Journal of Cleaner Production 349 (2022) 131243

Contents lists available at ScienceDirect

Journal of Cleaner Production

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

Exports and outward FDI as drivers of eco-innovations. An analysis based on Spanish manufacturing firms

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ARTICLE INFO

Handling Editor: Zhifu Mi

Keywords:
Exports
Foreign direct investment
Eco-innovations
GMM estimations

ABSTRACT

The literature about the drivers of eco-innovation has pointed out the importance of internationalization processes. This study explores the relationship between two international strategies -Exports and Outward Foreign Direct Investment (FDI)- over eco-innovations differentiating by type of innovation (product and process) and the degree of novelty (radical and incremental). We use a sample of Spanish Manufacturing firms, applying GMM estimations in the period 2008–2016. Results show different effects of learning by internationalization depending on the mode of internationalization and the type of eco-innovation. Specifically, effects of outward FDI for the different types of eco-innovations are lower and take longer to materialize in eco-innovations than exports effects.

1. Introduction

In recent years, the effects of climate change should boost companies to develop products and adopt processes in an environmentally friendly manner. In fact, environmental responsibility is becoming a priority for companies. The concept of eco-innovation was introduced by the pioneer work of Kemp and Arundel (1998) as the introduction of innovative resources efficiency and sustainable sensitiveness practices (Fernández et al., 2021).

The studies of the drivers of eco-innovation have recognized that one of the main drivers of eco-innovation is internationalization (Aguilera-Caracuel et al., 2012; Cainelli et al., 2012; Hojnik et al., 2018; Peñasco et al., 2017). Internationalization strategies allow firms to learn from foreign markets, giving firms new business opportunities for the launching of new products or processes. In this regard, following a learning perspective (Cohen and Levinthal, 1990), firms could learn abroad about eco-innovative practices or cleaner production systems that could have an ex-post effect on the level eco-innovation in the firms. Therefore, there is a component of the international market/demand pull factor that should be considered as an eco-innovative driver (Tsai and Liao, 2017).

In this sense, the relationship between internationalization strategies (export and Outward Foreign Direct Investment -FDI-) and eco-innovation, or in other words, learning abroad and its ex-post effects on eco-innovation has not been yet studied, even when there is a call for paper of this relationship -controlling by time and type of eco-innovation- in Hojnik et al. (2018) and, also, in Chiarvesio et al. (2015). In addition, authors recommend going further in the analysis of the relationship between the direct investment abroad and the eco-innovation practices (Galera-Quiles et al., 2021). Therefore, this research aims to fill the gap detected in the previous empirical literature regarding internationalization strategies and eco-innovation practices by addressing the following research questions: Does internationalization strategy -exports and outward FDI- lead the adoption of different types of eco-innovation? Or in other words: Could firm learn abroad through an international strategy about eco-innovation practices?

Two branches in the literature support this type of analysis. On the one hand, International Business and Innovation Economy literature that affirms that international strategies of firms affect positively to general innovation (Cassiman and Golovko, 2011; Salomon and Shaver, 2005a; Salomon and Jin, 2010; Santos- Arteaga et al., 2019). On the other hand, those specific literature focused on the green part of innovations that considers that eco-innovation increases because of its international drivers: exports, being part of a Multinational Group, international cooperation, or international sources (Aguilera-Caracuel et al., 2012; Chiarvesio et al., 2015; Hojnik et al., 2018; Peñasco et al.,

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https://doi.org/10.1016/j.jclepro.2022.131243
Received 21 July 2021; Received in revised form 28 January 2022; Accepted 5 March 2022
Available online 19 March 2022

2017; Tsai and Liao, 2017).

To answer the aforementioned research question, we will use the innovation technological panel elaborated in Spain -PITEC dataset- for the manufacturing sector in the period (2008–2016). This dataset collects information about innovation (*product, process, radical and incremental)*, the green part of the innovation (*material-efficiency, energy-efficiency and environment-responsiveness)* and the internationalization activities (exports and outward FDI) that we need to respond our research question. We apply GMM estimations, given that lags are very relevant to capture the time effect for the acquisition of eco-practices abroad.

Results show different relationships considering the international strategy and the types of eco-innovations. Outward FDI effects over eco-innovations are lower and take longer to materialize in eco-innovations than exports effects. These results emphasize the dilemma of whether Multinational Enterprises act or not as a "world engine" of eco-practices.

Our main contribution is the specific analysis of the relationship of two modes of internationalization –export and outward FDI- and three type of eco-innovations (material-efficiency, energy-efficiency and environment-responsiveness) differentiating by type of innovation -product and process- and by the degree of novelty -incremental and radical-. Therefore, this study analyses eco-innovations following an internationalization learning perspective, contributing to the idea that firms could learn through internationalization about eco-innovation practices. We specifically provide evidence about the relationship FDI –outward and inward- and eco-innovations. To date, this particular topic has been scarcely analyzed as an internationalization strategy that could boost eco-innovations.

Secondly, we introduce two minor contributions to the previous analysis. On the one hand, we consider the degree of novelty of the innovation -incremental and radical-, and there are not papers of this specific topic analysing the effect of the international strategy over incremental or radical eco-innovation. On the other hand, this is the first paper considering the dynamic of the international process of learning abroad over eco-innovations. Finally, several implications are obtained for managers and policy makers regarding the promotion of exports or outward FDI, as a green path for acquiring eco-practices.

The rest of the paper is organized as follows. The next section describes the literature background supporting our research and develops the main hypotheses being tested. The third section contains the data description and empirical analysis. Finally, section four explains the main findings, and the last section presents the key implications derived from the analysis.

2. Internationalization strategies and eco-innovation. Hypothesis development

Internationalization provides opportunities for the acquisition of new knowledge and networks that could increase firms' ability to boost general innovations (Álvarez and Torrecillas, 2020; Gkypali and Love, 2021; Lundvall, 2016; Santos-Arteaga et al., 2019; Salomon and Shaver, 2005a; Salomon and Jin, 2010). On the other hand, focusing on the green part of innovation, authors have also pointed out that Internationalization provides learning opportunities for the adoption of cleaner production and sustainability strategies (Chiarvesio et al., 2015; Galbreath et al., 2021; García-Quevedo et al., 2019; Hojnik et al., 2018; Peñasco et al., 2017).

From the pioneer eco-innovation work of Kemp and Arundel (1998), a large number of authors have analyzed the eco-innovation drivers -technological push factors, market pull and regulatory push-pull- (del Río et al., 2017; Fernández et al., 2021; Horbach, 2016; Triguero et al., 2014). In this sense, the international aspect as a driver will be included in the market or demand-pull factor and it can be called as international market pull driver (Dosi, 1988; Tsai and Liao, 2017; Wagner, 2007). Indeed, Internationalization is argued as one of the main demand drivers of eco-innovations (Cainelli et al., 2012; García-Quevedo et al., 2019; Hojnik et al., 2018; Peñasco et al., 2017). It has been argued in Hojnik et al. (2018, p. 1315):

> *"Internationalization offers the opportunity to learn from demanding customers, capable competitors and technologically advanced partners in overseas markets so that the firm can better serve the increased demand for environmentally friendly product and services."*

In this sense, firms can have an international eco-learning process by the achievement of green product and services, the introduction of corporate environment responsibility or the building of a green brand worldwide (Hojnik et al., 2018). In addition, the international driver of eco-innovation could be very relevant in countries with lower levels of investment in eco-innovations, or weak innovation systems, in which the domestic demand-pull factors for eco-innovation are limited (Peñasco et al., 2017).

The international driver of eco-innovation could be manifested in the following ways: 1) international strategies -exporting or being Multinational Enterprises-, 2) international cooperation, 3) international subsidies, and 4) international sources of knowledge (Peñasco et al., 2017; Hojnik et al., 2018). We focus on the dynamics of two forms of international strategies -exports and outward foreign direct investment-as international driver of eco-innovations.

Regarding the effect of exports over eco-innovation, previous literature has shown inconclusive results about this relationship. Horbach (2008), found in a study for Germany firms a positive relationship between international demand-pull factors and eco-innovation. For their part, Hojnik et al. (2018) showed strong evidence for the relationship between internationalization and adoption of eco-innovations in Slovenian firms. In the same line, Aguilera-Caracuel et al. (2012) noted a positive relationship between internationalization and the environmental strategy of firms, being internationalized firm more proactive in the adoption of environmental system and green certifications, the adoption of corporate environmental practices and eco-auditing (Hojnik et al., 2018; Luan et al., 2016; Zhu et al., 2012). However, it should be highlighted that some authors have not found evidence of this association (Borghesi et al., 2012; Cainelli et al., 2012; de Marchi and Grandinetti, 2013; Peñasco et al., 2017). This partially conclusive evidence of export effects over eco-innovation could be explained by the *time* needed for the acquisition of the knowledge abroad (Gkypali and Love, 2021). That is, the acquisition of knowledge abroad is a non-immediate process, and some years are needed for the manifestation of that knowledge in general innovations (Salomon and Jin, 2010; Santos-Arteaga et al., 2019; Rezende et al., 2019). Similarly, it takes some years for the materialization of the knowledge in eco-innovations, question that still requires further studies according to García-Quevedo et al. (2019) and Rezende et al. (2019).

In relation to the type of eco-innovation and the effects of exports over eco-innovations, available evidence has been focused on the type of innovation -product and process eco-innovations- (Chiarvesio et al., 2015; Hojnik et al., 2018; Peñasco et al., 2017). There is not previous evidence specifically supporting the relationship between exports and eco-innovations considering the degree of novelty-radical and incremental-, even when there is a call for papers with regard to this subject in Peñasco et al. (2017). In this sense, while Chiarvesio et al. (2015) consider product and process eco-innovations jointly, Galbreath et al. (2021) analyze only process innovation. In addition, Hojnik et al. (2018) and García-Quevedo et al. (2019) also studied organizational eco-innovations and showed a positive relationship with exports. In this sense, according to previous arguments, we assume that the international knowledge acquired by exports, after some period of time, could be manifested in an increase of the eco-innovation practices by type -product and process- and by the degree of novelty -radical and incremental-.

Therefore, considering the previous arguments we propose the following first hypothesis.

H1. Exports are positively related to the adoption of all type eco-innovations -product, process, incremental and radical-.

Regarding the effect of FDI over eco-innovation, authors have discussed two opposed arguments related to the role that Multinational Enterprises could have in the Eco-innovation practices.

On the one hand, the traditional arguments support the idea that Multinational Enterprises would be located in those places where environmental regulations would be more relaxed (Aguilera-Caracuel et al., 2012; Vernon, 1992). Therefore, there is not an eco-learning process since firms would remain headquartered in their home countries, installing subsidiaries with low environmental proactivity to provide products to less environmentally stringent markets (Aguilera-Caracuel et al., 2012). This is called as the *pollution haven hypothesis* or *industrial flight*, by which MNE will go abroad to avoid environmental rules with the so-called "Dirty industries" (Chung, 2014; D'Agostino, 2015). Following this argument, we could propose that the internationalization using outward foreign direct investment, or in other words, being a multinational enterprise is not positively connected to the development of eco-practices.

