ENVIRONMENTAL INNOVATION IN EUROPEAN TRANSITION COUNTRIES

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Abstract: *This paper explores the demand-pull, technology-push and regulation factors influencing the environmental innovation strategies. We focus on a subset of manufacturing firms of a group of European Transition Countries. The data available to investigate the driving factors that lead to eco-innovate are taken from the Community Innovation Survey data (CIS 2014). The data is a cross-section covering the three-year period between 2012 and 2014. We employ a multivariate probit model to observe the effect of several drivers on eco-innovation, captured by means of different measures. Empirical findings highlight that: (i) some drivers are common to some types of eco-innovation; (ii) regulation does have a positive impact on all drivers. The latter provides a clear-cut implication for policy-making. Broadly speaking, in transition economies public policies and incentives appear to trigger environmental innovation much more than demand-pull factors.*

Keywords: *environmental innovation, European Transition countries, demand-pull, technology-push, regulation*

Jel Codes: Q55; Q58; L6

INTRODUCTION

Eco-innovation is widely defined as "*product, process, marketing, and organizational innovations, leading to a noticeable reduction in environmental burdens"* (Horbach et al.,2012:119). Even if such definition is not universally acceptd environmental innovation has become an important goal of the European Union's policy strategies. In the latest years eco-innovation has also become a part of firms' strategy due to the influence and pressure of different stakeholders such as regulators, consumers, suppliers and competitors. In fact, eco-innovation appears to be a win-win strategy because it combines business goals and the reduction of environmental damage (Porter and Van der Linde, 1995).

There is a growing amount of research which attempts to examine the drivers and the determinants of eco-innovation (Mazzanti, 2018; Ghisetti et al., 2017; Horbach et al, 2012; Horbach, 2008; Rennings and Rammer, 2011; Lin et al. 2014, Marin et al., 2015). However, the topic is rather unexplored for European Transition countries. Therefore, this paper is intended to fill this vacuum by studying empirically the drivers of the adoption of eco-innovation practices in a set of transition economies by exploiting firm-level data drawn from the Community Innovation Survey (CIS 2014). In particular, this paper is based on a cross-sectional dataset covering the three years between 2012 and 2014. For this purpose, we rely on a multivariate probit model. To perform our empirical analysis, we use data for 8 European Transition countries, drawn from the Community Innovation Survey (CIS14) conducted by Eurostat. CIS14 provides information on environmental innovation strategies of firms. Our analysis is explicitly focused on the manufacturing sector. On the one hand, manufacturing sector has been proved to be harmful to the environment but, on the other hand, it also presents an innovative and eco-innovative potential (Barbieri et al., 2016; Borghesi, et al., 2015).

The remainder of the paper is structured as follows. Section 2 introduces the conceptual background to examine the main determinants of eco-innovation. Section 3 describes the data and the variables. Section 4 displays the econometric strategy and eventually discusses the results. In the following section some robustness checks are presented. The last section summarizes and concludes the paper.

II. DETERMINANTS OF ENVIRONMENTAL INNOVATION: LITERATURE REVIEW

In order to investigate the determinants of eco-innovation, following the prevailing literature we distinguish between: (i) demand factors; (ii) supply factors; (iii) set of regulations.

Demand side factors include market pull factors like consumer demand, preference for friendly products, clean production and, in general, the demand of more green products. These drivers are most important for product eco-innovation (Doran and Ryan, 2016). Empirical researches suggest that public opinion (Borghesi et al., 2015) and consumers press on environmental problem (Rennings, 2000). Borghesi et al. (2015) exploit a sample of 6,483 Italian firms in the manufacturing industry between 2006 and 2008. They employ a probit regression model and show that information relationship with clients, suppliers and conference are a stimulus for eco-innovation. Also a change in consumers' preferences could drive eco-innovation (Brohmann et al. 2009; van den Bergh, 2008). In particular, Triguero et al. (2018), applying a multivariate probit model, have investigated this topic by exploiting a sample of 2,732 firms in the Spanish food and beverage industry in the period 2008-2014. They have found that consumers proved to be capable of triggering the development of new products and production process. Some products such as food or baby clothes, are considered products with customer benefit, therefore, customers are inclined to pay a higher price for these products. At the same time, it is rather difficult for consumers to evaluate the environmental and health quality of goods, consequently, they show no intention of spending more for goods whose higher environmental quality and health benefits are not tested (Rennings 2000). In other words, it is obvious that eco-intentions of consumers and their real behavior about the buying decisions may be different since green products are too expensive (Ward et al., 2011; Kammerer, 2009; De Pelsmacker et al., 2005a, 2005b;).

Among the demand factors, several studies (Triguero et al., 2013, 2018; Horbach et al., 2013; Oltra and Saint Jean, 2009; Horbach, 2008) consider the customer demand and penetration of new market segments. The first reflects the customer's preference for eco-friendly products (Horbach et al., 2013). In fact, if a consumer considers the environmental quality of products as the added value, the firms are more sensitive to implement eco-innovation (Tsai and Liao, 2017). The second one refers to geographic dimension of markets, in other words, the entry in a national, European and foreign market to sell products (Tsai and Liao, 2017; Horbach et al., 2012). In fact, the adoption of specific environmental policy can widen the markets in those countries that introduce more restrictively regulations for the imported goods (Tsai and Liao, 2017). Thus, Chiaverso et al. (2015) have investigated the relationship between Italian firms' internationalization and their eco-innovation strategies by exploiting a sample of 684 firms in manufacturing sectors during May-July 2011. The authors employ a logit model and show how the firms that export their products to the countries characterized by strict environmental regulations will be encouraged to implement eco-innovation strategies.

Interestingly, empirical findings for geographic market dimension are, however, rather controversial. That is, it is not considered as a specific driver of eco-innovation. In this regard, Horbach, et al. (2013) using the CIS data survey (2002-2004) on France and German firms and employing a probit regression model, confirm the relevance of geographic market dimension if service and industry sectors are considered together. This effect changes when the analysis is limited to industrial sectors.

