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**ESSAYS ON ASYMMETRIC INFORMATION AND ENVIRONMENTAL
REGULATION THROUGH DISCLOSURE**

by

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A mis viejos

Abstract

This dissertation delves into different aspects of a relatively new policy approach for industrial pollution control: the public dissemination of information by regulators regarding the environmental performance of firms. These schemes are sometimes referred to as regulation through disclosure or informational regulation. It is presumed that disclosure as an environmental regulation triggers and intensifies interactions between polluting firms and workers, community groups, consumers, and owners. It thus increases the costs of non-compliance with environmental law through channels that do not directly involve the regulator.

The understanding that information is important for market emergence together with evidence suggesting that disclosure schemes can influence firms' environmental performance, have resulted in a certain enthusiasm for these approaches. There are however still voids in the theoretical foundations of disclosure as regulation, as well as in the empirical evidence supporting its alleged effectiveness (in particular in developing and emerging economies). This dissertation aims at contributing to the growing literature on disclosure in both these regards. The discussion consists of four self-contained chapters. Chapter 1 looks into some theoretical issues of environmental compliance under asymmetric information. Chapters 2 and 3 constitute an empirical evaluation of a well-structured disclosure program, Indonesia's PROPER, while Chapter 4 studies the more informal type of provision of information in Central and Eastern Europe.

Informal mechanisms such as public disgrace faced by managers and owners of polluting firms and moral suasion have been suggested as possible explanatory factors of firm environmental behavior. The first contribution of this dissertation is in this area. Building on earlier work, Chapter 1 develops a model of social interactions where managers and owners of highly polluting firms face stigmatization and losses in reputation in society. I argue that symmetric information is a silent assumption of earlier papers on social interactions that is not necessarily met in the industrial pollution case. I study situations where firms' environmental performance is perfectly observable and imperfectly observable. The findings show that relaxing the perfect observability assumption, even by a small margin, could have profound effects on the reputation functions in such a way that high levels of compliance cannot be sustained in equilibrium.

Chapters 2 and 3 evaluate the effectiveness of Indonesia's public disclosure program PROPER. The main result is that the policy was responsible for a rapid and significant reduction in emissions intensity as measured by biochemical oxygen demand, BOD, and chemical oxygen demand, COD (the characteristics of those firms that were most responsive to the program are also unveiled). Chapter 4 is also an empirical study of more informal type of provision of information in Central and Eastern Europe during the first years of transition. The analysis reveals that enforcement and public disclosure of the environmental performance of firms are the most important forces behind the implementation of Environmental Management Practices. The findings of Chapters 2, 3 and 4 strengthen the belief that thin markets and other sluggish mechanisms are the results of imperfect information and also indicate that informational regulation is a promising strategy to tackle industrial pollution in the presence of weak institutions.

Preface

While all the shortcomings of this dissertation are my entire responsibility, I would like to acknowledge a number of individuals and institutions who, in one way or another, supported the completion of my doctoral studies. I want to express my sincere gratitude to my Supervisors Thomas Sterner, Fredrik Carlsson and Åsa Löfgren for their guidance throughout these years. Thomas backed my application to the PhD program in Gothenburg and, at a very early stage in my studies, introduced me to the topic of regulation through disclosure. Through his leadership in the EEU (which among other things granted me access to the databases used in this research), and stimulating advice, he has been my mentor up to today. Fredrik has been a constant support since the moment I wrote the first paragraph of this dissertation. I also feel very lucky to have had him as a Supervisor. Apart from having a very sharp mind, I do not know of many teachers or researchers as committed and devoted to his students. Åsa became my Co-supervisor at a later stage than Thomas and Fredrik, nevertheless she has not only contributed with insightful comments to all chapters but has also been an extremely motivating force.

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I spent the academic year 2004-05 at ARE UC Berkeley. I would like to thank Peter Berck, Michael Hanemann, Shachar Kariv and Felipe Vasquez for their hospitality and stimulating discussions while visiting that institution. Special thanks to Felipe (and Patilu) for "hosting" me during that year. I am grateful to The International Office at the University of Gothenburg, and in particular to Dora Kós-Dienes, for facilitating my visit to the United States. I also want to thank Lennart Hjalmarson for offering his unconditional help in this enterprise.

Meeting so many good friends and this dissertation would have not been possible without the financial means provided by the Swedish International Development Cooperation Agency (Sida). I am evermore grateful for this funding.

The journey to this thesis started a few years back when I joined the masters program in environmental economics at the Universidad de los Andes in Bogotá. Much of what I learnt there, as a student and later as a research assistant, shaped the way I understand economics today. My special gratitude goes to Eduardo Uribe who initiated me in industrial pollution control issues and instructed me in environmental policy. The support of Darrell L. Hueth during, and after, my time in los Andes is also gratefully acknowledged.

Much farther back in time, while being an undergrad student of engineering I had to take a compulsory course in economics. I remember that the teacher was an eloquent and engaging speaker. After a few weeks however, I decided I need not listen to such esoteric matters. I stopped attending his lectures (and failed the course, of course). This thesis is, in a way, also an apology to him.

My studies have kept me away from loved ones back home. I have greatly missed my parents, Bertha and Hernan and my dear sisters Marce, Monic, Pato and Pilar. Not being around my nieces Laura, Natalia and Carolina and my nephew Pablo has been a particularly high price to pay. I fully appreciate the understanding and encouragement of all my family and friends during these years of absence. Last, but not least, I would like to thank Andrea for being such a sweat-heart and such a supportive partner, specially, during the last stage of my life as a PhD student.

Göteborg, January 2007

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Introduction

Portney (2000) states that three significant trends are likely to endure in the environmental policy arena in the period 2000 – 2050. Governments are expected to continue shaping their institutional arrangement to deal with environmental problems in more effective ways. This is related to the increased use of market-oriented approaches such as emission fees and tradable emission permits. Economics has been the major advocate of such policies due to the alleged efficiency properties to achieve overall levels of environmental quality. The second trend refers to the increased decentralization of environmental institutions. Given that many of the environmental problems occur at the local level, it is believed that they ought to be solved at that same level. The primary topic of this dissertation concerns the third trend: the public dissemination of information by regulators regarding the environmental performance of firms in terms of for example emissions to air and water. The first two major public disclosure programs in the developed and the developing worlds are the US Toxics Release Inventory TRI (1988 – today) and Indonesia's Program for Pollution Control Evaluation and Rating – PROPER (1995 – 1998 and 2002 – today). Such schemes are sometimes referred to as regulation through disclosure or informational regulation. The relative ease with which information can be disseminated with today's technologies and the generally accepted idea of citizens right-to-know about environmental hazards have helped pave the way for their use.

For over three decades the economics of information has highlighted that interactions among economic agents are largely mediated by the existing information structure. It is now acknowledged by economists that information is often imperfect, and that this leads to market failure. Akerlof's (1970) often cited paper on "lemons" was the seminal contribution in the field. It is thus presumed that disclosure as an environmental regulation triggers and intensifies interactions between polluting firms and workers, community groups, consumers, and owners, increasing the costs of non-compliance with environmental law through channels that do not directly involve the regulator (Tietenberg, 1998).