On the other hand, new and recent arguments support that the need of eco-practices in a more globalized world are conferring new roles to the Multinational Enterprises and their green activities. In this regard, MNE would be located in countries to compete with local firms and to obtain success and, in this sense, the knowledge of environmental practices could become an ownership advantage. This reasoning will support the strong version of the *Porter Hypothesis* by which international eco-practices encourage competitiveness and could boost eco-innovations in home and host location. Concretely, this argument is alluding to the well-known *eco-spillover* effect by which the own network of the MNE will contribute to the diffusion of the eco-practices around the world (D'Agostino, 2015; Ha, 2021).

In this sense, considering the above ideas, Multinational Enterprises (MNE) could have incentives to generate environmental practices in a globalized world due to the need to find international consumers demand and the need to face competitors around the world. In addition, it is argued that international customers are introducing more pressure on MNE for the development of green products, considering that MNE often use standardized environmental practices around the world (Aguilera-Caracuel et al., 2012; Zhu et al., 2012). Therefore, there is a green pressure and challenges in which MNE should act as ambassador of green practices, given that they have some facilities due to the large scale and volume of resources for the application of green certification and green options (Aguilera-Caracuel et al., 2012; Luan et al., 2016; Rezende et al., 2019). According to the previous arguments, it is also possible to propose that MNE are positively connected to the development of eco-practices. Therefore, the idea of both outward FDI -go abroad using FDI- and inward FDI -foreign equity-is positively linked with the introduction of eco-innovations as it has been recently defended by Peñasco et al. (2017), Chiarvesio et al. (2015), de Marchi and Grandinetti (2013) and Cainelli et al. (2012).

Few studies have analyzed specifically the effect of outward FDI (or having FDI abroad) on the development of eco-practices. As far as we know, only Chiarvesio et al. (2015) show as firms that have FDI (go abroad using FDI) has higher propensity to eco-innovate. Other empirical evidence shows as being part of a MNE group –Inward FDI- could affect positively to the generation of eco-innovations. In this sense, authors as Cainelli et al. (2012), Chiarvesio et al. (2015) and Duque-Grisales et al. (2019) have argued that the participation of a multinational groups may represent a valuable opportunity for firms to learn about new eco-innovation possibilities.

Differentiating by type of innovation and considering the effects of FDI over eco-innovations, there are mixed evidence for product and process eco-innovation, and we have not found evidence considering the degree of novelty -incremental and radical innovations-. Specifically, Chiarvesio et al. (2015) and de Marchi and Grandinetti (2013) found a positive association between multinational enterprises –inward and outward FDI- and eco-innovation practices, while Cainelli et al. (2012) and Peñasco et al. (2017) have not shown evidence of this relationship. In addition, Duque-Grisales et al. (2019) have pointed a positive relationship between the presence of the "Multilatinas" in foreign market and the development of a proactive environmental strategy. Finally, authors have argued the need of the introduction of time for capturing the effects of FDI over eco-innovative practices (Rezende et al., 2019).

In view of the above recent arguments and following the recommendation of Chiarvesio et al. (2015) about the need of going a step further in the analysis on the relationship between outward FDI and Eco-innovations, we hypothesize that there is a positive relationship between FDI and all type of eco-innovations.

H2. FDI is positively related to the adoption of all type eco-innovations -product, process, incremental and radical-.

Our research strategy has been synthesized in Fig. 1 which shows the linkage between internationalization (Exports and outward FDI[1]) and eco-innovations. In addition, Table 1 summarizes the literature background linked to our contributions.

3. Data and method

The database used is the Spanish Community Innovation Survey, the Technological Innovation Panel (PITEC), which is developed by the Spanish National Statistics Institute (INE), the Spanish Foundation for Science and Technology (FECYT) and the Foundation for Technical Innovation (COTEC). Following the Oslo Manual guidelines (OECD, 2005), PITEC contains a wide range of information at firm level (both basic firm characteristics and detailed information on innovation) providing information not only on firms' innovation objectives, but also on their international strategies. In addition, this database, which offers information from 2003 to 2016, includes firms of various sizes (large and SMEs, regardless of whether they are innovation oriented or not), from both manufacturing and service sectors. Therefore, in view of the above, PITEC is an appropriate database to investigate the effects of internationalization on the adoption of different types of eco-innovations by Spanish manufacturing firms in the period 2008–2016.[2] The resulting dataset presents an average of 8000 innovative companies.

Regarding the *dependent variables*, which capture the eco-innovative strategy, we will follow the methodology used in Fernández et al. (2021), Marzucchi and Montresor (2017) or Triguero et al. (2018). On the one hand, we consider four types of innovation: product innovation (PROD) which will take value 1 if a new or significantly improved product has been introduced to the market and 0 otherwise; process innovation (PROC) which will take value 1 if a new or improved production process, distribution method a supporting activity has been implemented and 0 otherwise; incremental innovation (INCRE) which will be assigned a value of 1 when the product or process is only new to the firm and 0 otherwise; radical innovation (RADI) which will be represented with a of value 1 when the firm introduces a significantly improved or new product or process to the market and 0 otherwise.

On the other hand, three dummies will be used to determine whether the innovative activity carried out by the companies has been oriented towards the achievement of using fewer materials per unit produced (MATER), less energy per unit produced (ENERGY) or reducing environmental impact (ENVIR). Specifically, these variables take the value 1 if companies have given high or medium importance to these objectives, and 0 otherwise.

[1] As a robustness test we consider also inward FDI.

[2] Although PITEC has information available from 2003 to 2016, the variables related to eco-innovation were not introduced until 2008, so the analysis can only be carried out for the period 2008–2016.

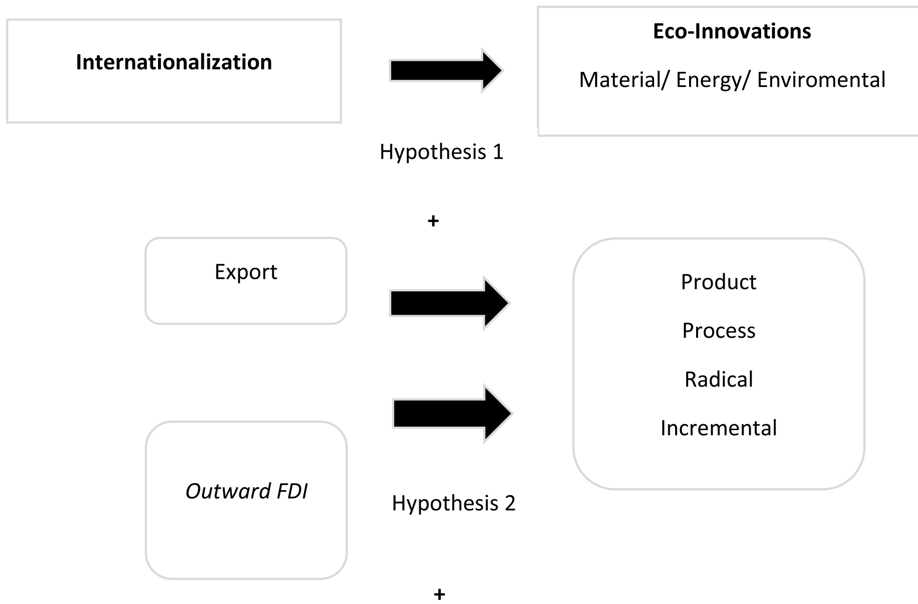

Fig. 1. General conceptual model.
Source: Own elaboration

Table 1
Summary and literature background and contributions.

Literature background and contributions	Contribution	Type of International strategies	Type of eco-innovation	Authors
Internationalization has positive effects over general innovation	New knowledge acquired by exports or MNE can boost innovations	Export and FDI	All type of general innovations	Gkypali and Love (2021); Santos-Arteaga et al. (2019); Salomon and Shaver, 2005a; Salomon and Jin (2010)
Internationalization as positive effects over eco-innovations	Internationalization as a main eco-innovation demand driver	Mainly Exports	Mainly Product and Process eco-innovation	Hojnik et al. (2018); Tsai and Liao (2017); Wagner (2007); Cainelli et al. (2012); García-Quevedo et al., 2019; Peñasco et al. (2017)
Exports as a driver of Eco-innovations	Positive relationship	EXPORTS	Product and Process -eco-innovations-	Horbach (2008); Hojnik et al. (2018); Aguilera-Caracuel et al. (2012); Luan et al. (2016); Zhu et al. (2012)
	Mixed evidence			Borghesi et al. (2012); Cainelli et al., (2012); de Marchi and Grandinetti, 2013 and Peñasco et al., (2017)
	Need of consideration of TIME in the process			Salomon and Jin (2010); Gkypali and Love (2021); García-Quevedo et al. (2019) and Rezende et al. (2019)
Foreign Direct investment as a driver of Eco-innovation	No effect: Pollution haven hypothesis of industrial flight Positive relationship based on the strong version of Porter hypothesis and the consideration of MNE as ambassadors of green practices	FDI	Product and Process eco-innovations	Aguilera-Caracuel et al., 2012; Chung (2014); D'Agostino (2015) Cainelli et al. (2012); Chiarvesio et al. (2015); Duque-Grisales et al. (2019)
Our contributions	*The analysis of the dynamics (considering time) of two international strategies jointly -Exports and FDI- and its effects on Eco-innovations*	Specific contribution to the FDI -outward and inward- effects due to the few analyses and the call for paper in Chiarvesio et al. (2015)	The analysis of the degree of novelty *-radical and incremental innovation-* and there is a call for it in Peñasco et al. (2017)	

Note:1) Hojnik et al. (2018) and García-Quevedo et al. (2019) analyze also organizational eco-innovation, 2) There are no evidence for the relationship considering radical and incremental, 3) Duque-Grisales et al. (2019) consider environmental strategies, 4) Cainelli et al. (2012) used a survey.

Finally, the "innovation" and "eco" variables are interacted, generating a total of 12 dependent variables: Product, Process, Incremental and Radical -*Material Efficiency*, *Energy Efficiency* and *Environment Responsiveness*- These 12 variables were also used in Triguero et al. (2018) in Fernández et al. (2021).

In relation to the *independent variables*, in line with previous studies of eco-innovation and internationalization (Aguilera-Caracuel et al., 2012; Chiarvesio et al., 2015 or Rezende et al., 2019), we use two variables according to the internationalization strategies. On the one hand, the EXPORT variable includes intra-EU and extra-EU exports in relation to the turnover of the companies. On the other hand, the variable outward FDI takes the value 1 if the company is a multinational enterprise whose headquarter is located in Spain, and 0 otherwise. Both variables are introduced in the model considering a lag structure in order to capture the learning abroad effects over eco-innovative practices, following the strategy of Salomon and Jin (2010); Salomon and Shaver (2005a); Santos-Arteaga et al. (2019) and Rezende et al. (2019).

