JEL Classification: Q53, Q58, C25
Keywords: environmental management, bivariate analysis, Central and Eastern Europe

Corporate Environmental Management in Transition Economies: The Case of Central and Eastern Europe*

Jorge H. GARCÍA – Department of Economic, University of Gothenburg, Sweden
Randy BLUFFSTONE – Department of Economic, Portland State University
Thomas STERNER – Department of Economic, University of Gothenburg, Sweden and Resources for the Future, Washington, D.C. – *corresponding author* (thomas.sterner@economics.gu.se)

Abstract
We study the adoption of environmental management practices in the most polluting industrial sectors in Bulgaria, Hungary, Lithuania, Poland, Romania and Slovakia during the first years of transition from central planning to market economies. Despite the stickiness of long established managerial regimes, 51% of the firms in our sample adopted environmental plans and/or established environmental departments in the 1990–1998 period. Our bivariate analysis reveals that some of the most important forces behind adoption are environmental enforcement, export orientation and public disclosure of firm environmental performance.

1. Introduction

This paper studies corporate environmental management and its determinants during transitions from Soviet style socialism toward market economies. Some proponents of this socialism asserted there would be less pollution in economies not driven by profit motives, because planners would (or at least could) take into account all costs and benefits of pollution. However, in reality we generally observe the opposite. Under central planning the bias towards heavy industry combined with a lack of incentives to implement practices that economize on inputs created considerable waste and pollution.[1]

We are particularly interested in the 1990–1998 period when the transition was taking its first and most dramatic steps; the fall of the Berlin wall, which marked the end the socialist era in Central and Eastern Europe (CEE), occurred in 1989. We analyze survey data, which were collected in 1998 from 1,719 firms in generally-recognized highly polluting sectors in Bulgaria, Hungary, Lithuania, Poland, Romania

* The authors are grateful to an anonymous referee, Allen Blackman, Runar Brännlund, Fredrik Carlsson, Åsa Löfgren and Celine Nauges for helpful comments and suggestions. Financial support from the Swedish International Development Cooperation Agency (Sida) to the Environmental Economics Unit, University of Gothenburg, the United States Agency for International Development (USAID) support for the data collection is gratefully acknowledged. We would also like to acknowledge the contributions of the researchers at Bulgarian Industrial Association (Bulgaria), TARKI Social Research Group (Hungary), Environmental Policy Center (Lithuania), Institute of Economics, Polish Academy of Sciences (Poland), Center for Environmentally Sustainable Economic Policies CESEP (Romania) and, Incoma Research (Slovakia), who collected the data used in this paper.

[1] There were some areas in which these economies did well from an environmental viewpoint. In the absence of private cars there were systems of public transport, which in some cases deteriorated during the transition period, resulting in more mobile-source emissions. Similarly, there were recycling systems that have now been abandoned. There were also some rural and wilderness areas that were less affected by pesticides and tourism than today.

and Slovakia. The survey results suggest that environmental awareness of firms rose as market reforms were introduced; indeed the number of firms that according to their own reports adopted Environmental Plans (EPs) quadrupled during the first nine years of transition and establishment of Environmental Departments (EDs) doubled. This study has two objectives. First, we seek to unveil the factors that spurred the adoption of Environmental Management Practices (EMPs) in CEE during the transition. During this period the forces created by the example of Western economies had to struggle against the considerable inertia created by a managerial regime that lasted for as long as seventy years in Russia and over forty in Eastern Europe. We are interested in the strength of the transition forces to bring about social and managerial innovation in the use of natural resources. For instance, the desire to participate in foreign markets, especially at a time when industrial output was declining, could have been a strong motivating force in undertaking steps to harmonize with international norms. Increased civil liberties, such as wider information availability and higher public awareness about pollution and health risks, could also have been a determining factor. In fact, it is possible that the existence of civil liberties was one of the most crucial differences between "East" and "West." Environmentalism did not develop automatically in the market economies either, but the existence of free press and civil liberties provided a mechanism to channel new information and preferences, which led to environmental improvements. Finally, the creation of environmental protection agencies that resembled those in western countries could have played an important role.

Our second aim is to add to the body of literature on environmental management by explicitly recognizing its multidimensional nature in a multivariate framework. Environmental management entails, by definition, a series of EMPs (Nash and Ehrenfeld, 2001), and different combinations of EMPs might emerge in different organizations in response to particular needs and demands. Earlier papers that test the determinants of environmental management seem to overlook this aspect. Henriques and Sadorsky (1996) study the determinants of one EMP, environmental plans, in Canada. Dasgupta et al. (2000) analyzed data from Mexican industry and look at the influences of different factors on separate EMPs and on an index defined by the number of EMPs adopted. A similar approach is used by Henriques and Sadorsky (2007) to analyze Hungarian firms. Khanna and Anton (2002) and Anton et al. (2004) also define a count of the number of EMPs to analyze U.S. firm data.[2] Instead of collapsing environmental management into an index, we study the joint adoption decision of two key EMPs, namely EPs and EDs.

We utilize a bivariate probit model that allows comparisons between the determinants of EP and ED adoption and some possible interactions between these two decisions. The results show that those firms that face higher *enforcement* and *public disclosure* of their environmental performance, are more likely to adopt EPs and/or EDs. *Public disclosure* referees to whether a firm appeared in reports about industrial pollution in the media. *Export oriented firms* and *larger firms* as measured by number of employees are also more prone to adoption, but the effects are smaller than those associated with enforcement and public disclosure. The findings on enforcement and firm size are consistent with studies carried out in countries with estab-

[2] Dasgupta et al. (2000) and Khanna et al. (2004) also study the impact of environmental management on actual emissions.

lished market economies (Dasgupta et al., 2000; Khanna and Anton, 2002; Anton et al., 2004). Regarding export orientation, our findings are in line with Neumayer and Perkins (2004), a cross-country study that reports that exports of goods and services per capita are highly correlated with ISO14000 certifications, a well-known international voluntary standard for environmental management. In a related paper, Henriques and Sadorsky (2007) find similar results for market pressure and firm size.[3] To the best of our knowledge, no other studies have attempted to relate information on disclosure of environmental events and firms' environmental management.[4] This finding should be interpreted in terms of increased public awareness and public pressure that are not related to other variables we control for in the analysis. Levels of private and foreign private ownership were expected to be important, but did not appear significant.

