (del Río et al., 2017; Jové-Llopis and Segarra-Blasco, 2018).

The last factor analyzed is related to the regulatory framework. To this purpose, a variable has been introduced for checking the acquisition of public funding by firms for the development of eco-innovations. H9 pointed out a possible positive influence of Public Support on the propensity of Chilean firms to eco-innovate. However, the results obtained only show this relationship for radical eco-innovations related to environmental awareness. This finding allows us to affirm that for Chilean firms, obtaining such public funds is not a determining factor in all types of eco-innovations. As Marzzuchi and Montresor (2017) found, this driver seems to be more closely linked to eco-innovations related to *Sustainable Sensitiveness* than to *Resources Efficiency*. Therefore, this result suggests the need for a change in the regulation of subsidies. Specifically, the regulation that connects subsidies with innovations, since more importance should be given to innovations that favor

[8] We are aware that the coefficient is very small in our estimations.

Table 6
Estimation results: Product, Process, Incremental and Radical *Resources Efficiency and Sustainable Sensitiveness in the Tenth Innovation Survey*

	Product		Process		Incremental		Radical	
	Resources Efficiency	**Sustainable Sensitiveness**	**Resources Efficiency**	**Sustainable Sensitiveness**	**Resources Efficiency**	**Sustainable Sensitiveness**	**Resources Efficiency**	**Sustainable Sensitiveness**
R&D Intensity	-0.156	0.006	-0.469	-0.687	-0.795	0.024	0.034	-0.043
	(0.231)	(0.132)	(0.583)	(0.645)	(1.294)	(0.223)	(0.167)	(0.181)
R&D	-0.000	-0.002	0.000	0.000	-0.002	-0.000	0.000	0.000
Formation	(0.001)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.002)	(0.001)
Non R&D	0.000*	0.000*	0.000**	0.000	0.000**	0.000*	-0.000	-0.000
Embeded	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Non R&D	-0.000	0.000	-0.000	-0.000	-0.000	-0.001	-0.000	0.000
Dissem	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)
External R&D	-0.001	0.001**	-0.001	-0.000	-0.002	-0.001	0.000	0.0009*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
Breadth	0.081*	0.0708*	0.004	-0.029	0.063	0.023	-0.007	-0.006
	(0.047)	(0.046)	(0.047)	(0.045)	(0.048)	(0.045)	(0.067)	(0.063)
Coop	0.293	0.347*	0.360*	0.290	0.027	0.022	0.689**	0.386
	(0.244)	(0.242)	(0.239)	(0.233)	(0.244)	(0.236)	(0.319)	(0.312)
Market Index	-0.083	-0.038	0.337***	0.347***	0.388***	0.328***	-0.037	0.090
	(0.135)	(0.132)	(0.125)	(0.119)	(0.129)	(0.122)	(0.092)	(0.084)
Public Support	0.183	0.124	-0.092	0.007	-0.072	-0.066	-0.098	0.151
	(0.301)	(0.302)	(0.311)	(0.300)	(0.322)	(0.312)	(0.411)	(0.380)
Age2	0.033	0.125**	0.161**	0.123*	0.100	0.133**	0.169*	0.148*
	(0.0061)	(0.061)	(0.068)	(0.065)	(0.068)	(0.064)	(0.092)	(0.080)
Size	-0.000	0.000	-0.108*	-0.034	-0.110*	-0.051	-0.037	0.090
	(0.000)	(0.000)	(0.064)	(0.061)	(0.065)	(0.063)	(0.092)	(0.084)
_cons	-1.337***‘	-1.886***	-1.314***	-1.202***	-1.095***‘	-1.305***	-2.414***	-2.802***
	(0.414)	(0.417)	(0.409)	(0.396)	(0.407)	(0.394)	(0.603)	(0.598)
/atrho21	1.207***		1.221***		1.084***		1.657***	
	(0.172)		(0.170)		(0.170)		(0.285)	
log likelihood	-156.8652		-172.126		-178.7468		-70.6093	
Observations	183		184		183		183	

Standard Errors in parentheses
note: *** p<0.01, ** p<0.05, * p<0.1

Table 7
Estimation results: Product, Process, Incremental and Radical *Resources Efficiency and Sustainable Sensitiveness in the Tenth Innovation Survey by sectors*