In addition, we consider inward FDI in order to capture the foreign MNE installed in Spain. This variable takes the value of 1 if the company has 10% or more of its social capital in the hands of foreign investors and 0 otherwise (Chiarvesio et al., 2015; Peñasco et al., 2017).

Finally, we introduce three control variables[3]: on the one hand, R&D INTENSITY is measured as the natural logarithm of total R&D expenditures over turnover. It is well known that R&D intensity is key to the acquisition and transformation of knowledge, since it improves the absorptive capacity (Cohen and Levinthal, 1990) of firms and the acquisition of knowledge abroad (Aw et al., 2000; Gkypali and Love, 2021; Golovko and Valentini, 2011).

On the other hand, regarding the characteristics of the firms, SIZE is the natural logarithm of the number of employees and AGE is the natural logarithm of the number of years the firm is old. These variables have been used in diverse studies on internationalization (Cassiman and Golovko, 2011; Salomon and Jin, 2010; Triguero and Córcoles, 2013) and on eco-innovation (Fernández et al., 2021; Triguero et al., 2018). Table 2 collects the description of the variables. Table A1 and A.2 in the appendix shows descriptive statistics and correlation matrix respectively. In addition, several tests have been carried out to check the problems of heteroscedasticity and multicollinearity, which satisfy the econometric requirements.[4]

Table 2
Description of the variables.

Dependent variables	Meaning
Product innovation	= 1 if firm has introduced a new or significantly improved good or service in the market. = 0 otherwise.
Process innovation	= 1 if firm has introduced a new or significantly improved production process, distribution method or supporting activity in the market. = 0 otherwise.
Incremental innovation	= 1 if firm has introduced a product or process innovation new just for the firm in the market. = 0 otherwise.
Radical innovation	= 1 if firm has introduced in the market a product or process innovation new for the market. = 0 otherwise.
Material Efficiency	Changes in product or process that involves a decrease in the consumption of inputs (Considering just high and medium importance, we have transformed those value in a dummy variable (0 1)).
Energy Efficiency	Changes in product or process that involves a decrease in the consumption of energy (Considering just high and medium importance, we have transformed those value in a dummy variable (0 1)).
Environment Responsiveness	Changes in product or process that reduce environmental damage of the firm's activity. (Considering just high and medium importance-. We have transformed those value in a dummy variable (0 1)).
Independent variables	
Export	Intra-EU and extra-EU exports in relation to the turnover of the firm.
Outward FDI	Takes the value 1 if the company is a multinational Spanish enterprise and 0 otherwise.
Inward FDI	Takes the value of 1 if the company has 10% or more of its social capital in the hands of foreign investors and 0 otherwise.
Control variables	
R&D Intensity	Natural logarithm of total R&D expenditures over turnover
Age	Variable that indicates the constitution year of the firms. We have calculated the Age as the natural logarithm of subtracting our final year to the year of constitution of the company.
Size	Natural logarithm of the number of employees

The descriptive analysis between the dependent and independent variables (eco-innovations & exports and eco-innovations and Multinational Enterprises (MNE)[5] is found in Table 3. Analyzing eco-innovative firms, descriptive analysis shows as the number of eco-innovators has decreased over the period analyzed. Specifically, while in 2008 almost 70% of the innovative companies were also eco-innovators, in 2016 around 60% of them carried out eco-innovations. On the other hand, if we distinguish by internationalization strategy, and considering exports, we find that more than half of the innovative Spanish manufacturing exporting companies carried out eco-innovations in the period 2008–2016. In addition, in general, we observe a diminution of the percentage in the period in the development of eco-innovations, reaching the minimum in 2013.

In relation to Spanish multinational companies, approximately half of them have carried out eco-innovation strategies. We find here also a diminution of the percentage over the period. This preliminary descriptive analysis pointed out that eco-innovative firms are internationalized, representing it in average a 50% in exports and FDI, and showing that it is needed to go further in this relationship.

In this regard, Table 4 shows the number of companies by type of eco-innovation and according to their internationalization strategy. The results indicate that companies that carry out internationalization strategies are mainly oriented towards product innovation. This result agrees previous findings described in Cassiman and Golovko (2011) for general innovation. Moreover, in terms of the degree of novelty of the eco-innovations, both types of companies are more incremental than radical innovators. There is no evidence connecting internationalization and the degree of novelty. In addition, while exporting companies seem to carry out innovation activities more oriented towards improving energy efficiency, Spanish multinational companies are more intense in the search for improved efficiency in the use of materials and energy efficiency.

The evolution of the number of exporting firms distinguishing by type of eco-innovation (*Material-efficiency*, *Energy-efficiency*, and *Environment-responsiveness*) has also been analyzed. Fig. 2 shows that the trend is decreasing and similar for the three variables, with e*nvironment-responsiveness* eco-innovations being the least adopted by exporting firms throughout the whole period. It should be noted that *Material-efficiency* eco-innovations and *energy-efficiency* eco-innovations are almost equally adopted by this type of firms, being the latter slightly higher in the first three years.

Fig. 3 shows the same analysis but for Spanish multinational firms. Again, the lowest number of companies is found for *environment-responsiveness* eco-innovations, highlighting the decrease in the number of this firms carrying out this type of eco-innovations in 2011. Although the other two types of eco-innovations present similar results, there is a slightly higher number of Spanish multinationals carrying out *material-efficiency* eco-innovations between 2009 and 2013, with a similar number of e*nergy-efficiency* eco-innovators in 2014. Similar results are found when analyzing subsidiary firms in Spain by type of eco-innovation (Fig. 4), highlighting the drop in energy-efficiency eco-innovations in the period 2011–2014.

We implement the Generalized Method of Moments (GMM) estimations (Arellano and Bond, 1991; Arellano and Bover, 1995; Arellano and Carrasco, 2003; Labra and Torrecillas, 2018; Roodman, 2009). Given that in the panel data N tends to infinity and T is small, and we aim to perform a dynamic model with panel data, we must choose whether to apply a System GMM or a Difference GMM. Following Bond (2002), we have observed how close the coefficient of the lagged dependent

[3] We have replicated out two models considering also international cooperation as a control variable. Results behave like those presented here with the exception of the models of Outward FDI.

[4] Tests results are available upon request from the authors.

[5] We consider here Outward FDI.

Table 3
Distribution of eco-innovators and internationalization strategy.

Year	Innov Prod. or Proc.	Eco-Innovators	%	Exporters			MNE		
				Exporters	Exporters & Eco	%	MNE	MNE & Eco	%
2008	4354	3004	68.99%	3822	2139	55.97	370	203	54.86
2009	4253	2937	69.06%	3801	2140	56.30	376	208	55.32
2010	4096	2792	68.16%	3771	2096	55.58	381	210	55.12
2011	3183	2071	65.06%	3669	1632	44.48	364	150	41.21
2012	2773	1795	64.73%	3599	1487	41.32	353	149	42.21
2013	2587	1684	65.09%	3459	1407	40.68	343	152	44.31
2014	2440	1549	63.48%	2956	1338	45.26	324	142	43.83
2015	2325	1486	63.91%	2873	1280	44.55	317	136	42.90
2016	2287	1453	63.53%	3060	1267	41.41	306	135	44.12

Source: Own elaboration based on PITEC

Table 4
Number of firms by type of eco-innovation and internationalization strategy.

	EXPORTS			MNE		
Types of Eco-innovation	Firms	Obs.	%	Firms	Obs.	%
Prod-Mater	984	8857	48.49%	102	917	42.75%
Prod-Energy	1002	9019	49.38%	101	909	42.38%
Prod-Envir	802	7221	39.53%	79	715	33.33%
Proc-Mater	875	7877	43.13%	93	838	39.07%
Proc-Energy	867	7802	42.72%	90	809	37.72%
Proc-Envir	741	6669	36.51%	72	652	30.40%
Incre-Mater	767	6904	37.80%	83	743	34.64%
Incre-Energy	786	7076	38.74%	81	726	33.85%
Incre-Envir	638	5744	31.45%	65	585	27.27%
Radi-Mater	527	4739	25.95%	61	546	25.45%
Radi-Energy	533	4801	26.29%	61	546	25.45%
Radi-Envir	401	3609	19.76%	44	396	18.46%

Source: Own elaboration based on PITEC

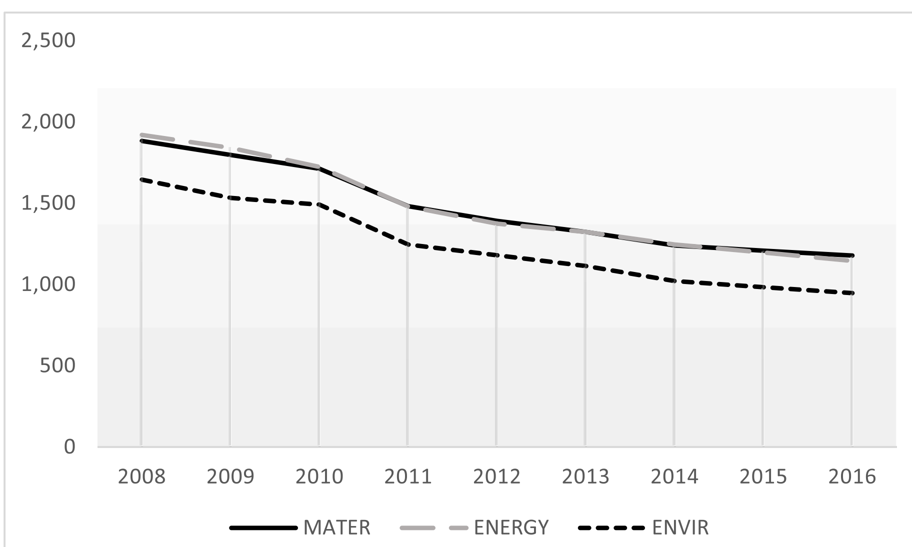

Fig. 2. Exporters firms by material, energy, and environmental eco-innovations.
Source: Own elaboration based on PITEC

variable in Difference GMM is to that obtained when applying a fixed effects model. The results for all models (both when we include exports and multinationals as independent variables) show that the estimator for Difference GMM is closer to that of the fixed effects model than to that of OLS. Therefore, the appropriate methodology will be System GMM.[6]

Because of this, we include the sequential lagged of our internationalization variables $EXPORT_{i,t-1}$; *and* $EXPORT_{i,t-1}$ & $EXPORT_{i,t-2}$ in equation (2) and *Outward* $FDI_{i,t-1}$; *and Outward* $FDI_{i,t-1}$& *Outward* $FDI_{i,t-2}$ in equation (3), in order to test whether or not it affects their current eco-innovation level. The number of lags of these variables (two lags[7]) is in line with the time required to observe learning effects in firms' innovation activities (Golovko and Valentini, 2011; Rezende et al., 2019; Salomon and Jin, 2010). Therefore, in this type of analysis, it is important to consider the time required for knowledge assimilation since learning abroad is not directly measurable (Aw et al., 2000; Gkypali and Love, 2021).