The factors affecting EP and/or ED adoption appear to be the same: *enforcement, public disclosure, exports,* and *firm size*. This is despite the fact that in our sample a fairly large proportion of EP adopters are not ED adopters, suggesting that some firms might see these as alternatives. However, the bivariate approach reveals that *enforcement* and *public disclosure* are more important in explaining the ED adoption decision, whereas *export orientation* and *firm size* perform better at explaining EP adoption. Notably, once a firm has decided to adopt an ED, then additional increases in *enforcement* or *disclosure* do not lead to EP implementation.

We begin in Section 2 by discussing the scope of environmental management in transition economies. In Section 3 we describe the data used in the analysis, while Section 4 introduces the methodological approach. Section 5 presents the results and Section 6 concludes the paper with a discussion of the findings.

2. Literature on Environmental Management Practices and Transition

During the socialist period CEE countries were known for severe pollution (Satre-Ahlander, 1994). Coal was the primary source of energy, providing 40% (Hungary) to 90% (Poland) of the total (Hughes, 1991; Chandler, 2000, p. 139; Carter, 1993). Industry, power and heating plants tended to be located near coal reserves in order to reduce transport costs and given the low quality of coal reserves, pollution was a severe threat to both people and ecosystems in these areas. Water quality was also a serious issue. Over 80% of the East German rivers were considered highly polluted and Czechoslovakia left almost half of its sewage untreated in 1980 (World Bank, 1994). In Lithuania, only the capital Vilnius had basic wastewater treatment. Poland's Teja River contained 65 times more bacteria than recommended by the World Health Organization (Hughes, 1991; Wilczynski, 1990; Carter, 1993; Chandler, 2000).

The CEE countries emitted much more pollution per unit of GDP and per person than OECD countries. For example, in 1980 the planned economies in Europe averaged 13 times more particulates per capita than EU countries and three times more wastewater emissions (OECD, 1999). SO_2 emissions per capita were on aver-

[3] That study uses Hungarian firm-level data from a more advanced stage of transition, namely year 2003, when Hungary signed the Treaty of Accession to the European Union.

[4] A number of papers have reported that releases of information about the environmental performance of firms do produce reductions in actual emissions (Konar and Cohen, 1997; Foulon et al., 2002; García et al., 2007).

age 75% more than the EU in 1990 (UNFCCC, 2008). Compared with Western Europe, CEE countries produced 30% more SO_2 per unit of energy consumed (Wilczynski, 1990; Sharma, 1997, p. 82).

Environmental management systems that are common today hardly existed in the planned economies of the time. In modern market economies, on the other hand, the use of EMPs was already widespread in 1990. According to one survey from that time of 400 senior managers of international firms, almost 80% reported that they utilized such methods (McKinsey & Company, 1991). We also see a broad range of EMPs, including the development of environmental plans, establishment of environmental departments, adoption of environmental audit programs and certificates such as ISO 14000, waste minimization and pollution prevention programs and internal monitoring of air and water pollution emissions. It is conceivable that these steps are complementary and that for instance the build-up of an environmental department leads to auditing and pollution prevention programs, which in turn necessitate a further strengthening of environmental departments. It is, however, also conceivable that they partly are substitutes, in particular if a firm views this as an "image issue". If firms, for example, manage to get a certification, they may feel they do not have to make additional improvements since they already acquired sufficiently green credentials for marketing or other purposes.

This latter possibility is, however, limited by the fact that many of these programs have their own logic. They lead to people being hired, trained, and focused on environmental issues and their interests have a tendency to become a force in their own right. Some programs are also quite formal and abide by rules set by outside organizations. This applies, for instance, to the set of measures necessary for International Standards Organization 14000 series certification. An ISO 14001 certification requires documentation of environmental planning, monitoring and assessment. In addition to being a potentially useful tool for management, it is assumed to signal commitment and quality, which may explain its value to firms (Boiral and Sala, 1998; Clapp, 2001). For example, it has been found that EU importers put great weight on ISO 14001 certification when choosing trade partners, (see Bellesi et al, 2005). King and Lenox (2001) suggest that cost savings may be a separate factor since US firms with ISO 140001 certification tend to also have ISO 9001, which addresses product quality.

There is a substantial literature that examines the determinants of EMPs. This includes Henriques and Sadorsky (1996), who study the existence of environmental plans in Canadian firms, the role of ownership structure and the existence of outside pressure from consumers, investors, community, and government. Anton et al. (2004) also find that consumers, investors and even competitors may prompt environmental action. Another study showing the importance of good relations with stakeholders, especially regulators and consumers is Benito and Benito (2005), who find that the main drivers of adoption are more effective regulatory compliance and cost savings. Khanna and Anton (2002) show that important factors are the threat of tougher regulation and fear of liabilities. They also note that EMPs are not necessarily alternatives to regulation, since they are usually undertaken against a backdrop of solid regulation that creates adoption incentives.

