Manuel Frondel, Jens Horbach
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# What Triggers Environmental Management and Innovation?

## Empirical Evidence for Germany

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## What Triggers Environmental Management and Innovation? – Empirical Evidence for Germany

Manuel Frondel, Jens Horbach and Klaus Rennings*

### Abstract

It is frequently hypothesized that environmental management systems (EMSs) may improve a firm's environmental performance. Whether or not this hypothesis is true is as important from the perspective of environmental policy as questions relating to the relevant incentives for (1) a firm's voluntary adoption of an EMS and (2) its environmental innovation behavior. Based on ample empirical evidence for German manufacturing, this paper addresses these issues on the basis of a recursive bivariate probit model that explicitly takes into account that a facility's decision on innovation activities is correlated with the decision on EMS certification. Our empirical results indicate that environmental innovation activities are not associated with EMS certification nor any other single policy instrument. Rather, innovation behavior seems to be correlated to the stringency of environmental policy.

**JEL Classification**: O33, O38, Q28

**Keywords**: Environmental Technological Change, Environmental Management Systems, Discrete Choice Models, Environmental Regulation

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# 1 Introduction

In contrast to conventional innovations, *environmental innovations* produce a *double* rather than *single externality* - see e. g. CARRARO (2000) and JAFFE, NEWELL, and STAVINS (2002): In addition to providing the typical positive spill-overs of R&D activities, environmental innovations may reduce negative environmental externalities of production. Although there may be market-based incentives to improve environmental performance, such as cost savings created by process improvements, the public good character of environmental innovations may require governmental intervention for their stimulation. For this reason, it is essential to analyze the variety of measures, including regulatory and market-based instruments, that may provide sufficient incentives to spur environmental innovation within firms.

For Germany, considerable empirical effort has been spent on identifying the characteristics, determinants, and obstacles of environmental innovation at the firm level, with the focus on the role of environmental policy - see RENNINGS (2000). In the early 1990s, firms began to implement individual environmental management systems (EMSs), including environmental reports and plans for continuous improvements in production processes and environmental performance. Since then, the voluntary adoption of international norms, such as the standards of the International Standards Organization (ISO) 14001 and the European Union Environmental Management and Auditing Scheme (EMAS), have become a vital supplement to mandatory environmental policies based on regulation and legislation, involving the monitoring of environmental performance and the assessment of achievements.

As an organizational environmental innovation, EMSs may lead to improved environmental performance; in fact, the econometric analysis of a recent investigation by RENNINGS et al. (2003) indicates a positive impact of the maturity of EMSs on organizational environmental innovations. With few exceptions, such as RENNINGS et al. (2003), the respective German literature is dominated by case studies. Yet, case studies do not provide a general assessment of the impact of EMSs on innovative activity. As a consequence, there appears to be a lack of econometric studies on the issue of environmental innovation based on large-scale surveys at the firm-level.

On the basis of a unique facility and firm-level data for German manufacturing originating from a recent OECD-survey, this paper empirically investigates the significance of a variety of incentives for environmentally innovative behavior, including the influence of pressure groups, as well as the impact of both regulatory and market-based policy instruments, such as eco-taxes and EMSs. Yet, we focus on aspects of policy style, such as stringency of environmental policy and co-ordination of different policy measures, rather than on the choice of single policy instruments. In detail, we address the following questions: What are the relevant incentives for (1) a facility's voluntary adoption of an EMS. (2) What triggers environmental innovation behavior. These issues are analyzed on the basis of a recursive bivariate probit model that explicitly takes into account that the decision on innovation activities within a facility may be correlated to the decision on EMS certification.

Our research complements a substantial body of international empirical evidence on environmental innovation and the proactive factors that trigger organizational environmental innovation activities by firms, such as the voluntary adoption of environmental plans and EMSs. The contribution by HENRIQUES and SADORSKY (1996) is an early example. Their empirical study on Canada reveals that pressures from customers, shareholders, government, and community groups positively influence firms' environmental responsiveness such that firms formulate "an official plan for dealing with environmental issues" (HENRIQUES and SADORSKY (1996:382)).

NAKAMURA, TAKAHASHI, and VERTINSKY (2001) empirically explore the determinants that lead large Japanese manufacturers to incorporate environmental goals in their decisions and obtain EMS certification. These authors conclude that, in addition to firm size and factors that affect company profits, managers' environmental values, beliefs, and attitudes – variables that have been derived from survey responses and explicitly integrated in their probit models – are important determinants of Japanese companies' voluntary commitment to environmental objectives.

While these studies investigate the underlying motives for voluntary *organizational* innovation activities, such as the adoption of EMSs, DASGUPTA, HETTIGE, and WHEELER (2000), KHANNA and ANTON (2002) as well as ANTON, DELTAS, and KHANNA (2004) explain the variability in the quality of EMSs, proxied by the count of environmental management practices. In their seminal paper, ANTON, DELTAS, and KHANNA (2004) also examine what effects the adopting of an EMS has on environmental performance. DASGUPTA, HETTIGE, and WHEELER (2000), finally, conclude that the voluntary adoption of ISO 14001 management practices significantly improves the compliance status of Mexican firms.

