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Dimension effects in the relationship between eco-innovation and firm performance: A European comparison

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Abstract

This study investigates the effect of eco-efficiency actions on firm performance, considering both turnover and employment growth, in the European enterprises with different firm size classes. The sample includes 63303 firms from 13 different European Union countries. The main contributions of this work are the use of the most recent Community Innovation Survey (CIS) and the consideration of firms' size when analysing the relationship between the introduction of environmental benefits and firm performance. Using the ordinary least squares and simultaneous equation models the results showed that eco-innovations may affect negatively turnover growth as well as employment growth, a result which is not sensitive to firms' size. However, environmental benefits introduced in products, demanded by the end user, are sensitive to the different size class to which the enterprise belongs. Both human capital and the number of adopted eco-innovation strategies influence positively firm performance, revealing to be more sensitive to the firm size. Overall, policy makers should be aware of the size as an important driver, or conditioning factor, for firm performance when forcing firms to introduce policies regarding environmental benefits.

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Keywords: Community innovation survey; Dimension effects; Eco-innovation; Europe; Firm performance

1. Introduction

Researchers have tried to understand how eco-innovation strategies are implemented by firms in order to accomplish the goal of reducing environmental impacts. However, strategies adopted by firms may affect firm performance as well and this issue is still widely debated [1]. If, for a long time, economists, policy-makers and business managers believed that eco-strategies necessarily increased firms' internal costs but not their profits, recent evidence [1–4] reveal diversity in the empirical results, ranging from negative to positive links between eco-innovation and firm performance. Thus, mixed evidence turns clear that this relationship is still poorly understood and indicates the

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need to investigate this linkage, especially considering firms' size and their easier access to financing in order to be able to invest in eco-innovation strategies and the impact in firm performance that might bring.

Eco-innovation is often evaluated by the enterprises actions in order to the development of products and processes that contribute to sustainable development. On the side of firm performance, different concepts are used in the literature to measure it, such as: productivity (value added, gross output, turnover per employee), growth (in terms of sales or turnover growth), employment growth and financial measures (operating margins, return on sales, Tobin's Q).

A recent literature survey regarding the relationship between eco-innovation and firm performance is provided by [2] showing that different conclusions have emerged with respect to this relationship. The study of [5] reveals the relation between firm size and diffusion of eco-innovations, whereas [6] provide a literature review of the diffusion of eco-innovations. Also, [7] use the Flash Eurobarometer survey (Attitudes of European Entrepreneurs towards Eco-innovation) from the European Commission (launched to 5222 managers of SMEs in the 27 EU Member States between January and February 2011) to analyse the incidence of eco-innovation across sectors and firm size classes. The authors conclude that medium-high technology manufacturing firms are more overrepresented in eco-product innovations, while medium-low technology firms are overrepresented in performing eco-process innovations, but no particular group is especially overrepresented or underrepresented in eco-organizational innovation. They also state that there are very significant differences in the composition of innovators and non-innovators as regards firm size, since there is a significantly larger share of mid-sized firms amongst all types of innovators. In [7], size is showed as a proxy for potential barriers for eco-innovation, provided that small companies face more difficulties to apply environmental innovations. Although firm size is not found to have any effect on the probability of a firm carrying out environmental product or process innovations in [8], the result of [7] is in line with previous literature that shows that the firm size has a positive effect on environmental activities in general [9].

This study contributes to the previous literature in several ways. First, the European sample of firms is mostly composed by small and medium enterprises (considering the entire sample contained within the CIS 2014 survey, a great part of the enterprises has less than 50 employees; see Table 2). It must be stressed the relevant role of small and medium enterprises in the European economies, which have received lower attention regarding that most of the studies focus on large firms [1,10] Furthermore, short run costs incurred by these firms regarding eco-innovations are higher and they face higher financial constraints, with lower access to external financing sources [11]. Second, firm size analysis of eco-innovations at firm level are still [1,9,12]. Different firms (considering size dimension) have different environmental costs and adopt different eco-innovation strategies, mostly due to money scarcity and hard financing access, thus turning important an analysis considering the dimension of the firms [1,13]. This enables to understand which are the most relevant and possible eco-innovations followed by different sized firms. Moreover, differently sized firms follow different motivations or incentives. Therefore, policy makers should be aware of the causes, which move these firms to adopt one or other eco-innovation strategy. Third, there are few studies that focus on the eco-innovation strategies and when they do it, they are presented in a disguised way, considering also other countries and or not considering firm size. The work of [1] is an exception, as it presents a study only for the European SMEs. In the present article we include other dimensions: small- (less than 50 employees), medium- (between 50 and 250 employees) and large-sized firms (more than 250 employees).

