Corporate environmental management in transition economies: The case of Central and Eastern Europe

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Abstract

We use firm-level data to study the adoption of Environmental Management Practices (EMPs) in the most polluting industrial sectors in Bulgaria, Hungary, Lithuania, Poland, Romania, and Slovakia during the 1990 – 1998 period when these countries were in a transition away from a centrally planned economy. Despite the stickiness of a long established managerial regime and the declines in industrial output during this period, around 42% of the firms in our sample adopted Environmental Plans (EPs) and/or established Environmental Departments (EDs). The analysis reveals that *enforcement* and *public disclosure* of the environmental performance of firms are the most important forces behind the implementation of both of these EMPs. Also, but to a lesser extent, *export oriented firms* and *larger firms* are prone to adoption. Finally, we use a methodology that clarifies some of the links between different EMPs not addressed in earlier studies. Notably, once a firm has decided to adopt (or not adopt) an ED, additional increases in *enforcement* do not to lead to EP implementation.

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1. Introduction

This paper studies different characteristics of corporate environmental management and their determinants during the transition from Soviet style socialism towards market economics. Some proponents of this socialism asserted the belief that there would be less pollution in economies not driven by the profit motive, 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. We are particularly interested in the in the 1990 – 1998 period when the transition was taking its very first steps. We analyze data on 1,719 firms from the most polluting sectors in Bulgaria, Hungary, Lithuania, Poland, Romania, and Slovakia. The data were collected in 1998 in a survey focusing mainly on environmental management. The survey shows that the environmental awareness of firms rose as market reforms were introduced. The number of firms that adopted Environmental Plans (EPs) and Environmental Department (EDs) during the first nine years of transition (1990 - 1998) increased by a factor of four and, two respectively.

This study has two objectives. First, we seek to unveil the factors that spurred the adoption of Environmental Management Practices (EMPs) in Central and Eastern Europe (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. During this period there was little room for change or even training in the necessary skills. 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. On more social grounds, 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 new preferences, which led to environmental improvements. Finally, the

creation of environmental protection agencies that resembled the western regulator could have played an important role.[1]

Our second aim is to add to the more general 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 Enrelfeld, 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 adoption, namely Environmental Plan (EP), in Canada. Dasgupta et al. (2000) analyzed data from the 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 decisions of two key EMPs, namely EP and Environmental Department (ED). We implement a bivariate probit that allows comparisons between the determinants of EP and ED adoption and some possible interrelations between these two decisions.

The results show that those firms that faced higher *enforcement* and *public disclosure* of their environmental performances by the regulator were more likely to have adopted EPs and/ or EDs. Also, *export oriented firms* and *larger firms* as measured by number of employees, were more prone to adoption, but to a lower degree. The findings on enforcement and firm

[1] The same data was used in Bluffstone and Sterner (2006), which contains further descriptive statistics of this data and background information. That study is more of a general description of environmental management concerns in Eastern Europe, but also includes a first exploratory analysis of the factors that determine the adoption of various kinds of EMPs. In this paper we overcome a number of methodological problems and probe deeper into the underlying determinants of EMPs. That initial analysis, for instance, does not use all information on enforcement actions to explain environmental behavior. Nor does it distinguish between those EMP that were adopted during central planning (before 1990) and transition (after 1990). The differences between this study and Bluffstone and Sterner (2006) are so numerous and far-reaching that the actual results cannot be directly compared.

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

size are consistent with studies carried out in countries with established 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 the country's count of ISO14000 certifications, a well-known international voluntary standard for environmental management. In a related paper, Henriques and Sadorsky (2007) find similar results on product market pressure and firm size.[3] To the best of our knowledge, no other studies has attempted to relate information disclosure on environmental events and firms' environmental management. Our results on the significant role of disclosure are novel in this respect.[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. A factor that was expected to play a role but did not appear significant was private and foreign private ownership (as opposed to public ownership).

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

We begin in Section 2 by discussing, as a background, 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.

[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; Garcia et al., 2004).