In the following section, we theoretically discuss the relationship of environmental innovation and regulation. Section 3 describes our data set. Section 4 presents the conceptual framework, in particular the employed discrete choice model. Our estimation results are discussed in Section 5. The last section presents a summary and conclusions.

## 2 Environmental Innovation and Regulation

According to e. g. KEMP and ARUNDEL (1998), and RENNINGS and ZWICK (2002), the notion of environmental innovation encompasses new and modified processes, techniques, practices, and products that reduce or even avoid detrimental environmental impacts. Environmental innovation can be divided into technical or organizational measures, with EMS being an example of organizational innovation. Technical measures include new or modified products and processes. In the specific case of EMSs, the question is whether or not such management systems induce technical changes in addition to organizational changes.

To date, the literature on the relationship between environmental policy and technological change has mainly focused on the choice of an optimal policy instrument to induce environmental innovation, see JAFFE, NEWELL, and STAVINS (2002).

For a long time, market-based instruments have been regarded as superior (DOWNING and WHITE (1986); MILLIMAN and PRINCE (1989)), a characterization that has been confirmed for situations of perfect competition and information. Yet, under conditions of imperfect competition, results originating from general equilibrium models of endogenous growth and game theory models suggest that regulation standards may be a more appropriate method for *stimulating* innovation, particularly when firms gain "strategic advantages" from innovation, see CARRARO (2000) and MONTERO (2002). Furthermore, assuming that technological innovation is endogenous, no instrument is generally preferable and the welfare gain of environmental policy instruments heavily depends on circumstances, see FISCHER, PARRY, and PIZER (2003). With particular respect to the use of either auctioned permits or taxes in environmental politics, REQUATE (1998) finds that whether auctioned permits or taxes provide stronger incentives to adopt an improved technology depends upon empirical values of relevant parameters.

These findings evoke the question as to whether or not evaluating and comparing single policy instruments is an appropriate approach to determine the optimal policy for stimulating environmental innovation. This "instrumentalism" in environmental policy, i.e. the assumption that it is the proper selection of the most appropriate policy instrument that guarantees policy success, is criticized by NORBERG-BOHM (1999) and BLAZEJCZAK et al. (1999). More important elements of a successful policy are, according to these authors, the mix of instruments and the stringency of environmental policy, including aspects such as legal enforcement and fines.

With particular respect to regulation as a determinant of environmental innovation, the importance of strictness in environmental policy has been emphasized by the PORTER *hypothesis*, for which a unanimous formulation, though, is not yet available – see JAFFE and PALMER (1997:610). PORTER and VAN DER LINDE (1995a; 1995b) argue that in a non-optimizing world, strict environmental policy may spur "innovation offsets" that "can not only lower the net cost of meeting environmental regulations, but can even lead to absolute advantages over firms in foreign countries not subject to similar regulations" (PORTER and VAN DER LINDE (1995a:98). Similarly, ASHFORD, AYERS, and STONE (1985) argue that strict regulation can induce fundamental technological changes in firms.

These arguments are based on a series of case studies, most prominently PORTER and VAN DER LINDE (1995a; 1995b). To date, only a few econometric studies appear to have been performed on the relationship between policy stringency and environmental innovation. In the econometric work of both JAFFE and PALMER (1997) and BRUNNERMEIER and COHEN (2003), environmental expenditures of firms have been used as a proxy for policy stringency. While BRUNNERMEIER and COHEN obtain a significant impact of environmental expenditures on environmental innovation, JAFFE and PALMER find no such empirical evidence. Our study complements the empirical evidence on potential promotion factors for environmental innovation, with particular emphasis on the role of EMSs.

Traditionally, German environmental policy has emphasized mandatory regulation that imposes limits on pollutant emissions or prescribes the use of specific abatement technology. While this kind of regulation certainly has protected the environment, it has also encouraged firms to focus on end-of-pipe technologies that control pollution at the factory smokestack, rather than on preventing pollution. Mandatory regulation has also tended to impose higher costs on both firms and regulators. The growing belief that firms need higher flexibility relating to the achievement of environmental goals – which is generally supposed to lower their cost – has led to an increasing number of voluntary initiatives to change corporate culture and management practices by incorporating environmental concerns in production decisions.

Emphasizing pollution prevention at the source as the preferred method of pollution control, these policy initiatives include the voluntary adoption of EMSs. Based on the implications of EMS certification, such as the monitoring of environmental performance and the assessment of achievements, EMSs are assumed to improve environmental performance by enhancing companies' environmental innovation activities. This assumption, however, has yet to be validated.