Additionally, as far as we are aware, the existent literature for European countries does not consider the more recent CIS 2014 survey. The CIS survey is a three years period survey, where only the 2008 (2006–2008) and 2014 survey (2012–2014) directly ask firms if they have adopted any eco-innovation strategy and if these are related to product, process, marketing or organizational innovations. Finally, despite the fact that the connection between eco-strategies and firm performance has been examined extensively for countries that have been members of the EU for many years, little is known for new EU members, at the group level, considering firm dimension. Although a lot more remains to be done within the field, we have considered different firm dimensions in order to analyse if the relationship between turnover growth (TG) and eco-innovation strategies changes among them. Conclusions undertaken could help managers bringing a win–win strategy for firms and society, as well as designing more effective eco-innovation policies in the future.

The study has, however, some limitations, namely with respect to the data availability that does not allow us taking a deeper look on other factors that influence turnover and employment growth, and that obliges to restrict the analysis to a cross section regression. Nevertheless, results suggest that conclusions undertaken are not sensitive to the estimation technique used and that employee's education have a positive and significant influence in both turnover and employment growth, when considering the entire sample of European enterprises, still being sensitive

to the firms' size classes. Results also seem to indicate that environmental benefits obtained within the enterprise have a negative impact over both performance measures considered, turnover growth and employment growth, independently of the firm size. The same is not true when considering environmental benefits obtained during the consumption or use of a good or service by the end user, provided that results reveal to be sensitive to the firm size class considered. Moreover, the number of environmental benefits encompassed by firms answering the CIS 2014 survey and the percentage of employees in 2014 with a tertiary degree (more than 25%) revealed to have a positive and significant impact over firm performance, showing also to be sensitive to different size classes. Therefore, policy makers should consider dimension issues when defining policies regarding the introduction of environmentally friendly innovations in the European firms, since these may both impact firm's turnover growth, and more importantly, condition employment growth within enterprises. Finally, it has been shown that results are consistent independently of the different estimation techniques used (in this study three different estimation techniques are presented).

The remaining of the article is structured as follows. Section 2 presents the database, some descriptive statistics, the variables and the econometric methodology. Section 3 shows our main findings and results and Section 4 presents our conclusions and the consequent policy implications.

2. Data and methodology

Our sample is composed by 63 303 firms, which answered the European CIS 2014 (the most recent CIS where data with respect to eco-innovation measures is available). Eco-innovations are measured on ten different areas of environmental impacts, as for instance, reducing material or water use, energy, pollution or recycling, as can be seen in Table 1. One of the questions to be answered was: "During the three years 2012 to 2014, did your enterprise

Table 1. Variables description.
Source: Own elaboration based on CIS 2014 questionnaire, section 13.

Environmental benefits obtained within the enterprise		
ecomat	Reduced material or water use per unit of output	1 = yes; 0 = no
ecoeno	Reduced energy use or CO2 footprint (reduced total CO2 production)	1 = yes; 0 = no
ecopol	Reduced air, water, noise or soil pollution	1 = yes; 0 = no
ecosub	Replaced a share of materials with less polluting or hazardous substitutes	1 = yes; 0 = no
ecorep	Replaced a share of fossil energy with renewable energy sources	1 = yes; 0 = no
ecorec	Recycled waste, water, or materials for own use or sale	1 = yes; 0 = no
	Number of environmental benefits obtained within the enterprise	0 to 6
EBWE	Introduced any environmental benefit within the enterprise	1 = yes; 0 = no
Environmental benefits obtained during the consumption or use of a good or service by the end user		
ecoenu	Reduced energy use or CO2 footprint	1 = yes; 0 = no
ecopos	Reduced air, water, noise or soil pollution	1 = yes; 0 = no
ecorea	Facilitated recycling or product after use	1 = yes; 0 = no
ecoext	Extended product life through longer-lasting, more durable goods	1 = yes; 0 = no
	Number of environmental benefits obtained by the end user	0 to 4
EBEU	Introduced any environmental benefit by the end user	1 = yes; 0 = no
ECOBREATH	Number of environmental benefits encompassed by CIS2014	0 to 10
ECOBREATH2	Squared values of ECOBREATH	Square of 0 to 10
Other variables		
empud	Percent of employees in 2014 with a tertiary degree: 0% = 0; 1%–5% = 1; 5%–10% = 2; 10%–25% = 3; 25%–50% = 4; 50%–75% = 5; 75% or more = 6	
empud1	If less than or equal to 25%	If empud <= 3 => 1; 0 otherwise
empud2	If more than 25%	If empud <= 4 => 1, 0 otherwise
SIZE1	If number employees under 50	1; 0 otherwise
SIZE2	If number employees from 50 until 249	1; 0 otherwise
SIZE3	If number of employees above 250	1; 0 otherwise
turn_growth	Turnover growth between 2012 and 2014	
emp_growth	Employees growth between 2012 and 2014	

introduced a product (good or service), process, organizational or marketing innovation with any of the following environmental benefits?". Environmental benefits could be obtained within the enterprise or during the consumption or use of a good or service by the end user. More details about these variables are provided in Table 1. Turnover growth was restricted to values no higher than 100.

