4th International Conference on Energy and Environment: bringing together Engineering and Economics
Guimarães, Portugal
16-17 May, 2019

EUROPEAN ASSESSMENT OF SUPPORT FOR ECO-INNOVATION: IMPACTS OVER FIRM PERFORMANCE

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KEYWORDS
Eco-innovation, European countries, Firm Performance

ABSTRACT

This work uses a sample of 63303 European firms, which answered the Community Innovation Survey (CIS) for the period 2012-2014, to relate the eco-innovation strategies implemented as well as the factors able to justify their introduction with firm performance, measured through turnover and employment growth. A mixed-effects regression model was implemented in order to derive results from the estimations, whereas at the same time some statistical evidence was presented. Results point that not all eco-innovation strategies implemented increase firm performance, nor even the factors able to justify these introductions are the most effective to justify firm performance increases. Eco-Innovations related with extended product life through longer lasting, more durable goods, have a positive impact on turnover growth and employment. Firms seem to have introduced eco-innovations mostly due to existing environmental regulations, to improve the enterprise reputation, and due to the high cost of energy, water or materials. On the other side, government grants, subsidies or other financial incentives for environmental innovations and the need to meet requirements for public procurement contracts are the factors that European firms consider most irrelevant.

INTRODUCTION

The present environmental pressures, as well as the national and international policies and goals related to energy, emissions, recycling and waste, put a growing burden on governments and policy makers, but also on micro agents, such as households and companies. In particular, companies suffer from various types of incentives, pressures, or legal constraints related to these issues, to which they attempt to respond without jeopardizing their financial performance.
Eco-innovation appears as a way to comply with these requirements, but also as a way of differentiation and competitiveness. EIO (2012) refers to eco-innovation as any innovation that reduces the use of natural resources and decreases the release of harmful substances across the whole life-cycle. But could these innovations improve enterprise performance? Or do they mean higher costs and the diminishing of hired workers? The debate is very present in the literature (see for instance Jové-Llopis and Segarra-Blasco, 2018; Barbieri et al., 2016; Dixon-Fowler et al., 2013; Albertini, 2013) and contradictory results emerge.
There are studies in the literature that argue that investing in environmental innovations reduces negative externalities, but brings a direct cost to the company, jeopardizing its competitiveness (Palmer et al., 1995). Marin and Lotti (2017), for a sample of 11938 Italian manufacturing firms, used real value added per employee, to find that eco-innovations exhibit a lower return relative to other innovations. In another line are the studies that show that these investments bring returns to the company in the long term, as Porter and Linde (1995). These authors argue that well-designed regulation (pollution taxes and tradable permits) can stimulate eco-innovation, improving productivity and company profits.
Turnover growth is often used in the literature as a proxy for financial performance of the firms. For instance, Cainelli et al. (2011) found a negative effect of eco-innovation on turnover growth and a negative but not significant effect of labour productivity growth, considering a sample of 773 Italian service firms (using CIS II). More positive results were found by Colombelli et al. (2015), considering 456240 firms from 6 European countries, that state that firms adopting eco-innovations have higher growth rates than those adopting generic innovations. Also Jové-Llopis and Segarra-Blasco (2018) used turnover growth and found a positive relashionship between eco-innovation and firm growth, for 223 Slovenian firms. Hojnik and Ruzzier (2016) found that not all eco-strategies are positively related to better performance, using a sample of 11336 small and medium enterprises located in 28 European countries. They found that

enterprises using renewable energy and recycling or designing products that are easier to maintain, repair or reuse, perform better, whereas those that aim at reducing water or energy pollution seemed to show a negative correlation to firm growth.

Riillo (2017) examined the relationship between eco-innovation strategies of 890 Italian firms and their productivity using turnover per employee, and concluded that green practices are U-shaped related to performance. The same conclusion was reached by Soltmann et al. (2015), for 12 OECD countries, but using value added and considering sectors (patents). Jové-Llopis and Segarra-Blasco (2018), using an ordered logistic model, also found a U-shaped relationship between eco-strategies and firm growth, indicating that a greater breadth of eco-strategies is associated with better firm performance. For a sample of 555 Italian firms, Antonioli et al. (2016) conclude that some firms' productivity performance is positively related with eco-innovation.