# 3 Data and Variables

Our facility and firm-level data set of German manufacturing originates from a recent OECD survey on environmental policy tools, which was performed in 2003 in 7 OECD-countries, such as the US, Japan, and Germany. The major task of the survey was to analyze the EMS-adoption decision of facilities. The German data set is based on 899 valid questionnaires, including questions relating to facility- and firm-specific characteristics, environmental behavior, and perception of the stringency of environmental regulation.

Almost half of our sample, i.e. 437 out of 899 facilities, has considered introducing an EMS. 246 facilities have even established such a system already, while implementation is in progress in 62 facilities. In our model presented in the subsequent section, the dichotomous variable *ems* indicates the implementation of an EMS in a sample facility or that implementation is in progress. The most important reasons why firms contemplate introducing EMSs are – according to the answers of our survey respondents – the wish to foster corporate image, economize on both waste management and resource input, and increase efforts to achieve regulatory compliance.

Whether or not a facility has undertaken significant changes in production technologies and/or product characteristics to reduce the environmental impacts associated with its activities, is captured by the dichotomous variable *abate*. This variable indicates the implementation of such measures, irrespective of their type, i. e. additive end-of-pipe technology versus process-integrated technology changes. Total private expenditures on R&D and the number of successful patent applications are innovation activity measures that are typically employed in the economic literature – see e.g. JAFFE and PALMER (1997:611). In the absence of patent data for our sample facilities, and due to a lack sufficient data on environmental R&D expenditures, we identify technological environmental innovation by the variable *abate*.

A facility's decision on both EMS certification and abatement activities depends on factors that are divided into the following four categories[1]: (1) *Pressure groups*: This category reflects the influence – as perceived by the survey respondents – of public authorities (captured by the variable *authorities*), interest groups such as industrial associations and labor unions (summarized in the variable *unions*), *internal forces*, such as corporate headquarters and management employees, commercial and private *customers*, and environmental (*green*) *organizations*. (Cursive terms stand for the names of the variables as used in the tables presenting our estimation results.) Our summary of the responses to the question of the influence of pressure groups on environmental practices indicates that internal stakeholders are more important than external forces, such as public authorities, commercial customers, and environmental organizations – see FRONDEL et al. (2004).

(2) *Motivations*: This category includes expected corporate *image* improvements and *cost savings* due to EMS certification and environmental innovation and also encompasses factors such as potential avoidance of environmental *incidents* and achievement of *compliance* with environmental regulation. Our descriptive summary of the survey results reveals that corporate image, cost savings, regulatory compliance, and the prevention of incidents are the most relevant motivations – see FRONDEL et al. (2004).

(3) *Environmental policy tools*: This category comprises respondents' assessment of the importance of *market*-based *instruments*, such as environmental taxes, *regulatory measures* (input bans and technology standards), *information* measures, as well as *subsidies*. All these policy instruments may have an impact on the intention to both acquire an EMS and establish abatement measures. The stringency of the governments environmental policy may also foster these decisions. How the survey respondents perceive the stringency of environmental regulation is described by the variable *policy stringency*.

[1] All variables are constructed from the answers provided by the survey respondents. This approach is far from unproblematic, since these responses reflect both genuine variations across facilities and individual differences in the perception of the respondents. For descriptive statistics and details on construction, see Table A in the appendix. An extensive description of the survey and its results is provided in FRONDEL et al. (2004)

What is most interesting in this context is that the vast majority of our sample facilities assess German environmental policy as only moderately stringent or not at all stringent, 47.7 % versus 32.1 % – see FRONDEL et al. (2004).

(4) *Covariates*: Both decisions may be affected by a set of covariates that include facility *size*, measured in terms of number of employees, and the relevance of environmental *impacts* of any kind of pollution. Focusing on facility size and prevalence of EMS certification, we find a strong positive correlation: It turns out that larger facilities adopt EMSs more frequently than smaller facilities do – see FRONDEL et al. (2004). In order to control for industry-specific differences, ten industry dummy variables are created in which similar industry sectors are pooled. Finally, two other factors might be relevant: the existence of an environmental department and persons explicitly responsible for environmental concerns, indicated by *department* and *officer*, respectively. Both factors may also be interpreted as organizational environmental innovation. In contrast to EMS, though, these organizational innovations typically had already been established in facilities a long time before the decision on EMS certification was at issue.

# 4 Conceptual Framework

This section presents a bivariate discrete-choice model that explicitly takes into account that the decision on environmental innovation or abatement activities within a facility is correlated to the decision on EMS certification. Therefore, our model is formulated as a system of two latent-variable equations with normally distributed and correlated disturbances: one for a facility's abatement decision and a second for the EMS adoption decision.