The following expression is the estimated equation (Arellano and Carrasco, 2003):

$$Y_{it} = 1\ (\gamma_t + \beta' X_{it} + u_{it} \geq 0)\ (i = 1,\ \ldots,\ N; t = 1, \ldots,\ T), \quad (1)$$

$$u_{it} = \eta_i + v_t,$$

where, Y_{it} points if the firm is an eco-innovator in year t, X_{it} collects if

[6] OLS, fixed effects, and Difference GMM results are available upon request from the authors.

[7] Also, econometric literature recommends the use of 2 or 3 lags given the limitation regarding bias and multicollinearity if we consider more lags. See: Gujarati (2003).

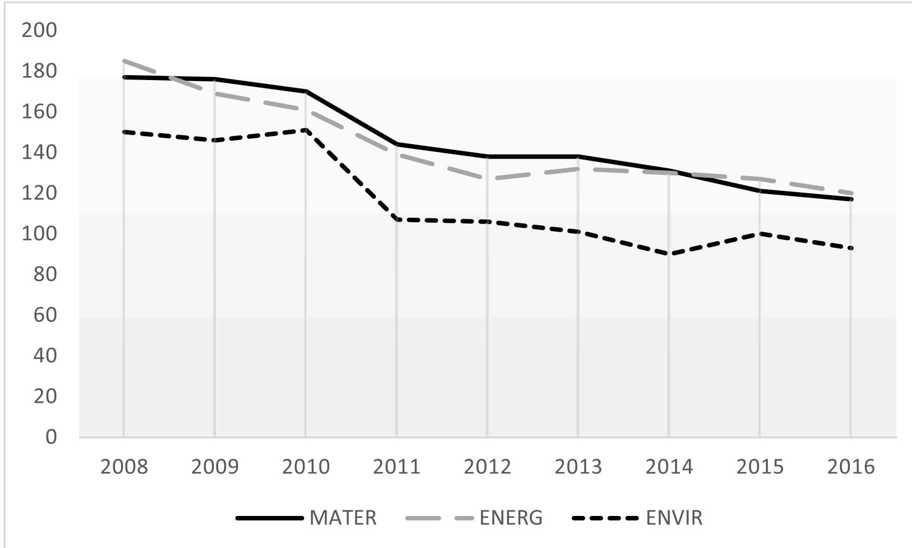

Fig. 3. Spanish multinational firms by material, energy, and environmental eco-innovations.
Source: Own elaboration based on PITEC

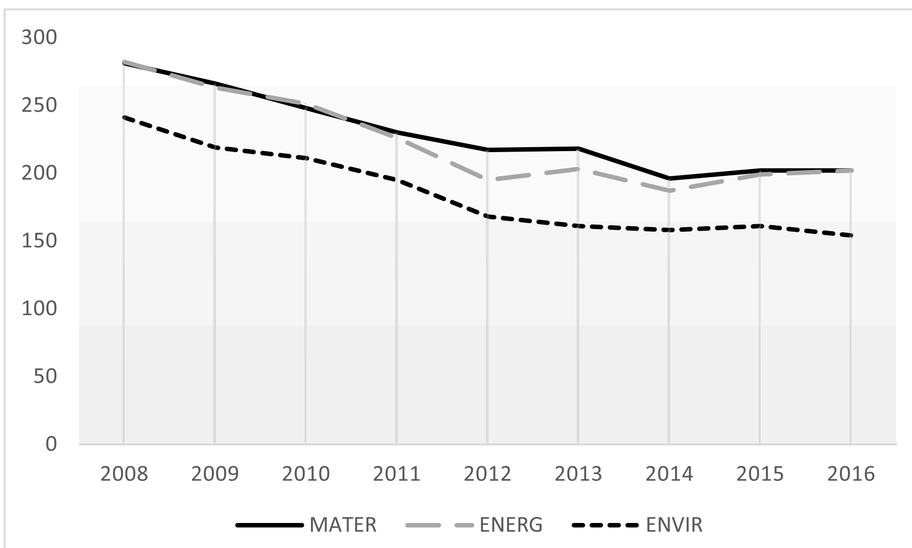

Fig. 4. Subsidiary firms in Spain by material, energy, and environmental eco-innovations.
Source: Own elaboration based on PITEC

the firm is internationalized (Exports and outward FDI).

More specifically, we propose these two sets of equations:

$$Y_{it} = \beta_0 + \beta_1 Y_{it-1} + \beta_2 EXPORT_{t-p} + V_{it} + \eta_{si} + v_{dt} + \varepsilon_{it} \quad (2)$$

$$Y_{it} = \beta_0 + \beta_1 Y_{it-1} + \beta_2 Outward\ FDI_{t-p} + V_{it} + \eta_{si} + v_{dt} + \varepsilon_{it} \quad (3)$$

where sub index i is the firm, p = 1,2 is the lag used, and t is the year. In addition, Y_{it} are the eco-innovation variables explained above, while Y_{it-1} is the lag of the dependent variable that gives the model a dynamic structure. Regarding the rest of the independent variables, $EXPORT_{it-p}$ in the second equation is the variable referring to total exports and Outward FDI_{it-p} (in the third equation) refers to Spanish multinational firms. Finally, V_{it} is a vector of other explanatory variables affecting the innovative output of firms (R&D $INTENSITY_{it}$, $SIZE_{it}$, and AGE_{it}) and η_{si}, υ_{dt} and ε_{it} correspond to specificities of the technique being used and represent individual and time effects, and the random error term, respectively.

In addition, as a robustness test, equation (3) will be replicated changing Outward FDI for Inward FDI in order to capture the effects of being part of a MNE group over eco-innovations practices and illustrate the relationship considering the network of the Multinational Enterprises -"in" an "out" flows-.

4. Results

Tables 5–8 show the results of GMM estimation for *material and energy-efficiency, and environment-responsiveness* in product, process, incremental and radical innovations, respectively. Our main finding highlights the existence of a learning by internationalization process that boost eco-innovations. However, several differences are found in the effect of the internationalization variables (EXPORTS and Outward FDI) when we differentiate by type of innovation (product vs. process) and degree of novelty (incremental vs. radical).

Regarding the models connecting exports and eco-innovation

Table 5
Exports t-1 effects over eco-innovations.

	PROD			PROC			INCRE			RADI		
	MATER	ENERGY	ENVIR	MATER	ENERGY	ENVIR	MATER	ENERGY	ENVIR	MATER	ENERGY	ENVIR
$MATER_{i,\ t-1}$	0.463*** (0.070)			0.323*** (0.075)			0.729** (0.284)			0.713** (0.322)		
$ENERGY_{i,\ t-1}$		0.476*** (0.074)			0.399*** (0.086)			0.732** (0.302)			0.379*** (0.023)	
$ENVIR_{i,\ t-1}$			0.628*** (0.083)			0.588*** (0.175)			0.358*** (0.021)			0.375*** (0.029)
$EXPORT_{i,t-1}$	0.005** (0.002)	0.004** (0.002)	0.001* (0.001)	0.001 (0.002)	0.002 (0.002)	0.001 (0.001)	0.005* (0.015)	0.006** (0.003)	0.004*** (0.002)	0.002 (0.003)	0.005** (0.002)	0.003* (0.002)
R&D INTENSITY $_{i,t-1}$	0.061 (0.055)	0.037 (0.058)	−0.064* (0.033)	3.49E-04 (0.052)	−0.009 (0.052)	−0.043 (0.032)	−0.006 (0.015)	−0.033 (0.041)	−0.008 (0.033)	−0.058 (0.095)	−0.066 (0.085)	−0.139* (0.077)
$SIZE_{i,t}$	−0.027* (0.016)	−0.034** (0.016)	−0.036*** (0.008)	−0.012 (0.014)	−0.020 (0.014)	−0.018** (0.007)	−0.038** (0.016)	−0.048** (0.020)	−0.048*** (0.009)	−0.028 (0.026)	−0.052** (0.020)	−0.058*** (0.017)
$AGE_{i,t}$	0.008 (0.010)	−0.007 (0.010)	−0.014** (0.006)	0.010 (0.009)	−0.003 (0.009)	−0.007 (0.006)	−1.98E-04 (0.011)	−0.115 (0.010)	−0.009 (0.010)	−0.005 (0.015)	−0.020 (0.015)	−0.031** (0.014)
$\_CONST_{i,t}$	−0.390 (0.517)	−0.107 (0.551)	0.773** (0.314)	0.154 (0.487)	0.241 (0.491)	0.521* (0.290)	0.122 (0.203)	0.397 (0.433)	0.345 (0.318)	0.607 (0.884)	0.811 (0.788)	1.483** (0.719)
AR(1)	−3.96***	−4.15***	−9.29***	−8.44***	−9.25***	−4.38***	−2.39**	−2.22**	−2.46**	−3.11***	−2.38**	−3.07***
AR(2)	1.07	1.25	1.94*	0.95	0.57	1.93*	1.81*	1.96*	1.62	1.45	1.93*	0.85
Hansen P-value	0.06*	0.2	0.5	0.4	0.2	0.2	0.8	0.9	0.1	0.1	0.2	0.2
Firms	4002	4002	4002	4002	4002	4002	3354	3354	3354	3354	3354	3354
Observations	20,402	20,402	20,402	20,402	20,402	20,402	14,423	14,423	14,423	14,423	14,423	14,423

GMM-two step. Robust standard errors in parentheses ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

Table 6
Exports (t-1 and t-2) effects over eco-innovations.