Data analysis was implemented considering that our dependent variable is a growth rate. The independent variables are represented by a binary-choice variable $x = 1$ if the event occurs and $x = 0$ otherwise. A cross-section regression was run for two dependent variables, the turnover growth and the employment growth between 2012 and 2014, and considering different firm size classes. Turnover is defined as the market sales of goods and services, including all taxes except VAT, being a useful measure of a business's health, though it is often confused with profit. Even if it is sometimes referred to as gross revenue, or income, it is different from profit, which is a measure of earnings. Turnover is one of the key measures of a business's performance. It is used throughout the lifetime of a business, from planning and securing investment to performance measurement, and also to a company value in the event of a sale. The main drawback is the use of a cross-sectional dataset, so the problem of simultaneity is somewhat unavoidable. Moreover, we cannot consider the possible lagged effect due to the natural delay between adoption of eco-innovation strategies and firm performance by firm size classes. Nevertheless, so far these have been problems common to all studies that use CIS. Another disadvantage is related with the, employment growth variable, which is the growth of the total number of full-time permanent workers, used as a measure of the increase in employment as more resources in production. This can be seen as positive, provided that firms are creating new jobs, but can be seen as a source of inefficiency, as more resources are used in the production process, which might not always be in an efficient way. Both turnover and employment measures are expressed as bi-annualized growth rates.

Table 2 presents a summary of the percentage of firms by countries and size. Most of the firms in our sample are small firms and there are countries like Cyprus where only small firms have answered the survey. However, Slovakia is the only country for which we have no small firms. As expected, and considering the fact that most of the firms in Europe are SMEs, the lowest percentage of firms' representativeness in the sample is that of large firms.

The methodology used consist in both OLS and simultaneous equation models. These equations are applied when phenomena are assumed to be reciprocally causal. Provided that we cannot consider time lags, we may suppose that causal effects are simultaneous in time, and complex as well, considering that variables behave simultaneous providing reasoning for the use of both two stages least squares (2SLS) and three stages least squares models (3SLS). The 2SLS model is an equation-by-equation technique where the endogenous regressors on the right-hand side of each equation are being instrumented with the regressors, conducting estimations in two steps. The 3SLS model is used also for robustness check and can be seen as a special case of multi-equation generalized method

Table 2. Percentage of firms by size.
Source: Own elaboration.

Country	Small	Medium	Large	All	Number
BG	77.17	19.28	3.56	22.43	14 202
CY	9.48	0.00	0.00	2.13	1 346
CZ	31.06	4.68	0.81	8.20	5 191
DE	20.84	12.11	11.27	9.92	6 281
EE	7.65	4.11	0.61	2.77	1 756
EL	12.65	3.81	1.20	3.96	2 507
HR	13.53	7.65	1.73	5.14	3 252
HU	29.98	13.63	4.36	10.76	6 813
LT	9.57	5.49	1.90	3.81	2 409
LV	6.36	3.20	0.94	2.36	1 491
PT	33.34	13.37	3.13	11.18	7 079
RO	26.45	23.75	7.46	12.94	8 190
SK	0.00	16.96	2.66	4.40	2 786
Total (number)	39 491	18 182	5629		63 303

Notes: BG-Bulgaria; CZ-Czech Republic; DE-Germany; EE-Estonia; EL-Greece; HR-Croatia; CY-Cyprus; LV-Latvia; LT-Lithuania; HU-Hungary; PT-Portugal; RO-Romania; SK-Slovakia.

of moments (GMM) where the set of instrumental variables is common to all equations. Results are presented in Table 3.

Table 3. OLS, 2SLS and 3SLS estimation results.
Source: Own elaboration.