Triguero et al. (2018) analyze Spanish food and beverage firms, over the period 2008-2014 by estimating a multivariate probit model and using the distinction among material efficiency, energy use and environmental responsiveness. They find that market demand influence positively the adoption of eco-innovation with the only exception represented by environmental process. Yet, Tsai and Liao (2017) exploiting a sample of 2955 Taiwanese manufacturing firms and applying a logit regression model find that firms are more prone to adopt eco-innovation strategies, when market demand is high. This study also shows the relevance of export destination when the destination has stricter environmental rules. In this context, the most innovative firms appear to be more willing to introduce eco-innovation (Tsai and Liao, 2017).

Connected to the demand factor is the reputation or brand image. Firms use brand image to communicate the safety and the positive environmental effect of their products (Galliano and Nadel, 2013; Srivastava, 2007) and reassure the stakeholders about the green quality of their products (Cazals, 2009). A firm with good reputation has a comparative advantage with respect to the others (Roberts and Dowling, 2002). For this end, enterprises choose to invest resources in advertising and corporate social responsibility (CSR) to improve their reputation (Lloyd-Smith and An, 2019).

Lloyd-Smith and An (2019), using a panel data of US-listed firms over the period 2005-2014, estimate a flexible production function employing both OLS and FE models. They find that advertising and CSR are substitutes, although a proportional increase in CSR leads to a larger and positive effect on firm reputation than advertising. CSR, in fact, is a crucial component of firm voluntary actions for environmental changes (Les Bas and Poussing, 2014; Antonioli and Mazzanti, 2009).

Les Bas and Poussing (2014) combine the CIS08 survey and CSR survey carried out in Luxembourg on a sample of 231 firms in all economic sectors and employing a probit model, they highlight the importance of CSR activities on environmental innovation. However, not all voluntary actions are associated with the CSR. The voluntary proactive approaches embrace "programs, codes, agreements, and commitments that encourage organizations to voluntarily reduce their environmental impact beyond the requirements established by the environmental regulatory system" (Darnall and Sides, 2008: 96). In other words, voluntary actions that have a positive impact on environmental innovation, are stimulated not only by CSR, but also by a better technological performance or a better competitive position related to cost reduction (Les Bas and Poussing, 2014).

Supply side factors are, also, an important element to favour the adoption of an eco-innovation. They refer to technology push, cost-saving (Triguero et al., 2013) and the cooperation with external sources. Companies, in fact, do not always have all the resources to innovate on their own, hence the need to cooperate with external partners (Chesbrough, 2003). Controversial is the effect of the cooperation on the decision to adopt an eco-innovation strategy.

De Marchi (2012) has investigated this topic by exploiting a panel of 6047 Spanish manufacturing firms during the period 2005-2007. The author employing a logit regression model has shown that cooperation with external partners affects positively the eco-innovation strategies. These findings are consistent with those found by Cainelli et al. (2012) and Triguero et al. (2013).

Del Rio et al. (2017) using the data from the Spanish Technological Innovation Panel (PITEC) on 3341 manufacturing firms for the period 2007-2009 and applying a dichotomous probit model, find that cooperation influences product and process eco-innovation, but it does not impact on incremental and radical eco-innovation. Finally, Borghesi et al. (2015) in Italian manufacturing industries do not find important effects.

Cost saving is a core eco-innovation driver (Demirel and Kesidou, 2011; Green et al., 1994; Horbach, 2008; Horbach et al., 2012) to improve resource and energy efficiency (Bossle et al., 2016). Cost reduction and the consequent growth in production volume is one of the most important factors related to process innovation (Doran and Ryan, 2016) and to product, process and organizational innovations if we consider the results of Borghesi et al. (2015). In order to recognize the cost-saving deriving from the eco-innovation and to overcome incomplete information (Porter and van der Linde, 1995), the environmental management system (EMS)is important. Most of the empirical analysis shows that the adoption of an EMS influences firm's propensity to engage an eco-innovation strategy.

Rennings et al. (2006) analyze the effects of the German Environmental Management and Auditing Scheme (EMAS) on process and product eco-innovations on a sample of 2270 validated manufacturing facilities taken from the survey data conducted in 2001. They employ a probit regression model and find a positive impact of EMS on technical eco-innovation. This result is in line with Wagner (2008). In fact, the author using the data for 9 European countries taken from the European Business Environment Barometer 2001/2002 and employing a multivariate probit model shows that the EMS is positively associated with both the product and process eco-innovation.

Crucial are the R&D activities that create technological knowledge in a firm (Tsai and Liao, 2017). R&D activities, firm's size and corporate affiliation are pre-condition for the eco-innovation (Galliano and Nadel, 2013). Usually, if a company has a higher innovation capacity and a higher technical knowledge, it could accumulate more easily knowledge and, consequently, be more innovative. Generally, companies with a high innovation capacity not always decide to implement eco-innovation strategies since they increase production costs and customers have a low propensity to buy eco-friendly products (Tsai and Liao, 2017). The empirical findings are controversial, the role of R&D on eco-innovation is not clear (Horbach et al. 2013).

Marzucchi and Montresor (2017) have investigated the effects of knowledge drivers on eco-innovations in Spanish manufacturing firms during the period 2007-2009 and 2010-2012. The authors, estimating a set of random effects of a logit regression, find that R&D activities are crucial for all types of eco-innovations. Yet, Triguero et al. (2018) focusing on the Spanish food sector, find that R&D is more relevant for product and radical eco-innovation with respect to process and incremental eco-innovation.

It is worth noting that the amount of resources that a firm address in R&D activities depends on many factors even if cost reduction is considered the most important. Regulatory pressure could have a significant effect when the firms do not place on the "technological frontier" of environmental investments; for the most advanced companies other determinants prevail. For example, Demirel and Kesidou (2011) show that among the factors that affect the investment in environmental R&D activities it is crucial the role played by the market driven by the UK firms during the year 2006.

Also firm dimension is associated with the eco-innovation activities (Triguero et al., 2018; Horbach et al., 2013; Kesidou and Demirel, 2012; Kammerer, 2009). In general, small and medium firms have less resources compared to the large ones and less market power. Large companies present a greater capacity to carry out an environmental innovation strategy since they have the resources to invest that can also generate benefits for the environment. Therefore, the limited number of employees can be considered as an obstacle if small firms have not human, technical and financial resources (Del Río, 2009).