The understanding that information is important for market emergence together with evidence suggesting that disclosure schemes can influence firms' environmental performance, have resulted in a certain enthusiasm for these approaches. There are however still voids in the theoretical foundations of disclosure as regulation, as well as in the empirical evidence

supporting its alleged effectiveness. This dissertation aims at contributing to the growing literature on disclosure in both these regards. The discussion consists of four self-contained chapters. Chapter 1 looks into some theoretical issues of environmental compliance under perfect and imperfect information structures. Chapters 2 and 3 constitute an empirical evaluation of a well-structured disclosure program, Indonesia's PROPER, while Chapter 4 studies the more informal type of provision of information in Central and Eastern Europe, as well as other aspects of firm environmental behavior in transition economies.

Although the advances in information economics have been remarkable, there are still several unexplored areas (Stiglitz, 2000). For instance, the bulk of the research in the field has focused on market interactions (Stiglitz, 2002). However, social interactions, such as those encompassed by the human tendency to conform to social codes of behavior, have been recognized to be a determining factor of economic performance; see Akerlof (1980)¹. Regarding the industrial pollution problem, informal mechanisms such as public disgrace faced by managers and owners of polluting firms and moral suasion have been suggested as possible explanatory factors of firm behavior. The first contribution of this dissertation is in this area. Building on earlier work, Chapter 1 develops a model of social sanctions where managers and owners of highly polluting firms face stigmatization and losses in reputation in society. I study situations where the environmental performance of firms is perfectly observable and, unlike earlier papers, imperfectly observable. I argue that perfect information is a tacit assumption of earlier work that is not necessarily met in the industrial pollution case. In fact, the individual compliance status of firms is unlikely to be perfectly observable in the social circles where owners and managers interact. I characterize (expected) loss in reputation functions for owners and managers. The results suggest that relaxing the perfect observability assumption has profound negative effects on the possible equilibrium outcome. Although this is not necessarily surprising, what is particularly striking is that the reputation functions and the incentives to comply in both the perfect and imperfect information worlds are “diametrically” different. For instance, social sanction approaches state that high levels of obedience to a costly norm (that is, a large proportion of the population following a norm that entails a cost to those who conform) can be supported in equilibrium. In fact, in a law-abiding high compliance world it is clear that the loss in reputation from being caught cheating could

¹ This is one of first papers to formally study social codes of behavior in the economics literature. In the model set up in this paper, managers and owners of firms face stigmatization in society when they do not pay what is considered a “fair” wage. The persistence of a “fair” wage higher than the market-clearing wage could thus explain the existence of unemployment in a “perfect” competitive market.

be devastating and we can imagine that this is a strong force explaining why high levels of compliance might be present. In contrast, the model of Chapter 1 shows that imperfect information causes the expected social sanction to be at its lowest precisely when obedience is more common. The essential aspect of the analysis lies in the way society forms expectations about the compliance status of firms. It is first presumed that although the compliance status of individual firms is not perfectly observable to society, the level of violation in the economy is and that this piece of information provides a natural estimate of the likelihood that any given firm is in violation. I then argue that society will find it hard to believe that any given firm is in non-compliance precisely when disobedience is rare. In fact, people find it difficult to conceive that someone is of a given type or has a certain characteristic when they know that very few in society are of that type or have that characteristic. Thus, high levels of obedience cannot be supported in equilibrium. Our findings highlight the difference between social and moral norms. Although the “punishment” borne by a disobedient individual in both settings may depend on the behavior of his or her peers in similar fashions, we show that in the latter case the individual decision and aggregate outcome depends dramatically on observability.

Disclosure as an environmental regulation is still in its infancy. The current evidence of its success at delivering emissions reductions and the different mechanisms through which it works is to some extent fragmentary and anecdotal. For instance, while the US TRI program, which was the first informational regulation scheme in the world, is claimed to have led to a 45% emissions reduction, there is no analysis that has actually been able to attribute these reductions to the policy itself (Hahn et al., 2003). However there exists partial evidence on the effectiveness of the TRI and on the success of a smaller scale Canadian program. A related issue arises here, regarding the possible performance of disclosure in less developed countries with weak governmental institutions and imperfect markets. Will attempts to restore perfect information trigger the necessary forces to induce environmental friendly behavior in these societies? We know, for instance, that perfect information is a necessary but not a sufficient condition for markets to emerge. In fact if society’s latent demand for environmental amenities is low, such amenities will not even be provided under perfect information. Chapters 2, 3, and 4 address this question and other related issues through two case studies from developing and transition economies.

Chapters 2 and 3 evaluate Indonesia’s PROPER disclosure program which was launched in June 1995. Faced with the discrepancy between a powerful and expanding industrial sector

and its own lack of resources, Indonesia's environmental authority decided to tackle industrial emissions control through an information disclosure program.² As mentioned earlier, PROPER was the first and most visible informational regulation scheme in the developing world. Chapter 2, to the best of the authors' knowledge, presents the first formal analysis addressing the effectiveness of information strategies in reducing pollution in a developing country. We analyze changes in emissions concentrations (mg/L) using panel data techniques with plant-level data for participating firms and a control group. The main result is that the policy was responsible for a rapid and significant reduction in emissions intensity as measured by biochemical oxygen demand, BOD, and chemical oxygen demand, COD. This finding strengthens the belief that thin markets and other sluggish mechanisms are the results of imperfect information and also indicate that informational regulation is a promising strategy to tackle industrial pollution in the presence of weak institutions.

Chapter 3 goes a step further in the analysis of PROPER. Here I analyze plant level data to relate environmental responses to facility characteristics. The broad objective of this chapter is to contribute to the understanding of the mechanisms through which provision of information programs work. The data set used in this chapter is one of the most comprehensive data sets available in the developing world (in that it includes both firm characteristics and environmental performance under a regulatory regime based on disclosure) although it is still somewhat limited in scope. A number of interesting findings are nevertheless identified: Firstly, foreign-owned firms were consistently most responsive to the program, which can be interpreted as managers of polluting firms facing higher pressure from foreign investors. It has also been shown that the technological levels of foreign-owned in Indonesia are higher as compared to local firms, and they could be better endowed to face new environmental challenges. Being located in Java, Indonesia's main island, seemed to be important in determining the extent to the response. Java is the most densely populated island on Earth, has higher incomes, better media coverage, access to political arena, and a greater potential for community pressure. Also, Chapters 2 and 3 find that, after controlling for a number of factors, those firms that were rated as heavy polluters were more likely to produce emissions reductions than the relatively greener firms. This result can initially be interpreted in terms of greener firms having more technological difficulties in achieving further emissions

² Whereas the origins of the disclosure approach of the US TRI program lie in the grassroots belief that citizens have the right to know about environmental hazards they are exposed to (Sunstein, 1999), the origins of Indonesia's PROPER fall into the regulatory functions of the state. This does not imply that citizen's right to know is not always a precondition for the implementation of disclosure strategies.

reductions due to increasing marginal costs of abatement. Note also that the incentives to abate emissions provided by a bad environmental performance are much stronger than those provided by a good one.