Dependent TG		OLS			Dependent EG			
	All	Size1	Size2	Size3	All	Size1	Size2	Size3
EBWE	−0.323***	−0.318**	−0.345**	−0.269*	−0.145***	−0.145***	−0.151**	−0.151*
EBEU	−0.344**	−0.373*	−0.290	−0.295	−0.155**	−0.125	−0.191*	−0.229
ECOBREATH2	0.125**	0.127	0.115	0.116	0.060***	0.054*	0.066*	0.084
empud2	0.060**	0.088**	−0.029	0.130**	0.013	0.016	0.009	0.003
SIZE1	0.288				0.471			
SIZE2	0.202				0.446			
SIZE3	0.106				0.415			
Constant	0.168	0.451***	0.394***	0.237***	−0.242	0.228***	0.208***	0.171***
RMSE	3.0088	3.2365	2.765	1.904	1.196	1.244	1.153	0.965
R2	0.0012	0.0006	0.001	0.002	0.001	0.001	0.001	0.001
Dependent TG		2SLS			Dependent EG			
	All	Size1	Size2	Size3	All	Size1	Size2	Size3
EBWE	−0.323***	−0.318**	−0.345**	−0.269*	−0.145***	−0.145***	−0.151**	−0.151*
EBEU	−0.344**	−0.373*	−0.290	−0.295	−0.155**	−0.125	−0.191*	−0.229
ECOBREATH2	0.125**	0.127	0.115	0.116	0.060***	0.054*	0.066*	0.084
empud2	0.060**	0.088**	−0.029	0.130**	0.013	0.016	0.009	0.003
SIZE1	0.288				0.471			
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RMSE	3.0088	3.2365	2.765	1.904	1.196	1.244	1.153	0.965
R2	0.0012	0.0006	0.001	0.002	0.001	0.001	0.001	0.001
Dependent TG		3SLS			Dependent EG			
	All	Size1	Size2	Size3	All	Size1	Size2	Size3
EBWE	−0.323***	−0.318**	−0.345**	−0.269*	−0.145***	−0.145***	−0.151**	−0.151*
EBEU	−0.344**	−0.373*	−0.290	−0.295	−0.155**	−0.125	−0.191*	−0.229
ECOBREATH2	0.125**	0.127	0.115	0.116	0.060***	0.054*	0.066*	0.084
empud2	0.060**	0.088**	−0.029	0.130**	0.013	0.016	0.009	0.003
SIZE1	0.288				0.471			
SIZE2	0.202				0.446			
SIZE3	0.106				0.415			
Constant	0.168	0.451***	0.394***	0.237***	−0.242	0.228***	0.208***	0.171***
RMSE	3.0087	3.2363	2.765	1.903	1.199	1.244	1.153	0.965
R2	0.0012	0.0006	0.001	0.002	0.001	0.001	0.001	0.001

Notes: Variables have been defined in Table 2. Size1, Size2, Size3 represent Small, Medium and Large firms, respectively. Dependent variables: TG — turnover growth and EG — employment growth.
*Represent coefficients statistical significance at 10%.
**Represent coefficients statistical significance at 5%.
***Represent coefficients statistical significance at 1%.

3. Results and discussion

In this section all the estimations performed are presented, considering both the total and the size class sample of the 13 European countries' firms, as well as the two independent variables (TG and EG). Results in Table 3 respect to the three different econometric models applied for robustness check. When considering OLS estimations for both dependent variables (TG and EG), the introduction of eco-innovations with environmental benefits obtained within the enterprise (EBWE) and during the consumption or use of good or service by the end user (EBEU), has a negative and significant impact on both performance measures. This may be explained by the increased costs incurred when adopting eco-innovations, inducing also negative effects in both turnover growth and employment

growth. These results favour those of [11] and [13]. Although only for large firms, results in [1] also point for the high costs incurred by firms by adopting more environmentally friendly innovations. This result is curiously similar to all firm size classes regarding EBWE, but not significant regarding EBEU.

Both, the squared value of the number of environmental benefits encompassed by firms answering the CIS 2014 survey (ECOBREATH2; in order to capture non-linear effects, more specifically, curvilinear effects) and the percentage of employees in 2014 with a tertiary degree (if more than 25% - empud2), have a positive and significant impact over firm performance. Both are significant for the entire sample when considering TG, but the same is not true when considering EG. Nevertheless, empud2 is relevant to explain positive TG impacts in different size classes, while ECOBREATH2 is relevant to explain positive EG impacts in different size classes. Thus, human capital positively contributes to turnover growth, especially in small and large-sized firms, while curvilinear effects of eco-innovations adopted within the firm and those obtained during the consumption of a good or service by the end user influence positively employment growth in small and medium sized firms.

Regarding the independent dummy variables of size for the entire sample, these do not reveal to be statistically significant in neither estimation technique. However, from Table 3, it can be observed that by size classes, TG and EG are significantly explained by the different eco-innovation strategies adopted. In terms of robustness check, under both 2SLS and 3SLS techniques we may observe that EBWE is still significant and exerts a negative impact over both TG and EG at different firms' size classes.