Several studies analyze the relationship between environmental regulations and eco-innovations (Arfaoui, 2018; Cainelli et al., 2012; Chen et al., 2012; Demirel and Kesidou, 2011; Jaegul et al., 2011; Johnstone et al., 2010; Mazzanti and Zoboli, 2009; Kammerer, 2008; Popp, 2006; Brunnermeier et al., 2003; Jaffe et al.,1997) emphasizing the role of regulation as a stimulus to the realization of eco-innovation activities (Doran & Ryan, 2016; del Rio et al., 2013; Horbach et al., 2012). It improves the competitive advantage of the firms and increases their productivity (Triguero et al., 2018). In other words, environmental regulation encourages, particularly, the organizational eco-innovation (Triguero et al., 2013).

If Popp (2006) showed that eco-innovation decisions in US, Japan and Germany, were mainly driven by national regulation, a recent literature finds that environmental innovation may also depend on European and international regulation (Tsai and Liao, 2017). Different, instead, is the role of future or anticipated (Horbach et al., 2012) environmental regulations in Germany that might influence the firm's choice about eco-innovation.

Given the absence of a monetary return for the improved environmental performance of the firms, there is the need for a public intervention aimed at creating markets to fill up the negative environmental externalities (Marini et al., 2015). In fact, environmental subsidies seem to be important for firms since they provide more resources to cope with an eco-innovation. At the same time, they define the future policy directives of government in the environmental field (Tsai and Liao, 2017). The public choice can act on both the demand and supply side (Johnstone et al., 2012) through subsidies or "carrots" for emission abatement or for the adoption of standards, government grants, taxes and environmental legislation or "sticks". Lastly, fiscal incentives are also important when benefits of environmental innovation adoption are higher than costs of paying penalties (Triguero et al., 2018).

The literature on environmental innovation underlines as the propensity to eco-innovate differs across sectors (Marin and Lotti, 2017). The technology implemented by a company is usually identified by its sector. If in the past in low-tech industries, such as textile, food, beverage, footwear and plastics, companies were less inclined to the environmental innovation with respect to the medium- and high-technology industry (Brunnermeier and Cohen, 2003; Horbach, 2008; Marin and Lotti, 2017), more recent studies (Triguero et al. 2018; Robertson et al., 2012) show that international competitiveness has required the introduction of new better-quality products and new improved process also in traditional sectors. Anyway, each sector is also subject to specific regulations, standards, taxes, obligations as in the case of polluting sectors (Antonioli et al., 2013) or polluting firms (Marin and Lotti, 2017).

III. DATA COLLECTION AND VARIABLES

As noted above, our empirical analysis is based on firm level data taken from the Community Innovation Survey (CIS) that is the most employed datasets in innovation and eco-innovation studies. This survey is managed by the Eurostat that develops a standard questionnaire in accordance with the standard definition of the Oslo Manual (OECD, 2005). The Community innovation survey is conducted in every member country of the EU to collect data on firms' activities. It provides a set of innovation indicators in order to examine the innovation process and how it affects the economy of a country.

This survey presents some advantages: (i) it provides firm-level information on the European enterprises which include both SMEs and large companies and both non-innovative and innovation-oriented companies and (ii) it allows to carry out comparisons across countries thanks to the standardization of the questionnaire and methodology. However, there are also some weaknesses. First, CIS is a cross-sectional dataset. Therefore, in this paper we investigate the association between determinants and eco-innovation strategy that does not allow to observe the direction of causality between the determinants and firms' eco-innovation activities. So, to overcome this weakness you should have time series data and cross-section information for an identical sample of firms. Second, CIS data provide only a few financial information about firms. Finally, the country coverage varies depending on the indicators considered. This caveat does not allow to include variables available for some countries but not for others. Therefore, we removed the Czech Republic from the group of transition countries.

In our empirical application we employ CIS 2014 that covers the period 2012-2014. The target population of the CIS 2014 is the total population of firms in NACE Rev. 2 sections A to N, while the activities O to U are excluded. We focus on a sample of European transition countries[1]. Through a filtering process, from the initial dataset we have selected companies in the manufacturing sector, namely those falling within the divisions 10-33 of NACE classification. The survey provides information about 20280 firms. From these data, we extract only the firms that during the period 2012-2014 have introduced a product, process, or organizational innovation that led to two types of environmental benefits within enterprises or from consumption or use of a good or service by the end user. In this way we reduce the number of firms to 2700.

According to the survey information, in the transition countries the firms that, over the period 2012-2014, have decided to adopt at least one eco-innovation strategy are about 72.30 percent. On the other hand, only 39.28 percent of the firms has adopted a mix of the three types of environmental innovation.

1Sample is made of 8 Countries (Bulgaria, Croatia, Estonia, Hungary, Latvia, Lithuania, Romania, Slovakia).

In the following, eco-innovation is our dependent variable and in particular, we consider 3 types of eco-innovations: (i) "eco-innovative good or service; (ii) eco-innovative production process or method and (iii) eco-innovative organizational change. This distinction should not be overemphasized since firms often decide to mix different types of eco-innovations.

The questionnaire of CIS14 contains also a set of variables that allows to investigate the factors that affect firms' eco-innovation decision. With reference to the relevance of drivers that lead a firm to adopt an eco-innovation, respondent firms replied using a four-point Likert response scale ranging from not to highly relevant, which were converted into dummies: "highly relevant" or "medium relevant" versus the rest. In our estimation, we consider the following set of variables (see Table 1).