	Product		Process		Incremental		Radical	
	Resources Efficiency	**Sustainable Sensitiveness**	**Resources Efficiency**	**Sustainable Sensitiveness**	**Resources Efficiency**	**Sustainable Sensitiveness**	**Resources Efficiency**	**Sustainable Sensitiveness**
R&D Intensity	-2.540	-1.018	5.004	-0.086	-0.649	-1.012	2.640	-1.221
	(1.681)	(0.209)	(3.411)	(1.370)	(0.930)	(0.950)	(3.424)	(4.168)
R&D	-0.001	-0.001	-0.005	-0.003	0.001	0.002	-0.012	-0.009
Formation	(0.003)	(0.002)	(0.004)	(0.003)	(0.001)	(0.001)	(0.012)	(0.010)
Non R&D	0.000	-0.000	0.000***	-0.000	-0.000	0.000	0.000***	-0.000
Embeded	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Non R&D	-0.000	-0.000	-0.000	0.000*	-0.002	-0.004	-0.000	0.000
Dissem	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)	(0.002)	(0.000)	(0.000)
External R&D	63.353	-0.411	18.805	6.364	26.184	1.185	33.478***	32.929**
	(39.164)	(18.162)	(16.673)	(16.276)	(16.050)	(19.867)	(12.821)	(16.102)
Breadth	0.044	-0.007	0.117	0.008	0.093	0.009	0.076	0.018
	(0.095)	(0.095)	(0.094)	(0.090)	(0.096)	(0.098)	(0.109)	(0.106)
Coop	0.561*	0.681**	-0.132	0.048	0.004	0.059	0.126	0.376
	(0.305)	(0.310)	(0.265)	(0.270)	(0.285)	(0.059)	(0.354)	(0.387)
Market index	0.149	0.247	0.125	0.265*	0.305*	0.388**	0.283	0.406**
	(0.167)	(0.169)	(0.155)	(0.151)	(0.162)	(0.169)	(0.187)	(0.203)
Public	0.135	0.313	-0.042	0.486	-0.155	0.171	0.486	0.972*
Support	(0.368)	(0.389)	(0.333)	(0.371)	(0.368)	(0.397)	(0.486)	(0.497)
Age2	0.000	-0.000	-0.000*	-0.000**	-0.000	-0.000	0.000**	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Size	-0.120*	-0.190***	0.000**	0.000**	0.000	0.000	-0.000***	-0.001**
	(0.067)	(0.068)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
_cons	-0.187	-0.246	-0.624*	-1.458***	-0.603	-1.217***	-1.674***	-2.043***
	(0.472)	(0.483)	(0.356)	(0.428)	(0.395)	(0.430)	(0.484)	(0.528)
Sector Dummies	YES		YES		YES		YES	
/atrho21	0.857***		0.663***		0.745***		0.857***	
	(0.172)		(0.172)		(0.173)		(0.173)	
log likelihood	-116.85984		-128.53759		-127.18534		-70.43179	
Observations	120		120		120		120	

Standard Errors in parentheses. Agriculture and Manufacturing dummies included

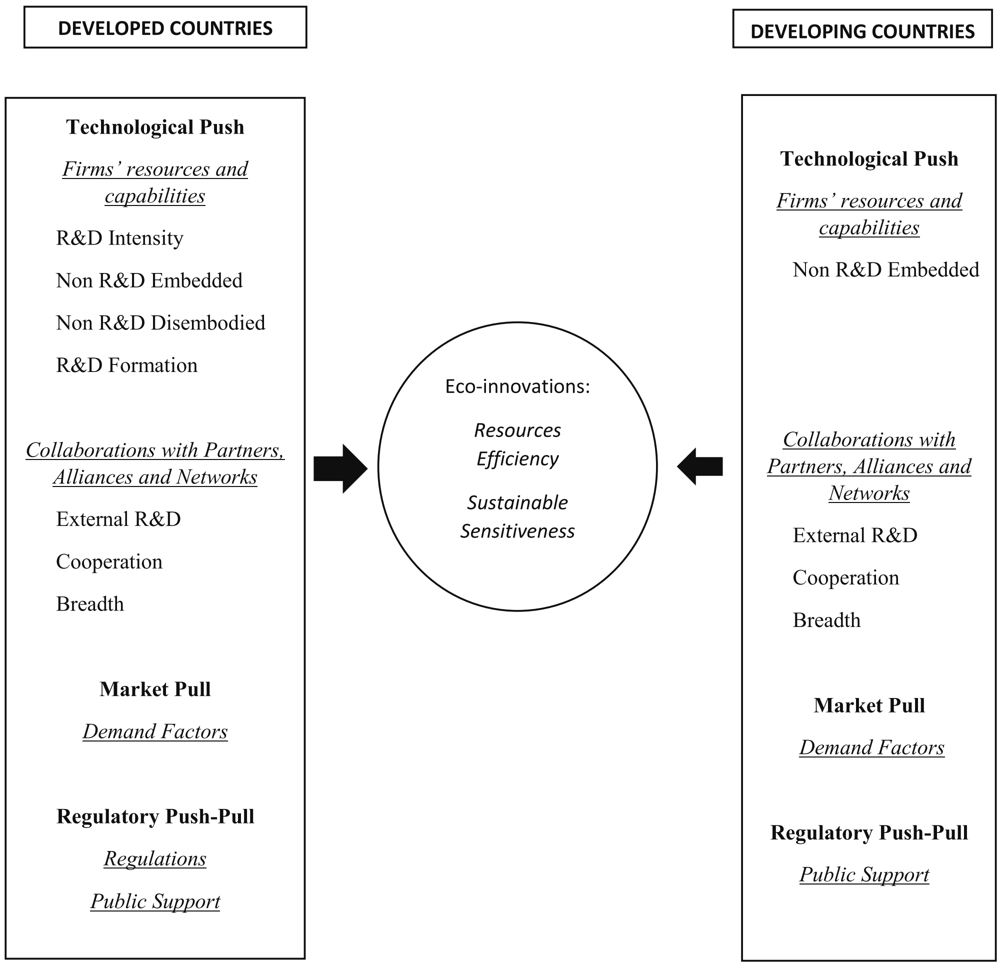

Figure 4. Drivers of eco-innovation: Developed vs. Developing Countries

efficient use of resources and environmental sensitiveness.

Finally, in relation to the specific characteristics of firms, results show that firm Size does not influence the development of eco-innovations of any nature. This finding is in line with other studies (Horbach, 2008; Mothe et al., 2018; Sanni, 2018). On the contrary, a positive and significant influence of the Age square term of the firm to implement eco-innovations is observed, with the exception of product and incremental eco-innovations related to the efficient use of energy and material resources and of all types of process eco-innovations.