In Chapter 4, 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 period of 1990 – 1998 when these countries were in transition away from central planning. Data on economies in transition offer us the opportunity to look at some fundamental factors of firm behavior. During the transition, some dramatic changes occurred such as the creation of secure property, functioning markets and inflows of foreign direct investment. Also, the official inspection, monitoring and regulatory authorities such as the Ministries of Environment, the environmental protection agencies and the inspectorates were strengthened during this period. Regarding civil rights, before 1990 there was generally little information available on pollution but today such information is often public since most of these countries enforce the public's right to know on the environment. The analysis reveals that enforcement and public disclosure of the environmental performance of firms are the most important forces behind the implementation of EMPs. Disclosure refers to the appearance of firms in media reports about emissions of major pollutants. It is interesting to see that such a mechanism also works in transition economies. In fact, the existence of civil liberties such as the right to information was one of the most crucial differences between “East” and “West.”

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On social sanctions and beliefs: A pollution norm example

Jorge García L.^{†‡}

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Abstract

The social sanction approach states that high levels of obedience to a costly norm (a large proportion of the population following a norm that entails a cost to those who conform) can be supported in equilibrium. The reason is that the social disapproval and stigmatization faced by the disobedient are at their highest when disobedience is the exception rather than the rule in society. In contrast, it is found in this paper that imperfect observability causes the expected social sanction to be at its lowest precisely when obedience is more common. The essential aspect of the analysis lies in the way beliefs are formed. Unless actions are fully observable, it is hard to conceive that someone is in disobedience when disobedience is rare. In this line of argumentation, the failure of an environmental norm as an internalization mechanism can be explained.

Key words: Social Norm, Imperfect Information, Bayesian Equilibrium

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1 Introduction

This paper attempts to increase our understanding of the effects of reputation on compliance with certain norms of behavior, and particularly the role of information in mediating this relationship. It has been argued that social sanctions imposed on managers and owners of polluting firms can provide an internalization mechanism of external costs and damages. Cropper and Oates (1992), in their survey of environmental economics, suggest that public opprobrium may explain the observed coexistence in the United States of high levels of firm compliance with environmental regulation and low expected penalties. This is known as the Harrington Paradox (HP) (Harrington, 1988). More recently, Elhauge (2005) argues extensively about the relevance that social sanctions have on influencing manager decisions to undertake environmental investments. Decision makers would decide to incur costs of compliance rather than face stigmatization and reputation losses in society.

Nyborg and Telle (2004) and Lay et al. (2003) formalize the notion of social sanction in the case where firms are expected to meet an environmental standard. The idea that social sanctions are relatively high when disobedience is uncommon in the economy allows a high compliance state to qualify as an equilibrium (Akerlof, 1980). However, the social sanction approach does not necessarily give a unique prediction of equilibrium. Low compliance equilibria could coexist since losses in reputation are low at high levels of disobedience.

An underlying assumption that seems ubiquitous in this literature is that of perfect observability of agent behavior, for example in terms of emissions and compliance status. We argue that, unlike other situations in which social sanctions have been used to explain economic behavior, this assumption is not necessarily met in the industrial pollution case. In fact, social sanctions are generated in different environments, and individual actions and compliance status of firms are unlikely to be perfectly observable in the social circles where owners and managers interact. In some cases, awareness of the identity of polluting sources may be limited to neigh-

boring communities, and even for these it may be very difficult to judge whether a given emitter is in or out of compliance with the legislation.

The purpose of this paper is to study the consequences of relaxing the perfect observability assumption. In our model, society forms beliefs (or expectations) about the compliance status of individual firms based on two pieces of information: the general level of violation in the economy, and signals that can convey some indication of the firm's compliance status. Managers' expected losses in reputation are in turn built on society's beliefs. We show how small deviations from perfect observability rule out the high compliance states as possible equilibria. The lynchpin of our argument is that the likelihood of being unveiled is a very different function from the loss in reputation function. As already mentioned, the potential loss in reputation is high when compliance is high, which is supposed to be a strong deterrent. However, in a society where most people conform, it is hard to conceive or believe that anyone would be in disobedience, in particular, when actions are not fully observable. Expected losses in reputation due to a violating behavior are accordingly low, actually at their lowest, so that the highest compliance states can not be supported in equilibrium. Thus, a social sanction explanation of the Harrington Paradox heavily relies on observability of firm actions.¹ Note that due to the way beliefs are formed in our model, the compliance incentives in the perfect and imperfect information worlds are diametrically opposed at high levels of compliance. We sometimes refer to this as a "belief curse."

The framework proposed in this paper provides insights into different situations where similar social interactions and information asymmetries come into play. The concluding section of the paper briefly discusses a corruption example in light of our model.

¹Haab and McConell (2002) discuss the relevance of observability of agents behavior in the imposition of social sanctions in the context of disposal of debris from recreational boats in a marine environment. In contrast to our example, they consider that the social sanction is only generated *in-situ* at the emission point and is equal to zero if individuals are not observed committing violations.

2 A model of reputation and compliance

The social norm in our model demands firms to meet a legal pollution standard. Compliance is costly, but non-compliance could lead to a loss in reputation which may also be costly. For simplicity we assume that regulatory costs due to non-compliance are negligible or nonexistent. As stated earlier, the main feature of social sanctions is that agent pay-off functions not only depend on own actions but also on actions of other agents. In a setting where the number of agents who follow a norm is relatively large, social disapproval due to deviation is high. Correspondingly, if very few agents follow the norm, then the costs of deviation are small. Let $\alpha \in [0, 1]$ represent the fraction of firms that violate the standard. The loss in reputation function is $R(\alpha)$, where $R_\alpha < 0$. By breaking the norm, violators derive pecuniary benefits represented by saved abatement expenditures c .

We will only be concerned with situations where firms adopt pure strategies, meaning they either comply or violate. Let $d \in \{0, 1\}$ be a firm's strategy, where 0 denotes compliance and 1 violation. A manager's utility function is then given by:

$$U(d; \alpha) = \begin{cases} -c & \text{if } d = 0 \\ -R(\alpha) & \text{if } d = 1 \end{cases} . \quad (1)$$

In order to make our point clear we use the simplest linear reputation function, $R(\alpha) = 1 - \alpha$. Furthermore, we assume that there is a unit mass of firms with homogeneous fixed costs of compliance $c \in (0, 1)$ and that a single firm's actions do not affect the value of $R(\alpha)$. This description fits that of perfect competition (or non-atomic games).

A silent feature of the manager utility function in equation (1) is that of perfect observability of firm behavior. The social sanction faced by managers is to a large extent given by society's beliefs concerning their firm type. Hereafter we will often

refer to a firm's type as its compliance status. Under perfect information, society's assessment of a given firm being either type matches the actual firm type. Table 1 illustrates this. For instance, the bottom left corner of the table shows that the probability of a violator being identified as a compliant is 0. This in turn implies that the probability that this firm is identified as a violator is 1 (upper left corner). If society was not capable of distinguishing between the two types, there would be the possibility that compliant firms were wrongly perceived as violators (and the other way around), which would lead to losses in reputation for the managers of these firms.

Table 1: Society's beliefs: Perfect Information.

True firm type	Beliefs on firm being:	
	Compliant	Violator
Compliant	1	0
Violator	0	1

In the analysis of the strategic interactions, the *Nash Equilibrium* and *Strict Nash Equilibrium* concepts will be used. In our game each firm plays against the aggregate of all other firms and a given level of violation, α , defines a strategy profile of the game.