Table 1. Definition of Variables and Descriptive Statistics

Name of variable	Description	Mean	Std. Dev.
Eco-Innovation			
Eco-process	Take value 1 when a firm introduce process innovations that generate Environmental Benefits, 0 otherwise	0.457	0.498
Eco-product	Take value 1 when a firm introduce product (goods or services) innovations that generate Environmental Benefits, 0 otherwise	0.457	0.498
Eco-organization	Take value 1 when a firm introduce organizational innovations that generate Environmental Benefits, 0 otherwise	0.244	0.429
Present Regulations	Take value 1 when a firm considers existing environmental regulations are medium or highly relevant to trigger an eco-innovation; 0 otherwise	0.792	0.406
Future Regulations	Take value 1 when a firm considers environmental regulations or taxes expected in the future are medium or highly relevant to trigger an eco-innovation; 0 otherwise	0.528	0.499
Tax and Fee	Take value 1 when a firm considers existing environmental taxes, charges or fees for environmental innovations are medium or highly relevant; 0 otherwise	0.555	0.497
Subsidies	Take value 1 when a firm considers government grants, subsidies or other financial incentives for environmental innovations are medium or highly relevant; 0 otherwise	0.331	0.471
Reputation	Take value 1 when improving reputation is medium or highly relevant to trigger an eco-innovation; 0 otherwise	0.728	0.445
Voluntary Actions	Take value 1 when a firm considers actions or initiatives for environmental good practice within your sector are medium or highly relevant to trigger an eco-innovation; 0 otherwise	0.596	0.491
Cooperation	Take value 1 when a firm has cooperation arrangements for product and/or process innovation activities; 0 otherwise	0.323	0.468
Cost saving	Take value 1 when a firm considers high cost of energy, water or materials are medium or highly relevant to trigger an eco-innovation; 0 otherwise	0.731	0.444
Market demand for eco-innovation	Take value 1 when a firm considers current or expected market demand for eco-innovations are medium or highly relevant to trigger an eco-innovation; 0 otherwise	0.513	0.500
EMS	Take value 1 when a firm has procedures in place to regularly identify and reduce your company's environmental impacts, 0 otherwise	0.198	0.399
National Market	Take value 1 when a firm sells goods and/or services in the national market; 0 otherwise	0.920	0.272
European Market	Take value 1 when a firm sells goods and/or services in the European market; 0 otherwise	0.615	0.487
International Market	Take value 1 when a firm sells goods and/or services in the international market; 0 otherwise	0.279	0.449
Turnover	Logarithm of turnover (year 2014)	14.141	1.813
Research & Development	Take value 1 when a firm introduces internal and/or external R&D for product and/or process innovation activities; 0 otherwise	0.408	0.492
Afflliation	Take value 1 when a firm is part of an enterprise group, 0 otherwise	0.236	0.425
Polluting Sectors	Take value 1 when a firm is a part of polluting sectors, 0 otherwise	0.168	0.374

With reference to the set of regulations and in line with the prevailing literature (i.e. Bitat, 2018; Barbieri et al., 2016; Horbach et al., 2012; Rennings and Rammer, 2011; Porter, 1991), we employ both the present and the expected environmental regulation. We also add subsidies and tax fees (Tsai and Liao, 2017).

Among the demand side factors, we consider the market demand for eco-innovation effect by consumers that drive the firms' eco-choices (Doran and Ryan, 2016) and perform firm's future turnover (Barbieri et al., 2016); the market geographic dimension, reputation and voluntary actions.

With regard to the supply side factors, Environmental Management Systems introduced between 2012-2014 (EMS 2012-2014) are considered in order to understand the firm's eco-innovation capacity (Horbach et.al, 2012). Cost saving is related to the firm's efficiency (Bossle et al., 2016) and cooperation with external partners (Chesbrough, 2003). Another supply side driver added in our estimations is R&D: the firm that makes intramural and extramural R&D has actually a greater probability to adopt an eco-innovation strategy.

Finally, we include some control variables that could affect firms' eco-innovation solutions. Therefore, we introduce the affiliation of a firm to a group and firm's size. Given the uneven nature of the information on firm dimension exploiting CIS14 data with reference to the European Transition Countries, we decide to refer to the firm's turnover as a way of getting to their size (Calvino et al., 2018; Dean et al., 2000; Wagner, 2003; Dhanaraj and Beamish, 2003).

Industry sector is also crucial to observe the technological context of a company (Galliano and Nadel, 2013). Following Antonioli et al., (2013) and Marin and Mazzanti (2013), we distinguish the manufacturing sector classified according NACE REV.2 in rule-based polluting and non polluting (table A1 in Appendix). Industry sector and country dummies are control variables to seize the specific differences between firms.

IV. EMPIRICAL STRATEGY AND RESULTS

The econometric estimations presented are to assess the association between eco-innovation decisions and drivers in the European Transition Countries on the basis of CIS14 for the period 2012-2014. According to the questionnaire, eco-innovation is defined as the introduction of a product (good or service), process, organizational change and marketing innovation that lead to two types of environmental benefits within enterprises or from consumption or use of a good or service by the end user.

In this paper, the three types of eco-innovations considered are identified through dummies: "eco-innovative good or service" (in this case *eco-product* is equal to 1), "eco-innovative production process or method" (*eco-process*) and "eco-innovative organizational change" (*eco-organizational*).

We follow the prevailing literature and we choose a multivariate probit model (Triguero et al., 2013, 2018; Capozza and Divella, 2018; Wagner, 2008). It allows a simultaneous estimation of the three types of eco-innovation: eco-product, eco-process and eco-organizational. In addition, the multivariate probit model does not require to consider the same explanatory variables. Therefore, this model fits with our theoretical background, in fact, the explanatory variables vary across equations since the drivers of the three types of eco-innovations are different.

In fact, we define the following equation relating to the key explanatory determinants plus controls to the probability that a company adopts one of the three types of eco-innovation outputs:

$$y_{ih} = x'_{ih}\beta_{ih} + \varepsilon_{ih}$$

y_{ih} is a binary variable which denotes whether a firm i has adopted one of the three types of eco-innovation output, where h indicates the type of innovation; x_{ih} is the matrix of explanatory variables, β_h represents the vector of coefficients and ε_{ih} is the error term. The multivariate approach allows the modelling of complementary decisions, firms could simultaneously realize different eco-innovation outputs. In addition, this approach includes a correlation structure for the unobservable factors associated with different eco-innovation outputs. The error term is the sum of two components, one specific for each equation that describes the output of interest and one common to the others:

$$\varepsilon_{ih} = \eta + u_{ih}$$

To sum up, the multivariate approach predicts several correlated binary outputs and it allows to control the potential correlation of the error terms. Yet, this approach allows to compare shared variables. This is crucial for our analysis whose purpose is to define the demand and the supply factors associated with eco-innovation and whether these factors differ across the types of eco-innovation outputs.

We perform the likelihood ratio test on the null hypothesis that the correlation coefficients ρ of the error terms are jointly equal to zero to assess if the multivariate approach fits. The rejection of the null indicates that the multivariate probit modelling is better than the univariate probit modelling.

Table 3 collects the empirical findings. Column 1, 2 and 3 report the specifications for eco-process, eco-product and eco-organizational respectively. The lower part of the table exhibits the three pairwise correlation coefficients across equation errors. The error terms are correlated across most of all equations. There is a statistical significance of most of the correlation coefficients (ρ) between the error terms. The likelihood ratio test on the null hypothesis that ρ are equal to zero is also rejected. Therefore, we employ the multi-equation estimation since it represents the appropriate model with respect to the estimation of three independent binary probit models.