Finally, we have summarized the hypotheses and the main results in Table 5.

As a robustness check, we apply the previous model in the Tenth Chilean Innovation Survey, and we repeat the analysis controlling by sector. These results appear in Table 6 and 7, respectively.

Table 6 shows the results of the multivariate probit model for *Resources Efficiency* and *Sustainable Sensitiveness* in product and process, incremental and radical innovation, respectively for the last wave of the Chilean Innovation Survey. Our main finding reaffirms the previous results explained in Table 4. In this sense, eco-innovations in Chile are more depending on Collaborations with partners, Alliances and Networks rather than Firms Resources and Capabilities. In addition, Market factors play a key role in these estimations.

In detail, regarding the resources and capabilities of the firms, the results corroborate that R&D Intensity is not a relevant factor for eco-innovation in Chilean firms, instead it is the Non R&D Embedded that has a greater importance in this set of variables (Non R&D Embedded explains product, incremental for both type of eco-innovations and process innovation for *Resources Efficiency*). On the other hand, Collaborations with Partners, Alliances and Networks affect positively both type of eco-innovations in product (Breadth, External R&D and Cooperation), process (Cooperation) and radical innovations (Cooperation and External R&D). Finally, Market factor is crucial for process and incremental innovation for both type of eco-innovations (*Resources Efficiency and Sustainable Sensitiveness*)[9].

On the other hand, Table 7 shows results of the Tenth Chilean Innovation Survey controlling by sector (agriculture, manufacturing, and services). These results also confirm the previous ones (Table 4 and Table 6). We can observe that for firm resources and capabilities, Non R&D Embedded positively affects eco-innovations (process and radical -*Resources Efficiency*-) and none of our estimations show that R&D Intensity has a positive effect on studied eco-innovations. However, Collaborations with Partners, Alliances and Networks positively affect the development of product and radical eco-innovations. Once again, Market index affects positively to process (*Sustainable Sensitiveness*) and incremental eco-innovations. Finally, we have captured how Public

[9] We are aware of that some results are different of the previous one considering the four waves of Innovation Survey. The differences are based on different samples and observations that we have in both samples of data. We could say that the result in the Tenth Chilean Innovation Survey collect the results at the short term.

Support affects positively to radical *Sustainable Sensitiveness*.

5. Conclusions

This paper analyses the drivers of eco-innovation- *Resources Efficiency and Sustainable Sensitiveness*- in a country no leader technologically as Chile, but with an economy based on commodities. Using data of the Chilean Innovation Survey for the period 2009-2016 (biannual data) and multivariate probit models, we found that in this particular developing country, the eco-innovation activities are explained mainly by other sources of innovation strategies instead of the traditional internal R&D Intensity. We have found that Non R&D Embedded (the acquisition of machinery, equipment or software), Cooperation and other knowledge sources of innovation (Breadth) are playing a key role for the development of eco-innovations in this country. Therefore, we have found evidence about that the drivers of eco-innovation in developing countries could be different to those in developed countries.

In detail, analyzing the Technological Push and considering product and process the results indicate that there are other drivers of innovation related to the collaboration of firms, the acquisitions of new machinery and equipment and sources of customer or universities that boost product and process eco-innovation, according to a strategy to reduce technology gap more than one to create technologies. Moreover, this result is in line with the finding pointed out by Benavente (2006) for the particular analysis of Chile, and it is opposed to those studies of drivers of eco-innovation in developed countries which consider that internal R&D Intensity is one of the most important driver of eco-innovation activities (Cainelli et al., 2015; Horbach et al., 2012; Horbach et al., 2016; Triguero et al., 2018). Distinguishing between the novelty degree of the eco-innovations (incremental and radical), we have found as Breadth of knowledge sources is the main driver for both type of incremental eco-innovations, as well as Non R&D Embedded for *Resources Efficiency*. Regarding radical innovation, we have found as Cooperation will affect *Resources Efficiency* and Breadth will affect *Sustainable Sensitiveness.* These last results for radical innovation agree the finding of Triguero et al. (2018) in which Breadth is crucial for the developing of radical innovations. Finally, we have not found evidence for R&D Formation and R&D disembodied as drivers for the different type of eco-innovations.

Regarding the Market pull factors, we have found evidence in process and incremental eco-innovation. Therefore, this type of eco innovations is more affected by the green demand factors, such as product differentiation, green label or high quality or safety (Capitanio et al., 2010; Cleff and Rennings, 1999; Grunert et al., 2014; Kammerer, 2009). On the other hand, we have only found significant results for Regulatory push-pull -Public Support- in radical eco-innovations related to *Sustainable Sensitiveness*. This result is based on the improved but still undeveloped programs of funding that are applying countries as Chile, as well as the focus of its innovation policies, which it is opposed to previous analysis for developed countries, such as Ghisetti et al. (2015) and Triguero et al. (2018).

The main contributions of our paper are specifically shown in Figure 4. This figure differentiates between the drivers previously found by the empirical literature for developed countries (left hand of the figure) and those found in this research for developing countries in coherence with the scarce studies of drivers of eco-innovation in these countries. In the right hand of the figure, we propose a framework of the eco-innovation drivers in developing countries differentiating by groups of factors. The evidence obtained in this research shows that in the technology push pillar in a developing country, only Non-R&D Embedded, Cooperation, External R&D[10] and knowledge sources of innovation can be considered as determinants of eco-innovation. Furthermore, in relation to the factors identified as market-pull and regulatory push-pull, the results indicate that in a developing country, Market factors and Public Support (although it seems to have a weaker effect) would act as drivers of eco-innovations.[11]

In addition, our study is the first one in developing countries considering the degree of novelty in the innovations -incremental and radical innovations-. For a visual analysis of this findings see Figure 3.