Definition 1. Let $d^*(\alpha)$ be a firm's best response strategy to level of violation α , so that $U(d^*(\alpha); \alpha) \geq U(d; \alpha)$ for $d \in \{0, 1\}$. A strategy profile is a *Nash Equilibrium* if all firms' strategies are best response strategies. Further, a *Nash Equilibrium* is *Strict* if each firm has a unique best response strategy. That is $d^*(\alpha)$ is such that $U(d^*(\alpha); \alpha) > U(d; \alpha)$ for $d \in \{0, 1\}$ for all firms.

Recall that a *Nash Equilibrium* requires that the outcome of a deviation be *no better* for the deviant than the equilibrium outcome, whereas in a *Strict Nash*

Equilibrium a deviation leads to an outcome that is worse for the deviant than the equilibrium outcome.² We now have all the elements to state the base case proposition.

Proposition 1. *Under perfect information concerning the compliance status of firms, two strict Nash equilibria coexist: equilibrium ($d^* = 0$ for all firms) and the violation equilibrium ($d^* = 1$ for all firms). A third nonstrict equilibrium with partial compliance is also present.*

Figure 1 illustrates the insight provided by this proposition by showing the (dis)utilities of compliance and violation for different levels of violation (see appendix B for proof). Proposition 1 presents two strict equilibria, namely states K and M in the figure, where all firms behave identically (or pooling equilibria). The social sanction at high levels of compliance is high enough to keep this society in full compliance, state K . Nevertheless, the compliance incentives are undermined at low levels of compliance in such a way that a violation equilibrium could persist, state M .³

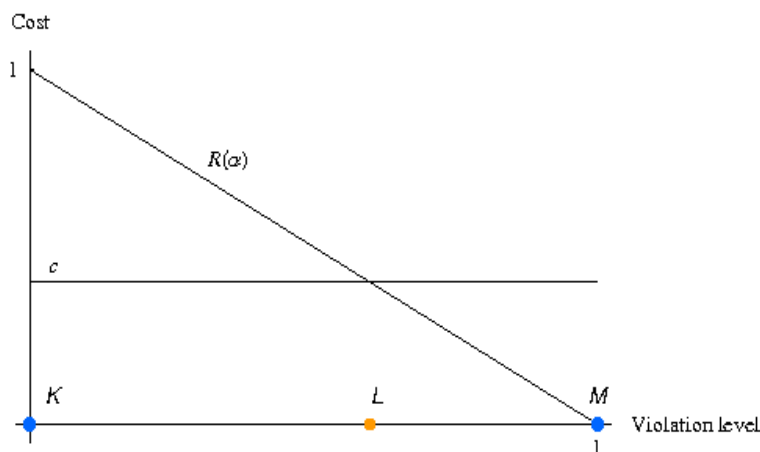
It is important to note that the non-strict equilibrium in this full information case, state L , comes across as arbitrary. It demands that exactly a fraction α' of firms choose violation and that the remaining $1 - \alpha'$ fraction of firms choose com-

²For a discussion on the properties of the *strictness* concept, see Fudenberg and Tirole (1998), pg 11.

³The notion that reputation costs can be used to solve the Harrington Paradox is tempting at first sight but a little reflection will point to the fact that this is not straightforward: In a law-abiding high compliance world it is clear that the loss in reputation from being caught cheating could be devastating and we can imagine that this is a strong force to comply. But what happens in the context of lawlessness? If virtually everyone cheats then surely there will not be much loss in reputation if I also cheat?. This weakens the power of the hypothesis - because we have to assume high compliance in order to invoke the “loss in reputation” hypothesis that was supposed to explain why high compliance is common. In this context, the loss in reputation hypothesis only provides a partial explanation of the Harrington Paradox.

pliance, although all firms in both groups are indifferent between their “chosen” strategy and their “alternative” strategy. Still, in our model all firms (managers) are identical and face the same external pressure, so there is no strong reason to expect them to behave in different ways.

Figure 1: Perfect information equilibria.



The two straight lines represent the manager’s costs of compliance and violation. The losses in reputation due to violation, $R(\alpha)$, are decreasing in the level of violation, α , whereas the cost of compliance are constant and equal to c . The full compliance and the full violation states, K and M , are both Strict NE whereas the state L , with partial compliance, is a Non-Strict NE.

We now turn to the imperfect information case. We assume that society has fragmentary information based on which it forms expectations about the compliance status of firms. Since beliefs are now formed with partial information, losses in reputation could be imputed to both compliant firms and violators. We assume that society knows the actual level of violation in the economy, α . This in fact constitutes society’s (prior) belief on the violation type. If no other information is available, α is society’s most sensible estimate of the chances that any given firm, either compliant or violator, is in violation.⁴ Further, although society does not

⁴Environmental degradation may be an indicator of the level of violation in the economy. Assume that compliant firms emit 0 and violating firms emit z units of pollution. Since the number of firms is normalized to unity, if they were all noncompliant then total pollution would be “ z ”.

observe the compliance status of firms, it does receive a signal from each firm that conveys information about its type. A signal could be denoted as either a violation signal or a compliance signal. Note that since signals are mutually exclusive, the occurrence of a compliance signal is equivalent to the non-occurrence of a violation signal. Let π and θ be the respective probabilities that society receives a violation signal from a violator and a compliant firm. Consequently, $1 - \pi$ and $1 - \theta$ are the probabilities that a compliance signal is received from a violator and a compliant firm respectively. Note that these primitive probabilities are exogenous and that firms cannot influence them. The imperfect information case is characterized by the relation $0 < \theta \leq \pi < 1$. That is, society can not be less (more) likely to receive a violation (compliance) signal from a violator than from a compliant firm.⁵ Table 2 presents a cross tabulation of signals and firm types.

Table 2: Probabilities of signals.

Signal	Firm Type	
	Compliant	Violator
Compliance	$1 - \theta$	$1 - \pi$
Violation	θ	π

Once signals are realized, then society's beliefs on the expected types of firms are calculated using Bayes' rule. Specifically, society's beliefs about an individual firm being the violation type when a violation signal is received take the following form:

$$A(\alpha, \pi, \theta) = \frac{\pi}{\pi\alpha + \theta(1 - \alpha)} \alpha. \quad (2)$$

If total pollution can be observed and is measured as W , then the statistic used by society to calculate the share of polluting firms is given by $\tilde{\alpha} = \frac{W}{z}$.

⁵Society's knowledge about polluters in this model resembles that of the regulator in a non-point source pollution problem.