Table 3. Multivariate probit regressions. Drivers of process, product and organizational eco-innovations

		Dependent Variables	
VARIABLES	Eco Process	Eco Product	Eco Organization
Regulation	0.42***	0.28***	0.45***
	(0.10)	(0.10)	(0.12)
Future Regulation	0.09	0.12	0.09
	(0.08)	(0.08)	(0.09)
Voluntary Actions	0.31***	-0.05	0.36***
	(0.07)	(0.08)	(0.08)
R&D	0.02	0.45***	
	(0.07)	(0.07)	
Cooperation	0.28***	0.09	
	(0.07)	(0.07)	
Demand Market for Innovation	-0.18**	0.44***	-0.04
	(0.08)	(0.08)	(0.08)
Subsidies	0.05	0.04	0.06
	(0.08)	(0.07)	(0.08)
Tax and Fee	-0.19**	-0.16*	0.05
	(0.08)	(0.08)	(0.09)
Turnover	0.07***	-0.01	0.04*
	(0.02)	(0.02)	(0.02)
Environmental Management System	0.18***		
	(0.07)		
Cost Saving	0.69***		
	(0.08)		
Ref. International Market			
European Market	-0.01	0.04	0.19*
	(0.10)	(0.10)	(0.11)
National Market	-0.11	0.31**	0.01
	(0.13)	(0.13)	(0.13)
Ref. No Polluting Sectiors			
Polluting Sectors	0.09	0.01	-0.04
	(0.07)	(0.07)	(0.07)
Affiliation	-0.06	0.02	0.14*
	(0.08)	(0.08)	(0.08)
Reputation		0.32***	
		(0.09)	

Ref. Croatia			
Bulgaria	0.34***	0.59***	0.35***
	(0.11)	(0.11)	(0.11)
Slovakia	-0.10	0.28**	-0.19
	(0.13)	(0.13)	(0.14)
Lithuania	0.33***	-0.04	-0.29**
	(0.11)	(0.11)	(0.12)
Latvia	0.45***	0.24	0.28*
	(0.16)	(0.15)	(0.16)
Romania	-0.11	0.41***	0.21
	(0.14)	(0.14)	(0.14)
Estionia	-0.06	-0.03	-0.27
	(0.16)	(0.16)	(0.17)
Hungary	-0.44***	0.32**	-0.44***
	(0.13)	(0.13)	(0.14)
ρ 1	1		
ρ 2	-0.09**	1	
ρ 3	0.18***	-0.016	1
Log likelihood ratio test of H0: ρ21 = ρ31 = ρ32 = 0			
LR $X^2(3)$	27.17***		
Log pseudolikelihood	-3338.81		
Number of Firms	1957	1957	1957

Robust Standard errors in brackets; statistical significance *** p < 0.01, ** p < 0.05, * p <0.1

Among the demand side factors, demand market for innovation has strongly significant and positive association with the decision to engage a product environmental innovation. This result is in line with the literature (see e.g. Horbach et al., 2013; Triguero et al., 2013) which confirms the importance of market demand for green products. At the same time, the demand market for innovation is strongly significant but negatively associated with the firms' process eco-innovation activities. In this respect, the plausible interpretation in that product eco-innovators substitute process eco-innovations. Reputation or brand image is strongly significant and positively related to the decision to adopt product eco-innovation, on the contrary, voluntary actions is positively related to the decision to implement eco-process and eco-organization innovation activities.

Going back to supply side factors, cost-saving, cooperation, and EMS are significant and positively associated with the decision to booster a process environmental innovation. EMS and cost saving could be considered as the combined result of the change in the production process and the research of firm's efficiency. Even the external agreements' cooperation is important to improve the eco-process. It could be considered as a guiding driver to elaborate a public policy able to develop network systems among firms, institutions and external partners.

It is important the role played by regulations, especially, by current regulations. It is the only driver which turns out to be significant and positively associated with all three categories of the eco-innovation outcome. Our results are consistent with the literature which shows that the regulations tend to favor "end of pipe" innovation (Galliano and Nadel, 2013; Horbach et al., 2012). Tax and fee are negative and significant in relation to eco-product and eco-process. Taxes are considered as an instrument to quantify the value of the environmental damage caused by firm activities. Thus, they represent the value of the negative environmental externality. Lastly, future regulations and access to subsidies are never significant in this respect.

The turnover, that in our model is also a proxy of the firms' size, shows a significant and positive association only with the eco-process. This result confirms that firms characterized by a higher turnover may address a high amount of resources to achieve a production process that has a less damaging effect on the environment. The national market dimension has a significant and a positive association only with the eco-product. The size of the European market is positively and significantly associated only with the eco-organizational innovation activities. These results probably mean that for selling goods and/or services in the national market, firms must change only the products.

R&D activities exhibit a positive and significant association with the product eco-innovation activities. These results are consistent with those obtained by Triguero et al. (2018). The authors underline that R&D allows firms to be more responsive to adopt an eco-innovation.

We also analyze this possible association for countries since each country has its socio-economic characteristics. We have chosen Croatia as reference country. According to the composite Eco-innovation Index [2] developed by Eco-Innovation Observatory (EIO), this country with Lithuania, is characterized by a medium eco-innovation capacity, for this reason, it is part of the group called "Average Eco-I performers" (European Commission, 2014). We selected Croatia since during the period 2013-2015 the ranking of this country, in the eco-innovation scoreboard, has not been changed. On the contrary, the ranking of Lithuania is rather unstable. In fact, Lithuania, in the eco-innovation scoreboard, dropped from the 19th position in 2013 to the 24th in 2014. In 2015, this country experienced an improvement in its eco-innovation performance gaining two positions (European Commission, 2015). In the

[2] Eco-Innovation Index shows eco-innovation performance across the EU Member States. It is calculated by considering 16 indicators grouped into five dimensions such as eco-innovation inputs, eco-innovation activities, eco-innovation outputs, resource efficiency and socio-economic outcomes.

same year, the other countries considered presented a low eco-innovation capacity; they belong to the group called "Countries catching up with Eco-I".