Our findings have implications for manager and policy makers. On the one hand, in our paper we show, as developing countries could be more depending on external collaborative networks for the developing of eco-innovations. Considering this result, managers need to be aware that collaboration between different sources can improve the capabilities of firms in the development of eco-innovations and thus, when designing their eco-innovation strategy, this factor cannot be excluded. Therefore, managers should promote the cooperation, alliances, and networks with other actors of the Innovation System inside and outside the country for satisfying environmental innovation strategies. Moreover, in a developing country where investment in internal R&D is reduced, other forms of R&D that enhance the capabilities and resources of companies must take over as drivers of eco-innovation. In this regard, managers should be sensible to the role that the acquisition of machinery, equipment and software have in the developing of eco-innovations, promoting it as a suitable source of eco-innovation inside the firms in developing countries. On the other hand, policy makers should encourage the creation of networks between firms, universities, government and consumers and firms' internal acquisitions. This allows the firm's internal knowledge base to be complemented with external information facilitating the development of eco-innovations and taking benefits of environmental practices. In addition, the lack of importance of public support in a country such as Chile leads us to consider that policy makers should review the innovation policies and subsidies in order to increase the impact on innovation, and particularly, eco-innovations. In this sense, they could create much more flexible regulations that do not constitute barriers to companies that are trying to carry out eco-innovations.

Our results are subject to several limitations. On the one hand, we were not able to apply a completed panel data analysis because we have a biannual survey, and because in this survey we are not able to identify firms over the time. This last limitation inhibits us to obtain the "individuals" that we need for panel data. The no-identification of the firms could also introduce a bias in the longitudinal analysis because some companies can appear several years in the survey. We have tried to correct it introducing time dummies and Age square.

We have control by sector dummies in the robustness check. However, a deep analysis of the eco-innovations by sector can be proposed as future research. In this sense, Chile is a country in which agri-food sector is the most important one in term of employment and sales, and is particularly this sector, the leader one in the introduction of eco-innovations. This reflection needs to go further for Chile. Moreover, this is almost the first analysis for different types of eco-innovations in developing countries (it is for Latin American and the Caribbean countries). In fact, we use a framework built for testing developed countries in a developing country. Therefore, for the elaboration of a more exhaustive framework in developing countries, we call more researches in this topic. In addition, we have analyzed just a developing country and we need more evidence for expanding our findings to other developing countries. Because of this, future research testing these findings in other developing country would contribute to filling this gap in the literature.

Author statements

Sara Fernández: Conceptualization, Methodology, Writing-Original Draft, Writing-Review & editing, Supervision.

Celia Torrecillas: Conceptualization, Methodology, Writing-Original

[10] We have found evidence of External R&D in the Robustness Check

[11] We have found some evidence in the robustness check

Draft, Writing-Review & editing, Supervision.

Romilio Ernesto Labra: Conceptualization, Methodology, Writing-Original Draft, Writing-Review & editing.

Acknowledgements

Authors gratefully acknowledge the linguistic correction of Braulio Soto in the previous version of this paper. Authors also thank to Álvaro Abdenago Martín for his work in the Chilean Survey dataset.

Funding

This work was supported by the Spanish Ministry of Science, Innovation and Universities (RTI2018-101867-B-I00) and ISPEC GROUP (2020-GRIN-28721).

APPENDIX

Table 1.A
Sectoral Classification in the Chilean Innovation Survey

SECTOR CLASSIFICATION ANALYSIS	
Primary	01, 02, 031, 032, 04, 05, 07
Secondary	10, 16, 17, 18, 20, 21, 24, 25, 26, 27, 28, 29, 31, D, E, 41 and 42
Tertiary	G, H, I, 58, 61, K, L, 69, 72, N, P, Q, R, S
DETAILED SECTOR CLASSIFICATION	
01 Crop and animal production, hunting and related service activities	
02 Forestry and logging	
031 Fishing	
032 Aquaculture	
B Mining and quarrying	
10 Manufacture of food products	
16 Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	
17 Manufacture of paper and paper products	
18 Printing and reproduction of recorded media	
20 Manufacture of chemicals and chemical products	
21 Manufacture of basic pharmaceutical products and pharmaceutical preparations	
24 Manufacture of basic metals	
25 Manufacture of fabricated metal products, except machinery and equipment	
26 Manufacture of computer, electronic and optical products	
27 Manufacture of electrical equipment	
28 Manufacture of machinery and equipment n.e.c.	
29 Manufacture of motor vehicles, trailers and semi-trailers	
31 Manufacture of furniture	
D Electricity, gas, steam and air conditioning supply	
E Water supply; sewerage; waste management and remediation activities	
41 Construction of buildings	
42* Civil engineering	
G Wholesale and retail trade; repair of motor vehicles and motorcycles	
H Transporting and storage	
I Accommodation and food service activities	
58* Publishing activities	
61* Telecommunications	
K Financial and insurance activities	
L Real estate activities	
69* Legal and accounting activities	
72 Scientific research and development	
N Administrative and support service activities	
P Education	
Q Human health and social work activities	
R Arts, entertainment and recreation	
S Other services activities	