Society's prior belief on the violation type, α , is updated via the ratio factor given by the first part of the expression. When signals are uninformative, that is $\pi = \theta$, then the updating factor equals 1 for all values of $\alpha \in [0, 1]$. With informative signals, that is $\pi > \theta$, this factor is higher than 1 for $\alpha \in [0, 1)$ and equal to 1 for $\alpha = 1$. Note that the denominator of the equation gives the total probability that society receives a violation signal from any given firm. $\pi\alpha$ is the probability that a violation signal comes from a violator, whereas $\theta(1 - \alpha)$ is the probability that a violation signal comes from a non-violator (wrongly accused compliant firms). Thus, equation (2) provides society with an estimate of the probability that a received violation signal comes from a violator after correcting for the fact that violation signals could also come from non-violators. Appendix A provides an idea of the order of magnitude of the changes in beliefs induced by Bayesian updating in our model. Society's beliefs about a given firm being the violation type when a compliance signal is received take the following form:

$$B(\alpha, \pi, \theta) = \frac{(1 - \pi)}{(1 - \pi)\alpha + (1 - \theta)(1 - \alpha)} \alpha. \quad (3)$$

In this case the updating factor with informative signals is lower than 1 for $\alpha \in [0, 1)$ and equal to 1 for $\alpha = 1$. Now the denominator of the equation gives the total probability that society perceives a compliance signal from any given firm. $(1 - \pi)\alpha$ is the probability that a compliance signal comes from a violator and $(1 - \theta)(1 - \alpha)$ is the probability that a compliance signal comes from a compliant firm. Thus, equation (3) gives the probability that a received compliance signal comes from a violator after correcting for the fact that such signals are typically expected to come from a compliant firm. Table 3 presents a tabulation of society's beliefs under imperfect information. Unlike the perfect information case (see Table 1), compliant firms risk being confused as violators, while violators could benefit from passing as complaints.

From the previous discussion it follows that $A(\alpha, \pi, \theta) > \alpha > B(\alpha, \pi, \theta)$ for

Table 3: Society's beliefs: Imperfect Information.

Signal	Beliefs on firm being:	
	Compliant	Violator
Compliance	$B(\alpha, \pi, \theta)$	$1 - B(\alpha, \pi, \theta)$
Violation	$A(\alpha, \pi, \theta)$	$1 - A(\alpha, \pi, \theta)$

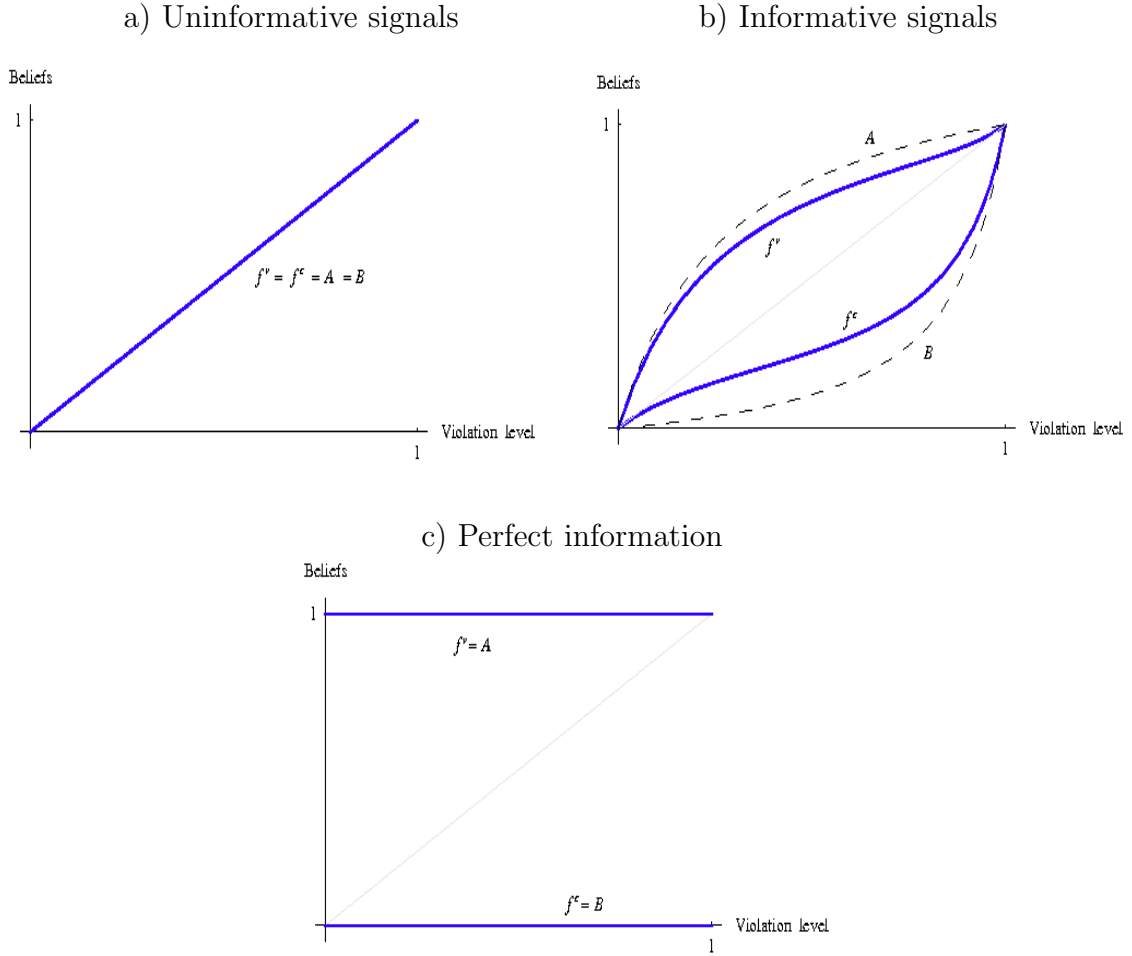
$\alpha \in (0, 1)$ when signals are informative. The probability that a firm is in violation is higher when it emits a violation signal than when it emits a compliance signal. When there is either total violation, $\alpha = 1$, or total compliance, $\alpha = 0$, then signals become irrelevant and society is fully certain about all firm types: $A(0, \pi, \theta) = B(0, \pi, \theta) = 0$ and $A(1, \pi, \theta) = B(1, \pi, \theta) = 1$. When signals are uninformative, then firms are completely anonymous and the level of violation, α , is the most sensible estimate of the chances that any given firm is in violation: $A(\alpha, \pi, \theta) = B(\alpha, \pi, \theta) = \alpha$. Firms make their compliance decisions taking into account their own expectations of being identified as violators. Unlike society, managers know their own types since they make the decision on which type to adopt. Firms' unconditional expectations of being identified as violators when in violation and compliance are given by the following expressions:

$$f^v(\alpha, \pi, \theta) = \pi A(\alpha, \pi, \theta) + (1 - \pi)B(\alpha, \pi, \theta). \quad (4)$$

$$f^c(\alpha, \pi, \theta) = \theta A(\alpha, \pi, \theta) + (1 - \theta)B(\alpha, \pi, \theta). \quad (5)$$

Figure 2 shows the form these beliefs take under imperfect information. The solid curves represent firms' unconditional beliefs, whereas the dashed curves represent society's beliefs. With uninformative signals, panel a), we have that $f^c(\alpha, \pi, \theta) = f^v(\alpha, \pi, \theta) = \alpha$. With informative signals, panel b), we have that $f^v(\alpha, \pi, \theta) > \alpha > f^c(\alpha, \pi, \theta)$ for $\alpha \in (0, 1)$. That is, signals allow compliant types to decrease their chances of being identified as violators, while violators see these chances increase. As noted earlier, signals become irrelevant in the extreme cases $f^c(0, \pi, \theta) = f^v(0, \pi, \theta) = 0$ and $f^c(1, \pi, \theta) = f^v(1, \pi, \theta) = 1$.

Figure 2: Beliefs under imperfect and perfect information.