Our results are puzzled. In fact, findings highlight several differences across countries. Only firms in Bulgaria present a significant and positive association with each type of eco-innovation. In addition, the Hungarian firms present a significant and positive association with the eco-product activities and a negative association with the other two types of eco-innovation activities.

V. ALTERNATIVE ESTIMATIONS AND ROBUSTNESS CHECKS

(i) Alternative sample of countries

As robustness check, we eventually examined the potential association between eco-innovation determinants and the decision to adopt them comparing: (i) Baltic and non-Baltic countries and (ii) Romania, EU member from 2007 and the other countries that are members of the EU from 2004.

We decided to compare Baltic and non-Baltic countries because the first is a homogeneous group of countries while the latter is characterized by several differences. In fact, the Baltics present many similarities. These countries are geographically concentrated and have the same size, economic structure and development. For this reason, they seem to be an integrated economy that share common factors and economic links. In the Table 4 below we show the estimations obtained by the first robustness test.

Table 4. Multivariate probit regressions. Drivers of process, product and organizational eco-innovations

		Dependent Variables	
VARIABLES	Eco Process	Eco Product	Eco Organization
Regulation	0.44***	0.27***	0.50***
	(0.10)	(0.10)	(0.12)
Future Regulation	0.10	0.12	0.10
	(0.08)	(0.08)	(0.08)
Voluntary Actions	0.35***	-0.04	0.36***
	(0.07)	(0.08)	(0.08)
R&D	-0.04	0.39***	
	(0.06)	(0.06)	
Cooperation	0.23***	0.06	
	(0.06)	(0.06)	
Demand Market for Innovation	-0.23***	0.45***	-0.07
	(0.07)	(0.07)	(0.08)
Subsidies	0.08	0.03	0.09
	(0.07)	(0.07)	(0.08)
Tax and Fee	-0.21**	-0.17**	0.04
	(0.08)	(0.08)	(0.08)
Turnover	0.04*	-0.01	0.01
	(0.02)	(0.02)	(0.02)

Environmental Management System	0.15**		
	(0.07)		
Cost Saving	0.67***		
	(0.08)		
Ref. International Market			
European Market	-0.05	-0.01	0.13
	(0.10)	(0.10)	(0.11)
National Market	-0.12	0.28**	-0.01
	(0.12)	(0.13)	(0.13)
Ref. No Polluting Sectiors			
Polluting Sectors	0.09	0.00	-0.03
	(0.07)	(0.07)	(0.07)
Affiliation	-0.14**	0.03	0.03
	(0.07)	(0.07)	(0.08)
Reputation		0.36***	
		(0.09)	
Ref. No Baltic Countries			
Baltic	0.27***	-0.34***	-0.22***
	(0.07)	(0.07)	(0.07)
ρ 1	1		
ρ 2	-0.07*	1	
ρ 3	0.21***	-0.00	1
Log likelihood ratio test of H0: ρ21 = ρ31 = ρ32 = 0			
LR $X^2(3)$	33.22***		
Log pseudolikelihood	-3411.38		
Number of Firms	1957	1957	1957

Robust Standard errors in brackets; statistical significance *** p < 0.01, ** p < 0.05, * p <0.1

In general, the results are consistent with the main findings with exception of the affiliation that, in this estimation, presents a negative and significant association with the firms' eco-process strategies. This result could probably be explained by the lack of decision-making autonomy of branches with respect to their head office.

If we consider the results for the Baltic group, we can observe that firms are strongly related with the decision to adopt a process environmental innovation. On the contrary, Baltic firms are significantly and negatively associated with the decision to booster a product and organizational environmental innovation with respect to the non-Baltic firms.

Finally, in Table 5 we report the findings comparing Romania with other countries. Croatia has been excluded because it could be considered as a potential outlier since it is a UE Member from 2014. We performed this estimation to understand if the countries joining EU from 2004 are more responsive to engage eco-innovation activities with respect to Romania.

Table 5. Multivariate probit regressions. Drivers of process, product and organizational eco-innovations

		Dependent Variables	
VARIABLES	Eco Process	Eco Product	Eco Organization
Regulation	0.51***	0.27**	0.44***
	(0.11)	(0.11)	(0.12)
Future Regulation	0.03	0.17*	0.09
	(0.09)	(0.09)	(0.09)
Voluntary Actions	0.37***	-0.11	0.34***

	(0.08)	(0.08)	(0.09)
R&D	0.02	0.47***	
	(0.07)	(0.07)	
Cooperation	0.29***	0.05	
	(0.07)	(0.07)	
Demand Market for Innovation	-0.20**	0.46***	-0.06
	(0.08)	(0.08)	(0.09)
Subsidies	0.06	0.01	0.02
	(0.08)	(0.08)	(0.08)
Tax and Fee	-0.20**	-0.14	0.06
	(0.09)	(0.09)	(0.09)
Turnover	0.06***	-0.02	0.04*
	(0.02)	(0.02)	(0.02)
Environmental Management System	0.21***		
	(0.07)		
Cost Saving	0.62***		
	(0.09)		
Ref. International Market			
European Market	-0.00	0.07	0.22*
	(0.10)	(0.10)	(0.12)
National Market	-0.11	0.28**	-0.00
	(0.13)	(0.13)	(0.14)
Ref. No Polluting Sectiors			
Polluting Sectors	0.11	0.01	-0.09
	(0.07)	(0.07)	(0.08)
Affiliation	-0.14	0.03	0.14
	(0.09)	(0.09)	(0.09)
Reputation		0.35***	
		(0.10)	
Ref. Romania			
Bulgaria	0.46***	0.18	0.15
	(0.13)	(0.13)	(0.13)
Slovakia	0.05	-0.10	-0.40***
	(0.15)	(0.15)	(0.16)
Lithuania	0.47***	-0.43***	-0.50***
	(0.13)	(0.13)	(0.14)
Latvia	0.58***	-0.17	0.07
	(0.17)	(0.17)	(0.17)
Estonia	0.10	-0.43**	-0.48**
	(0.18)	(0.18)	(0.19)
Hungary	-0.27*	-0.08	-0.66***
	(0.14)	(0.15)	(0.16)
ρ 1	1		
ρ 2	-0.12***	1	
ρ 3	0.12***	-0.02	1
Log likelihood ratio test of H0: ρ21 = ρ31 = ρ32 = 0			
LR $X^2(3)$	18.39***		
Log pseudolikelihood	-2882.0597		
Number of Firms	1705	1705	1705

Robust Standard errors in brackets; statistical significance *** p < 0.01, ** p < 0.05, * p <0.1

The empirical results are in line with the findings obtained through the baseline model. The only exception is the future regulation that becomes significant and positively associated with the firms’ eco-product strategies. This means that although future regulation is uncertain and evolving, in this case it does not hinder the firms' decisions to invest in eco-innovation.