In formal terms, we assume that a facility's propensity for abatement activities, $abate_i^*$, depends on, among other things, $ems_i$, the actual implementation of an EMS in facility $i$, whereas facility $i$'s propensity for EMS acquisition, $ems_i^*$, is not affected by the abatement propensity $abate_i^*$ or actual abatement:

$$
\begin{aligned}
abate_i^* &= \theta \cdot ems_i + x_i'\alpha - \eta_i, && (1)\\
ems_i^* &= y_i'\beta - \xi_i. && (2)
\end{aligned}
$$

The error terms $\eta$ and $\xi$ are assumed to be normally distributed vectors with zero mean. By including *ems*$_i$ as a regressor in equation (1), we check whether or not there is a direct correlation between the abatement and EMS adoption decisions, rather than only an indirect correlation. Note that this recursive simultaneous-equation model will be logically inconsistent if the EMS adoption equation (2) contains $abate_i$, the observed abatement decision of facility $i$. The intuitive argument indicating logical inconsistency is the resulting circular reasoning, while the statistical reason for inconsistency relies on the fact that the four probabilities $P(abate_i = 1, ems_i = 1), P(abate_i = 1, ems_i = 0), P(abate_i = 0, ems_i = 1)$ and $P(abate_i = 0, ems_i = 0)$ necessarily add to unity – see e. g. MADDALA (1983) for more details on simultaneous discrete-choice models.

Both sets of regressors, $x_i$ and $y_i$, include variables belonging to the four categories of variables described in the previous section. It is important to note that the set of observable variables $x_i$ in abatement decision equation (1) is partly common to the set of regressors $y_i$ in EMS adoption equation (2), but not identical. If both sets $x_i$ and $y_i$ do not differ in at least one variable, and if $\eta$ and $\xi$ are not independent, i. e. $\rho \neq 0$, the parameters in (1) are not identified. To see this, consider the special case in which $x_i$ and $y_i$ are both constants – see MADDALA (1983:122). In this case, four parameters, $\alpha, \beta, \theta$ and $\rho$, are to be estimated, but sample information would allow us to determine only three probabilities, while the fourth is obtained as residual. From three probabilities, though, we cannot estimate four parameters.

The propensities *abate*$_i^*$ and *ems*$_i^*$ are typically unobservable. Instead, only binary choices are observed. Therefore, we need to impose the conditions $Var(\eta) = I$, $Var(\xi) = I$, where $I$ denotes the unity matrix. Moreover, $Cov(\eta, \xi) = \rho I \neq 0$, with $\rho$ reflecting a non-idiosyncratic correlation of both decisions in firms – see e. g. MADDALA (1983:122) for this specific kind of model, which is called a *recursive* model. It is most likely that the disturbances $\eta_i$ and $\xi_i$ are correlated, since these disturbances may capture unobserved variables, such as "green" preferences of the management and its attitude towards innovation. Such unobservable factors would affect both the abatement and adoption decision and may contaminate our estimation results (simultaneity problem): In particular, the estimate of parameter $\theta$, conceived to capture environmental innovation effects due to EMS certification, may also reflect the influence of common unobservable driving forces, rather than the genuine impact of EMS certification. Being aware of the potential existence of simultaneity problems due to common unobservable factors, we shall interpret our estimation results with caution.

An ideal solution to such a simultaneity problem would be performing an appropriate and well-designed experiment in which EMSs are not adopted on a voluntary basis[2]. Rather, the firms that implement an EMS are randomly determined by a regulator (treatment group). While such an experimental approach appears to be unrealistic, the effect of potential unobservable driving factors would be eliminated through the randomization process: In effect, if sample sizes are sufficiently large, randomization will generate a complete balance of all relevant observable and unobservable characteristics across treatment and control groups, thus facilitating comparability between experimental treatment and control groups. Then, true impacts of EMS certification on environmental innovation activities could be elicited by comparing the innovation behavior of treatment and control groups on the basis of, for instance, a difference-in-differences approach. A more realistic, feasible approximation to an experimental design would be given if EMS certification were mandatory in one country, but unusual in another, comparable country. Unfortunately, this is not the case for the data set received from the OECD survey.

Rather than observing the propensities $abate_i^*$ and $ems_i^*$, merely the corresponding actions – that is, the actual implementation of EMSs, indicated by $ems_i$=1, and actual abatement activities ($abate_i = 1$) – can be observed, provided that these propensities exceed a certain threshold, which is – without any loss of generality – commonly set at

[2]See FRONDEL and SCHMIDT (2001) for a survey on experimental and non-experimental evaluation approaches to environmental policy instruments.

zero:

$$abate_i = 1, \quad \text{if } abate_i^* > 0, \quad abate_i = 0 \quad \text{otherwise}, \tag{3}$$

$$ems_i = 1, \quad \text{if } ems_i^* > 0, \quad ems_i = 0 \quad \text{otherwise}. \tag{4}$$

From an economic perspective, the interpretation of condition (3) is that a profit-maximizing firm or facility adopts an EMS (*ems*$_i$=1) if the net benefit due to EMS acquisition is positive:

$$ems_i^* = y_i'\beta - \xi_i > 0. \tag{5}$$

In economic terms, the propensity *ems*$_i^*$ of facility $i$ to adopt an EMS is determined by the net benefit. This unobservable net benefit depends on observable factors, for example, image improvements that are captured in vector $y_i$, as well as on unobservable factors that are summarized in disturbance $\xi_i$. Of course, similar interpretations hold for environmental innovations: A profit-maximizing facility invests in abatement measures, *abate*$_i$=1, if the net benefit $abate_i^* > 0$ is positive.