Turnover per employee is also used by Doran and Ryan (2012) and Doran and Ryan (2016) for a sample of 2181 Irish firms in the CIS 2006-2008. They found a positive and significant effect of eco-innovation on firm performance only through reduced CO_2 "footprint" and recycled waste, water or materials..

With this research we intend to contribute to the literature, first clarifying on the effects of different types of eco-innovations on firm's performance, considering both turnover and employment growth; second, there are few studies that focus on eco-innovation impacts at the European firm level, as most studies focus on individual countries and outdated samples (Mavi et al, 2018; Jové-Llopis and Segarra-Blasco, 2018); third, the scarce literature relating eco-innovation and firm performance in European countries does not consider the most recent CIS 2014 survey, as far as we are aware.

The goal of this article is to empirically examine whether firm performance (turnover growth (TG) and employment growth (EG)) is affected by four sets of variables: (i) by ten different types of eco-innovations adopted, (ii) by the kind of innovation adopted (product, process, organizational or marketing innovation) that drived environmental innovations (iii) by the factors driving the enterprise's decisions to introduce innovations with environmental benefits and (iv) by some control variables, as the firm size.

The remaining of this article is structured as follows. Next section presents the database, some descriptive statistics, the variables and the econometric methodology. The following section shows our main findings and results and the final section presents our conclusions and future work suggestions.

DATA AND METHODOLOGY

Several firms from different sectors answered the European CIS2014, where eco-innovations are measured on ten different areas of environmental impacts. The questions to be answered were: "During the three years 2012 to 2014, did your enterprise introduced a product (good or service), process, organisational 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. All environmental innovations had to be introduced during the three years' period, 2012 to 2014, the most recent CIS where data with respect to eco-innovation measures is available. After data adjustment, we arrived to a final sample of 63303 firms (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 0 otherwise. A cross-section regression was run for two dependent variables, the turnover growth and the employment growth between 2012 and 2014. Turnover is defined as the market sales of goods and services, including all taxes except VAT. Turnover is a useful measure of a business's health, though it is often confused with profit, and even if it is sometimes referred to as gross revenue, or income, it is different to profit, which is a measure of earnings. Turnover is one of the key measures of a business's performance. It's used throughout the life 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 that it is a cross-sectional dataset and so the problem of simultaneity is somewhat unavoidable, but so far this has been a problem common to all studies that use CIS. Employment growth, is the growth of the total number of full-time permanent workers, so it is used as a measure of the rise of employment as more resources in production. Both turnover and employment measures are expressed as biannualized growth rates.

Linear mixed models (LMMs) also called multilevel models can be thought of as a trade off between individual regressions (it has many estimates and lots of data, but is noisy) and aggregate data (is less noisy, but may lose important differences by averaging all samples within each firm). Therefore, linear mixed models rely somewhere inbetween. LMMs were used as a method for analyzing data that are non independent, multilevel/hierarchical, longitudinal, or correlated. This methodology is an extension of simple linear models allowing for both fixed and random effects.

Independent variables and control variables include all the variables presented in table 1, except turnover growth and employment growth that are our dependent variables. Altogether, each firm might have reported from 0 to 10 innovations with environmental benefits (the first two strands of variables in the table). To avoid multicollinearity

issues, separate estimations were performed. The second set of variables refer to the type of innovation adopted to reach environmental benefits, the third set to factors driving the enterprise's decisions to introduce innovations with environmental benefits, and the forth set refers to the control variables. As control variables we include size (a dichotomous variable) measured by the number of employees (Size1: 1 if under 50, 0 otherwise; Size2: 1 if from 50 until 249 employees, 0 otherwise; Size3: 1 if from 250 and more, 0 otherwise), and the percentage of the enterprise's employees with a tertiary degree in 2014 (Empud1: 1 if less than 25%; Empud2: 1 if more than 25%; 0 otherwise), as well as whether the firm has procedures in place to regularly identify and reduce environmental impacts.