These studies all look at mature market economies. Examining economies in transition offers us special opportunities to look at other, perhaps more fundamental,

drivers of firm behaviour. During major economic transitions dramatic changes in fundamental firm-level behavioural parameters, like production technology, customer base, regulatory pressures and even motivations for production occur. Examples of major contextual changes that occurred during the 1990s in CEE countries include the creation of more secure property rights, development of functioning markets and creation of competitive business environments, all of which may be expected to strongly enhance incentives for efficient production. Brown et al. (2006) find, for example, that privatization is associated with 15 to 50% increases in productivity in Romanian manufacturing and 8% to 28% in Hungary. Collins and Harris (2002) analyze a sample of UK metal manufacturing plants and find that foreign-owned plants are more likely to invest in pollution abatement and invest more than purely domestic plants. Sterner (1990) finds in Mexican cement manufacturing that cooperative ownership is superior, but foreign multinational ownership could be either more or less energy efficient than local ownership. Dasgupta et al. (2000) analyze Mexican firms as well and report that formal regulation and public trading of a firm's stock are associated with adoption of EMPs.

One of the most striking results of the transition from planning to market economies in CEE countries was the internationalization of previously isolated economies.[5] This opening up could have important ramifications for corporate environmental management. For example, in a survey of 1,000 potential foreign corporate investors in CEE countries, over three-quarters said they utilized headquarter country environmental management standards when they were stricter than those in their countries of investment (Klavens and Zamparutti, 1995; Environment for Europe, 1994).

Similarly, increased exports to market economies could also spur better environmental management, including adoption of EMPs. Quality standards are often higher in western markets and can typically only be met by using improved technologies mediated by EMPs (Andonova, 2003). Consumers in many of these countries also prefer products manufactured using environmentally benign methods, but have little direct information on these processes. While requiring some proof of environmental management may be popular as a convenient non-tariff trade barrier, firms with higher foreign trade shares may also adopt EMPs to signal green production methods (Bellesi et al., 2005).

Finally, freedom of speech, press and association may have fundamental effects on the adoption of EMPs. We know that environmental management in industrialized countries is the result of interactions between members of society who place different weights on environmental quality and that the effects of open media and existence of civil liberties are very important for resolving these differences (Sachs, 1995). We also know from the literature on environmental information that making information available can have significant effects on firms' emissions levels (Konar and Cohen, 1997; Foulon et al., 2002; García et al., 2007).

While little information on pollution was available before 1989, during the economic transitions such information became widely available as most CEE countries

[5] CEE countries experienced significant foreign direct investment (estimated at USD 70 billion) flowing into the region in the 1990s. Export earnings averaged almost 9% during 1993–98, with the share of exports to the West increasing to 67% by 1999 (World Bank, 2000).

began to enforce the public's right to know about the environment. Under socialism there were also very few independent environmental advocacy groups, but even by 1997 the Regional Environment Centre headquartered in Budapest had identified 3,000 NGOs advocating for improved environmental quality in the region. Furthermore, official regulatory authorities, such as ministries of environment, environmental protection agencies and inspectorates were strengthened during the transition period. Monitoring systems were also put in place and though by no means perfect, the produced data were increasingly used for enforcement purposes.

3. Data

In order to identify the key drivers of transition-period adoption of key EMPs, we analyze data from firms located in Bulgaria, Hungary, Lithuania, Poland, Romania and Slovakia.[6] These countries represent a wide variety of cultures and transition experiences, with Hungary and Poland considered the most advanced in terms of private sector development, followed by Lithuania and Slovakia and then Romania and Bulgaria. The data were gathered in 1998 by professional research firms or institutes that either had substantial experience in environmental economics research or specialized in survey implementation. The sample was stratified to include only firms operating in industries that are generally highly polluting and therefore likely to face environmental management challenges. Our analysis covers animal raising, mining, power and manufacturing sectors.

Our focus is on the establishment of Environmental Plans (EPs) and Environmental Departments (EDs) during the first nine years of transition and we take EP and ED adoption as dependent variables in the analysis. The survey asked firms whether they had an EP or an ED in 1998 and the year(s) of initiation. Before 1990, relatively few firms had EPs and around 51% of the firms adopted either EPs or EDs between 1990 and 1998.[7] An Environmental Plan (EP) could well be based on EMAS or EMS but actually in the questionnaire was more broadly conceived. An EP was any document or plan that was defined by management as an environmental plan. This treatment reflects the realities of the transition setting when relatively few firms had harmonized their EMSs with Western Europe and a variety of western-style EM requirements were just emerging. *Table 1* shows that adoption of EPs increased by a factor of 4 and the number of firms that established EDs doubled during 1990––1998.

Table 2 presents joint EP and ED adoption frequencies for both the full sample and a restricted sample that excludes firms that had adopted either an ED or EP before 1990. The first panel (all firms) gives a general picture of the adoption levels for 1998: almost 40% of the firms did not have an ED or an EP, about one third of the firms had either an ED or an EP and around 30% had both. Roughly 60% of

[6] The data were collected within a project run by the Harvard Institute for International Development and are described in somewhat greater detail in Bluffstone and Sterner (2006). That study is more of a general description of environmental management concerns in Eastern Europe, but also includes an exploratory analysis of EMP adoption.

[7] The survey also asked about the possible presence of other EMPs in 1998, such as the existence of a functioning water treatment plant or the presence of internal monitoring. No information on the year of initiation was however requested, thus it is not possible to attribute their implementation to social planning forces (before 1990) or to the transition forces (after 1990).

Table 1 Environmental Plan (EP) and Environmental Department (ED) Adoption

Period	EP adoption	ED adoption
Before 1990	159 (9%)	272 (16%)
During 1990–98	583 (34%)	554 (32%)
Never	977 (57%)	893 (52%)
Total	1,719 (100%)	1,719 (100%)

Table 2 Cross Tabulation EP and ED Adoption Observed in 1998

All firms (N = 1719)				Without firms that had adopted either ED or EP before 1990 (N = 1376)			
	ED = 0	ED = 1	Total		ED = 0	ED = 1	Total
EP = 0	658 (38%)	319 (19%)	977 (57%)	EP = 0	658 (48%)	235 (17%)	893 (65%)
EP = 1	235 (14%)	507 (29%)	742 (43%)	EP = 1	199 (14%)	284 (21%)	483 (35%)
Total	893 (52%)	826 (48%)	1719 (100%)	Total	857 (62%)	519 (38%)	1376 (100%)

the firms that had an ED also had an EP, but the fact that one third only had one of them suggest that some firms might see them as alternatives. We will therefore look more closely at how these decisions are interrelated.