	PROD			PROC			INCRE			RADI		
	MATER	ENERGY	ENVIR	MATER	ENERGY	ENVIR	MATER	ENERGY	ENVIR	MATER	ENERGY	ENVIR
$MATER_{i,\ t-1}$	0.438*** (0.068)			0.313*** (0.086)			0.754** (0.313)			0.482*** (0.156)		
$ENERGY_{i,\ t-1}$		0.645*** (0.243)			0.487*** (0.090)			0.450** (0.209)			0.615** (0.269)	
$ENVIR_{i,\ t-1}$			0.387** (0.164)			0.556*** (0.157)			0.442** (0.193)			0.377*** (0.025)
$EXPORT_{i,t-1}$	0.002* (0.001)	0.003* (0.002)	−1.11E-04 (0.001)	0.002 (0.003)	−0.002 (0.002)	0.001 (0.001)	−1.43E-04 (0.002)	3.01E-04 (0.001)	2.50E-05 (6.92E-05)	2.72E-05 (8.26E-05)	−0.002 (0.001)	0.001* (0.001)
$EXPORT_{i,t-2}$	0.001 (4.89E-04)	0.001 (0.001)	1.35E-04*** (4.66E-5)	−0.001 (0.002)	0.002 (0.002)	−6.08E-05 (5.42E-05)	2.14E-04*** (6.30E-05)	1.46E-04*** (0.035)	1.60E-04*** (2.40E-05)	3.13E-06 (6.34E-05)	0.002*** (0.001)	0.001* (0.001)
R&D INTENSITY $_{i,t-1}$	0.054 (0.048)	0.047 (0.066)	−0.025 (0.023)	3.70E-04 (0.056)	−0.041 (0.031)	−0.043 (0.032)	−0.064 (0.059)	−0.023 (0.035)	−0.007 (0.011)	−0.006 (0.010)	0.002 (0.083)	0.004 (0.028)
$SIZE_{i,t}$	−0.023* (0.012)	−0.021 (0.024)	−0.030*** (0.007)	−0.010 (0.014)	−0.013* (0.007)	−0.016** (0.007)	−0.025 (0.024)	−0.040*** (0.015)	−0.030*** (0.009)	−0.019*** (0.006)	−0.016 (0.018)	−0.026*** (0.006)
$AGE_{i,t}$	0.015 (0.010)	0.006 (0.011)	−0.010 (0.007)	0.014 (0.010)	2.28E-04 (0.007)	−0.006 (0.006)	−0.003 (0.011)	2.97E-04 (0.009)	−0.007 (0.008)	0.005 (0.007)	−0.005 (0.014)	−0.008 (0.009)
$\_CONST_{i,t}$	−0.311 (0.454)	−0.326 (0.692)	0.532** (0.227)	0.128 (0.525)	0.524* (0.287)	0.508* (0.292)	0.736 (0.652)	0.551 (0.356)	0.373*** (0.140)	0.244** (0.122)	0.143 (0.785)	0.172 (0.271)
AR(1)	−9.83***	−3.76***	−3.85***	−5.00***	−3.41***	−4.59***	−3.15***	−3.53***	−3.67***	−4.64***	−4.03***	−16.09***
AR(2)	1.91*	1.42	0.48	0.32	1.27	1.59	1.88*	1.89*	1.58	1.84*	1.32	0.34
Hansen P-value	0.1	0.2	0.1	0.3	0.3	0.3	0.7	0.5	0.1	0.2	0.3	0.2
Firms	3584	3584	3584	3584	3584	3584	3034	3034	3034	3034	3034	3034
Observations	16,914	16,914	16,914	16,914	16,914	16,914	11,757	11,757	11,757	11,757	11,757	11,757

GMM-two step. Robust standard errors in parentheses ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

Table 7
Outward FDI t-1 effects over eco-innovations.

	PROD			*PROC*			*INCRE*			*RADI*		
	MATER	***ENERGY***	***ENVIR***	***MATER***	***ENERGY***	***ENVIR***	***MATER***	***ENERGY***	***ENVIR***	***MATER***	***ENERGY***	***ENVIR***
$MATER_{i,\ t\text{-}1}$	0.932** (0.422)			0.448*** (0.032)			0.381*** (0.037)			0.299*** (0.041)		
$ENERGY_{i,\ t\text{-}1}$		0.566** (0.266)			0.442*** (0.031)			0.758*** (0.164)			0.337*** (0.045)	
$ENVIR_{i,\ t\text{-}1}$			0.366*** (0.036)			0.684*** (0.241)			0.376*** (0.046)			0.305*** (0.050)
$OUTWARD_{\ i,t\text{-}1}$	−0.753 (1.036)	−0.131 (0.345)	0.025* (0.014)	0.083 (0.102)	0.038 (0.317)	−0.112 (0.119)	0.064 (0.152)	0.575 (0.651)	0.063 (0.127)	0.292*** (0.103)	0.138 (0.115)	−0.285 (0.278)
$R\&D\ INTENSITY_{\ i,t\text{-}1}$	0.028 (0.039)	−0.143** (0.062)	−0.010 (0.005)	−0.012 (0.018)	0.016 (0.056)	−0.007 (0.007)	−0.006 (0.021)	−0.217* (0.115)	−0.001 (0.023)	0.016 (0.020)	0.018 (0.019)	0.063 (0.068)
$SIZE_{i,t}$	0.216 (0.268)	−0.048 (0.030)	−0.025*** (0.005)	−0.007 (0.009)	−0.008 (0.021)	−0.018* (0.010)	−0.031*** (0.012)	0.005 (0.049)	−0.023** (0.011)	0.003 (0.010)	−0.014 (0.010)	−0.034** (0.015)
$AGE_{i,t}$	−0.063 (0.074)	0.010 (0.030)	−4.92E-06 (0.012)	0.003 (0.013)	−0.007 (0.026)	0.007 (0.012)	0.028 (0.017)	−0.043 (0.052)	−0.001 (0.015)	−0.017 (0.017)	−0.028* (0.016)	0.006 (0.024)
$\_CONST_{\ i,t}$	−0.851 (1.095)	1.542*** (0.518)	0.342*** (0.062)	0.229 (0.183)	0.055 (0.048)	0.228 (0.146)	0.282 (0.224)	1.719* (0.978)	0.241 (0.235)	−0.047 (0.202)	0.119 (0.199)	−0.133 (0.502)
AR(1)	−2.61***	−2.96***	−13.37***	−14.73***	−14.66***	−3.53***	−12.45***	−4.81***	−10.49***	−11.86***	−11.37***	−8.40***
AR(2)	1.88*	1.91*	1.53	1.09	0.42	1.44	0.09	1.30	0.32	1.11	0.30	0.54
Hansen P-value	0.6	0.6	0.3	0.3	0.2	0.5	0.9	0.6	0.3	0.3	0.1	0.5
Firms	1194	1194	1194	1194	1194	1194	1022	1022	1022	1022	1022	1022
Observations	5476	5476	5476	5476	5476	5476	4054	4054	4054	4054	4054	4054

GMM-two step. Robust standard errors in parentheses***p < 0.01; **p < 0.05; *p < 0.1.

Table 8
Outward FDI (t-1 and t-2) effects over eco-innovations.

	PROD			*PROC*			*INCRE*			*RADI*		
	MATER	***ENERGY***	***ENVIR***	***MATER***	***ENERGY***	***ENVIR***	***MATER***	***ENERGY***	***ENVIR***	***MATER***	***ENERGY***	***ENVIR***
$MATER_{i,\ t\text{-}1}$	0.800** (0.345)			0.477*** (0.033)			0.393*** (0.044)			0.279*** (0.044)		
$ENERGY_{i,\ t\text{-}1}$		0.273** (0.123)			0.452*** (0.037)			0.389** (0.190)			0.304*** (0.064)	
$ENVIR_{i,\ t\text{-}1}$			0.380*** (0.041)			0.576*** (0.078)			0.374*** (0.056)			0.324*** (0.054)
$OUTWARD_{\ i,t\text{-}1}$	−2.861 (2.075)	1.672 (1.823)	0.307* (0.179)	0.044 (0.053)	−0.053 (0.090)	−0.093 (0.066)	0.039 (0.196)	0.076 (0.815)	1.334 (1.165)	0.127*** (0.048)	0.854 (1.210)	−0.174 (0.290)
$OUTWARD_{\ i,t\text{-}2}$	2.847 (2.163)	−2.136 (1.686)	0.268 (0.176)	−0.030 (0.054)	0.187* (0.111)	0.112* (0.067)	−0.061 (0.194)	−0.596 (0.803)	−1.719 (1.283)	−0.057 (0.055)	−1.201 (1.295)	0.180 (0.226)
$R\&D\ INTENSITY_{\ i,t\text{-}1}$	−0.005 (0.009)	−0.157 (0.136)	−2.67E-04 (0.022)	−0.019 (0.017)	−0.206 (0.149)	−0.004 (0.006)	2.06E-04 (0.024)	−0.040 (0.074)	−0.225** (0.105)	−0.016 (0.018)	0.011 (0.069)	0.01 (0.044)
$SIZE_{i,t}$	−0.002 (0.030)	−0.078*** (0.029)	0.005 (0.022)	−0.011** (0.005)	0.215*	0.041 (0.035)	−0.039* (0.021)	−0.071** (0.029)	−0.065** (0.027)	0.059 (0.064)	−0.048** (0.022)	−0.021** (0.009)
$AGE_{i,t}$	−0.006 (0.040)	0.042 (0.053)	−0.056 (0.036)	0.005 (0.010)	−0.068*	−0.013 (0.026)	0.036 (0.032)	0.054* (0.032)	0.031 (0.039)	−0.040 (0.036)	0.014 (0.032)	−0.014 (0.015)
$\_CONST_{\ i,t}$	0.130 (0.178)	1.892 (1.170)	0.092 (0.272)	0.323** (0.151)	0.823 (0.993)	−0.073 (0.184)	0.266 (0.291)	0.863 (0.735)	2.343** (0.941)	0.076 (0.237)	0.393 (0.668)	0.108 (0.372)
AR(1)	−2.74***	−4.14***	−11.46***	−12.67***	−11.53***	−6.68***	−10.43***	−3.30***	−4.94***	−10.18***	−7.69***	−8.12***
AR(2)	1.94*	1.93*	1.89*	0.59	0.56	1.26	1.09	1.94*	1.68	1.17	0.62	0.69
Hansen P-value	0.9	0.9	0.9	0.2	0.8	0.3	0.5	0.2	0.4	0.3	0.9	0.6
Firms	961	961	961	961	961	961	824	824	824	824	824	824
Observations	4292	4292	4292	4292	4292	4292	3116	3116	3116	3116	3116	3116

GMM-two step. Robust standard errors in parentheses***p < 0.01; **p < 0.05; *p < 0.1.

(Table 5), we can observe as the previous eco-innovation *(material and energy-efficiency,* and *environment-responsiveness)* affects positively to current eco-innovation in product, process, incremental and radical eco-innovations, which is shown by the lag t-1 of our dependent variable. The persistence in eco-innovation, or in other words, the path dependence of the eco-innovation, has been confirmed in different studies Jové-Llopis and Segarra-Blasco (2018), Raymond et al. (2010), Triguero et al. (2018) and Triguero and Córcoles (2013).

The exports status affects positively to all type of eco-innovations in product and incremental (m*aterial and energy efficiency and environmental responsiveness),* and in radical innovation *(energy efficiency and environmental responsiveness)*. These results contribute to the mixed evidence of the relationship -Exports and Eco-innovations- considering the type of innovation (process and product) pointed out by Aguilera-Caracuel et al. (2012), Borghesi et al. (2012), Cainelli et al. (2012), de Marchi (2012), Hojnik et al. (2018); Luan et al. (2016), Peñasco et al. (2017) and Zhu et al. (2012).

