DETERMINANTS OF POLLUTION ABATEMENT AND CONTROL EXPENDITURE: EVIDENCE FROM ROMANIA

Guglielmo Maria Caporale
Brunel University, London

Christophe RAULT
LEO, University of Orleans and IZA

Robert SOVA
CES, Sorbonne University and A.S.E

Anamaria SOVA
CES, Sorbonne University and EBRC

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Abstract

The aim of the present study is to shed some light on the factors affecting Pollution Abatement and Control Expenditure (PACE) in the context of a transition economy such as Romania, in contrast to the existing literature which mostly focuses on developed economies. Specifically, we use survey data of the Romanian National Institute of Statistics and estimate Multilevel Regression Model (MRM) to investigate the determinants of environmental behaviour at plant level. Our results reveal some important differences vis-à-vis the developed countries, such as a less significant role for collective action and environmental taxes, which suggests some possible policy changes to achieve better environmental outcomes.

Key Words: Pollution Abatement and Control Expenditure, Transition Economy, Multilevel Regression Model (MRM)

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Corresponding author: Professor Guglielmo Maria Caporale, Centre for Empirical Finance, Brunel University, West London, UB8 3PH, UK. Tel.: +44 (0)1895 266713. Fax: +44 (0)1895 269770. *Email:* Guglielmo-Maria.Caporale@brunel.ac.uk

1. Introduction

Romania, like other countries of Central and Eastern Europe (CEE), has been making several efforts to comply with the environmental legislation of the European Union (EU). Such compliance requires firms to implement substantial changes at plant level. In particular, both capital expenditure and operating costs are associated with pollution abatement efforts.

Early in the transition process, Romania and the other CEE countries experienced a decline in industrial production and a consequent decrease in pollution levels. In subsequent stages, higher economic growth may lead to higher pollution, unless concerted action is taken to implement more effective environmental policies. Unfortunately, environmental efforts in Romania face the twin obstacles of severe budgetary constraints and a legacy of poor practice in investment programming and project management. In this context, innovative and effective financing strategies for environmental protection need to be developed or strengthened, and steps must be taken to ensure that scarce financial resources are allocated efficiently to address priority issues.

The aim of the present study is to shed some light on the factors affecting Pollution Abatement and Control Expenditure (PACE) in Romania. Its contribution is threefold: first, it analyses the case of a transition economy, in contrast to the existing literature which mostly focuses on developed economies; second, it uses a database at plant level, namely survey data of the Romanian National Institute of Statistics; third, it adopts a suitable econometric method, i.e. the Multilevel Regression Model (MRM) to investigate the determinants of environmental behaviour at plant level taking into account the context.

The remainder of the paper is organized as follows. Section 2 briefly reviews the relevant literature on environmental performance. Section 3 outlines the econometric framework and presents the empirical findings. Section 4 offers some concluding remarks.

2. Literature Review

The basic economic processes are production and consumption: firms transform natural resources, through the production process, into commodities supplied by consumers. However, this conversion is never perfectly efficient: by-products (residuals) are produced. When such residuals have no economic value then they can be thought of as waste, which may lead to pollution.

Thus, firms impose costs on other agents in the economy. This is a typical case of a negative externality. As prices do not take into account the negative effects on the environment, they do not reflect full production costs for the economy; to correct this form of market failure it is necessary to introduce environmental regulations, as otherwise there is no incentive for a polluting profit-maximizing firm to internalize the externality (DiMaggio and Powell 1983). When formal regulation is weak or perceived to be insufficient, communities may informally regulate firms indirectly or directly through bargaining, petitioning and lobbying. Clearly, determining the “right” amount of pollution requires evaluating its negative effects - the willingness to pay to reduce pollution is an obvious measure. Environmental issues invariably involve a trade-off between using resources for conventional goods and services and using those same resources for environmental protection - i.e. how much is the consumer willing to pay for a particular level of an environmental good?

Since the Brundtland Report was published in 1987 as a result of the work of the World Commission on Environment and Development, extensive research has been done by economists on how to improve environmental performance through pollution abatement, in some cases using capital expenditure as a proxy for environmental performance (Panayotou et al 1997, Ferraz and Seroa da Motta 2002, OECD 2001). Pollution abatement and control of residuals from production processes can be done either using end-of-pipe technology attached to a given production process, or by changing the process itself. Investment in the former does not affect the production process itself, and the amount of pollution generated; instead, it aims to treat pollution already generated. By contrast, investment in integrated technologies is synonymous with reducing the amount of potential pollutants at source, reducing the consumption of resources and energy, and recycling residues and used products.