Table 1: Description of variables

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
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
Environmental benefits due to the type of enterprise's innovation		
ecoprd	Product (goods or services) innovations	1=yes; 0=no
ecoprc	Process innovations	1=yes; 0=no
ecorg	Organisational innovations	1=yes; 0=no
ecomkt	Marketing innovations	1=yes; 0=no
Factors driving the enterprise's decisions to introduce innovations with environmental benefits		
enereg	Existing environmental regulations	High=3; Medium=2; Low=1; Not relevant=0
enetx	Existing environmental taxes, charges or fees	High=3; Medium=2; Low=1; Not relevant=1
enregf	Environmental regulations or taxes expected in the future	High=3; Medium=2; Low=1; Not relevant=2
engra	Governmet grants, subsidies or other financial incentives for environmental innovations	High=3; Medium=2; Low=1; Not relevant=3
endem	Current or expected market demand for environmental innovations	High=3; Medium=2; Low=1; Not relevant=4
enrep	Improving your enterprise's reputation	High=3; Medium=2; Low=1; Not relevant=5
enagr	Voluntary actions or iniciatives for environmental good practice within your sector	High=3; Medium=2; Low=1; Not relevant=6
encost	High cost of energy, water or materials	High=3; Medium=2; Low=1; Not relevant=7
enrequ	Need to meet requirements for public procurement contracts	High=3; Medium=2; Low=1; Not relevant=8
Other variables		
envid	Enterprise has procedures in place to regularly identify and reduce environmental impacts?*	1=yes; 0=no
empud1	Percent of employees in 2014 with a terciary degree: If less than or equal to 25%	If empud <=3 => 1; 0 otherwise
empud2	Percent of employees in 2014 with a terciary degree: 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_grow	Turnover growth between 2012 and 2014	
emp_grow	Employees growth between 2012 and 2014	

Note: * For example preparing environmental audits, setting environmental performance goals, ISO 14001 certification, ISO 50001 certification, etc.

In table 2 we present the percentage of firms, which have introduced eco-innovations (of the 10 different types) and that have simultaneously stated which of these environmental benefits were due to the type of enterprise's innovation (product, process, marketing and organizational), as well as the percentage of firms that introduced any of the 10 kinds of eco-innovation and jointly argued which factors have driven the enterprise's decisions to introduce innovations with environmental benefits (only considering the highly relevant possible answer).

For the entire sample of the European firms, those that have introduced any of the 10 types of eco-innovations, have done it due to process innovations (table 2), and the highest relevance attributed by firms to factors driving the enterprise's decisions to introduce innovations with environmental benefits was the existing environmental regulations, due to the high cost of energy, water or materials and to improve the enterprise's reputation. From table 2 it is visible that reduced material or water use per unit of output, reduced energy use or CO_2 footprint (reduced total CO_2 production) and the replacement of the fossil energy share by renewable energy sources were eco-innovations introduced mainly due to the high cost of energy, water or materials. Existing environmental regulations mainly justified the introduction of reduced air, water, noise or soil pollution and recycled waste, water, or materials for own use or sale. With respect to the improvement of the enterprise's reputation, firms seem to have replaced a share of materials with less polluting or hazardous substitutes, reduced energy use or CO_2 footprint, reduced air, water, noise or soil pollution, facilitated recycling or product after use and extended product life through longer-lasting, more durable goods.

Figure 1 presents, in a ranking, the percentage of firms that stated the relevance of the factors driving the enterprise's decision to introduce innovations with environmental benefits. It is possible to observe that government grants, subsidies or other financial incentives for environmental innovations, like the need to meet requirements for public procurement contracts, seem to be considered, by most of the European firms, as not being relevant for the introduction of eco-innovations. Current or expected market demand for environmental innovations and existing environmental taxes, charges or fees, also seem to be irrelevant within the context. Moreover, of medium importance for most of the firms are voluntary actions or iniciatives for environmental good practice within their activity sector.