Generally, bivariate probit models are estimated using Full-Information-Maximum-Likelihood (FIML) methods[3]. On the basis of this estimation procedure, no problem arises due to the endogenous nature of $ems_i$ in equation (1): It is correct to simply ignore the simultaneity in our model by treating $ems_i$ as if it were an exogenous variable. The explanation for this procedure is given by GREENE (2000:849) and is based on the fact that the term $P(abate_i = 1|ems_i = 1) \cdot P(ems_i = 1)$, for instance, which enters the log-likelihood, equals the joint probability $P(abate_i = 1, ems_i = 1)$. Of course, if unobservable heterogeneity is such that the disturbance vectors $\eta$ and $\xi$ are independent, one can obtain consistent estimates by estimating both equations separately and using ordinary single-equation probit ML methods. Yet, we do not know

[3]Note that two-stage procedures – similar to two-stage least squares in linear simultaneous-equations models, for which one first performs a probit ML estimation of equation (2) and then substitutes $\Phi(z_i'\hat{\delta})$ for $ems_i$ – would not provide consistent estimates of the parameters of the abatement decision equation (1) – see MADDALA (1983:123). By contrast, such a two-stage procedure would be correct if the variable *abate*$_i^*$ were observable rather than latent – see MADDALA (1983:120).

whether or not this is the case unless we test the null-hypothesis $H_0 : \rho = 0$ upon FIML estimation of system (1) and (2).

# 5 Empirical Results

Estimation results for our recursive bivariate probit model are reported in Table 1. First of all, on the basis of a Likelihood-Ratio (LR) test, we do not reject the hypothesis $H_0 : \rho = 0$: Upon accounting for the influence of all factors included in equations (1) and (2) – for example, the role of pressure groups –, the LR statistic of $0.642 < \chi^2_{0.995}(1) = 7.89$ indicates that unobserved variables might be uncorrelated[4]. In order to circumvent identification problems, the sets $x_i$ and $y_i$ have to differ from each other in at least one variable if $\eta$ and $\xi$ are not independent. We thus have assumed that environmental innovation activities are not motivated by expected image improvements and that the existence of an R&D budget related to environmental matters, indicated by the dummy variable *R&D*, does not affect the decision to adopt an EMS[5]. That is, *R& D* has only been included in abatement equation (1), while *image* only occurs in equation (2).

In line with the stylized facts presented in the previous section, our estimation results[6] indicate that EMS certification is strongly correlated to an expected enhance-

[4]On the basis of a WALD test, whose test statistic 0.713 equals the square $(-0.260/0.308)^2$ of the $t$ ratio for $\rho$, we come up with the same conclusion. Due to the large number of variables included in both equations, and owing to a fairly large number of missing values for some of these variables – as is the case for *policy stringency*, the survey respondents' impression of environmental regulation stringency – the remaining number of observations employed in the estimation amounts to 728, rather than 899, the overall number of valid questionnaires.

[5]These assumptions are confirmed by the estimation of the single equation probit models, including *image* and *R&D*.

[6]Sample selection biases may, of course, be considered problematic. In fact, the share of larger facilities in terms of employees is higher in our sample than in the population of facilities of German manufacturing. For larger facilities, it is in turn more likely that an environmental department is established and an employee exists who is explicitly responsible for environmental matters. These persons are most likely to have completed our questionnaires. Since we control for the existence of such persons, there should

ment of corporate *image*, while expected *cost savings* are negatively associated with EMS certification, probably because survey respondents expect EMS certification to be costly. In contrast, neither the occurrence of environmental *incidents* nor achievement of *compliance* with environmental regulation seem to be important motivations for either decision. *Policy stringency* has, in statistical terms, a significantly positive impact on environmental innovation and abatement activities. In contrast, the stringency of environmental policy does not seem to be correlated to EMS certification.