Some research has analysed specific external factors that drive companies to improve their environmental performance, such as regulatory regime or government support (Delmas, 2003; Chan & Wong, 2006; Rivera, 2004; Rivera & de Leon, 2004; Rivera et al, 2006; Shin, 2005,), pressure from local wealthy stakeholders, civil society, and foreign customers in Europe and Japan (Neumayer & Perkins 2004) and industry pressure (Guler et al. 2002, Corbett & Kirsch, 2004; Viadiu et al., 2006). Other research has focused on the role of internal organisational factors such as “organisational structure and culture.” Only a few studies have begun integrating key organisational characteristics with institutional theory. This approach can yield new insights into understanding differences between firms’ strategies. (Seroa da Motta, 2006; Gunningham, 1995 ; Hoffman 2001).

Almost all these empirical studies focus on the developed countries. Additional challenges are faced by the developing economies, including the CEE countries such as Romania, which underwent a transition process. Under central planning, the well-known bias towards heavy industry combined with a lack of incentives to economise on inputs created considerable waste and pollution. Thus, in the transition countries production technologies are substantially less efficient than in the developed economies, and therefore emissions per unit of output are higher. In addition to the environmental problems inherited from the period of central planning, transition economies have experienced various other difficulties, including financial and economic hardship. The adjustment to market equilibrium is a gradual process, during which many variables such as provision of public goods, willingness to pay, technology and capital markets etc. are in disequilibrium. This creates both constraints and opportunities that may not be available to more "settled" economies. From an econometric viewpoint, the Multilevel Regression Model (MRM) is the most appropriate for our sample which contains hierarchical data structured in two levels (plant and county).

3. Econometric Analysis

3.1 Econometric method

In the statistics literature MRM is alternatively referred to as multilevel analysis, hierarchical models, random coefficients models, and variance components analysis. The common element of all of these methods is that the dependent variable is analysed as a function of predictors measured at the lowest level and of those measured at one or more higher levels. The rationale for using the multilevel model is based on the assumption that the variation in the dependent variable is a function of both lower-level and higher-level factors. This variation is not only a function of individual-level attributes, but also extra-individual factors. Besides, the relationship between lower-level and higher-level factors and the dependent variable is not assumed to be fixed or constant across space or time. Therefore, the regression coefficients in micro-level models are not fixed, and they can vary across these factors.

Conceptually, the model is often viewed as a hierarchical system of regression equations. The simplest multilevel model that can be formulated takes into consideration only two levels of analysis[1]. The analysis focuses on level-1 (individuals), whilst level-2 (group) provides the context for the level-1 units. For instance, in our case, level-1 units are the plants

1 For more details concerning MRM see Greene W. H. (2002).

who are nested in different counties (level-2 units). The dependent variable (note: in Y_{ij} , i refers to level-1 units and j refers to level-2 units) is measured for level-1 units, since this is the primary level of analysis. The explanatory variables are X_{ij} for level-1 and Z_j for level-2. By assumption, there are J groups and in each group there are N_i individuals.

Thus, there is a separate regression equation for each group

$$Y_{ij} = \beta_{0j} + \beta_{1j} X_{ij} + \varepsilon_{ij} \quad \text{with} \quad (j = 1,2, \ldots\ldots J;\ i = 1,2,\ldots\ldots N) \qquad (1)$$

where :

β_0 is the regression intercept;

β_1 is the regression slope for the explanatory variable X;

ε_{ij} is the residual term.

To model group variation (this time for the level-2 units) in regression parameters additional equations are required, with the level-1 regression parameters as their dependent variables. The regressors include at least a constant, one level-2 explanatory variable and a disturbance.

Thus, a typical level-2 model consists of the following equations:

$$\beta_{0j} = \mu_{00} + \mu_{01} Z_j + u_{0j} \quad \text{with } (j = 1,2,\ldots N) \qquad (2)$$

$$\beta_{ij} = \mu_{10} + \mu_{11} Z_j + u_{1j} \quad \text{with } (j = 1,2,\ldots N) \qquad (3)$$

After substituting equations (2) and (3) into equation (1), one obtains:

$$Y_{ij} = \mu_{00} + \mu_{01} Z_j + \mu_{10} X_{ij} + \mu_{11} X_{ij} Z_j + u_{1j} X_{ij} + u_{0j} + \varepsilon_{ij} \qquad (4)$$

where: μ_{00} is the intercept; μ_{01} μ_{10} are the effect of the level-2 variable Z_j on level-1 X_{ij} ; μ_{11} is the cross-level interaction between the level-1 and level-2 variables. The last three terms in equation [4] are the disturbance terms.