Table 2: Percentage of enterprises with Eco-Innovations, mixed with the type and driver of innovation, size and employees qualification

	All European Firms									
1/1 (%)	ecomat	ecoeno	ecopol	ecosub	ecorep	ecorec	ecoenu	ecopos	ecorea	ecoext
ecoprd	2.39	2.69	2.33	2.24	0.86	2.44	2.49	2.10	1.98	2.37
ecoprc	3.22	3.85	3.34	2.63	1.10	3.32	2.61	2.40	2.29	2.20
ecorg	2.02	2.14	1.98	1.76	0.67	2.33	1.63	1.56	1.75	1.52
ecomkt	0.97	0.98	0.95	0.95	0.41	1.07	0.89	0.87	0.98	0.90
3 (High Relevance)/1 (%)										
enereg	3.11	3.67	3.45	2.67	1.15	3.61	2.74	2.6	2.43	2.16
enetx	1.68	1.97	1.84	1.47	0.62	2.02	1.44	1.41	1.35	1.19
enregf	1.74	2.02	1.90	1.52	0.71	1.96	1.59	1.51	1.40	1.26
engra	0.91	1.14	1.04	0.76	0.44	1.01	0.90	0.86	0.76	0.68
endem	1.36	1.56	1.38	1.30	0.58	1.43	1.46	1.30	1.21	1.20
enrep	3.07	3.79	3.38	2.79	1.14	3.46	2.87	2.63	2.52	2.44
enagr	2.15	2.71	2.40	1.89	0.87	2.50	1.96	1.84	1.79	1.59
encost	3.36	4.33	3.42	2.48	1.26	3.39	2.86	2.45	2.10	2.11
enrequ	1.00	1.19	1.05	0.94	0.36	1.17	0.98	0.92	0.89	0.87
1/1 (%)	ecomat	ecoeno	ecopol	ecosub	ecorep	ecorec	ecoenu	ecopos	ecorea	ecoext
envid	3.15	3.61	3.30	2.65	1.10	3.50	2.59	2.43	2.25	2.05
empud1	6.95	8.91	7.17	5.33	2.45	7.86	6.03	5.12	4.81	4.80
empud2	1.90	2.53	1.74	1.47	0.79	2.21	2.07	1.49	1.53	1.45
SIZE1	4.02	5.3	4.11	3.28	1.47	5.18	3.95	3.23	3.37	3.34
SIZE2	2.94	3.85	2.97	2.17	1.02	3.18	2.58	2.13	1.93	1.91
SIZE3	1.89	2.29	1.83	1.35	0.74	1.71	1.57	1.24	1.04	0.99

Note: See table 1 for variables description.