**Table 1**: FIML-Estimation Results for our Recursive Probit Model System (1) and (2).

| Equation | abate | | ems | | Equation | abate | | ems | |
|---|---|---|---|---|---|---|---|---|---|
| | Motivations | | | | | Covariates | | | |
| *image* | – | – | **0.451 | (3.18) | *officer* | **0.472 | (2.65) | **0.980 | (6.11) |
| *incidents* | 0.035 | (0.28) | -0.117 | (-0.83) | *department* | 0.137 | (0.77) | **0.719 | (5.49) |
| *compliance* | 0.107 | (0.75) | 0.239 | (1.62) | *impacts* | **0.394 | (2.96) | 0.015 | (0.11) |
| *policy stringency* | **0.526 | (3.44) | 0.009 | (0.05) | *R&D* | 0.399 | (1.09) | – | – |
| *cost savings* | 0.232 | (1.93) | *-0.289 | (-2.22) | *size* | $1.6\cdot10^{-4}$ | (1.30) | **$4.7\cdot10^{-4}$ | (3.58) |
| | Policy Instruments | | | | | Industry Dummies | | | |
| *voluntary measures* | 0.126 | (0.181) | -0.101 | (-0.55) | *food* | *0.786 | (2.28) | 0.497 | (1.38) |
| *subsidies* | -0.125 | (-0.88) | 0.096 | (0.61) | *textile* | 0.279 | (0.75) | -0.809 | (-1.78) |
| *market instruments* | 0.026 | (0.22) | -0.199 | (-1.48) | *paper* | 0.623 | (1.93) | 0.034 | (0.10) |
| *regulatory measures* | 0.196 | (1.65) | -0.076 | (-0.58) | *chemicals* | *0.697 | (2.11) | 0.560 | (1.68) |
| *information* | -0.134 | (-0.78) | 0.216 | (1.20) | *minerals* | *0.850 | (2.05) | -0.530 | (-1.15) |
| *ems* | 0.559 | (1.08) | – | – | *metals* | 0.491 | (1.64) | -0.083 | (-0.25) |
| | Pressure Groups | | | | *machines* | 0.171 | (0.57) | -0.297 | (-0.09) |
| *internal forces* | **0.397 | (2.88) | **0.410 | (3.11) | *transport* | – | – | – | – |
| *authorities* | *-0.295 | (-2.04) | -0.102 | (-0.68) | *recycling* | 0.351 | (0.62) | 0.881 | (1.53) |
| *customers* | -0.099 | (-0.77) | 0.046 | (0.34) | *wood* | **1.137 | (2.62) | -1.272 | (-1.87) |
| *unions* | -0.169 | (-0.66) | 0.139 | (0.52) | | Constants | | | |
| *green organizations* | 0.092 | (0.49) | 0.102 | (0.52) | *cons.* | **-1.450 | (-4.86) | **-1.986 | (-5.81) |

**Note**: Z-statistics are in parentheses. * denotes significance at the 5 %-level and ** at the 1 %-level, respectively. Number of observations: 728. Log-Likelihood: -701.59. $\chi^2(57) = 417.75$: The hypothesis that all slope coefficients are jointly zero has to be rejected.

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be no sample bias caused by this mechanism.

It is surprising that none of the various environmental policy tools included in our model, whether market-based or regulation-based instruments, appears to be important for a facility's decision in favor of EMS and pollution abatement. With particular respect to the role of EMS certification for environmental pollution, our estimation results do not indicate any association of a facility's abatement activities with EMS certification. These findings seem to be in line with the widely discussed hypothesis that policy style is more important for innovation than single policy instruments. Furthermore, our econometric analysis reveals that among pressure groups, *internal forces* have a statistically significant influence on the decision for the establishment of both EMSs and abatement measures. Apart from public *authorities*, which are likely to push abatement activities, external forces, such as *customers*, do not seem to be influential with respect to either decision.

Not surprisingly, the existence of at least one employee who is explicitly responsible for environmental concerns, indicated by the dummy variable *officer*, displays a statistically significant positive correlation to the introduction of both abatement activities and EMSs within a facility. The existence of an environmental or a related department, indicated by *department*, only exhibits a positive statistical effect on EMS certification, but not on pollution abatement activities. As one might expect, abatement activities are most likely triggered by strong environmental *impacts* of a facility's production processes: More polluting facilities seem to be more inclined to innovate and abate than less polluting facilities.

In perfect accord with the previous section, which reports that EMS adoption is strongly correlated to facility size, EMS certification is more likely in larger facilities, which tend to have the capacity for such an organizational environmental innovation. However, larger facilities do not seem to spend more effort on abatement activities. Finally and not surprisingly, there are industry-specific differences: abatement activities are more common in the chemical and plastic products sector, for instance, than in any other industry.

In order to estimate marginal effects, we exploit the result that the null-hypothesis

$H_0 : \rho = 0$ cannot be rejected. We thus assume that there is no correlation between the disturbance vectors $\eta$ and $\xi$ of equations (1) and (2) and consistent estimates can be obtained by estimating both equations separately using ordinary single equation probit ML methods. The marginal effects of both single equation estimations are reported in Table 2. In qualitative terms, our single equation estimation results reiterate the pattern already observed from Table 1.