2. Environmental management practices in transition

During the socialist period, CEE countries were known for severe pollution (Satre-Ahlander, 1994). Coal was the primary source of energy ranging from 40% of the total energy use in Hungary to nearly 95% in Poland (Hughes, 1991; Chandler, 2000 p.139; Carter, 1993). Industry and power and heating plants tended to be located near coal reserves in order to reduce transport costs, and given the low quality of the coal, pollution was a severe threat to both people and ecosystems in these areas. Water quality was also a very serious problem: Over 80% of the East German rivers were considered highly polluted, and Czechoslovakia left almost half of its sewage untreated in 1980 (Environment for Europe, 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 the OECD countries. For example, in 1980 the planned economies in Europe averaged 13 times more particulates per capita than the EU countries and three times more wastewater emissions. SO_2 emissions per capita were on average twice that of the EU countries (OECD, 1999). Compared with Western Europe, the CEE countries produced 30% more SO_2 per unit of energy consumed (Wilczynski, 1990; Sharma, 1997 p. 82). However, it should be acknowledged that there were some areas in which these economies did well from an environmental viewpoint. In the absence of many goods such as private cars, there well well-developed systems of public transport, which have in some cases been reduced during the transition period. Similarly, there were recycling systems that have now been abandoned. Due to the nature of agriculture and transport, there were also some rural and wilderness areas that were less affected by pesticides and tourism than today.

Separate environmental management systems in the sense that we are accustomed to, hardly existed in the planned economies of the time. Some, although very few, plants did of course have some form of waste treatment. However, the combination of a low overall interest in the environment and the fact that firms did not have the same need for signaling to customers and investors meant that there was little interest in creating special EMPs such as the ISO 14000 certification.

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 more frequent monitoring of air and water pollution emissions. It is conceivable that these are mainly complements 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 the environmental departments. It is however also conceivable that they partly are substitutes, in particular if a firm views this as an "image issue". If they then manage to get a certification, they may feel they do not have to make any more 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 its 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 the firm (Boiral and Sala, 1998; Clapp, 2001). It has been found that EU importers put great weight on the 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 at least US firms with an ISO 140001 certification tend to also have an ISO 9001 certification, which deals with product quality.

There is a group of articles that study the determinants of EMPs. This includes Henriques and Sadorsky (1996) who study the existence of environmental plans in Canadian firms, and the role of ownership structure and the existence of outside pressure from consumers, investors, community, and government. Another study showing the importance of good relations with stakeholders, especially regulators and consumers is Benito and Benito (2005), who find that the main mechanism is more effective regulatory compliance and cost savings. Khanna and

Anton (2002) show that important factors are the threat of tougher regulation and the fear of liabilities. They also note that EMPs are not necessarily alternatives to regulation, since they are usually undertaken against a backdrop of solid regulatory regimes which create the necessary incentives. Anton et al. (2004) find that not only consumers, but also concern for the opinion of investors and even competitors, may prompt environmental action.

The studies just mentioned all look at market economies. Data on economies in transition offer us the opportunity to look at other, more fundamental, factors of firm behavior. During the transition some dramatic changes occur in the parameters that we believe are fundamental but, that are usually constant in modern economies. Examples include the creation of secure property, functioning markets, and competition, all of which may be expected to strongly enhance the 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 that while cooperative ownership is superior, foreign multinational ownership could be either more or in fact less energy efficient than local ownership in Mexican cement manufacturing. 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 EMPs.

One of the most striking features of the transition was the internationalization of the economies that had previously been fairly isolated.[5] Foreign direct investment is likely to have important environmental implications. In a survey of 1,000 potential foreign corporate investors, over three-quarters said they utilized corporate or headquarter country environmental management standards when they were stricter than those in their countries of investment (see Klavens and Zamparutti,1995; Environment for Europe, 1994).

Similarly, increased exports to market economies could also spur 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

[5] CEE countries experienced significant foreign direct investment (estimated at $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).

countries often prefer products manufactured using environmentally benign methods, but have little direct information on these processes. Firms with higher foreign trade shares may therefore adopt EMPs to signal green production methods (Bellesi et al., 2005). Requiring some proof of environmental management may finally also be very popular since it provides a convenient non-tariff trade barrier that can help protect domestic firms against cheap imports.

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 a result of a struggle, and, that the effects of open media and civil liberties such as the right to organize action groups were very important. The literature on voluntary environmental agreements and environmental information shows that making information available can have significant effects on firm behavior.