Regarding our control variables, R&D INTENSITY behaves no significant for all models, except for product *environmental responsiveness* in product and radical innovation. where the value is negative. This result could be justified but the short-term disruption effects as it is argued in Gkypali and Love (2021). In addition, it should be noticed that this country is embedded in a weak innovation system in which R&D intensity could not be considered the main driver of eco-innovation, as it has been pointed out in Fernández et al. (2021). These authors argued that there are other determinants as cooperation, breadth of external sources or external R&D that boost eco-innovations. SIZE negatively affects all types of product and incremental eco-innovations, while for radical we only found such evidence for *energy efficiency* and *environment responsiveness* and in process only for *environmental responsiveness*. This result confirms that small firm's eco-innovate more than large firms as the finding obtained by Marzucchi and Montresor (2017) to product innovation. Finally, we have found negative evidence for AGE in *environmental responsiveness* for product and radical innovation. This is in line with those arguments that consider that young firms are more environmental responsible (Peeters and de la Potterie, 2007; Ziegler and Rennings, 2004).

Sequential effects of exports over eco-innovation confirms our previous results (Table 6). When introducing EXPORTS_{t-1} and EXPORTS_{t-2} into the model, we find a positive and significant relationship of the second lag in *environmental responsiveness* for product innovation, *material, energy efficiency* and *environmental responsiveness* in incremental innovation, and *energy efficiency and environmental responsiveness* in radical innovation. Therefore, we can conclude that some of the effects of exports over eco-innovations take longer to drive eco-innovations and they are significant only after two years.

These results also show as the level of significance (significant at 1%) of EXPORTS in the second lag is higher than in the previous table when we were analyzing only one lag (significant at 5%). Therefore, it supports the need of introduction of time for the analysis of the relationship between Internationalization-Eco-innovation (Gkypali and Love, 2021; Rezende et al., 2019). Moreover, it is shown as the lag of the dependent variable (previous eco-innovation) is significant in all the estimations. Finally, the rest of the control variables behaves like the previous estimations. Therefore, we can confirm our H1 for eight out of twelve dependent variables -for product and incremental eco-innovation, and partially for radical innovation, while we have not found evidence for process eco-innovations-.

Regarding the models connecting outward FDI and eco-innovations (Tables 7 and 8), we have found that previous eco-innovations affect positively to eco-innovations in all our models. Therefore, the path dependence of the eco-innovation processes is also confirmed in our MNE models (Jové-Llopis and Segarra-Blasco, 2018; Triguero et al., 2018).

Results highlight that there is a learning process by outward FDI manifested in the increase of eco-innovations. In this sense, we show as the effects of the Outward FDI affects *environment responsiveness* in product innovation and *material efficiency* in radical innovation. We have not found more evidence for the rest of our dependent variables. These results contribute to the mixed evidence found in the literature: Chiarvesio et al. (2015), de Marchi (2012) and Duque-Grisales et al. (2019) showed a positive relationship, while Cainelli et al. (2012) and Peñasco et al. (2017) did not find evidence. In addition, these results are only in favor of MNE as the “world engine” of eco-practices in two out of our twelve dependent variables.

Regarding our control variables, R&D INTENSITY is negative and significant in product and incremental *energy efficiency*, arguing the short-term disruption effects as it is argued in Gkypali and Love (2021) and the searching of other eco–drivers abroad given the weaknesses in the innovation system (Fernández et al., 2021). SIZE behaves negative and significant for all our model except for *energy and material efficiency* in product, process and radical innovations and e*nergy efficiency* in incremental innovations. In addition, AGE is negative and significant for *energy efficiency* in radical innovation. These results are in favor, again, of those arguments that support that young firms are more eco-innovators (Peeters and de la Potterie, 2007; Ziegler and Rennings, 2004).

Sequential learning by FDI is found introducing in our estimations also Outward FDI $_{t-1}$ and Outward $\text{FDI}_{t-2.}$ in Table 8. We reinforce the evidence that Outward FDI $_{t-1.}$ status affects the current volume of product *environmental responsiveness* and radical *material efficiency*. However, this effect disappears when we introduce the second lag. In addition, we have found two effects of this relationship that take longer to appear on time: *energy efficiency and environmental responsiveness* affects positively to process innovation considering the second lag. Therefore, we can conclude that some effects of learning by FDI take longer to lead to eco-innovations and they are significant only after two years in process *-energy efficiency and environmental responsiveness-*. These results help to define the relationship -MNE & eco-innovations-, since is needed a period for the manifestation of the knowledge effects in innovation outputs (Santos-Arteaga et al., 2019). Again, these results show evidence of the path dependence process in innovations studies (Raymond et al., 2010; Triguero and Córcoles, 2013). The rest of the control variables behaves similarly to the previous estimations.

These results have shown the relationship between Outward FDI and

Table 9
Summary of hypothesis results.

Hypotheses	Type	RESULTS
H1-Exports effects over eco-innovations		
Eco-product	Material-efficiency	Supported
	Energy-efficiency	Supported
	Environment-responsiveness	Supported
Eco-process	Material-efficiency	Not Supported
	Energy-efficiency	Not Supported
	Environment-responsiveness	Not Supported
Eco-Incremental	Material-efficiency	Supported
	Energy-efficiency	Supported
	Environment-responsiveness	Supported
Eco-Radical	Material-efficiency	Not Supported
	Energy-efficiency	Supported
	Environment-responsiveness	Supported
H2- Outward FDI effects over eco-innovations		
Eco-product	Material-efficiency	Not Supported
	Energy-efficiency	Not Supported
	Environment-responsiveness	Supported
Eco-process	Material-efficiency	Not Supported
	Energy-efficiency	Supported
	Environment-responsiveness	Supported
Eco-Incremental	Material-efficiency	No Supported
	Energy-efficiency	Not Supported
	Environment-responsiveness	Not Supported
Eco-Radical	Material-efficiency	Supported
	Energy-efficiency	Not Supported
	Environment-responsiveness	Not Supported

eco-innovations for a limited type of eco-innovations. In view of the above, we can confirm our hypothesis 2 only partially. Table 9 summarizes our set of hypotheses with the obtained results.

As robustness check, we replicate the third equation considering now the other direction of the foreign investment -inward FDI-. These results are found in Tables 10 and 11. Results show as inward FDI affects positively to eco-innovation in process innovation *-energy efficiency-,* incremental eco-innovation *-material efficiency-, and* radical eco-innovation *-energy efficiency-*. We have not found evidence for product eco-innovations. In these models, we have also found a path-dependence of eco-innovation in all our estimations and control variable behaves similarly to previous estimations. Regarding our second model considering Lag 1 and Lag 2, previous findings are confirmed. These results agree with the previous background of positive relationship between foreign equity and the propensity to eco-innovate (Chiarvesio et al., 2015; de Marchi, 2012; Duque-Grisales et al., 2019).

5. Conclusions

This paper analyzes one specific driver of eco-innovation -Internationalization-. Considering exports and Outward Foreign Direct Investment (FDI), we tried to test whether the exports status and the Multinational Enterprises (MNE) status of firms affect eco-innovations *–material and energy efficiency and environment responsiveness-*according to the type of innovation (product and process) and the degree of novelty (incremental and radical). Using an intermediate country in technological terms -Spain- and GMM estimations in the period 2008–2016, we show how exports effects over eco-innovative practices are greater and appear earlier than the effects of FDI over eco-innovation practices.

Specifically, our results show as H1 -the effect of exports over eco-innovation- has been confirmed by 8 of our 12 dependent variables: product innovation and incremental innovation*-material, energy efficiency and environment responsiveness-* and radical innovation*-energy efficiency and environment responsiveness-*, while our H2 -the effect of outward FDI over eco innovation-is satisfied just in 4 of our 12 dependent variables: product innovation *-environment responsiveness-*, process innovation *-energy efficiency and environment responsiveness-* and radical innovation *-material efficiency-*. In addition, our robustness test indicates that the network of the MNE also matters for the developing of eco-practices. In this sense, we have found evidence of inward FDI in 3 of our dependent variables: process innovation *-energy efficiency-,* incremental innovation *-material efficiency-,* and radical innovation *-energy efficiency-*.

The above general findings are described in Fig. 5 -the sequential effects of internationalization over eco-innovations-. This figure shows in the horizontal axis the internationalization strategies over time -exports and FDI-, and in the vertical axis the eco-innovative practices. Firstly, the figure indicates as both types of international strategies have positive effect over environmental innovation (the slope of the continuous line -exports- and discontinuous line -outward FDI- is positive). However, as this figure shows, eco-learning effects using export appear in t+1, while most of the eco-learning effects by outward FDI appear in t+2, showing the need of more time for acquiring the green practices abroad. Therefore, effects of eco-practices acquired abroad using exports appears before than those eco-practices using foreign direct investment.

Our main contribution in the literature is the introduction of the causal direction between internationalization and eco-innovations, analyzing therefore an external aspect of the drivers of eco-innovations: exports and outward FDI. Our results differ from the studies that analyze the effects of internationalization as a driver of green practices in the following senses. Firstly, we offer a complete picture considering two internationalization strategies -exports and outward FDI- and analyzing their effects over time on eco-practices, following those authors who argue the need of a lag structure for the analysis of this relationship (Galbreath et al., 2021, and the Gkypali and Love, 2021). In this sense, while there are some inconclusive results

Table 10
Inward FDI t-1 effects over eco-innovations.