If there are P variables X at level-1 (lowest level) and Q variables Z at level-2 (highest level) the equations (1→4) become:

$$Y_{ij} = \beta_{0j} + \sum_{p=1}^{P} \beta_{pj} X_{ij}^{p} + \varepsilon_{ij} \qquad (1a)$$

$$\beta_{0j} = \mu_{00} + \sum_{q=1}^{Q} u_{oq} Z_j^{q} + u_{0j} \qquad (2a)$$

$$\beta_{pj} = \mu_{p0} + \sum_{q=1}^{Q} \mu_{pq} Z_j^q + u_{pj} \quad (3a)$$

$$Y_{ij} = \mu_{00} + \sum_{p=1}^{P} \mu_{p0} X_{ij}^p + \sum_{q=1}^{Q} \mu_{0q} Z_j^q + \sum_{q=1}^{Q}\sum_{p=1}^{P} \mu_{pq} Z_j^q X_{ij}^p + \sum_{p=1}^{P} u_{pj} X_{ij}^p + u_{0j} + \varepsilon_{ij} \quad (4a)$$

where:

μ are the regression coefficients (fixed parts of the model – they do not change across groups);

u are the residuals at the group level;

ε are the residuals at the individual level. The residuals ***u*** and ***ε*** are the random or stochastic part of the model.

The multilevel model can be extended across more than two levels of analysis. In this case the parameters at the highest level of analysis are allowed to vary up to the next level. Always the parameters at the highest level of analysis are considered as fixed. A multilevel model extended to a greater number of levels produces structures that are even more complex and implies more complex disturbance term. Recent advances in computational power and software packages allows the analysis of at least 3-level models, and even nine levels, but the interpretation of complex multi-level models is very difficult. That is why more than two levels should not be included unless one has a clear rationale for doing so and strong expectations about the nature of the effects.

Model specification

The econometric model considers four determinants of pollution expenditure: plant characteristics, market incentives, communities' characteristics and regulation intensity. The dependent variable is plant environmental pollution expenditure (PACE) defined as:

$$PACE = f(PLANT, MARKET, COMMUNITY, REGULATORY) \quad \textbf{(5)}$$

Plant - Plant characteristics,

Market – Market incentives,

Community - Community characteristics,

Regulatory - Regulatory intensity.

Table 1 provides a list of variable definitions and a summary of theoretical priors for their effects on participation.

Table 1 Variable Definitions and Expected Signs

Variables	Explanations	Sign
Plant characteristics variables		
Product	Plant productivity as a measure of economic performance	+
Debt	Debt ratio measure of a company's financial leverage	-
Turnover	Plant activity size defined as turnover	+
Market incentives variables		
Iso	ISO 14000 certification, indicating environmental management adoption	+
Mark	Listing on Bucharest Stock Exchange, proxy for the firm's visibility	+
Community characteristics variables		
UnEmp	Unemployment proxy for population welfare	-
EnvNGO	Number of environmental non-governmental organizations; proxy for population reactivity	+
Regulatory intensity variables		
PollSect	Pollution industry sectors as proxy for intensity of the regulation - command and control environmental policy instruments	+
EnvGuard	Environmental penalties, proxy for the regulatory pressure to adopt an environmental behaviour- liability environmental policy instruments	+
EnvTx	Environmental taxes, proxy for the economic incentives to adopt an environmental behaviour – economic environmental policy instruments	+
EnvSub	Environmental subsidies, policy instruments to promote plant environmental behaviour- economic environmental policy instruments	+

Thus, the econometric specification used is the following:

$$\begin{aligned}\log(PACE_{it}) = \beta_0 + \beta_1 \log(\Pr oduct_{it}) + \beta_2 \log(Debt_{it}) + \beta_3 \log(Turnover_{it}) + \beta_4 \log(Mark_{it}) + \\ + \beta_5 PolSect_{it} + \beta_6 \log(EnvTx_{it}) + \beta_7 \log(EnvSub_{it}) + \beta_8 \log(UnEmp_{it}) + \beta_9 \log(EnvNGO_{it}) + \\ + \beta_{10} \log(EnvGuard_{it}) + \beta_{11} Iso_{it} + u_{it}\end{aligned} \quad \textbf{(6)}$$

where:

- $PACE_{it}$ = pollution abatement expenditure incurred by plant ***i*** in year ***t***
- $Product_{it}$ = plant productivity of plant ***i*** in year ***t***
- $Debt_{it}$ = debt ratio of plant ***i*** in year ***t***
- $Turnover_{it}$ = turnover of plant ***i*** in year ***t***
- $Mark_{it}$ = listing on Bucharest Stock Exchange of plant ***i*** in year ***t***
- Iso_{it} = dummy variable with value=1 if plant ***i*** is certified ISO 14001 and 0 in other case
- $UnEmp_{it}$ = unemployment rate of county ***i*** in year ***t***
- $EnvNGO_{it}$ = number of environmental non-governmental organizations of county ***i*** in year ***t***
- $PollSect_{it}$ = dummy variable which takes value 1 if plant ***i*** becomes active in year ***t*** in pollution sectors and 0 otherwise
- $EnvTx_{it}$ = environmental taxes of plant ***i*** in year ***t***
- $EnvSub_{it}$ = environmental subsidies of plant ***i*** in year ***t***
- $EnvGuard_{it}$ = environmental penalties in county ***i*** in the year ***t***
- u_{it} – error term

3.3 Data

The analysis has been carried out for Romania in the period 2002 – 2005. The data are taken from the yearly survey of plant pollution abatement effort conducted by the Romanian National Institute of Statistic which inquires about capital expenditures and operating cost associated with pollution abatement efforts. Data from the survey are tabulated by industry.

The data are in the form of a panel providing environmental and financial information at establishment level (on pollution abatement and control expenditure, environmental taxes and subsidies) and community characteristics and regulation intensity data at county level for the period 2002-2005. The sample contains 535 plants in 2002, 573 plants in 2003, 608 plants in

2004 and 593 plants in 2005 covering almost all industrial sectors. We selected only the plants with continuous activity in this period.

The establishment characteristics (economic and financial information) are taken from plant financial reports. Also, we identified the firms who were traded on the capital market and listed on the Bucharest Stock Exchange, and those certified ISO 14001, using information from the Romanian Accreditation Association. The community characteristics were obtained from the Romanian National Institute of Statistics, except for the number of environmental ONG which comes from the Ministry of Environment. Using the information from Environmental Guard we constructed a proxy variable for regulation intensity (environmental penalties levied).

3.4 Empirical results

The econometric results from the model are reported in Table 2.

Table 2: Econometric results

Variables	Coefficient	
Product	0.004	(2.12)**
Debt	-0.129	(7.03)***
Turnover	0.001	(1.74)*
Mark	0.614	(15.18)***
Iso	0.046	(1.68)*
EnvNGO	0.053	(1.15)
UnEmp	-0.087	(0.66)
PollSect	0.173	(3.99)***
EnvGuard	0.099	(1.97)**
EnvTx	0.007	(0.55)
EnvSub	0.006	(1.99)**
Observations	2309	-
Absolute value of z statistics in parentheses		
* significant at 10%; ** significant at 5%; *** significant at 1%;		

It can be seen that the signs of the statistically significant variables are in general as expected. The large and successful firms with capital availability are more likely to adopt an environmental behaviour and invest in environmental protection.

Market pressure from consumers, investors and competing firms, estimated by the adoption of ISO 14001 and by the listing on the Bucharest Stock Exchange, has a significant positive impact.

The influence of community groups, proxied by unemployment and the number of environmental non-governmental organisations, has no statistically significant impact on PACE. In general, in the transition economies the concern for the environment is not a top priority for the community, which is confronted with economical and financial problems.

Public authorities which are concerned with regulatory enforcement and monitoring are critical factor influencing plants' decisions to take an environmental approach and carry out environmental investment. Environmental penalties and subsidies are found to have a statistically significant positive impact, whilst environmental taxes are not statistically significant.

4. Conclusions

This paper has tested some hypotheses formulated in the environmental literature about PACE patterns at plant level. Its original contribution is to examine them using survey data in the case of a country such as Romania, which has undergone a process of economic and political transition and has been a EU member since 2007; also, we apply an appropriate econometric method, namely MRM.

Our results are generally consistent with the literature suggesting that plant characteristics, formal pressure through substantial regulatory actions and informal pressure through market incentives and community aspects may be important drivers of the level of plant PACE. However, unlike in the case of developed countries, we find that in Romania the population's potential for collective action in the environmental area is not significant. Whether the influence of these stakeholders on PACE will strengthen as Romania completes its development process remains to be seen. Also, there is no evidence that environmental taxes work as incentives to adopt an environmental behaviour at plant level. As expected, the actions of regulators (command and control and liability instruments), market pressure and plant characteristics are the most important determinants of the level of PACE.

These findings enable us to gain a better understanding of the factors increasing the level of plant PACE in the case of transition economies in general and Romania in particular. They point to the need to redesign environmental taxes in order to achieve better outcomes.

Further, it appears that adopting measures to increase the population's interest in environmental issues would also be useful in this respect.

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