Our interest is mainly in explaining the determinants of ED and EP implementation during 1990 to 1998, which were the first eight years of the transition period. This is therefore the time period for all explanatory variables used in our econometric models and we limit our sample (N = 1,376) to firms that had adopted neither an EP nor an ED before 1990.[8]

Table 3 presents a description of the explanatory variables, their role in the analysis and some basic statistics.[9] The top of *Table 3* shows descriptive statistics for our explanatory variables of primary interest. The first set of variables captures the external market, social and regulatory pressures that were discussed in the Section 2. The ownership structure of the firm is included as a proxy for investor pressure and corporate culture and is captured by two variables: the proportion of private ownership (*Private owner*) and a dummy (*Foreign owner*) for firms that had some foreign ownership. Two-thirds of the total capital stock was owned by private shareholders and around 15% of firms were partially or totally owned by foreign investors.

The dummy variable *Disclosure* is an indicator of public awareness and public pressure, taking the value of one if the public was informed about firms' environmental performances and emissions of major pollutants during the 1990–1998 period. This category includes reports in local news papers and the media. About a quarter of

[8] Some firms reported EMS implementation as far back as 1972 and this raises questions on the reliability of such data. See section 5 for further details on EMS implementation prior to 1990.

[9] Manufacturing firms represent 85% of the sample while 7.3% of the firms belong to mining, 8.9% to power generation and 3.3% to animal raising.

Table 3 Independent Variables: Definition and Descriptive Statistics (N = 1376)

Variable	Description	A proxy for	Mean	SD
Private	Proportion of private (national & foreign) ownership	Shareholders pressure	66.4883	39.7687
Foreign owner	1 if firm had foreign ownership	Shareholders pressure (FDI)	0.1418	0.3489
Export share	Proportion exports of total production	Product market pressure	24.4574	35.1378
Disclosure	Public was informed about firms pollution	Public awareness and public pressure	0.2290	0.4204
Warnings	1 if firm received any warnings	Government regulatory pressure	0.1672	0.3733
Orders	1 if firm received any order to reduce pollution	Government regulatory pressure	0.1061	0.3081
Fines	1 if firm was fined	Government regulatory pressure	0.1410	0.3482
Age	Age of most firm equipment	Capital quality	26.1265	19.2722
Employees	Number of employees (log)	Employment	5.4514	1.4083
Bulgaria	1 if located in Bulgaria	Country control	0.1810	0.3852
Hungary	1 if located in Hungary	Country control	0.1934	0.3951
Lithuania	1 if located in Lithuania	Country control	0.1374	0.3444
Poland	1 if located in Poland	Country control	0.1745	0.3797
Romania	1 if located in Romania	Country control	0.3090	0.4622
Slovakia	1 if located in Slovakia	Country control	0.0043	0.0659

our sample were subject to such scrutiny. Finally, three dummy variables, *Warnings*, *Orders*, and *Fines*, capture regulatory pressure during the same period. Although the proportion of firms that were subject to each type of enforcement action appears fairly similar, it was not the same firms that were subject to each action and correlations between the three enforcement dummies are relatively low, ranging from 0.21 between *Orders* and *Fines* to 0.29 between *Warnings* and *Orders*.

The variable *Age* refers to the age of most firm capital equipment as of 1998. The average year of installation was 1972, indicating that substantial upgrading was needed. Our hypothesis is that firms with older capital had organizations that were more rooted in the communist times and would therefore oppose the implementation of new strategies; those that had upgraded technology probably also found it less costly to simultaneously implement EMPs. The variable *Employees* denotes the average number of employees in the 1990–1998 period. Since the costs of coordination in large organizations are expected to be high, a plan of action, such as an EP, and a coordinating body, such as an ED, could reduce such costs. Also, firms can exploit labor economies of scale in the development of EMPs.

The bottom of *Table 3* presents a set of country control variables. The existence of EDs varied widely across countries with less than 15% prevalence among Hungarian, Lithuanian and Polish firms versus 45% and 78% in Bulgaria and Romania. Thus, a need to control for possible country-specific effects seems apparent. Cross-country variance in EPs was a bit smaller, however, with one-third to one-half of firms having environmental plans.

4. Empirical Approach

Our empirical approach is based on a latent regression. Firm *i*'s net benefit of adopting a given environmental management practice *j* can be represented as:

$$\pi_{ij}^{*} = \beta_j' x_i + \varepsilon_{ij} \tag{1}$$

where x_i are observable firm characteristics and other factors that determine the profitability, π_{ij}^{*}, of the adoption decision, and ε_{ij} is an unobserved random component. In practice, π_{ij}^{*} is unobservable. What we observe is a dummy variable defined by:

$$y_{ij} = \begin{cases} 1 & \text{if} \quad \pi_{ij}^{*} > 0 \\ 0 & \qquad\quad \pi_{ij}^{*} < 0 \end{cases}$$