**This survey classification has been completed with the NACE code
Source: own elaboration

Table 2.A
List of variables

Dependent variables		Meaning	Question in the survey
Prod	Product innovation	Introduction to the market of a new or significantly improved good or service (Sum of the value of each question and transformation in a dummy variable (0 1)).	P3000 and 3002
Proc	Process innovation	Introduction to the market of a new or significantly improved production process distribution method or supporting activity (Sum of the value of each question and transformation in a dummy variable (0 1)).	P3235, P3237 and 3239
Incre	Incremental innovation	Introduction to the market of a product or process innovation new just for the firm (Sum of the value of each question and transformation in a dummy variable (0 1)).	P3006 and P3026
Rad	Radical innovation	Introduction to the market of product or process innovation new for the market (Sum of the value of each question and transformation in a dummy variable (0 1)).	P3004 and P3024
Resources Efficiency	Material and Energy Eco-Innovator	Reduction of costs per unit produced, i.e. labor, consumption of materials and energy, etc. (Considering just answer 4 and 3- high and medium importance-.We have transformed those value in a dummy variable (0 1)).	P3050
Sustainable Sensitiveness	Environmental Eco-Innovator	Reduction of the environmental impact or health and safety improvement. (Considering just answer 4 and 3- high and medium importance-. We have transformed those value in a dummy variable (0 1)).	P3051
Independent variables			
Firms' knowledge resources and capabilities	R&D Intensity	% of R&D in thousands of Chilean pesos over total sales	P4118 and P3344
	R&D Formation	Training for innovation (internal or external training of the employees, specifically aimed at the development or introduction of new or significantly improved products or processes) in thousands of Chilean pesos over the number of employees.	P3088 and P3089
	Non R&D- Embedded	Acquisition of machinery, equipment, and advanced hardware or software for the innovation in thousands of Chilean pesos over the number of employees	P3084 and P3085
	Non R&D Dissembeded Index	Introduction of innovations to the market (including market research, advertising campaigns), for innovation in thousands of Chilean pesos over the number of employees.	P3090 and P3091
		Installation and commissioning of new equipment (production start-up) for innovation in thousands of Chilean pesos over the number of employees.	P3092 and P3093
		Design (refers to the shape and appearance of the products and not to their technical specifications or other functional or use characteristics) for innovation in thousands of Chilean pesos over the number of employees.	P3294 and P3295
		The index has been developed as the average value of the for Non R&D Dissembeded components.	-
	External R&D	% of External R&D in millions of Chilean pesos over total sales.	P4119 and P3345
Collaborations with Partners, Alliances and Networks	Breadth	Knowledge sources composed by 10 sources of innovation:1) internal sources, 2) suppliers, 3) customer, 4) competitors, 5) consultants, laboratories and private research centers, 6) universities, 7) public research organism, 8) conferences and expositions, 9) research journal, and 10) professional or industrial associations. (All these variables report values between 1-4. These values have been transformed in a dummy variable (0-1), considering 1 high and medium importance, and 0 otherwise. The resulting variable (Breadth) has a range between 0-10 as a sum of the 10 knowledge sources)	P3136, P3139, P 3142,P 3145, P3281, P3154, P3157, P3332, P3333and P3334
	Coop	A cooperative innovation is the active participation with other companies or non-commercial institutes (universities, research institutes, others) in innovation activities. The survey reports a dummy variable (1-0).	P3162
Market Pull	Market index	Market Penetration: Entering new markets or increasing participation in the current market. We have built a dummy variable (0-1), where 1 correspond to high and medium importance, and 0 otherwise.	P3047
		Extend product range: Expansion of the range of goods and services. We have built a dummy variable (0-1), where 1 correspond to high and medium importance, and 0 otherwise.(The final Market index has a range between 0-2, because it is composed by the sum of the tow market variables)	P3046
Regulatory Pull/ Push	Funding	Firms applied for support and got it from the different institutes in Chile. This is a variable built as the sum of all the different possibilities of obtaining fund, and then we have transformed the resulting variable in a dummy variable (0-1).	P4012, P4016, P4020, P4024 and P4028
Control variables			
Age		Variable that indicates the constitution year of the firms. We have calculated the Age subtracting 2016 (our final year) to the year of constitution of the company. We have developed Age2 in order to identifying non-linear trends associated with this variable.	P024
Size		Number of employees (We have the data for the total years of the survey).	P224 and P225
Variables used for transformation of variables			
Sales		Sale in millions of Chilean pesos in both years of the survey.	P200 and P201

* The interaction of the "Eco" and " Innovation variables" have developed 8 dependent variables: Prod -Resources Efficiency, Prod -Sustainable Sensitiveness, Proc -Resources Efficiency, Proc -Sustainable Sensitiveness, Incre -Resources Efficiency, Incre-Sustainable Sensitiveness, Rad -Resources Efficiency and Rad -Sustainable Sensitiveness.
** These questions and the transformation of the variables are equal in the region and in the sector dataset
*** For the continuous variables the survey report two years (t-1 and t) that is the reason because we have to question in those variables: ie: R&D intensity
****We have used question number P200 and P2001 of the survey for the calculation of the continuous variables over sales. ie: R&D intensity and R&D external.
Source: own elaboration