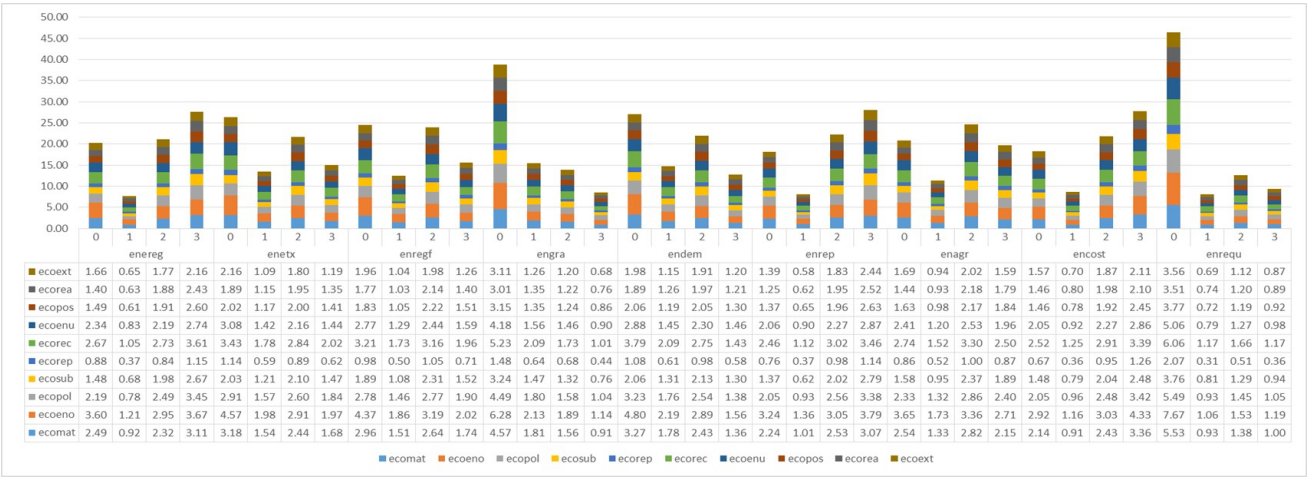

Figure 1: Factors driving the enterprise's decisions to introduce innovations with environmental benefits (European sample (2012-2014)

Note: See table 1 for variables description.

EMPIRICAL RESULTS

In this section it is intended to analyse the impact on firm performance (turnover growth (TG) and employment growth (EG)) considering four sets of variables: (i) any of the ten types of eco-innovations adopted, (ii) the kind of innovation, that is, product, process, organisational or marketing innovation (iii) the factors driving the enterprise's decisions to introduce innovations with environmental benefits and (iv) control variables. We present in table 3 the mixed-effects regression results considering both dependent variables, with different model specifications, combining the four sets of variables.

It is possible to infer from the results, that on one hand turnover growth seems to be significantly and negatively affected by the reduction of material or water used, the energy use or CO_2 footprint reduction, to recycling and also facilitated recycling or product after use. But on the other hand, it is positively influenced by reduced air, water, noise or soil pollution, replacement of a share of materials with less polluting or hazardous substitutes and extended product life through longer-lasting, more durable goods. This may be justified by the fact that firms intention to increase the enterprise's reputation may lead to higher costs, but at the same time reputation increases could lead to higher turnover growth, as for instance when the enterprise produces more durable goods.

Employment growth is negatively influenced by reduced energy use and recycling, but positively influenced by extended product life through longer-lasting, more durable goods. Both the results considering TG and EG, as well as firm performance measures, are sensitive to different model specifications. As results in table 3 seem to evidence, product, process and organizational enterprise's innovation types positively increase TG.

With respect to the factors driving the enterprise's decision to introduce innovations with environmental benefits, the high cost of energy, water or materials negatively impact TG and EG, but only when considered with the rest of the pool of variables used in estimations. When these factors are used individually, both the higher cost of energy, water or materials and the fact that the enterprise has procedures in place to regularly identify and reduce environmental impacts, seem to exert a positive and significant impact over TG and EG. For EG, also environmental regulations or taxes

expected in the future, affect it negatively, whereas the enterprise's reputation improvement and voluntary actions or initiatives for environmental good practice within the enterprise seem to justify EG increases.

Table 3: Mixed-effects regression results

Regression: Y	TG	TG	TG	TG	TG	EG	EG	EG	EG	EG
ecomat	-0,026		-0.067**			0,008		-0,018		
ecoeno	0.109**		-0.067*			0.067***		-0.039**		
ecopol	0,031		-0,012			0,021		-0,008		
ecosub	0.053*		0,015			0,012		-0,010		
ecorep	-0,035		-0,006			-0.036**		-0,022		
ecorec	0.103***		-0.074**			0.056***		-0.041***		
ecoenu	-0,012		-0.081*			0,005		-0,029		
ecopos	0.099*		0.090*			0,022		0,018		
ecorea	-0.070**		-0.106***			-0,024		-0.045**		
ecoext	0.097***		0,001			0.084***		0,033		
ecoprd		0,066	0.082*	0.209***			0,031	0,033	0.103***	
ecoprc		0,017	0,030	0.150***			0.043*	0.051**	0.123***	
ecorg		0,017	0,047	0.126***			0,008	0,021	0.067**	
ecomkt		-0,075	-0,047	-0,026			-0,006	0,007	0,018	
enereg		-0,027	-0,014		0,006		-0.029***	-0.022**		-0,010
enetx		0,028	0,024		0,007		0.023**	0.022**		0,014
enregf		-0,029	-0,022		-0,033		-0.019*	-0,015		-0.022*
engra		0,011	0,008		0,016		0,008	0,007		0,010
endem		0,004	0,010		0,005		-0,009	-0,007		-0,010
enrep		-0,022	-0,015		0,019		0,007	0,010		0.032***
enagr		0,007	0,019		0,025		0,011	0.018**		0.022***
encost		-0.036***	-0,013		0.029**		-0.013**	-0,002		0.023***
enrequ		0,027	0,021		0,010		0,010	0,006		0,002
envid		-0,048	-0,053		0.251***		-0.065***	-0.066***		0.101***
empud1		0,000	-0,025				-0,300	-0.283***		
empud2		0.062**	0,033				-0.286***	-0.271***		
SIZE1		0.442***	0.476***				0.526***	0.514***		
SIZE2		0.360***	0.393***				0.507***	0.494***		
SIZE3		0.262***	0.304***				0.478***	0.469***		
Wald chi2	299,73	1214,86	3486,21	102,34	153,09	368,91	1347,08	328+04	96,05	107,24
Prob > chi2	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000