It is thus assumed that adoption occurs if it is profitable to the firm. We intend to explain the establishment of not only one but two EMPs. Note that *Table 2* represents a joint distribution between the variables ED and EP and that a positive correlation between the two is apparent. In principle it is natural to think that at least some of the observed and unobserved determinants of different EMPs are similar. We thus implement a bivariate probit model where the two decisions are jointly estimated and are allowed to be correlated (Green, 2003). The model is characterized by:

$$\pi_{iEP}^{*} = \beta' x_i + \varepsilon_{iEP} \qquad EP_i = \begin{cases} 1 & \text{if} \quad \pi_{iEP}^{*} > 0 \\ 0 & \qquad\quad \pi_{iEP}^{*} < 0 \end{cases}$$

$$\pi_{iED}^{*} = \beta' x_i + \varepsilon_{iED} \qquad ED_i = \begin{cases} 1 & \text{if} \quad \pi_{iED}^{*} > 0 \\ 0 & \qquad\quad \pi_{iED}^{*} < 0 \end{cases}$$

where $(\varepsilon_{iEP}, \varepsilon_{iED})$ is distributed as a bivariate normal with zero means, unit variances and correlation ρ between its two components. Since we do not have strong *a priori* hypotheses on different determinants of ED and EP adoption, the vector of explanatory variables x_i in (1) is the same in both equations. There are four types of observations in our sample, $(EP, ED) \rightarrow (0,0),(0,1),(1,0),(1,1)$. Using the bivariate normal distribution, probabilities for each one of these events are constructed and incorporated in a log-likelihood function for estimation. If we recall that *marginal*, *joint* and *conditional* probabilities can be defined within a multivariate framework, in our bivariate case the associated *marginal* probability for ED adoption is:

$$\Pr\left[ED_i = 1\right] = \Phi_1(\beta_1 x_i) \tag{2}$$

where $\Phi_1(\cdot)$ is the cumulative univariate normal distribution function. The *joint* probabilities associated with ED adoption are:

$$\begin{aligned} \Pr\left[ED_i = 1\,,\, EP_i = 1\right] &= \Phi_2(\beta_1 x_i, \beta_2 x_i, \rho) \\ \Pr\left[ED_i = 1\,,\, EP_i = 0\right] &= \Phi_2(\beta_1 x_i, -\beta_2 x_i, -\rho) \end{aligned} \tag{3a, 3b}$$

where $\Phi_2(\cdot)$ is the cumulative bivariate normal distribution function. *Marginal* and *joint* probabilities can be used to calculate the following *conditional* probabilities:

$$\Pr(ED_i = 1 \mid EP = 1) = \frac{\varphi_2(\beta_1 x_i, \beta_2 x_i, \rho)}{\varphi_1(\beta_2 x_i)} = \frac{\varphi_2(\beta_1 x_i - \rho\beta_2 x_i)}{(1-\rho^2)^{1/2}} \tag{4a}$$

$$\Pr(ED_i = 0 \mid EP = 1) = \frac{\varphi_2(\beta_1 x_i - \beta_2 x_i - \rho)}{\varphi_1(-\beta_2 x_i)} = \frac{\varphi_1(-\beta_1 x_i + \rho\beta_2 x_i)}{(1-\rho^2)^{1/2}} \tag{4b}$$

Equations (2), (3a, 3b) and (4a, 4b) can also be defined for EP and will have similar forms (Christofides et al., 1997). Note that when the correlation coefficient is zero, then *conditional* probabilities reduce to *marginal* probabilities and *joint* probabilities equal the product of the *marginal* probabilities.

The model described above resembles a seemingly unrelated regression (SUR) model where the dependent variables are dummy variables. SUR models are usually justified by higher efficiency relative to single equation techniques where possible correlation across error terms is not exploited. It has however been established that gains in efficiency are reduced when the sets of independent variables are the same across equations, as they are in our case (Wooldrige, 2001).

We are particularly interested in the estimation of the correlation coefficient itself, since it provides evidence on possible similarities (or dissimilarities) of unobservable ED and EP determinants. *Marginal*, *joint* and *conditional* probabilities of the estimated bivariate distribution give further insights on firm motives to adopt ED and/or EP and, most importantly, the level of interdependence.

5. Results

Table 4 presents marginal effects for *marginal* and *joint* probabilities based on full information maximum likelihood estimates of the bivariate probit model for ED and EP adoption. For the continuous variables the estimates measure the increase in the probability of observing a given event due to a partial change in independent variables. For dummy variables, the marginal effects are calculated as differences in the probabilities of observing adoption for the two possible values. All marginal effects are calculated at sample means. The cross tabulation in the bottom right panel of the table relates predicted outcomes to actual events using a threshold probability value of 0.5. The estimated model correctly predicts 84% of the outcomes. The correlation between the two random terms is positive, large and highly significant implying that some of the unobserved determinants of ED and EP adoption could be the same and that there are complementarities between these EMPs.[10]

[10] Frequency calculations based on *Table 6* (in *Appendix*) reveal that firms that adopted EPs and EDs before 1990 have somewhat higher probabilites to adopt the other EMPs during the period 1990–98. When including control dummies in our specification, we find severe collinearity with the other independent variables. Note, however, that the bivariate model explicitly tests for contemporaneous EP-ED correlation and this is exploited in the estimation. The estimated correlation coefficient is positive and significantly different from zero, which underscores the presumption that EP and ED are interlinked. Although this is not a test for the influence of prior implementation it suggests that such a possibility exists.

Table 4 Marginal effects on *Marginal* and *Joint* Probabilities

Variable	Δ Prob [ED = 1] / Δ*x*	Δ Prob [EP = 1] / Δ*x*	Δ Prob [ED = 1, EP = 1] / Δ*x*
Private	0.0003	-0.0003	0.0000
	(0.0005)	(0.0004)	(0.0003)
Foreign owner[d]	-0.0310	-0.0111	-0.0000
	(0.0466)	(0.0416)	(0.0284)
Exportshare	0.0013 **	0.0022 ***	0.0010 ***
	(0.0006)	(0.0005)	(0.0002)
Disclosure[d]	0.1052 ***	0.0739 **	0.0745 ***
	(0.0407)	(0.0364)	(0.0274)
Warnings[d]	0.1781 ***	0.0103	0.0735 ***
	(0.0587)	(0.0432)	(0.0334)
Orders[d]	0.1279 **	0.1100 **	0.0914 ***
	(0.0631)	(0.0502)	(0.0350)
Fines[d]	0.0843 *	0.0450	0.0509 *
	(0.0481)	(0.0438)	(0.0290)
Age	0.0007	-0.0006	-0.0005
	(0.0010)	(0.0008)	(0.0006)
Employees (log)	0.0268 *	0.0341 ***	0.0243 ***
	(0.0137)	(0.0119)	(0.0084)
Bulgaria [d]	-0.2558 ***	0.1812 ***	-0.1604 ***
	(0.0351)	(0.0393)	(0.0193)
Hungary [d]	-0.40921 ***	0.0670	-0.1911 ***
	(0.0323)	(0.0688)	(0.0209)
Lithuania [d]	-0.4040 ***	-0.1259 ***	-0.2160 ***
	(0.0262)	(0.0439)	(0.0157)
Poland[d]	-0.3887 ***	0.0428	-0.1865 ***
	(0.0263)	(0.0501)	(0.0167)
Slovakia[d]	-0.3039 ***	0.1724	-0.1641 ***
	(0.0340)	(0.2474)	(0.0291)