**Table 2**: Marginal Effects originating from Single Equation Probit Estimations.

| Equation | abate | | ems | | Equation | abate | | ems | |
|---|---|---|---|---|---|---|---|---|---|
| Motivations | | | | | Covariates | | | | |
| *image* | – | – | **0.146 | (2.94) | *officer* | **0.224 | (4.47) | **0.305 | (6.27) |
| *incidents* | 0.010 | (0.20) | -0.036 | (-0.76) | *department* | 0.092 | (1.86) | **0.251 | (5.61) |
| *compliance* | 0.058 | (1.13) | 0.075 | (1.51) | *impacts* | **0.157 | (3.19) | 0.025 | (0.54) |
| *policy stringency* | **0.198 | (3.50) | 0.017 | (0.30) | *R&D* | 0.154 | (1.14) | – | – |
| *cost savings* | 0.080 | (1.74) | *-0.094 | (-2.18) | *size* | $0.8\cdot10^{-4}$ | (1.94) | **$1.5\cdot10^{-4}$ | (3.46) |
| Policy Instruments | | | | | Industry Dummies | | | | |
| *voluntary measures* | 0.047 | (0.67) | -0.027 | (-0.45) | *food* | **0.287 | (2.56) | **0.174 | (1.37) |
| *subsidies* | -0.047 | (-0.83) | 0.026 | (0.49) | *textile* | 0.087 | (0.62) | * -0.227 | (0.62) |
| *market instruments* | 0.001 | (0.03) | -0.075 | (-1.66) | *paper* | 0.226 | (1.97) | -0.009 | (-0.07) |
| *regulatory measures* | 0.072 | (1.55) | -0.027 | (-0.60) | *chemicals* | **0.275 | (2.51) | 0.178 | (1.54) |
| *information* | -0.042 | (-0.63) | 0.090 | (1.43) | *minerals* | *0.269 | (1.95) | -0.1784 | (-1.43) |
| *ems* | 0.055 | (1.06) | – | – | *metals* | 0.184 | (1.62) | -0.061 | (-0.59) |
| Pressure Groups | | | | | *machines* | 0.068 | (0.58) | -0.043 | (-0.41) |
| *internal forces* | **0.157 | (3.59) | **0.148 | (3.31) | *transport* | – | – | – | – |
| *authorities* | *-0.127 | (-2.29) | -0.040 | (-0.82) | *recycling* | 0.177 | (0.90) | 0.305 | (1.42) |
| *customers* | -0.032 | (-0.63) | 0.036 | (0.75) | *wood* | **0.329 | (2.50) | -0.271 | (-1.91) |
| *unions* | -0.049 | (-0.49) | 0.006 | (0.07) | Constants | | | | |
| *green organizations* | 0.042 | (0.57) | 0.017 | (0.26) | *cons.* | – | – | – | – |

Exclusively facility-related internal factors, such as management personnel and enhancement of corporate image, appear to be important for the decision in favor of EMS certification, rather than external incentives and forces, such as regulatory pressure. Therefore, apart from general policy stringency and the influence of public authorities, these internal factors are likely to be the driving force for a facility's abatement activities. In sum, we do not find any empirical evidence for the hypothesis that the choice of a single policy instrument determines the environmental innovation behavior of firms. It is the policy style, comprised of policy stringency, policy implementation, and co-ordination of different measures, that seems to be more important.

# 6 Summary and Conclusion

The major question addressed in this paper is: How can public authorities support the introduction of, specifically, environmental management systems (EMSs), which can be interpreted as an organizational environmental and technical innovation that may lead to improved environmental performance? On the basis of a unique facility and firm-level data set for German manufacturing, we find that facility-related internal factors and incentives, such as potential enhancement of the corporate image, and, hence, rational self-interest, may explain a firm's decision for the voluntary adoption of an EMS, a result also obtained by KHANNA and ANTON (2002:556). In contrast, neither external pressure groups nor any single policy instrument tends to push EMS certification. Accepting these results, it would be advisable to focus environmental policy on stimulating internal factors in order to enhance voluntary adoption of EMSs, for instance, through the opportunity to employ certification as a marketing instrument for firms that are already validated.

In addition to internal forces and incentives displaying a statistically positive impact on innovation activities of facilities, the influence of public authorities and the strictness of environmental policy seem to be catalysts for innovation and abatement activities. By contrast, neither EMS certification nor any other single policy instrument appears to affect environmental innovation and abatement behavior. These empirical results are in line with the widely known hypothesis that factors of policy style, such as the stringency of their design and implementation, trigger firm decisions in favor of innovation and abatement activities.