Table 3.A
Basic descriptive statistic

Independent Variables	Mean	Std. Dev.	Min	Max
R&D intensity	0.2191291	2.399377	0	100
R&D formation/employees	85.99234	3889.615	0	350000
Non R&D Embedded/employees	81569.34	9744859	0	1.34E+09
Non R&D Disembodied (Index)	57304.16	4370820	0	4.47E+08
External R&D	9.900536	410.1858	0	30635
Breadth	2.188332	3.801955	0	10
Coop	0.1943757	0.3957543	0	1
Market (index)	0.204473	0.5597	0	2
Public Support	0.0134089	0.1150207	0	1
Age2	607.1084	1707.303	0	72900
Size	241.8408	1104.804	0	60588
Dependent Variables				
Resources Efficiency product	0.0062238	0.0786469	0	1
Sustainable Sensitiveness product	0.0183677	0.1342803	0	1
Resources Efficiency process	0.0087031	0.0928861	0	1
Sustainable Sensitiveness process	0.0238324	0.1525307	0	1
Resources Efficiency incremental	0.0092091	0.0955237	0	1
Sustainable Sensitiveness incremental	0.0257046	0.1582566	0	1
Resources Efficiency radical	0.0022264	0.0471332	0	1
Sustainable Sensitiveness radical	0.0095127	0.0970706	0	1

*This descriptive statistics are very similar to those found in the sample of the Tenth Innovation Survey

Table 4.A
Correlation Matrix

	R&D Intensity	**R&D Formation**	**Non R&D Embedded**	**Non R&D Disem (Index)**	**External R&D**	**Breadth**	**Coop**	**Market Index**	**Public Support**	**Age2**	**Size**
R&D Intensity	1										
R&D Formation	-0.0118	1									
Non R&D Embedded	-0.015	-0.0137	1								
Non R&D Disem (Index)	-0.0118	0.0242	0.0307	1							
External R&D	-0.0093	0.0739	-0.0208	0.0629	1						
Breadth	-0.0346	0.0167	-0.0254	0.0021	0.0995	1					
Coop	0.0079	0.0125	-0.0562	0.0156	0.0552	0.4016	1				
Market Index	-0.01	-0.04	0.0159	0.0393	-0.0361	-0.0637	-0.0039	1			
Public Support	-0.0144	0.0354	-0.0506	-0.0268	0.0547	0.1988	0.266	-0.0656	1		
Age2	-0.0045	-0.0334	-0.04	-0.0184	-0.0127	0.1517	0.0992	0.0742	0.1234	1	
Size	0.0051	-0.039	-0.0448	-0.0272	-0.0243	0.1735	0.1537	0.0267	0.0716	0.2177	1

*Correlation table in the sample of the Tenth Chilean Innovation Survey is very similar

Table 5.A
VIF test

Variable	VIF	1/VIF
Coop	1.26	0.793655
Breadth	1.25	0.798946
Public Support	1.11	0.903882
Age2	1.09	0.919593
Size	1.09	0.92058
External R&D	1.02	0.976381
Market Index	1.02	0.978575
Non R&D Embeded.	1.01	0.986335
R&D Formation	1.01	0.98917
Non R&D Dissem.	1.01	0.991543
R&D Intensity	1	0.997512
Mean VIF	**1.08**	

*All the value of VIF test are lower to 10.
** Variables ordered in decreased order
*** VIF test calculated for Product Resources Efficiency

References

Aloise, P.G., Macke, J., 2017. Eco-innovations in developing countries: The case of Manaus Free Trade Zone (Brazil). Journal of Cleaner Production 168, 30–38.

Ashford, N.A., Hall, R.P., 2011. The importance of regulation-induced innovation for sustainable development. Sustainability 3 (1), 270–292.

Álvarez, R., Bravo-Ortega, C., Navarro, L., 2010. Innovation, R&D Investment and Productivity in Chile. IDB Working Paper No. IDB-WP-190. Inter-American Development Bank, Washington, DC.

Álvarez, R., Bravo_Ortega, C., Navarro, L., 2011. Innovación, investigación y desarrollo, y productividad en Chile. Revista CEPAL 104, 141–166.

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

Bossle, M.B., De Barcellos, M.D., Vieira, L.M., 2016. The drivers for adoption of eco-innovation. Journal of Cleaner Production 113, 861–872.

Bravo-Ortega, C., Benavente, J.M., Á, González., 2014. Innovation, exports, and productivity: Learning and self-selection in chile. Emerging Markets Finance and Trade 50 (supplement 1), 68–95.

Cai, W.G., Zhou, X.L., 2014. On the drivers of eco-innovation: empirical evidence from China. Journal of Cleaner Production 79, 239–248.

Cainelli, G., De Marchi, V., Grandinetti, R., 2015. Does the development of environmental innovation require different resources? Evidence from Spanish manufacturing firms. Journal of Cleaner Production 94, 211–220.

Cappellari, L., Jenkins, S.P., 2003. Multivariate probit regression using simulated maximum likelihood. Stata Journal 3, 278–294.

Capellari, L., Jenkins, S.P., 2006. Calculation of multivariate normal probabilities by simulation, with applications to maximum simulated likelihood estimation. Stata Journal 6 (2), 214–228.

Capitanio, F., Coppola, A., Pascucci, S., 2010. Product and process innovation in the Italian food industry. Agribusiness 26 (4), 503–518.

Cassiman, B., Veugelers, R., 2006. In search of complementarity in innovation strategy: internal R&D and external knowledge acquisition. Management Science 52 (1), 68–82.