N	1375	*Cross tabulation of EP and ED*	
Rho	0.5280 ***	*Fitted values in brackets*	
	(0.0444)	ED = 0	ED = 1
Log likelihood	-1347.71	EP = 0	658 [894]	199 [48]
Pseudo R^2	0.22	EP = 1	235 [178]	284 [256]

Notes: Standard errors are in parentheses. * significant at a 10% level; ** significant at 5%; *** significant at 1%. Marginal effects for dummy variables are measured at the means of other variables whereas marginal effects for continuous variables are given at the means of all variables. Superscript *d* indicates dummy variable.

5.1 Marginal Probabilities of EP and ED Adoption

The first two columns of *Table 4* present marginal effects for *marginal* probabilities where the decisions to adopt an ED and an EP are considered separately (see equation 2). These marginal effects take the signs and significance levels from the regression estimates, which have been omitted for the sake of brevity. Apart from some country controls, similar sets of variables appear consistently significant and with the same signs in both sets of parameter estimates. Although the warnings and fines dummy variables are both significant in the ED equation, neither appears significant in the EP equation. The third measure of government enforcement, the orders dummy variable, is significant in both models. The fact that not only the observed, but also the unobserved factors that determine EP and ED adoption are alike is an interesting finding, because not all EP adopters are ED adopters and vice versa. Apparently, firms

with similar characteristics that are faced with similar external pressure undertake either or both strategies. Firms with larger numbers of employees that are more export-oriented and that are faced with public disclosure requirements and higher enforcement are more likely to adopt EMPs. Age and ownership variables appear non--significant in the regression results and throughout the analysis.

Regarding the magnitude of marginal effects for *marginal* probabilities (first two columns in *Table 4*), enforcement and disclosure have a strong effect on ED adoption, while employment and exports influence EP adoption. For example, the sum of the three marginal effects for warnings, orders and fines is 0.39 for ED adoption and only 0.16 for EP adoption. The existence of warnings increases the probability of ED adoption by 17.9%, whereas the presence of fines increases the likelihood of having such institutions by 8.4%. No significant effects of the fines and warnings dummy variables are found on EP adoption.

The marginal effects associated with orders to reduce emissions are similar in both models at around 12%. Those firms whose environmental performances are publicly disclosed increase the probability of ED (EP) adoption by 10.5% (7.4%), but an increase in the proportion of exported products increases the probability of ED (EP) adoption by only 0.1% (0.2%). A percentage point increase in the number of employees is reflected in a 2.7% and a 3.4% increase in the probability of ED adoption and EP adoption, respectively.

The third column of *Table 4* shows the marginal effects on the (*joint*) probability of firms implementing both an ED and an EP. The determinants of environmental management reveal themselves with high accuracy in this set of results compared to those of *marginal* probabilities shown in the first two columns. All determining variables except fines are significant at a 1% level when we analyze the firms that have both EP and ED.

Table 5 presents the marginal effects on *conditional* probabilities. The results on *marginal* probabilities show that enforcement, disclosure, export, and employment seem to explain both EDs and EPs. The results on *conditional* probabilities provide an indication of the relative importance of these four factors at explaining each of these EMPs. The first panel of *Table 5* shows that, given a constant EP adoption status, employment and export shares do not increase the probability of ED adoption whereas disclosure and warnings do have a positive and significant effect. Note also that other enforcement variables – the orders and fines dummies – are positive and have relatively small standard errors, although not small enough to make them significant at 10% levels.

It is found that *ceteris paribus*, employment and export shares increase the probability of EP adoption whereas disclosure and enforcement actions have no effect. We also find that if a firm is faced with an enforcement action and it already has an ED or does not have an ED and decides not to adopt one, then the likelihood of establishing an EP is not increased.

We have put quite some effort into making sure that the covariates used in the analysis are exogenous. For instance, although available to us, we did not use data on manager perceptions of the factors that could possibly induce EMP adoption. Neither did we use information on early adopters (those firms that implemented EMPs before 1990) since our covariates are defined for the 1990–1998 period.