Both 2SLS and 3SLS results evidence that for all firms EBEU has a negative impact over firm performance (measured either by TG or EG), although significant for only small firms when considering TG and for medium firms when EG is considered. Regarding ECOBREATH2 and empud2, results obtained by 2SLS and 3SLS are similar to those in the OLS estimations and reinforce the fact that different firm size classes may feel the impact of eco-innovations introduction over firm performance differently. This should raise awareness of policy makers to also consider size as a relevant variable when trying to force firms to introduce environmental benefits or to achieve environmental goals. It is also clear that although firms place efforts to improve their image with respect to consumers, either enforced by the end user or simply by firms' awareness, they can harm financial performance, or even lead to superior employment costs. This can also justify why firms are limited, with respect to their environmental efforts and benefits implementation regarding environmentally friendly practices.

4. Conclusions

We analyse data from 63 303 firms in Europe, from thirteen countries, which have answered the most recent released CIS survey (2014) that includes a separate section regarding eco-innovation adoptions. Overall, we may argue that environmental benefits obtained within the enterprise have negative effects over firm performance, independently of the size of the firms. This may be justified by the increased costs supported, which is a good indication of the increased efforts required to firms when adopting eco-innovations. Results seem to indicate that these translate into lower firm turnover growth and reduced employment rates. Therefore, policy makers should be aware of the difficulties faced by firms when introducing environmental benefits. These results indicate that additional support is needed for these firms, either by subsidies or by providing other benefits, as lower taxes, in order to compensate firms for the additional costs incurred. However, while environmental benefits obtained within the enterprise impact over firm performance is transversal to all firm size classes, the same is not true regarding environmental benefits obtained during the consumption or use of a good or service by the end user. For small firms, additional costs are imposed by the end user demand for environmental benefits, turning image issues harder to adopt and thus reducing firms' turnover growth. Additionally, end user demands are harder in terms of employment growth for medium sized firms. Thus, policy makers should take firm size as crucial into the relationship between eco-innovations and firm performance.

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References

[1] Jové-Llopis E, Segarra-Blasco A. Eco-efficiency actions and firm growth in european SMEs. Sustainability 2018;10(281):1–26.
[2] Barbieri N, Ghisetti C, Gilli M, Marin G, Nicolli F. A survey of the literature on environmental innovation based on main path analysis. J Econ Surv 2016;30:596–623.
[3] Dixon-Fowler HR, Slater DJ, Johnson JL, Ellstrand AE, Romi AM. Beyond does it pay to be green? a meta-analysis of moderators of the CEP-cfp relationship. J Bus Ethics 2013;112:353–66.
[4] Albertini E. Does environmental management improve financial performance? a meta-analytical review. Org Env 2013;26:431–57.
[5] Hockerts K, Wüstenhagen R. Greening goliaths versus emerging davids – theorizing about the role of incumbents and new entrants in sustainable entrepreneurship. J Bus Ventur 2010;25(5):481–92.
[6] Karakaya E, Hidalgo A, Nuur C. Diffusion of eco-innovations: A review. Renew Sustain Energy Rev 2014;33:392–9.
[7] Triguero A, Moreno-Mondéjar L, Davia MA. Drivers of different types of eco-innovation in european SMEs. Ecol Econ 2013;92:25–33.
[8] Wagner M. Empirical influence of environmental management on innovation: evidence from europe. Ecol Econ 2008;66:392–402.
[9] Wagner M, Van Phu N, Azomahou T, Wehrmeyer W. The relationship between the environmental and economic performance of firms: An empirical analysis of the european paper industry. Corp Soc Resp Environ Manag 2002;146:133–46.
[10] Melnyk SA, Sroufe RP, Calantone R. Assessing the impact of environmental management systems on corporate and environmental performance. J Opt Manag 2003;21(3):329–51.
[11] Ghisetti C, Mancinelli S, Mazzanti M, Zoli M. Financial barriers and environmental innovations: Evidence from EU manufacturing firms. Clim Policy 2016;3062:1–17.
[12] Aragón-Correa JA, Hurtado-Torres N, Sharma S, García-Morales VJ. Environmental strategy and performance in small firms: A resource-based perspective. J Environ Manag 2008;86:88–103.
[13] Mavi RK, Saen RF, Goh M. Joint analysis of eco-efficiency and eco-innovation with common weights in two-stage network DEA: A big data approach. Technol Forecast Soc Change 2019;144:553–62. http://dx.doi.org/10.1016/j.techfore.2018.01.035.