Chavez, C., Meller, P., 2020. *La gran región minera: Chile y Perú*. Publicaciones CIEPLAN. Editorial Universidad de Talca, Talca, Chile.

Chen, J., Cheng, J., Dai, S., 2017. Regional eco-innovation in China: An analysis of eco-innovation levels and influencing factors. Journal of Cleaner Production 153, 1–14.

Cimoli, M., Holland, M., Porcile, G., Primi, A., Vergara, S., 2006. Growth, structural change and technological capabilities: Latin America in a comparative perspective. LEM Working Paper Series. No. 2006/11.

Cleff, T., Rennings, K., 1999. Determinants of environmental product and process innovation. European Environment 9 (5), 191–201.

Cornell University, INSEAD, and WIPO (2020). The Global Innovation Index 2020: Who Will Finance Innovation?, Ithaca, Fontainebleau, and Geneva.

Crespi, G., Zuniga, P., 2011. Innovation and Productivity: Evidence from Six Latin American Countries. World Development 40 (2), 273–290.

Cuerva, M.C., Triguero, A., Córcoles, D., 2014. Drivers of green and non-green innovation: empirical evidence in Low-Tech SMEs. Journal of Cleaner Production 68, 104–113.

de Jesús Pacheco, D.A., ten Caten, C.S., Jung, C.F., Navas, H.V.G., Cruz-Machado, V.A, 2018. Eco-innovation determinants in manufacturing SMEs from emerging markets: Systematic literature review and challenges. Journal of Engineering and Technology Management 48, 44–63.

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

del Río, P., Peñasco, C., Romero-Jordán, D, 2016. What drives eco-innovators? A critical review of the empirical literature based on econometric methods. Journal of Cleaner Production 112, 2158–2170.

del Río, P., Romero-Jordán, D., Peñasco, C., 2017. Analysing Firm-Specific and Type-Specific Determinants of Eco-Innovation. Technological and Economic Development of Economy 23 (2), 270–295.

Díaz-García, C., González-Moreno, Á., Sáez-Martínez, F.J., 2015. Eco-innovation: insights from a literature review. Innovation: Organization and Management 17 (1), 6–23.

Frondel, M., Horbach, J., Rennings, K., 2008. What triggers environmental management and innovation? Empirical evidence for Germany. Ecological Economics 66 (1), 153–160.

Ghisetti, C., Marzucchi, A., Montresor, S., 2015. The open eco-innovation mode. An empirical investigation of eleven European countries. Research Policy 44 (5), 1080–1093.

Green, K., McMeekin, A., Irwin, A., 1994. Technological trajectories and R&D for environmental innovation in UK firms. Futures 26 (10), 1047–1059.

Grunert, K.G., Hieke, S., Wills, J., 2014. Sustainability labels on food products: Consumer motivation, understanding and use. Food Policy 44, 177–189.

Hervas-Oliver, J., Albors Garrigos, J., Gil-Pechuan, I., 2011. Making sense of innovation by R&D and non-R&D innovators in low technology contexts: a forgotten lesson for policymakers. Technovation 31 (9), 427–446.

Horbach, J., 2008. Determinants of environmental innovation—new evidence from German panel data sources. Research Policy 37 (1), 163–173.

Horbach, J., 2016. Empirical determinants of eco-innovation in European countries using the community innovation survey, 19. Environmental Innovation and Societal Transitions, pp. 1–14.

Horbach, J., Rammer, C., Rennings, K., 2012. Determinants of eco-innovations by type of environmental impact — The role of regulatory push/pull, technology push and market pull. Ecological Economics 78, 112–122.

IDB, 2016. Study of Social Entrepreneurship and Innovation Ecosystems in the Latin American Pacific Alliance Countries. Fundación Ecología y Desarrollo IDB-TN-1148 Office of the Multilateral Investment Fund Technical note Nº. Regional Analysis, Chile, Colombia, Costa Rica, Mexico & Peru. July 2016.

Iizuka, M., Roje, P., Vera, V., 2016. The development of Salmon aquaculture in Chile into an internationally competitive industry: 1985–2007. Chile's Salmon Industry. Springer, Tokyo, pp. 75–107.

Jové-Llopis, E., Segarra-Blasco, A., 2018. Eco-innovation strategies: A panel data analysis of Spanish manufacturing firms. Business Strategy and the Environment 27 (8), 1209–1220.

Jové-Llopis, E, Segarra-Blasco, A., 2020. Why does eco-innovation differ in service firms? Some insights from Spain. *Business Strategy and the Environment* 29, 918–938.

Kammerer, D., 2009. The effects of customer benefit and regulation on environ-mental product innovation. Empirical evidence from appliance manufacturers in Germany. Ecological Economics 68 (8), 2285–2295.

Katz, J., 2001. Structural reforms and technological behaviour: The sources and nature of technological change in Latin America in the 1990s. Research Policy 30 (1), 1–19.

Katz, J., 2020. Recursos naturales y crecimiento: aspectos macro y microeconómicos, temas regulatorios, derechos ambientales e inclusión social. Comisión Económica para América Latina y el Caribe (CEPAL, Santiago, p. 2020. Documentos de Proyectos (LC/TS.2020/14.

Kemp, R., Pearson, P., 2007. Final report MEI project about measuring eco-innovation. Available at: http://www.oecd.org/env/consumption-innovation/43960830.pdf.

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

Ketata, I., Sofka, W., Grimpe, C., 2014. The role of internal capabilities and firms' environment for sustainable innovation: evidence for Germany. R&D Management 45 (1), 61–75.