Table 5 Marginal Effects on Conditional Probabilities

Variable	ΔProb[ED=1 | EP=1] / Δ*x*	ΔProb[ED=1 | EP=0] / Δ*x*	ΔProb[EP=1 | ED=1] / Δ*x*	ΔProb[EP=1 | ED=0] / Δ*x*
Private	0.0005	0.0004	-0.0006	-0.0004
	(0.0005)	(0.0004)	(0.0005)	(0.0004)
Foreign owner[d]	-0.0444	-0.0298	0.0286	0.0188
	(0.0574)	(0.0381)	(0.0486)	(0.0365)
Exportshare	0.0006	0.0005	0.0021 ***	0.0017 ***
	(0.0007)	(0.0004)	(0.0006)	(0.0005)
Disclosure[d]	0.0915 **	0.07356 **	0.0394	0.0363
	(0.0437)	(0.0357)	(0.0396)	(0.0308)
Warnings[d]	0.1959 ***	0.1637 ***	-0.0655	-0.0401
	(0.0531)	(0.0541)	(0.0470)	(0.0322)
Orders[d]	0.0998	0.08407	0.0702	0.0626
	(0.0638)	(0.0561)	(0.0520)	(0.0446)
Fines[d]	0.0793	0.0632	0.0152	0.0163
	(0.0511)	(0.0419)	(0.0480)	(0.0368)
Age	-0.0006	-0.0005	-0.0004	-0.0003
	(0.0012)	(0.0008)	(0.0011)	(0.0008)
Employees (log)	0.0171	0.0143	0.0287 **	0.0230 **
	(0.0163)	(0.0116)	(0.0139)	(0.0101)
Bulgaria [d]	-0.2772 ***	-0.1728 ***	-0.0914	-0.0928 ***
	(0.0593)	(0.0305)	(0.0635)	(0.0356)
Hungary [d]	-0.6159 ***	-0.319 ***	0.3469 ***	0.1925 ***
	(0.0473)	(0.0291)	(0.0619)	(0.0677)
Lithuania [d]	-0.5990 ***	-0.2894 ***	0.1944 ***	0.0062
	(0.0367)	(0.0269)	(0.0626)	(0.0433)
Poland[d]	-0.5872 ***	-0.2982 ***	0.3143 ***	0.1633 ***
	(0.0376)	(0.0257)	(0.0479)	(0.0497)
Slovakia[d]	-0.5154 ***	-0.2082 ***	0.3684 ***	0.2753
	(0.0603)	(0.0208)	(0.1004)	(0.2494)

Notes: Standard errors are in parentheses. * significant at a 10% level; ** significant at 5%; *** significant at 1%. Marginal effects for dummy variables are measured at the means of other variables whereas marginal effects for continuous variables are given at the means of all variables. Superscript *d* indicates dummy variable.

The types of variables that we did use are, however, interlinked in complex ways and we acknowledge that our estimates could still suffer bias due to some endogeneity. For instance, we find that facilities that faced higher enforcement and whose pollution levels were publicly disclosed were more likely to have EDs and/or EPs. However, it could be true that firms that adopt EMPs might subsequently face less pressure from authorities, because EMPs signal compliance. As compliers, they might then be less likely to appear in the news as heavy polluters. This line of reasoning would actually still strengthen our general conclusions, because it would just imply that our results underestimate the effects of enforcement and disclosure.

6. Conclusions

The findings in this paper suggest that a variety of factors and not just the fall in industrial output that occurred during the early 1990s might have lead to the improvements in ambient quality in CEE countries.[11] We know that changes in production processes and the implementation of abatement technologies, which are arguably results of managerial strategies, could also lead to emissions reductions.[12] In fact, 42% of the firms in our sample adopted EPs and/or EDs during the 1990–1998 period. In this paper, we delve into the determinants of these EMPs.

Our results show that the observed determinants of EP and ED adoption are practically the same and that the unobserved determinants of these two EMPs are highly correlated. These findings, although not necessarily surprising, are not directly evident from the data where a high proportion of EP adopters did not adopt EDs and vice versa. The factors that appear to drive both EP and ED adoption are: (a) enforcement activities, which seemed to increase during the transition thanks to the creation or strengthening of environmental management agencies; (b) public disclosure of environmental performances of firms; c) export-orientation; and finally, (d) firm size. Factors that were expected to play a role but did not appear significant in the analysis were private and foreign private ownership (as opposed to public ownership) and plant age.

Looking deeper we find that enforcement and disclosure are more important for explaining the build up of environmental bureaucracies (ED), whereas employment and export orientation are more important at explaining environmental plans (EP). One possible interpretation might be that the former is the more "Soviet" or, in this context, "old-fashioned" response, which is mainly triggered by variables such as regulatory policies and disclosure, while the adoption of environmental plans is a more "modern" or market based response and thus more sensitive to variables such as export orientation. From a policy viewpoint, perhaps the most important new knowledge to emerge is that enforcement is a strong and positive determinant of both EPs and EDs. The implication of this is that market reform and deregulation are not necessarily going to lead to an automatic enthusiasm for environmental management; there is still an important role for regulators.

[11] The economic transitions in CEE countries greatly reduced stationary source air and water pollution. For example, in the Slovak Republic emissions of particulate matter (an important air pollutant) by stationary sources declined by 80% during the eight years between 1990 and 1997. SO_2 emissions fell by over 60% and NO_x declined by 45% during the same period (Ministry of Environment of the Slovak Republic, 1998). In Lithuania, for example, industrial emissions of chrome and copper declined by 65–70% during 1989––1994 alone. Biological oxygen demand in surface waters fell by about 90% during the 1990s (Ministry of Environment of Lithuania, 2001).

[12] A number of studies have shown that firms with EMPs produce less pollution and are more likely to comply with environmental legislation. Anton et al. (2004) found that firms with more comprehensive environmental management systems had lower toxic releases per unit of sales. Newbold (2006) found that adoption of EMPs in the Chilean mining sector improves the environmental performance of firms. Nash and Ehrenfeld (2001) cite several examples where adoption of EMPs likely improved environmental performance in US firms. They also note that when EMPs conflict with other goals, firms may drop or revise them.

APPENDIX

Table 6 Cross Tabulation EP and ED Adoption. Complete Sample

	ED = 0	ED 1990-1998 = 1	ED prior 1990 = 1	Total
EP = 0	658 (38%)	235 (14%)	84 (5%)	977 (57%)
EP 1990–1998 = 1	199 (12%)	284 (17%)	100 (6%)	583 (34%)
EP prior 1990 = 1	36 (2%)	35 (2%)	88 (5%)	159 (9%)
Total	893 (52%)	554 (32%)	272 (16%)	1719 (100%)

REFERENCES

Aden J, Kyu-Hong A, Rock M (1999): What is driving the Pollution Abatement Expenditure Behavior of Manufacturing Plants in Korea? *World Development*, 27(7):1203–1214.