Our results are also in accordance with KING and LENOX (2000), who hypothesize that while the adoption of an EMS may insulate firms from stakeholder pressure, it does not necessarily trigger environmental innovation. NASH and EHRENFELD (2001) presume that, in the absence of sanctions on lack of improvement, firms may develop an EMS to disguise poor performance and avoid regulatory scrutiny, but will not make the effort required to really improve environmental performance. According to ANTON, DELTAS, and KHANNA (2004), EMSs do not necessarily guarantee improved environmental performance, as most EMSs solely focus on the means – that is, the proactive efforts for pollution control – rather than the ends – that is, the actual environmental performance.

ANTON, DELTAS, and KHANNA (2004) also find that none of the market-based or regulatory pressures considered have a significant *direct* impact on the pollution intensity of firms. Rather, their effect is indirect and operates through the adoption of a higher quality EMS that, in turn, has a significant negative impact on the intensity of toxic emissions. In sum, on the basis of our paper's empirical results, we conclude that policy style, including policy stringency and the mix of different policy instruments, deserves at least as much attention in environmental politics as the proper choice of an appropriate policy instrument.

# Appendix

Table A provides the list of variables included in our bivariate recursive probit model. Without exception, all variables are derived from survey responses. Apart from *size* – the variable capturing the number of facility employees –, all variables are constructed as dummy variables, generally indicating whether or not the response option "very important" has been selected for a certain question[7].

**Table A**: Description and Descriptive Statistics of Independent Variables.

| Variable | Description | Mean | Std. Dev. |
|---|---|---|---|
| Motivations for environmental practices: | | | |
| *image* | Corporate image | 0.262 | 0.440 |
| *incidents* | Prevent or control environmental incidents | 0.385 | 0.486 |
| *compliance* | Regulatory compliance | 0.524 | 0.450 |
| *policy stringency* | Stringency of environmental policy | 0.202 | 0.412 |
| *cost savings* | Cost savings | 0.342 | 0.475 |
| Environmental policy instruments: | | | |
| *voluntary measures* | Voluntary or negotiated agreements | 0.130 | 0.337 |
| *subsidies* | Subsidies, tax preferences | 0.205 | 0.404 |
| *market instruments* | Market-based measures: Taxes, tradable permits, liability for environmental damages | 0.593 | 0.499 |
| *regulatory measures* | Regulatory measures: input bans, performance and technology standards | 0.438 | 0.497 |
| *information* | Information measures for consumers | 0.157 | 0.364 |

For example, *image* characterizes whether or not the corporate image is a very important motivation for environmental practices of a facility. There are two exceptions to this rule: *policy stringency* = 1 indicates whether respondents assess the general policy regime as very stringent, while *policy stringency* = 0 means moderately or not stringent.

[7] Alternatively, we have constructed dummy variables that reflect both the response options "very important" and "important". In qualitative terms, estimation results for our model based on such dummy variables are the same.

The variable *impacts* indicates *very negative* environmental impacts of a facility's products and production process with respect to at least one of the following issues: water effluents, air pollution, waste generation, etc.

**Table A**, continued: Description and Descriptive Statistics of the Independent Variables.

| Variable | Description | Mean | Std. Dev. |
|---|---|---|---|
| Pressure groups: | | | |
| *internal forces* | Corporate headquarters, employees, shareholders | 0.555 | 0.497 |
| *authorities* | Public authorities | 0.438 | 0.497 |
| *customers* | Private and commercial consumers, | 0.291 | 0.455 |
| *unions* | Industrial associations, labor unions | 0.059 | 0.237 |
| *green organizations* | Environmental organizations, neighborhood groups | 0.125 | 0.331 |
| Covariates: | | | |
| *department* | Existence of an environmental or related department | 0.438 | 0.496 |
| *officer* | Existence of a person explicitly responsible for environmental concerns | 0.658 | 0.475 |
| *impacts* | Importance of environmental impacts | 0.258 | 0.438 |
| *size* | Number of a facility's employees | 476.5 | 3801.2 |
| *R&D* | Existence of an R&D budget related to environmental matters | 0.036 | 0.187 |
| Industry Dummies (ISIC Codes): | | | |
| *food* | Food products, beverages and tobacco (15-16) | 0.086 | 0.280 |
| *textile* | Textiles, textile products, leather and footwear(17-19) | 0.045 | 0.206 |
| *paper* | Pulp paper, paper products, printing and publishing (21-22) | 0.102 | 0.303 |
| *chemicals* | Chemical, fuel, rubber and plastic products (23-25) | 0.166 | 0.372 |
| *minerals* | Other non-metallic mineral products (26) | 0.039 | 0.194 |
| *metals* | Basic metals and fabricated metal products (27-28) | 0.235 | 0.424 |
| *machines* | Machinery, electrical and optical equipment (29-33) | 0.253 | 0.435 |
| *transport* | Transport Equipment (34-35) | 0.036 | 0.185 |
| *recycling* | Recycling (37) | 0.011 | 0.185 |
| *wood* | Wood and wood products, furniture (20, 36) | 0.029 | 0.168 |

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