Li-Ying, J., Mothe, C., Nguyen, T.T.U, 2018. Linking forms of inbound open innovation to a driver-based typology of environmental innovation: Evidence from French manufacturing firms. Technological Forecasting and Social Change 135, 51–63.

Marzucchi, A., Montresor, S., 2017. Forms of knowledge and eco-innovation modes: Evidence from Spanish manufacturing firms. Ecological Economics 131, 208–221.

McDonagh, P., Prothero, A., 2014. Sustainability marketing research: past, present and future. Journal of Marketing Management 30 (11-12), 1186–1219.

Meller, P., Yuri, JA., 2020. *Cuando la fruta es más que solo fruta: Chile y Perú*. Publicaciones CIEPLAN. Editorial Universidad de Talca, Talca, Chile.

Moreno-Brieva, F., Marín, R., 2019. Technology generation and international collaboration in the Global Value Chain of Lithium Batteries. Resources, Conservation and Recycling 146, 232–243.

Moreno-Mondéjar, L., Triguero, A., Sáez-Martínez, FJ, 2020. Successful eco-innovators: Exploring the association between open inbound knowledge strategies and the performance of eco-innovative firms. Business Strategy and the Environment 29, 939–953.

Mothe, C., Nguyen-Thi, U.T., Triguero, Á., 2018. Innovative products and services with environmental benefits: design of search strategies for external knowledge and absorptive capacity. Journal of Environmental Planning and Management 61 (11), 1934–1954.

Navarro, J.C., Llisterri, J.J., Zuñiga, P., 2010. The importance of ideas: Innovation and productivity in Latin America. In: Pagés, C. (Ed.), *The age of productivity: transforming economies from the bottom up*. Development in the Americas Report. Inter-American Development Bank/Palgrave-McMillan, Washington, DC, United States.

OECD, 2005. Oslo Manual: guidelines for collecting and interpreting innovation data. The Measurement of Scientific and Technological Activities, third ed. OECD Publishing, Paris.

OECD, 2018. Production transformation policy review of Chile: reaping the benefits of new frontiers. OECD and United Nations. https://doi.org/10.1787/9789264288379-en. Available in.

OECD (2020, October 20). *Main Science and Technology Indicators*[Data file]. Retrieved from https://stats.oecd.org/#.

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

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

Sanni, M., 2018. Drivers of eco-innovation in the manufacturing sector of Nigeria. Technological Forecasting and Social Change 131, 303–314.

Sáez-Martínez, F.J., González-Moreno, A., Díaz-García, C., 2014. Environmental orientation as a determinant of innovation performance in young SMEs. International Journal of Environmental Research 8 (3), 635–642.

Segarra-Oña, M.D.V., Peiró-Signes, A., Mondéjar-Jiménez, J, 2013. Identifying Variables Affecting the Proactive Environmental Orientation of Firms: An Empirical Study. Polish Journal of Environmental Studies 22 (3), 873–880.

Solinamo, A., 2017. Estrategias de Desarrollo Económico en Chile: Crecimiento, Pobreza Estructural y Desigualdad de Ingresos y Riqueza. Working Paper No. 28. International Center for Globalization and Development. Available in. www.ciglob.or.

Triguero, A., Corcoles, D., Cuerva, M.C., 2014. Persistence of innovation and firm's growth: evidence from a panel of SME and large Spanish manufacturing firms. Small Business Economics 43 (4), 787–804.

Triguero, A., Fernández, S., Sáez-Martinez, F.J., 2018. Inbound open innovative strategies and eco-innovation in the Spanish food and beverage industry. Sustainable Production and Consumption 15, 49–64.

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

Vargas, M. (2003). Estimación del Modelo Probit Multivariante: Una Mejora, en MPRA Paper No. 5241. Available in: < http://mpra.ub.uni-muenchen.de/5241 >.

Dr. Sara Fernández is professor of Applied Economics at the Faculty of Economics and Business Sciences in the Complutense University of Madrid. She got her PhD. in Economics and Business in 2018. Her research interests include innovation, eco-innovation and mergers and acquisitions as corporate strategies in the field of International Corporations and Industrial Organization. She has published in journals such as *Regional Studies, Sustainable Production and Consumption, Economics of Innovation and New Technology, Management Decision*. Email: Sarafe21@ucm.es

Dr. Celia Torrecillas is assistant Professor at the Economic Department of Applied and Structural Economics and History, Universidad Complutense de Madrid (Spain). PhD in Social and Legal Sciences in the specific field of International Economics, Universidad de Jaén, Master degree in Innovation Economic and Management, Universidad Complutense de Madrid. Her research interests are on the topic of Multinational Enterprises and Innovation and Development. She is starting her academic career and she has various publications in journals, such as: *Journal of Technology Transfer and Technological* and *Economic Development of Economy*. She has been visiting scholar at the Trinity College in Dublin (Ireland) and at the Lineaus University in Kalmar (Sweeden). Email: Celiatorrecillas@ucm.es

Dr. Romilio Labra is development and innovation manager at the Chilean Agri-aquaculture nutritional genomics Center(CGNA) and academic at the University of Talca. PhD in Economics and Innovation Management, Universidad Autónoma de Madrid and Master in Business Administration, Universidad de Talca - Chile. His professional activity is related to the management of innovation in the agribusiness, food and natural resources sectors. In the academic field, his interests are policies and networks of innovation as well as company's innovation. Email: Ernesto.labra@cgna.cl