While little information on pollution was available before 1989, today such information is generally public since most of these countries enforce the public's right to know about the environment. Under socialism there were very few independent environmental advocacy groups, but by 1997 the Regional Environment Center headquartered in Budapest had identified 3,000 such NGOs working for improved environmental quality in the region. Furthermore, the official inspection, monitoring, and regulatory authorities (such as Ministries of Environment), environmental protection agencies, and inspectorates were strengthened during this period. Monitoring systems were put in place and though by no means perfect, the produced data are increasingly used for enforcement purposes.

3. Data

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.

[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).

The sample was stratified to include only firms operating in industries that are generally highly polluting and therefore likely to face environmental management challenges. The present study covers animal raising, mining, electric power and manufacturing.

Our focus is on the establishment of Environmental Plans (EPs) and Environmental Departments (EDs) during the first years of transition; thus, 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. Table 1 shows that the rate of adoption of EMPs during 1990 - 1998 was large; the number of firms that adopted EPs and EDs increased by a factor of four and two respectively. Before 1990, relatively few firms had EPs and around 42% of the firms adopted either EPs or EDs in the 1990 -1998 period.[7]

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

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 presents the joint EP and ED adoption frequencies for both the full sample and a restricted sample that excludes the firms that had adopted either an ED or an 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% hd both. Roughly 60% of 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. The proportion of early adopters is relatively small and patterns similar to those of the unrestricted sample are observed. 19.9% of the 1,719 firms in the original sample had implemented either an EP or an ED prior to 1990.

[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 2. Cross tabulation EP and ED adoption observed in 1998

All firms (N = 1719)			
	ED = 0	ED = 1	Total
EP = 0	658 (38%)	319 (19%)	977 (57%)
EP = 1	235 (14%)	507 (29%)	742 (43%)
Total	893 (52%)	826 (48%)	1719 (100%)

Without firms that had adopted either ED or EP before 1990 (N = 1376)			
	ED = 0	ED = 1	Total
EP = 0	658 (48%)	235 (17%)	893 (65%)
EP = 1	199 (14%)	284 (21%)	483 (35%)
Total	857 (62%)	519 (38%)	1376 (100%)

We are mainly interested in explaining the determinants of ED and EP implementation during the first years of transition, or the 1990 – 1998 period. In fact, the information on the explanatory variables used in the econometric analysis is defined for this period. Note that once adoption occurs in a given period, we do not observe further changes in environmental behavior in later periods for these firms. In light of these constraints, the sample considered in the econometric analysis (N=1,376) consists of the firms that had adopted neither an EP nor an ED before 1990.

Table 3 presents a description of the explanatory variables, their role in the analysis, and some basic statistics. The upper panel presents a set of country control variables. The existence of EDs varied widely across countries with less than a 15% prevalence among Hungarian, Lithuanian and Polish firms while the adoption rater was 45% and 78% in Bulgaria and Romania. Thus, a need to control for possible country-specific effects seems apparent. On the other hand, about one-third to one-half of the firms reported having environmental plans. The lower panel of Table 3 shows descriptive statistics for additional explanatory variables. The variable AGE refers to the age of most firm equipment. Our presumption is that firms with older capital infrastructure had organizations that were more rooted in the communist times, and would oppose the implementation of new managerial strategies. Notably, the equipment of "the average firm" was built as far back as 1972. The variable EMPLOYMENT is used as a measure of firm size. 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, large firms can exploit economies of scale in the development of EMPs.

The last set of variables captures external pressure sources, which were widely discussed in the Section 2. The ownership structure of the firm is included as a proxy for investor pressure

and is captured by two variables: the proportion of private ownership (PRIVATE OWNER) and a dummy (FOREIGN OWNER) for firms that were foreign-owned. Two-thirds of the total capital stock was owned by private shareholders and around 15% of the 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 regulator informed the public about the firms' emissions of major pollutants. About a quarter of our sample of firms were subject to public scrutiny. Finally, three dummy variables, namely WARNINGS, ORDERS, and FINES, capture regulatory pressure. 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 such actions; the correlations among the three enforcement dummies is relatively low (0.29 between WARNINGS and ORDERS, 0.23 between WARNINGS and FINES, and 0.21 between ORDERS and FINES).