The curves f^v and f^c are the manager's expectations of being identified as a violator when violation and compliance strategies are adopted (A and B are society's beliefs after signals have been received from the firm). When signals are uninformative, panel a), the level of violation, α , define the manager's beliefs of being identified as a violator for both the violation and the compliance strategy. When signals are informative, panel b), the chances of being identified as a violator typically diverge from α for both types of managers. In the perfect information case, panel c), society's beliefs always match the actual behavior of firms in such a way that only violators are likely be identified as such (see also Table 1).

Note that firms in violation can be unveiled with a probability $f^c < 1$, but firms in compliance may be wrongly perceived as or accused of violating with a proba-

bility $f^c > 0$. This is sometimes referred to as monitoring errors of type I and type II.

We started by looking at losses in reputation with perfect information and then turned to probabilities of violation detection with imperfect information. We are now in a position to synthesize and look at expected losses in reputation. These are now given by $f^v(\alpha, \pi, \theta) R(\alpha)$ for the violation type and $f^c(\alpha, \pi, \theta) R(\alpha)$ for the compliant type. Following the notation used in equation (1) managers' expected utility is:

$$U^E(d; \alpha, \pi, \theta) = \begin{cases} -f^c(\alpha, \pi, \theta) R(\alpha) - c & \text{if } d = 0 \\ -f^v(\alpha, \pi, \theta) R(\alpha) & \text{if } d = 1 \end{cases}. \quad (6)$$

Proposition 2. *With imperfect information on the compliance status of firms we have that:*

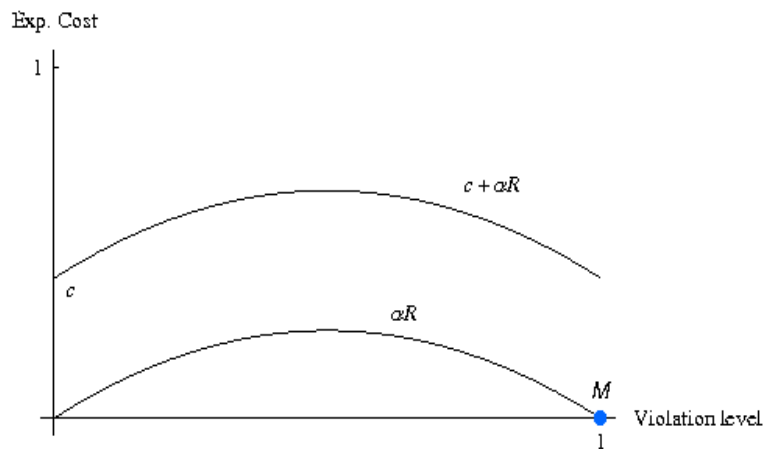
- *The full violation state ($d^* = 1$ for all firms) is the only Strict Bayesian equilibrium of the game.*
- *The full compliance state ($d = 0$ for all firms) does not qualify as an equilibrium.*
- *Two non-strict Bayesian equilibria emerge if the frequency of violation signals received from the compliant types, θ , is sufficiently low compared to the frequency of the violation signals received from the violation types, π .*

The first two parts of Proposition 2 follow directly from the Bayesian belief formation (see proof in appendix B). Since beliefs are completely accurate when there

is full violation, the pay-offs in the perfect and imperfect information cases are exactly the same. The full violation state is thus preserved as a Strict Equilibrium under imperfect information. On the other hand, an important consequence of the existence of imperfect information is the ruling out of full compliance as a possible equilibrium. Note that the expected losses in reputation due to violation are zero at full compliance under imperfect information. In a society where most people conform, people find it hard to conceive that anyone would be in disobedience.

Figures 3, 4 and 5 illustrate the third part of Proposition 2: Emergence of partial compliance.

Figure 3: Imperfect information equilibrium with uninformative signals, $\pi = \theta$.



The two curves represent the manager's expected costs of compliance and violation. With uninformative signals the losses in reputation faced by the manager are equal to $\alpha R(\alpha)$ regardless of his or her decision to comply or not. Thus, the full violation state, M , is the only (Strict) Bayesian Equilibrium.

Figure 4: Imperfect information equilibrium
with informative signals, $\pi > \theta$.

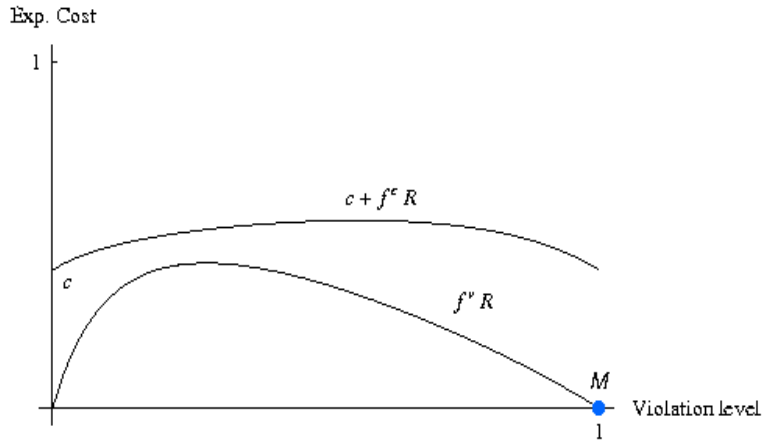
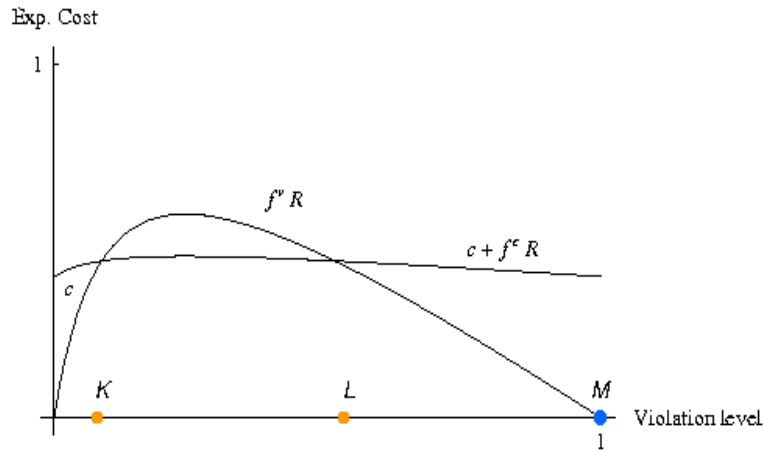


Figure 5: Imperfect information equilibria
with very informative signals, $\pi \gg \theta$.



The curves in Figures 4 and 5 represent the manager's expected costs of compliance and violation. The state M in both figures is a Strict Bayesian Equilibrium, while the states K and L in Figure 5 are Non-Strict Bayesian Equilibria. In Figure 4 the only prediction of the game is full violation as signals do not allow compliant firms to be distinguished from violators with accuracy. When signals are informative enough, Figure 5, two partial compliance states emerge as possible equilibria.