Note: See table 1 for variables description. TG – Turnover growth; EG – Employment growth. *,**,*** statistical significance at 10%, 5% and 1%, respectively.

Looking at control variables, independently of the firm size, this variable positively influences both TG and EG. However, whereas the higher percentage of employees with a terciary degree leads to positive TG, it seems to decrease EG. Finally, some of the contradictory results can be justified by the increased cost due to eco-innovations introduction, the existent environmental regulations, the higher supported energy, water or materials cost, and the need for the improvement of the enterprises reputation.

CONCLUSIONS AND FURTHER RESEARCH

This work uses a sample of 63303 European firms, which answered the Community Innovation Survey for the period 2012-2014, where there was a section asking firms directly if they have introduced innovations with environmental benefits. We try to relate these eco-innovation implemented strategies as well as the factors able to justify their introduction with firm performance as measured through turnover and employment growth. A mixed-effects regression model was implemented in order to derive results from the estimations, whereas at the same time some statistical evidence was presented. Results seem to point that not all eco-innovation implemented strategies increase firm performance, nor even the factors able to justify these introductions are the most effective to justify firm performance increases. Eco-Innovations related with extended product life through longer lasting, more durable goods, have a positive impact on turnover growth and employment. This could mean that although the enterprise could have higher cost in producing more durable goods, even selling them at a higher price, it could raise the enterprise profits, by catching more clients, more awared about circular economy concepts and sensitive to the importance of buying more durable goods. These conclusions are in accordance with Hojnik and Ruzzier (2016). Firms seem to have introduced eco-innovations mostly due to existing environmental regulations, forcing them to implement these innovations with environmental benefits; also to improve the enterprise reputation, demonstrating image concerns; and due to the high cost of energy, water or materials, where costs increase but government grants, subsidies or other financial incentives for environmental innovations are insufficient to lead to firm performance increases. On the other side, it was possible to infer from the results that government grants, subsidies or other financial incentives for environmental innovations and the need to meet requirements for public procurement contracts are the factors that European firms consider most irrelevant.

The present work can be extended in several different ways like employing different model estimation techniques, which is not easy due to data limitations, which also limits the analysis to a cross-section analysis and prevents the use of panel data models or even time series analysis. Moreover, it would be important to perform a single country analysis to study whether the same pointed reasons emerge as relevant or irrelevant to justify the introduction of innovations with environmental benefits.

ACKNOWLEDGEMENTS

This paper is based on data from Eurostat, Community Innovation Survey (CIS), 2014. The responsibility for all conclusions drawn from the data lies entirely on the author(s). This work has been in part financially supported by the Research Unit on Governance, Competitiveness and Public Policy - GOVCOPP (project POCI-01-0145-FEDER-008540), funded by FEDER funds through COMPETE2020 - Programa Operacional Competitividade e Internacionalização (POCI) – and by national funds through FCT - Fundação para a Ciência e a Tecnologia. Any persistent error or missing's are the authors' entire responsibility.

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