Table 3. Independent Variables: Definition and descriptive statistics
N = 1376

Variable	Description	A proxy for	Mean	SD
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
AGE	Age of most firm equipment	Control	26.1265	19.2722
EMPLOYEES	Number of employees (log)	Control (Firm size)	5.4514	1.4083
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

4. Empirical approach

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

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

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:

$$y_{ij} = \begin{cases} 1 & if \quad \pi_{ij}^{*} > 0 \\ 0 & \quad\;\; \pi_{ij}^{*} \le 0 \end{cases}.$$

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:

$$\begin{aligned} \pi_{iEP}^{*} &= \beta_1' x_i + \varepsilon_{iEP} \qquad EP_i = \begin{cases} 1 & if \quad \pi_{iEP}^{*} > 0 \\ 0 & \quad\;\; \pi_{iEP}^{*} \le 0 \end{cases} \\ &\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad (1) \\ \pi_{iED}^{*} &= \beta_2' x_i + \varepsilon_{iED} \qquad ED_i = \begin{cases} 1 & if \quad \pi_{iED}^{*} > 0 \\ 0 & \quad\;\; \pi_{iED}^{*} \le 0 \end{cases} \end{aligned},$$

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 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. 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:

$$\begin{aligned} &\Pr\left[ED_i = 1\ \mid EP_i = 1\right] = \frac{\Phi_2(\beta_1 x_i, \beta_2 x_i, \rho)}{\Phi_1(\beta_2 x_i)} = \frac{\Phi_1(\beta_1 x_i - \rho\beta_2 x_i)}{(1-\rho^2)^{1/2}} \\ &\Pr\left[ED_i = 1\ \mid EP_i = 0\right] = \frac{\Phi_2(\beta_1 x_i, -\beta_2 x_i, -\rho)}{\Phi_1(-\beta_2 x_i)} = \frac{\Phi_1(-\beta_1 x_i + \rho\beta_2 x_i)}{(1-\rho^2)^{1/2}} \end{aligned}, \tag{4a,4b}$$

Equations (2), (3a, 3b) and (4a, 4b) can also be defined for EP; in fact, they will have similar forms. Note that when the correlation coefficient is zero, then *conditional* probabilities degenerate into *marginal* probabilities and *joint* probabilities become equal to the product of *marginal* probabilities.

The model described above resembles a seemingly unrelated regression (SUR) where the dependent variables are dummy variables. SUR models are usually justified by higher efficiency relative to single equation techniques, where the possible correlation across error terms is not exploited in estimation. It has however been established that gains in efficiency are reduced when the sets of independent variables across equations are the same, as they are in our case (Wooldrige, 2001). Note though that in the application presented in this paper we are particularly interested in the estimation of the correlation coefficient itself, since it provides evidence on possible similarities (or dissimilarities) of ED and EP determinants that are not observable to us. Also *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 a full information maximum likelihood estimates of the bivariate probit model for ED and EP adoption. For the continuous variables, the estimates measure a partial increase in the probability of observing a given event due to a partial change in the independent variables. For dummy variables, the marginal effects are calculated as differences in the probabilities of observing adoption for the two possible values of the variables. 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. Also, 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 is a complementarity in both of these EMPs.

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 inherit the signs and the 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. Recall that 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 and

higher enforcement, are more likely to adopt EMPs. Age and ownership variables appear non-significant in the regression results and throughout the analysis.

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
BULGARIA [d]	-0.2558 *** (0.0351)	-0.1812 *** (0.0393)	-0.1604 *** (0.0193)
HUNGARY [d]	-.40921 *** (0.0323)	0.0670 (0.0688)	-0.1911 *** (0.0209)
LITHUANIA [d]	-0.4040 *** (0.0262)	-0.1259 *** (0.0439)	-0.2160 *** (0.0157)
POLAND[d]	-0.3887 *** (0.0263)	0.0428 (0.0501)	-0.1865 *** (0.0167)
SLOVAKIA[d]	-0.3039 *** (0.0340)	0.1724 (0.2474)	-0.1641 *** (0.0291)
AGE	0.0007 (0.0010)	-0.0006 (0.0008)	-0.0005 (0.0006)
EMPLOYEES (log)	0.0268 * (0.0137)	0.0341 *** (0.0119)	0.0243 *** (0.0084)
PRIVATE	0.0003 (0.0005)	-0.0003 (0.0004)	0.0000 (0.0003)
FOREIGN OWNER[d]	-0.0310 (0.0466)	-0.0111 (0.0416)	-0.0000 (0.0284)
EXPORTSHARE	0.0013 ** (0.0006)	0.0022 *** (0.0005)	0.0010 *** (0.0002)
DISCLOSURE[d]	0.1052 *** (0.0407)	0.0739 ** (0.0364)	0.0745 *** (0.0274)
WARNINGS[d]	0.1781 *** (0.0587)	0.0103 (0.0432)	0.0735 *** (0.0334)
ORDERS[d]	0.1279 ** (0.0631)	0.1100 ** (0.0502)	0.0914*** (0.0350)
FINES[d]	0.0843 * (0.0481)	0.0450 (0.0438)	0.0509 * (0.0290)