The expected cost of violation function is concave with respect to the level of violation, α . It starts at zero, since the risk of being unveiled is zero when no one violates. The function will rise as detection risk rises until a maximum when the effect of a decreasing $R(\alpha)$ sets in. The expected costs of compliance function is also concave and follows a similar pattern but naturally it does not fall below the costs of compliance, c . When signals are uninformative (Figure 3) the losses in reputation faced by the two types or firms are the same. Since obedient types also incur in a compliance cost, disobedience is the only best strategy for the firm at all levels of violation. As signals become informative (Figure 4 and 5) the expected costs of violation typically increase, while the expected costs of compliance decrease.

Figure 5 shows that the equilibrium state K has moved, in relation to the perfect information case, to the interior of $\alpha \in [0, 1]$. This state however does not meet the strictness refinement, and is a less likely prediction of the game in this regard.⁶ Note also that although equilibrium L has been preserved in its original form of non-strictness, it now occurs at higher levels of violation.

To sum up, our model has introduced three important elements in the analysis of social sanctions:

1. Due to imperfect information, losses in reputation can “wrongly” be imputed to compliant firms, while violators face lower expected costs of reputation as they could pass as compliants.
2. When firm actions are observable losses in reputation due to non-compliance are at their highest at high levels of compliance, providing a support for the full compliance state to be an equilibrium. In contrast, imperfect information makes this expected losses in reputation due to violation be at their lowest levels precisely when compliance is relatively high.

⁶State K (but not state L) in Figure 5 would qualify as an equilibrium under more sophisticated equilibrium concepts such as *perfectness* or *evolutionary stability*.

3. Losses in reputation due to violation are increasing in the level of violation at high levels of compliance, as opposed to decreasing as in the perfect information case. A thicker veil of anonymity is drawn over violators as the proportion of firms that meet the standard increases.

3 Conclusions and discussion

It has been stated that social sanctions imposed on managers and owners of polluting firms, in the forms of losses in reputation, can provide an explanation of the puzzling coexistence of high levels of firm compliance with environmental regulation and low expected penalties in the United States (Harrington Paradox). This paper has argued that such an explanation heavily relies on perfect information of firms environmental behavior. We showed how the internalization mechanism of an environmental externality via social sanctions imposed on polluters is eroded due to information asymmetries. When polluter actions are not fully observable, then full compliance cannot be sustained in equilibrium as the expected social sanction, in the form of losses in reputation, is at its lowest at such compliance levels. Using a Bayesian belief formation model it is shown that people find it hard to believe that someone is in disobedience when disobedience is rare. Note that a society where social pressure is somewhat unimportant could nevertheless exhibit higher obedience than a society where social disapproval does play a more important role, if the latter suffers more acute information asymmetries than the former.

To a certain extent, the “classical” environmental regulator can be viewed as an agent that solves an information asymmetry between polluters and the judiciary (Garvie and Keeler, 1994). In fact, its budget is spent in two different activities, namely monitoring and enforcement, or the actual process of prosecuting firms. If provision of information to the general public is relatively cheap, as seems to be the case with today’s information technologies, then the regulator could publicly disclose the environmental indicators of polluters and make use of social sanctions

as a substitute for conventional enforcement.

Although the discussion has focused on an industrial pollution example, the basic framework lends itself to study other situations where similar social interactions and information asymmetries are present. Direct examples may be found in the exploitation of (other) common property resources and the contribution to a public good.

The “belief curse” of our model could also help in understanding, for instance, the relentless presence of corruption in some societies. As Bardhan (1997) puts it:

...the tenacity with which it [corruption] tends to persist in some cases easily leads to despair and resignation on the part of those who are concerned about it...

In this context, the social norm demands public officials not to engage in corruption whereas the costs of compliance with the norm are represented by the foregone bribery benefits. Since corruption activities are carried out behind closed doors the most likely equilibrium in light of our model is one in which most officials are corrupt and society knows it but does not care, i.e. the social sanction is very low. Thus, countries that currently exhibit low levels of corruption appear to be likely to move to a violation state in the future, whereas more corrupt societies seem condemned to the current state of affairs.

There are of course a number of other situations that do not fit the approach undertaken here. There are circumstances where individuals may have internal motives to follow a certain norm. It may also be the case that, although an individual's incentives to follow the norm depend on the behavior of his or her peers, it does not depend on observability. In some societies, it may suffice for an individual to know that most peers are not corrupt to deter him or her from engaging in corruption. This is, in fact, the case of moral norms and this paper illustrates how valuable such norms can be.

Appendix A

Table 4: A simulation of beliefs

Society's Prior α	Society's Posterior			Firm Belief		
	A	B	$dif.$	f^v	f^c	$dif.$
$(\theta, \pi) = (0.25, 0.50)$						
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.25	0.40	0.18	0.22	0.29	0.24	0.05
0.50	0.67	0.40	0.27	0.53	0.47	0.06
0.75	0.86	0.67	0.19	0.76	0.71	0.05
1.00	1.00	1.00	0.00	1.00	1.00	0.00
$(\theta, \pi) = (0.25, 0.75)$						
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.25	0.50	0.10	0.40	0.40	0.20	0.20
0.50	0.75	0.25	0.50	0.63	0.38	0.25
0.75	0.90	0.50	0.40	0.80	0.60	0.20
1.00	1.00	1.00	0.00	1.00	1.00	0.00
$(\theta, \pi) = (0.50, 0.75)$						
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.25	0.33	0.14	0.19	0.29	0.24	0.05
0.50	0.60	0.33	0.27	0.53	0.47	0.06
0.75	0.82	0.60	0.22	0.76	0.71	0.05
1.00	1.00	1.00	0.00	1.00	1.00	0.00

The first column gives society's prior belief on a given firm being in violation, which actually corresponds to the level of violation in the economy. The second and third columns are society's respective posterior beliefs of a firm being in violation after a violation signal and a compliance signal have been received (Equations 2 and 3). The fourth column show the difference between these posteriors. The fifth and sixth columns give the firm's expectation of being identified as a violator for both the violation and the compliant types (Equations 4 and 5), while the last column shows the difference between these expectations.

Table 4 shows that society's posterior beliefs diverge from the initial prior, α , for $\alpha \in (0, 1)$. In the extreme cases, that is $\alpha = 0, 1$, society's beliefs, and thus the firm's expectations, match the firm behavior. For $\alpha = 0.5$ in the upper and lower panel, where the frequency of the violation signals for the violation types is 0.25 points higher than the compliance types, the gap between the two society's posteriors is 0.27. Note though, that the probabilities of being identified as a violator are higher in the former case. In the middle panel, where the frequency of the violation signals for the violation types is three times that of the compliant types, the gap is 0.50. Both gaps and also the difference between them decrease as we move away from the prior $\alpha = 0.5$. Although firm's beliefs follow a similar pattern, they do not diverge as much from the initial prior α .