To underline the different eco-innovation responsiveness at country level we observe the three eco-innovation separately. As in the main estimation, the findings are puzzled. Bulgaria, Lithuania and Latvia show a significant and positive association with eco-process strategies with respect to Romania. On the contrary, Hungary presents a significant and a negative association with eco-process activities compared to Romania. Slovakia, Lithuania, Estonia and Hungary show, with respect to Romania, a significant and negative association with the eco-organization strategies. Yet, Estonian and Lithuanian firms present a significant and negative association with the eco-product innovation.

In sum, the last results show that the firms in those countries that joined the EU before Romania have a lower level of eco-innovation. Only Bulgarian, Lithuanian and Latvian firms are more prone to adopt the eco-process strategies and are more efficient with respect to Romania.

(ii) The interaction between turnover and environmental policy instruments

Given the crucial role played by the environmental policy to promote green firm activities (Tsai and Liao, 2017), we re-estimate the baseline model by considering how turnover, that is a key measure of the firm's economic performance, interacts with the environmental policy. In particular, we consider the following eco-policy categories: (a) current regulation; (b) future regulation; (c) subsidies and grant; (d) taxes and fees. We perform this further estimation to observe the effects of these interactions on the tendency of a firm to introduce an eco-innovation strategy. Table 6 displays only the interaction findings.

Table 6. Multivariate probit regressions. Interaction between turnover and eco-policy

	Dependent Variables		
VARIABLES	Eco-process	Eco-product	Eco-organization
Turnover	0.017	-0.040	-0.033
	(0.040)	(0.042)	(0.055)
Regulation	-0.468	-0.258	-0.542
	(0.643)	(0.663)	(0.855)
Turnover*Regulation	0.059	0.035	0.067
	(0.042)	(0.043)	(0.056)
ρ 1	1		
ρ 2	-0.089**	1	
ρ 3	0.182***	-0.016	1
Log likelihood ratio test of H0: ρ21 = ρ31 = ρ32 = 0			
LR $X^2(3)$	27.97***		
Log pseudolikelihood	-3341.66	-3341.66	
Turnover	0.024	-0.019	0.034
	(0.028)	(0.027)	(0.031)
Future Regulation	-1.077**	-0.117	0.250
	(0.507)	(0.505)	(0.549)
Turnover*Future Regulation	0.074**	0.015	-0.009
	(0.032)	(0.032)	(0.034)
ρ 1	1		
ρ 2	-0.089**	1	
ρ 3	0.184***	-0.016	1

Log likelihood ratio test of H0: ρ21 = ρ31 = ρ32 = 0			
LR $X^2(3)$	28.24***		
Log pseudolikelihood	-3340.63		
Turnover	0.056**	-0.021	0.012
	(0.024)	(0.023)	0.025
Subsidies	-0.395	-0.435	-0.504
	(0.521)	(0.514)	(0.054)
Turnover*Subsidies	0.028	0.030	0.037
	(0.033)	(0.032)	(0.034)
ρ 1	1		
ρ 2	-0.088**	1	
ρ 3	0.182***	-0.016	1
Log likelihood ratio test of H0: ρ21 = ρ31 = ρ32 = 0			
LR $X^2(3)$	27.87***		
Log pseudolikelihood	-3342.28		
Turnover	0.017	0.007	-0.003
	(0.028)	(0.028)	(0.031)
Taxes and Fees	-1.500***	0.293	-0.691
	(0.507)	(0.505)	(0.549)
Turnover*Taxes and Fees	0.084***	-0.029	0.047
	(0.504)	(0.032)	(0.035)
ρ 1	1		
ρ 2	-0.086**	1	
ρ 3	0.181***	-0.015	1
Log likelihood ratio test of H0: ρ21 = ρ31 = ρ32 = 0			
LR $X^2(3)$	27.19***		
Log pseudolikelihood	-3339.28		

Robust Standard errors in brackets; statistical significance *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Interesting are the results obtained by interacting: (i)turnover and future regulation; (ii) turnover and taxes and fees.

The first interaction shows a significant and positive association with the eco-process innovation.

This means that an increase in turnover and expectations deriving from future environmental policy directives, firms can identify their inefficiencies. Therefore, they use the profits to adopt eco-innovative process strategies in advance.

The second interaction shows also a significant and positive association between turnover and taxes and fees and eco-process innovation. In this case, when there is an increase in turnover and taxes and fees, firms are stimulated to engage an eco-innovation process. In this respect, the plausible interpretation is that the eco-innovative firms are more efficient. This allows the firms to save from a fiscal point of view since if a firm reinvests in eco-innovation it allocates lower revenue rates when paying taxes. Thus, a high tax rate leads the firm to address their profits on eco-innovation investment rather than having them taxed.

VI. FINAL REMARKS AND CONCLUSION

The main purpose of this paper was to investigate the empirical association between determinants and eco-innovation strategy of the European transition countries using the CIS 2014 data survey. In order to observe this association, we have employed a multivariate probit model that allows a simultaneous estimation of the three types of eco-innovation (eco-process, eco-product, eco-organizational).

The multivariate estimations allowed us to reveal possible complementarities across the three types of eco-innovation and to underline the differences across sectors and countries. The main findings show that several drivers are common to some categories of eco-innovation and only the current regulation affects all of them. The market demand for eco-innovation presents a positive correlation with eco-product and a negative association with eco-process. These results are inconsistent with the previous research (Triguero et al., 2018) that showed a positive association between market demand and eco-product and eco-process. At the same time, eco-process strategy is strongly associated with the supply side factors such as cost saving, cooperation and EMS.

Voluntary actions are positively associated with eco-process and eco-organization, while reputation and R&D activities are positively and significantly related only with eco-product strategies. We also find that if national market is positively associated with the eco-product innovation, the European market is positively associated with the eco-organizational innovation since companies in these countries need to reorganize to adopt European regulations. The main difference across countries is not easy to justify since it depends on their socio-economic characteristics and environmental policy.