Andonova L (2003): Openness and the Environment in Central and Eastern Europe: Can Trade and Foreign Investment Stimulate Better Environmental Management in Enterprises? *Journal of Environment and Development*, 12(2):177–204.

Anton WRQ, Deltas G, Khanna M (2004): Incentives for Environmental Self-Regulation and Implications for Environmental Performance. *Journal of Environmental Economics and Management*, 48(1):632–654.

Arora S, Cason TN (1996): Why do Firms Volunteer to Exceed Environmental Regulations? Understanding Participation in EPA's 33/50 Program. *Land Economics*, 74(4):413–432.

Bellesi F, Lehrer D, Tal A (2005): Comparative Advantage: The Impact of ISO 14001 Environmental Certification on Exports. *Environmental Science & Technology*, 39(7):1943–1953.

Benito J, Benito O (2005): An Analysis of the Relationship between Environmental Motivations and ISO 14001 Certification. *British Journal of Management*, 16(2):133–148.

Bluffstone R, Sterner T (2006): Explaining Environmental Management in Central and Eastern Europe. *Comparative Economic Studies*, 48(4):619–640.

Boiral O, Sala J (1998): Environmental Management: Should Industry Adopt ISO 14001? *Business Horizons*, 41(1):57–64.

Brown JD, Earle J, Telegdy A (2006): The Productivity Effects of Privatization: Longitudinal Estimates from Hungary, Romania, Russia and Ukraine. *Journal of Political Economy*, 114(1):61–99.

Clapp J (2001) ISO Environmental Standards: Industry's Gift to a Polluted Globe or the Developed World's Competition-Killing Strategy? In: Stokke OS, Thommessen ØB (Eds): *Yearbook of International Co-operation on Environment and Development 2001/2002*. Earthscan Publications, London, 27–33.

Carter FW, Turnock D (1993): *Environmental Problems in Eastern Europe*. Routledge, London.

Collins A, Harris R (2002): Does Plant Ownership Affect the Level of Pollution Abatement Expenditure? *Land Economics*, 78(2):171–189.

Chandler WU (2000): *Energy and Environment in Transition Economies.* Westview Press, Oxford and Boulder, Co.

Christofides LN, Stengos T, Swidinsky R (1997): On the calculation of Marginal Effects in the Bivariate Probit model. *Economic Letters*, 54(3):203–208

Dasgupta S, Hettige H, Wheeler D (2000): What Improves Environmental Compliance? Evidence from Mexican Industry. *Journal of Environmental Economics and Management*, 39(1):39–66.

García JH, Sterner T, Afsah S (2007): Public disclosure of industrial pollution: The PROPER approach for Indonesia? *Environment and Development Economics*, 12(6):739–756.

Henriques I, Sadorsky P (1996): The Determinants of an Environmentally Responsive Firm: An Empirical Approach. *Journal of Environmental Economics and Management*, 30(3):381–395.

Hughes G (1991): Are the Costs of Cleaning up Eastern Europe Exaggerated? Economic Reform and the Environment. *Oxford Review of Economic Policy*, 7(4):106–136.

King A, Lenox MJ (2001): Lean and Green? An Empirical Examination of the Relationship between Lean Production and Environmental Performance. *Productions and Operations Management*, 10(3):244–257.

Khanna M, Anton WRQ (2002): Corporate Environmental Management: Regulatory and Market--Based Incentives. *Land Economics*, 78(4):539–558.

Klavens J, Zamparutti A (1995): *Foreign Direct Investment and Environment in Central and Eastern Europe: A Survey*. World Bank Publications, Washington DC.

McKinsey and Company (1991): *The Corporate Response to the Environmental Challenge, Summary Report*. Amsterdam.

Nash J, Ehrenfeld JR (2001) Factors that Shape EMS Outcomes in Firms. In: Coglianese G, Nash J (Eds): *Regulating from the Inside: Can Environmental Management Systems Achieve Policy Goals?* RFF Press, Washington, DC, 61–81

Neumayer E, Perkings R (2004): What Explains the Uneven Take-Up of ISO 14001 at the Global Level? A Panel-Data Analysis. *Environment and Planning*, A 36:823–839

OECD (1999): *Environment in the Transition to a Market Economy: Addressing Environmental Challenges in Central and Eastern Europe and the New Independent States Organization for Economic Co-operation and Development*. Paris.

Newbold J (2006): Chile's Environmental Momentum: ISO 14001 and the Large-Scale Mining Industry – Case Studies from the State and Private Sector. *Journal of Cleaner Production*, 14(3):248–261.

Sachs J (1995): Economies in Transition: Some Aspects of Environmental Policy. *Environment Discussion Paper #1*, *Harvard Institute for International Development*, Boston MA.

Sharma S (1997): *Restructuring Eastern Europe: The Microeconomics of the Transition Process.* Edward Elgar Publishing Ltd, Cheltenham, UK.

Sätre-Åhlander A (1994): *Environmental Problems in the Shortage Economy.* Edward Elgar Publishing Ltd, Cheltenham, UK.

Sterner T (1990): Ownership, Technology and Efficiency: A comparison of domestic, multinational and cooperative enterprises in the Mexican Cement Industry. *Journal of Comparative Economics*, 14(2):286–300.

UNFCC (2008): *National Greenhouse Gas Inventory Data for the Period 1990–2006*. United Nations Framework Convention on Climate Change. Poznan.

Wilczynski P (1990): Environmental Management in Centrally-Planned Non-Market Economies of Eastern Europe. *Research Paper*, *World Bank Publications*, Washington, DC.

Wooldridge JM (2001): *Econometric Analysis of Cross Section and Panel Data*. MIT Press, Cambridge, MA.

World Bank (1994): Environment for Europe: Environmental Action Plan for Central and Eastern Europe. *World Bank Publications*, Washington DC.