	PROD			PROC			INCRE			RADI		
	MATER	*ENERGY*	*ENVIR*	*MATER*	*ENERGY*	*ENVIR*	*MATER*	*ENERGY*	*ENVIR*	*MATER*	*ENERGY*	*ENVIR*
MATER$_{i,\ t-1}$	0.669** (0.324)			0.976*** (0.335)			0.311*** (0.028)			0.664*** (0.093)		
ENERGY$_{i,\ t-1}$		0.465* (0.257)			0.550*** (0.127)			0.476** (0.202)			0.333*** (0.034)	
ENVIR$_{i,\ t-1}$			0.324** (0.146)			0.711*** (0.223)			0.374*** (0.028)			0.734*** (0.124)
INWARD $_{i,t-1}$	0.226 (0.184)	0.195 (0.157)	0.050 (0.053)	0.410 (0.374)	0.740** (0.638)	0.170 (0.121)	0.147* (0.078)	0.107 (0.098)	0.097 (0.155)	0.115 (0.041)	0.653** (0.325)	0.209 (0.266)
R&D INTENSITY $_{i,t-1}$	−0.053 (0.056)	−0.104* (0.053)	−0.008 (0.012)	−0.082 (0.115)	−0.075 (0.111)	0.023 (0.042)	−0.020 (0.016)	−0.025 (0.017)	−0.021 (0.054)	−0.004 (0.014)	−0.025 (0.112)	−0.164 (0.124)
SIZE$_{i,t}$	−0.043** (0.020)	−0.063*** (0.020)	−0.034*** (0.009)	−0.053 (0.046)	−0.086* (0.044)	−0.016 (0.013)	−0.054*** (0.009)	−0.045*** (0.017)	−0.044*** (0.017)	−0.020*** (0.008)	−0.083** (0.037)	−0.058* (0.035)
AGE$_{i,t}$	0.003 (0.011)	−0.008 (0.010)	−0.009 (0.009)	−0.001 (0.011)	−0.006 (0.015)	−2.20E-04 (0.007)	0.022** (0.011)	−0.001 (0.009)	−0.003 (0.010)	0.003 (0.007)	−0.011 (0.018)	−0.009 (0.012)
_CONST $_{i,t}$	0.661 (0.526)	1.295*** (0.486)	0.413*** (0.138)	0.804 (1.080)	0.946 (1.049)	−0.102 (0.375)	0.532*** (0.154)	0.570*** (0.194)	0.527 (0.506)	0.168 (0.141)	0.616 (1.053)	1.651 (1.145)
AR(1)	−2.71***	−2.77***	−3.95***	−3.27***	−5.64***	−3.99***	−17.12***	−3.65***	−15.06***	−6.79***	−14.36***	−5.56***
AR(2)	1.86*	1.49	0.16	1.45	1.03	1.91*	1.36	1.84*	0.44	1.76*	1.52	1.37
Hansen P-value	0.3	0.1	0.2	0.4	0.2	0.4	0.9	0.3	0.5	0.2	0.5	0.7
Firms	2013	2013	2013	2013	2013	2013	1686	1686	1686	1686	1686	1686
Observations	9929	9929	9929	9929	9929	9929	7187	7187	7187	7187	7187	7187

GMM-two step. Robust standard errors in parentheses ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

Table 11
Inward FDI (t-1 and t-2) effects over eco-innovations.

	PROD			PROC			INCRE			RADI		
	MATER	ENERGY	ENVIR	MATER	ENERGY	ENVIR	MATER	ENERGY	ENVIR	MATER	ENERGY	ENVIR
$MATER_{i,\ t-1}$	0.330*** (0.104)			0.510*** (0.101)			0.516*** (0.108)			0.622*** (0.113)		
$ENERGY_{i,\ t-1}$		0.509** (0.199)			0.541*** (0.118)			0.863*** (0.287)			0.844*** (0.300)	
$ENVIR_{i,\ t-1}$			0.423*** (0.024)			0.401*** (0.030)			0.382*** (0.034)			0.347*** (0.041)
$INWARD_{i,t-1}$	1.384 (1.331)	0.902 (0.587)	0.672 (0.439)	1.112 (0.876)	0.909* (0.507)	0.022 (0.052)	0.913* (0.512)	0.576 (1.533)	1.245 (0.964)	0.080 (0.066)	0.096* (0.058)	0.437 (0.411)
$INWARD_{i,t-2}$	−1.074 (1.222)	−0.577 (0.521)	−0.572 (0.381)	−0.976 (0.786)	−0.665 (0.452)	0.048 (0.041)	−0.595 (0.375)	−0.535 (1.402)	−1.299 (0.845)	0.004 (0.077)	0.020 (0.067)	−0.415 (0.306)
$R\&D\ INTENSITY_{i,\ t-1}$	−0.012 (0.056)	−0.056 (0.051)	−0.055 (0.047)	0.004 (0.052)	−0.005 (0.047)	−4.85E-04 (0.012)	−0.019 (0.058)	0.115 (0.142)	-.145** (0.071)	−0.005 (0.015)	0.002 (0.017)	−0.042 (0.045)
$SIZE_{i,t}$	−0.055** (0.021)	−0.060*** (0.019)	−0.044*** (0.015)	−0.018 (0.017)	−0.030** (0.014)	−0.019** (0.008)	−0.058*** (0.021)	0.007 (0.025)	−0.053*** (0.020)	−0.019* (0.011)	−0.014 (0.014)	−0.033** (0.015)
$AGE_{i,t}$	0.012 (0.013)	−0.007 (0.012)	−0.009 (0.009)	0.007 (0.008)	−0.004 (0.008)	−0.008 (0.008)	0.010 (0.014)	0.008 (0.013)	−0.019 (0.014)	0.002 (0.008)	−0.005 (0.007)	−0.008 (0.010)
$\_CONST_{i,t}$	0.430 (0.507)	0.819* (0.448)	0.804* (0.427)	0.116 (0.470)	0.240 (0.424)	0.227* (0.118)	0.464 (0.552)	−0.978 (1.240)	1.699** (0.660)	0.185 (0.154)	0.071 (0.246)	0.643 (0.423)
AR(1)	−3.69***	−4.35***	−13.99***	−5.40***	−6.50***	−16.05***	−5.96***	−4.28***	−5.20***	−5.83***	−3.54***	−10.73***
AR(2)	1.85*	1.94*	0.72	0.52	1.10	1.30	1.56	1.89*	1.88*	1.81*	1.76*	0.17
Hansen P-value	0.9	0.7	0.1	0.3	0.2	0.5	0.7	0.8	0.2	0.1	0.5	0.3
Firms	1744	1744	1744	1744	1744	1744	1469	1469	1469	1469	1469	1469
Observations	8026	8026	8026	8026	8026	8026	5713	5713	5713	5713	5713	5713

GMM-two step. Robust standard errors in parentheses ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

about the relationship between export and eco-innovative practices without considering time (Borghesi et al., 2012; Cainelli et al., 2012; de Marchi, 2012; Hojnik et al., 2018; Luan et al., 2016; Peñasco et al., 2017; Zhu et al., 2012), there are just a few analyses focusing on the internationalization process through outward FDI (Cainelli et al., 2012; Chiarvesio et al., 2015; de Marchi, 2012; Duque-Grisales et al., 2019; Peñasco et al., 2017). Therefore, we also contribute to the relationship between MNE and eco-practices introducing FDI as an international strategy of firms -inward and outward FDI-.

On the other hand, we analyze the effect of international strategy on eco-innovation considering the type of innovation -product and process- and the degree of novelty -radical and incremental-, which has not been considered until now. Finally, we carry out a deep analysis of FDI and its connection of green practices, fulfilling with the call for paper indicated in Chiarvesio et al. (2015) and, we consider the degree of novelty as pointed out by Peñasco et al. (2017).

These results have several implications for managers and policy makers. On the one hand, government should promote and coordinate the internationalization policies by exports and FDI as a green path for acquiring eco-practices. More specifically, regarding FDI, it has been tested as our two variables of FDI -Outward and Inward FDI- have a positive effect over eco-innovation practices. In this sense, government should promote FDI as international strategy, but at the same time, policies promoting the attraction of foreign companies in a country would be needed. Therefore, both types of FDI -inward and outward FDI- will have positive effects for the increase of the eco-innovation levels.

On the other hand, managers should be aware of the internationalization strategy as a way for increasing eco-innovations. Managers need to consider the internationalization process as a path to upgrade and diversity products to match the needs of domestic and foreign eco-products. In this sense, the connection between export and eco-innovation appears to be easier than the connection between FDI -both inward FDI and Outward FDI- and eco-innovations due to these latter effects are not manifested immediately and require more time. In addition, managers should be aware that internationalization could be the main driver for the acquisition of eco-innovative practice, particularly in those countries that are not leader technologically (Hojnik et al., 2018).

These results are subject to several limitations. On the one hand, learning abroad is a complex process. Even when we have followed a lag structure (two time of periods) considering the internationalization status of firms and its ex-post effects on eco-innovative practices as Salomon and Jin (2010); Salomon and Shaver (2005a), and Santos-Arteaga et al. (2019), this analysis have some limitations and we cannot confirm that these effects were caused only for the learning abroad. Other variables regarding the institutions as a moderator in this relationship would be also proposed as future research. On the other hand, we could not control by the host destination of the FDI, and this could limit the effects outward FDI and exports over eco-practices. In addition, we have analyzed this relationship in a sample of Spanish firms. Therefore, we should be cautious in the generalization of this results.

Finally, we propose as future research to go further in this analysis considering different countries samples. Moreover, it should deal with the analysis of the relationship -internationalization strategy and eco-practices- considering the technological sectors and introducing the host destination.

CRediT authorship contribution statement

Celia Torrecillas: Conceptualization, Methodology, Writing – original draft, Writing – review & editing, Supervision. **Sara Fernández:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing, Supervision.

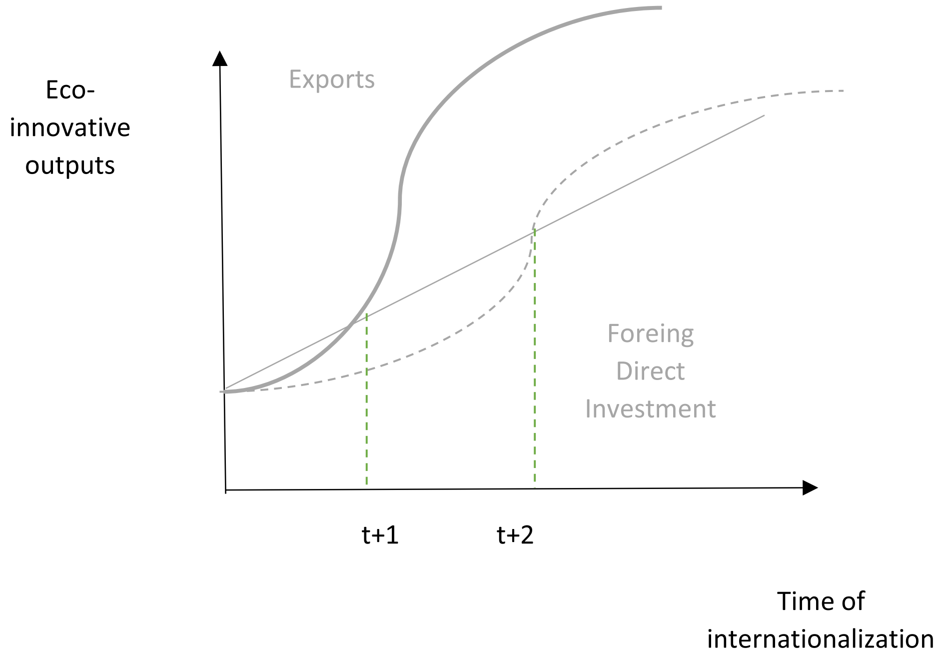

Fig. 5. Dynamic of the relationship Internationalization & Eco-innovation.
Source: Own elaboration

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements[1]

Authors gratefully acknowledge the linguistic correction of Braulio Soto in the previous version of this paper. The authors would like to recognize the valuable comments received in the EIBA 2021 in Madrid. In addition, authors acknowledge funding from INFESE Project -PID2020-112984GBC21- funded by the Ministry of Economy and Innovationof Spain. The usual disclaimer applies.