N	1375
Rho	0.5280 *** (0.0444)
Log likelihood	-1347.71
Pseudo R2	0.22

Cross tabulation of EP and ED.
Fitted values in brackets

	ED= 0	ED=1
EP= 0	658 [894]	199 [48]
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.

Regarding the size of the marginal effects for *marginal* probabilities (first two columns in Table 4), enforcement and disclosure have a stronger effect on ED adoption, while employment and exports have a stronger effect on EP adoption. 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 emission dummies 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%). An increase in the proportion of exported products increases the probability of ED (EP) adoption by only 0.1% (0.2%). A percentage 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.

Conditional Probabilities of EP and ED adoption

Table 5 presents the marginal effects on *conditional* probabilities. The first panel 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 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 a 10% level. If a given firm is faced with, lets say, some enforcement action, and it already has an EP (or does not have an EP and decides not to adopt one), then the likelihood of ED is not increased. On the other hand, the second panel reveals that, "other things being equal," employment and export shares do increase the probability of EP adoption whereas disclosure and enforcement actions have no effect.

Table 5: Marginal Effects on *Conditional* Probabilities

VARIABLE	$\frac{\Delta Prob[ED=1 \mid EP=1]}{\Delta x}$	$\frac{\Delta Prob[ED=1 \mid EP=0]}{\Delta x}$	$\frac{\Delta Prob[EP=1 \mid ED=1]}{\Delta x}$	$\frac{\Delta Prob[EP=1 \mid ED=0]}{\Delta x}$
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)
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)
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)

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.

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.

We have put quite some effort into making sure that the covariates used in the analysis are exogeneous. 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. The types of variables that we did use are however interlinked in complex ways and we do acknowledge that our estimates could still

be biased due to some endogeneity. For instance, facilities that faced higher enforcement and whose pollution levels were publicly disclosed in the news were more likely to have EDs and/or EPs. However, the firms that had adopted EMPs might subsequently have faced less pressure from authorities and would thus have been less likely to appear in the news as heavy polluters since EMPs could signal compliance. This line of reasoning would actually still strengthen our general conclusions since it indicates that our results underestimate the effects of enforcement and disclosure.[8]

6. Conclusions

The findings in this paper suggest that the fall in industrial output during the early 1990s in CEE might not have been the only factor leading to the observed improvements in ambient quality, as has often been noted.[9] In fact, 42% of the firms in our sample adopted EPs and/or EDs during the 1990 -1998 period. 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.[10] In this paper, we delved into the determinants of both 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

[8] There is another possibility: if the firms that adopted EMPs were rewarded in foreign markets our export variable might suffer some upward bias. Note however that we recognize in our discussion that this variable, although significant, seems to have a small effect on EMP implementation.

[9] 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. SO2 emissions fell by over 60% and NOx 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).

[10] A number of studies have shown that firms with EMPs produce less pollution and are more likely to comply with environmental legislation. Anton, Deltas, and Khanna (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) note 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.

findings, although not necessarily surprising, are not directly evident from the data where a fairly good proportion of EP adopters are not ED adopters and vice versa. The factors that appear to have driven both EP and ED adoption are: (a) enforcement activities, which seemed to increase during the transition thanks to the creation of environmental management agencies; (b) public disclosure of environmental performance indicators of firms; c) export-orientation of a firm; 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.

We also 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 the adoption of 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

We find a correlation between the EP and ED decisions, which may suggest some unobserved variables determining them both, which in turn shows that these decisions need to be modeled and analyzed with discretion. 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 the regulator.

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