To conclude, although based on cross-sectional datasets, our analysis intends to provide some suggestions to overcome many countries' environmental problems through well-targeted policy interventions. Furthermore, according to our results, for Transition countries it is crucial a new environmental legislation since these countries are characterized by a low or modest level of eco-innovation performance. Therefore, the main objective of policy makers is to promote new and future regulations and encourage eco-innovation through more benefits or "carrots" on one side and government grants, taxes and environmental legislation or "sticks" and more taxes and fees on the other one. Of particular interest have been the results when interacting the turnover alternatively when public policies. Interestingly, the interaction between turnover and tax rates is positively associated with the probability of a eco-innovation. The plausible interpretation is that when tax rate appears to be too high firms prefer to invest into environmental innovation rather than being subject to a too high tax rate. In other words, as taxes raise the incentive of firms to invest increases as well. Broadly speaking, in transition economies public policies and invectives appear to trigger environmental innovation much more than demand-pull factors. This is an extremely relevant result because it points out that market-driven advancements did not take shape in transition countries in the period 2012-2014. Rather the role of public decision-makers is still decisive.

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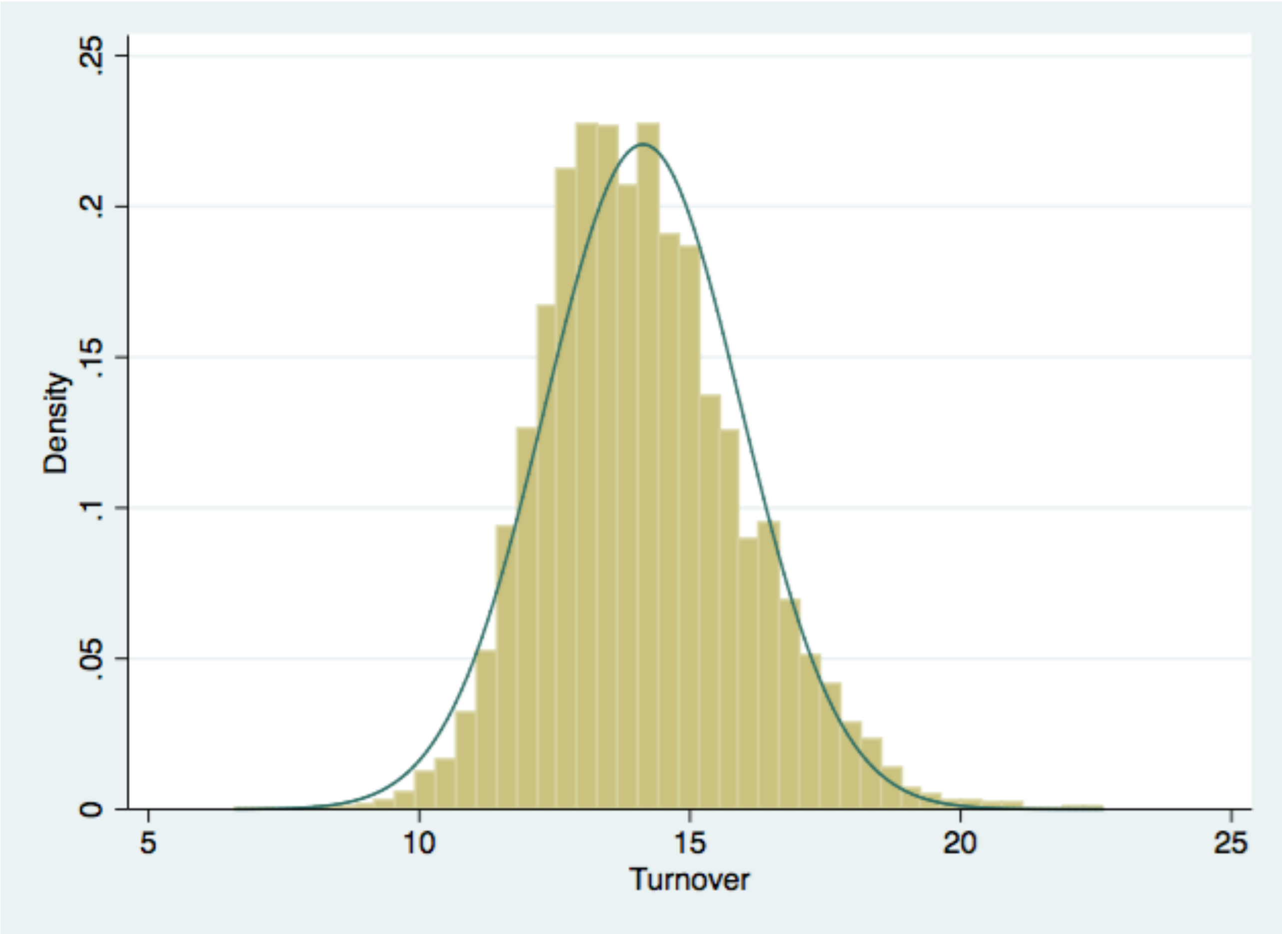
APPENDIX

Table A1. Sector Sample Classification

	Division	N. Division
Polluting Sectors		
	Manufacture of coke and refined petroleum products	19
	Manufacture of chemicals and chemical products	20
	Manufacture of rubber and plastic products	22
	Manufacture of other non-metallic mineral products	23
	Manufacture of basic metals	24
	Manufacture of fabricated metal products, except machinery and equipment	25
No Polluting Sectors		

Manufacture of food products	10
Manufacture of beverages	11
Manufacture of tobacco products	12
Manufacture of textiles	13
Manufacture of wearing apparel	14
Manufacture of leather and related products	15
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	16
Manufacture of paper and paper products	17
Printing and reproduction of recorded media	18
Manufacture of basic pharmaceutical products and pharmaceutical preparations	21
Manufacture of computer, electronic and optical products	26
Manufacture of electrical equipment	27
Manufacture of machinery and equipment n.e.c.	28
Manufacture of motor vehicles, trailers and semi-trailers	29
Manufacture of other transport equipment	30
Manufacture of furniture	31
Other manufacturing	32
Repair and installation of machinery and equipment	33

Figure A1. The turnover distribution


.25
.2
.15
.1
.05
0
Density
5
10
15
20
25
Turnover