APPENDIX

Table A.1
Descriptive statistics

Dependent Variables	Mean	Std, Dev,	Min	Max
Prod-Mater	0.3478	0.4763	0	1
Prod-Energy	0.3550	0.4785	0	1
Prod-Envir	0.2863	0.4520	0	1
Proc-Mater	0.3192	0.4662	0	1
Proc-Energy	0.3158	0.4649	0	1
Proc-Envir	0.2730	0.4455	0	1
Incre-Mater	0.3848	0.4865	0	1
Incre-Energy	0.3951	0.4889	0	1
Incre-Envir	0.3233	0.4677	0	1
Radi-Mater	0.2633	0.4404	0	1
Radi-Energy	0.2678	0.4428	0	1
Radi-Envir	0.2032	0.4024	0	1
Independent Variables	Mean	Std. Dev.	Min	Max
EXPORT	30.8485	40.8116	0	100
OUTWARD FDI	0.3435	0.4749	0	1
INWARD FDI	0.3193	0.4662	0	1
R&D INTENSITY	8.1236	1.3102	0.7703	13.2499
SIZE	3.9997	1.4227	0	9.2339
AGE	3.2937	0.5825	0	5.1985

Table A.2
Correlation Matrix

	EXPORT	OUTWARD FDI	INWARD FDI	R&D INTENSITY	SIZE	AGE
EXPORT	1					
OUTWARD FDI	−0.1058	1				
INWARD FDI	0.1634	−1.0000	1			
R&D INTENSITY	0.0685	0.0498	−0.0601	1		
SIZE	0.1868	−0.1255	0.2195	−0.2524	1	
AGE	0.0821	0.0486	0.0878	−0.1202	0.3107	1

References

Aguilera-Caracuel, J., Hurtado-Torres, N.E., Aragón-Correa, J.A., 2012. Does international experience help firms to be green? A knowledge-based view of how international experience and organisational learning influence proactive environmental strategies. Int. Bus. Rev. 21, 847–861.

Alvarez, I., Torrecillas, C., 2020. Interactive learning processes and mergers and acquisitions in national systems of innovation. Transnat. Corpor. Rev. 12, 63–81.

Arellano, M., Bond, S., 1991. Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. Rev. Econ. Stud. 58 (2), 277–297.

Arellano, M., Bover, O., 1995. Another look at the instrumental variable estimation of error-components models. J. Econom. 68 (1), 29–51.

Arellano, M., Carrasco, R., 2003. Binary choice panel data models with predetermined variables. J. Econom. 115 (1), 125–157.

Aw, B.Y., Chung, S., Roberts, M.J., 2000. Productivity and turnover in the export market: micro-level evidence from the Republic of Korea and Taiwan (China). World Bank Econ. Rev. 14 (1), 65–90.

Bond, S.R., 2002. Dynamic panel data models: a guide to micro data methods and practice. Portuguese Econ. J. 1 (2), 141–162.

Borghesi, S., Cainelli, G., Mazzanti, M., 2012. The European Emission Trading Scheme and Environmental Innovation Diffusion: Empirical Analyses Using Italian CIS Data. UNIFE-Dipartimento di Economia Istituzioni Territorio. Quaderno n.1/2012. http://out.economia.unife.it/uploads/dip_deit/quaderni/201201.pdf.

Cainelli, G., Mazzanti, M., Montresor, S., 2012. Environmental innovations, local networks and internationalization. Ind. Innovat. 19 (8), 697–734.

Cassiman, B., Golovko, E., 2011. Innovation and internationalization through exports. J. Int. Bus. Stud. 42 (1), 56–75.

Chiarvesio, M., De Marchi, V., Di Maria, E., 2015. Environmental innovations and internationalization: theory and practices. Bus. Strat. Environ. 24, 790–801.

Chung, S., 2014. Environmental regulation and foreign direct investment: evidence from South Korea. J. Dev. Econ. 108, 222–236.

Cohen, W.M., Levinthal, D.A., 1990. Absorptive capacity: a new perspective on learning and innovation. Adm. Sci. Q. 35 (1), 128–152.

D'Agostino, L.M., 2015. How MNEs respond to environmental regulation: integrating the Porter hypothesis and the pollution haven hypothesis. Econ. Politic. 32 (2), 245–269.

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

de Marchi, V., Grandinetti, R., 2013. Knowledge strategies for environmental innovations: the case of Italian manufacturing firms. J. Knowl. Manag. 17 (4), 569–582.

del Río, P., Romero-Jordán, D., Peñasco, C., 2017. Analyzing firm-specific and type-specific determinants of eco-innovation. Technol. Econ. Dev. Econ. 23 (2), 270–295.

Dosi, G., 1988. The nature of the innovative process. In: Dosi, G., et al. (Eds.), Technical Change and Economic Theory. Pinter, London, pp. 221–235.

Duque-Grisales, E., Aguilera-Caracuel, J., Guerrero-Villegas, J., García-Sánchez, E., 2019. Can proactive environmental strategy improve Multilatinas' level of internationalization? The moderating role of board independence. Bus. Strat. Environ. 29 (1), 291–305.

Fernández, S., Torrecillas, C., Labra, R.E., 2021. Drivers of eco-innovation in developing countries: the case of Chilean firms. Technol. Forecast. Soc. Change. https://doi.org/10.1016/j.techfore.2021.120902.

Galbreath, J., Chang, C.Y., Tisch, D., 2021. Are exporting firms linked to cleaner production? A study of eco-innovation in Taiwan. J. Clean. Prod. 303 (20) https://doi.org/10.1016/j.jclepro.2021.127029.

Galera-Quiles, M.C., Piedra-Muñoz, L., Galdeano-Gómez, E., Carreño-Ortega, A., 2021. A review of the Eco-Innovations and Exports Interrelationship, with special reference to international agrifood supply chain. Sustainability 13, 1378. https://doi.org/10.3390/su13031378.

García-Quevedo, J., Kesidou, E., Martínez-Ros, E., 2019. Driving sectoral sustainability via the diffusion of organizational eco-innovations. Bus. Strat. Environ. 29 (3), 1437–1447. https://doi.org/10.1002/bse.2443.

Gkypali, A., Love, J.H., 2021. Export status and SME productivity: learning to export versus learning by exporting. J. Bus. Res. 128, 486–498.

Golovko, E., Valentini, G., 2011. Exploring the complementarity between innovation and export for SMEs' growth. J. Int. Bus. Stud. 42 (3), 362–380.

Gujarati, D.N., 2003. Basic Econometrics. McGraw-Hill Education.

Ha, J.Y., 2021. Attention green aliens? Activities of multinational enterprises in host countries and eco-innovation diffusion. J. Bus. Res. 123, 32–43.

Hojnik, J., Ruzzier, M., Manolova, T.S., 2018. Internationalization and economic performance: the mediating role of eco-innovation. J. Clean. Prod. 171, 1312–1323.

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

Horbach, J., 2016. Empirical determinants of eco-innovation in European countries using the community innovation survey. Environ. Innov. Soc. Transit. 19, 1–14.

Jové-Llopis, E., Segarra-Blasco, A., 2018. Eco-innovation strategies: a panel data analysis of Spanish manufacturing firms. Bus. Strat. Environ. 27 (8), 1209–1220.

Kemp, R., Arundel, A., 1998. Survey Indicators for Environmental Innovation. IDEAreport. Step group, Oslo.

Labra, R., Torrecillas, C., 2018. Estimating dynamic Panel data. A practical approach to perform long panels. Rev. Colomb. Estadística 41 (1), 31–52.

Luan, C.J., Tien, C., Chen, W.L., 2016. Which "green" is better? An empirical study of the impact of green activities on firm performance. Asia Pac. Manag. Rev. 21 (2), 102–110.

Lundvall, B.Å., 2016. The Learning Economy and the Economics of Hope. Anthem Press, New York, NY.

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

OECD, 2005. Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data. The Measurement of Scientific and Technological Activities, third ed. OECD Publishing, Paris.

Peeters, C., de la Potterie, B.V.P., 2007. Innovation strategy and the patenting behavior of firms. In: Innovation, Industrial Dynamics and Structural Transformation. Springer, Berlin, Heidelberg, pp. 345–371.

Peñasco, C., Del Rio, P., Romero-Jordán, D., 2017. Analyzing the role of international drivers for eco-innovators. J. Int. Manag. 23, 56–71.

Raymond, W., Mohnen, P.A., Palm, F., Van der Loeff, S.S., 2010. Persistence of innovation in Dutch manufacturing: is it spurious? Rev. Econ. Stat. 92, 495–504.

Rezende, L.D.A., Bansi, A.C., Alves, M.F.R., Galina, S.V.R., 2019. Take your time: examining when green innovation affects financial performance in multinationals. J. Clean. Prod. 233, 993–1003.

Roodman, D., 2009. A note on the theme of too many instruments. Oxf. Bull. Econ. Stat. 71 (1), 135–158.

Salomon, R.M., Shaver, J.M., 2005. Learning by exporting: new insights from examining firm innovation. J. Econ. Manag. Strat. 14 (2), 431–460.

Salomon, R., Jin, B., 2010. Does knowledge spill to leaders or laggards? Exploring industry heterogeneity in learning by exporting. J. Int. Bus. Stud. 39 (1), 132–150.

Santos-Arteaga, F.J., Torrecillas, C., Tavana, M., 2019. Dynamic effects of learning on the innovative output and productivity in Spanish multinational enterprises. J. Technol. Tran. 44 (1), 97–131.

Triguero, A., Córcoles, D., 2013. Understanding innovation: an analysis of persistence for Spanish manufacturing firms. Res. Pol. 42 (2), 340–352.

Triguero, A., Córcoles, D., Cuerva, M.C., 2014. Persistence of innovation and firm's growth: evidence from a panel of SME and large Spanish manufacturing firms. Small Bus. Econ. 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. Sustain. Prod. Consum. 15, 49–64.

Tsai, K.H., Liao, Y.C., 2017. Innovation capacity and the implementation of eco-innovation: toward a contingency perspective. Bus. Strat. Environ. 26 (7), 1000–1013.

Vernon, R., 1992. Transnational corporations. Where are they coming from, where are they headed? Transnatl. Corp. 1 (2), 7–35.

Wagner, M., 2007. On the relationship between environmental management, environmental innovation and patenting: evidence from German manufacturing firms. Res. Pol. 36, 1587–1602.

Zhu, Q., Sarkis, J., Lai, K.H., 2012. Internationalization and environmentally-related organizational learning among Chinese manufacturers. Technol. Forecast. Soc. Change 79 (1), 142–154.

Ziegler, A., Rennings, K., 2004. Determinants of Environmental Innovations in Germany: Do Organizational Measures Matter? ZEW-Centre for European Economic Research Discussion Paper (04-030).