Appendix B: Proofs

Proof Proposition 1. *The Proposition consists of three parts and each part will be proved separately:*

- $d^*(0) = 0$ for all firms is a Strict Nash Equilibrium (NE) since $U(0;0) > U(1;0)$, which holds given the assumption $c < 1$. QED
- $d^*(1) = 1$ for all firms is a Strict NE since $U(1;1) > U(0;1)$, which holds given the assumption $c > 0$. QED
- $d^*(1 - c) = 1$ for a fraction $\alpha = 1 - c$ of firms and $d^*(1 - c) = 0$ for the remaining population of firms is a Non-Strict NE since $U(1;1-c) \geq U(0;1-c)$ and $U(0;1-c) \geq U(1,1-c)$ hold simultaneously. Note that $U(0;1-c) = U(1;1-c) = c$. QED

Proof Proposition 2. *Definition 1 can be extended to analyze the game under imperfect information (Bayesian game) by studying expected pay-offs. We will use $U^E(d; \alpha)$ as a short form for $U^E(d; \alpha; \pi, \theta)$. Thus, a firm's best response strategy is now defined by $d^*(\alpha)$ such that $U^E(d^*(\alpha); \alpha) \geq U^E(d; \alpha)$ for $d \in \{0, 1\}$. This Proposition also consists of three parts and each part will be proved separately:*

- When $\alpha = 1$, society's beliefs are accurate and match the actual behavior of firms: $f^v(1, \pi, \theta) = 1$ and $f^c(1, \pi, \theta) = 0$. This implies that $U^E(1; 1) = U(1; 1)$ and $U^E(0; 1) = U(0; 1)$. Since $U(1; 1) > U(0; 1)$, by the assumption $c > 0$, we have that $U^E(1; 1) > U^E(0; 1)$, which defines $d^*(1) = 1$ for all firms as a Strict Bayesian Equilibrium. QED
- When $\alpha = 0$, society's beliefs also match the actual behavior of firms: $f^v(0, \pi, \theta) = 0$ and $f^c(0, \pi, \theta) = 1$. This implies that $U^E(0; 0) = U(0; 0) = -c$ and $U^E(1; 0) = 0$. Since $U^E(1; 0) > U^E(0; 0)$, $d(0) = 0$ is not a best response for any firm and the full compliance state does not qualify as an equilibrium. QED

- *Presence of partial compliance equilibrium.*

a) We start by characterizing the expected utility functions for the compliant and violation types. $U^E(0; \alpha)$ and $U^E(1; \alpha)$ are both convex w.r.t α since:

$$U_{\alpha\alpha}^E(0; \alpha) = \frac{2\theta^2\pi^2}{[\pi\alpha + \theta(1 - \alpha)]^3} + \frac{2(1 - \theta)^2(1 - \pi)^2}{[(1 - \pi)\alpha + (1 - \theta)(1 - \alpha)]^3} > 0$$

$$U_{\alpha\alpha}^E(1; \alpha) = \frac{2\theta\pi^3}{[\pi\alpha + \theta(1 - \alpha)]^3} + \frac{2(1 - \theta)(1 - \pi)^3}{[(1 - \pi)\alpha + (1 - \theta)(1 - \alpha)]^3} > 0$$

Appendix A illustrated that for $\alpha \in (0, 1)$ we have that $f_{\pi}^v(\alpha, \pi, \theta) > 0$, $f_{\theta}^v(\alpha, \pi, \theta) < 0$, $f_{\pi}^c(\alpha, \pi, \theta) < 0$ and $f_{\theta}^c(\alpha, \pi, \theta) > 0$. it directly follows that $U^E(0; \alpha)$ is increasing in π and decreasing in θ for all $\alpha \in (0, 1)$, while $U^E(1; \alpha)$ is decreasing in π and increasing in θ for all $\alpha \in (0, 1)$. In the extreme cases, $\alpha \in \{0, 1\}$, signals become irrelevant so that π and θ are not parameters of the expected utility functions.

b) When signals are uninformative, that is $\pi = \theta = k$, α is society's best prediction of any firm being in violation. The losses in reputation for both compliant and violators are thus given by $\alpha R(\alpha)$ and the expected utility functions take the following form (see Figure 3):

$$U^E(1; \alpha) = \alpha^2 - \alpha$$

$$U^E(0; \alpha) = (\alpha^2 - \alpha) - c$$

$U^E(1; \alpha) > U^E(0; \alpha)$ for all α . It is important to note that the difference in expected utilities between the compliance strategy and the violation strategy is constant and given by c .

c) From step a), it follows that as signals become informative, that is $\pi = k + \epsilon_1$ and/or $\theta = k - \epsilon_2$, this difference in expected utilities is reduced for all $\alpha \in (0, 1)$ however, it is maintained for $\alpha \in \{0, 1\}$ (see Figure 4). When signals are even more informative we have that $U^E(1; \alpha) < U^E(0; \alpha)$ for some values of $\alpha \in (0, 1)$ (see Figure 5).

d) The values of the parameters that make $U^E(0; \alpha, \pi, \theta)$ and $U^E(1; \alpha, \pi, \theta)$ equal and tangent w.r.t. α define threshold points. Explicitly,

$$U^E(1; \alpha, \pi, \theta) = U^E(0; \alpha, \pi, \theta)$$

$$U_{\alpha}^E(1; \alpha, \pi, \theta) = U_{\alpha}^E(0; \alpha, \pi, \theta)$$

Let the pairs $\{\alpha^1(\pi), \theta^1(\pi)\}$ and $\{\alpha^2(\theta), \pi^2(\theta)\}$ be solutions to the system of equations (1) and (2) for values of π and θ respectively (although existence has not formally been proved, their presence is apparent in several simulations for relevant values of π and θ carried out by the author). If $\theta < \theta^1(\pi \rightarrow 1)$ and/or $\pi > \pi^2(\theta)$ the two expected utilities intersect in two points, that is $U^E(0; \alpha) = U^E(1; \alpha)$ for two values of α . Note that in these states, $d^*(\alpha) = 1$ is a best response strategy for α proportion of firms, while $d^*(\alpha) = 0$ is a best response strategy for the remaining set of firms. There thus exist two Non-Strict Bayesian Equilibria with partial compliance (see Figure 5). QED

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Public disclosure of industrial pollution. The PROPER approach for Indonesia?

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Abstract

This paper evaluates the effectiveness of the Program for Pollution Control Evaluation and Rating (PROPER) in Indonesia. PROPER, the first major public disclosure program in the developing world, was launched in June 1995; though it collapsed in 1998 with the Asian financial crisis, it is currently being revived. There have been claims of success for this pioneering scheme, yet little formal and conclusive analysis has been undertaken. We analyze changes in emissions concentrations (mg/L) using panel data techniques with plant-level data for participating firms and a control group. The results show that there was indeed a positive response to PROPER, especially among firms with poor environmental compliance records. The response was immediate, and firms pursued further emissions reductions in the following months. The total estimated reductions in biochemical oxygen demand (BOD) and chemical oxygen demand (COD) were approximately 32%.

Key Words: Environmental Policy, Pollution Control, Public Disclosure, Indonesia.
JEL Classification: Q53, Q58, C23

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1. Introduction

In the past decade, public disclosure of pollution has appeared as a new instrument aimed at reducing industrial pollution. One of the first and most notable was the U.S. Toxics Release Inventory (TRI) program of 1988. The Program for Pollution Control Evaluation and Rating (PROPER) in Indonesia can claim to be the first large-scale program in the developing world.¹ These schemes can be seen as either a complement or a substitute to traditional regulation, the enforcement of which is difficult and expensive but critical for policy success.² Information disclosure can also be seen as an alternative to market-based instruments, such as taxes.

The principle behind the public disclosure approach is the correction of an information asymmetry. Tietenberg (1998) refers to information disclosure as the third wave of instrument choice (after regulation and market-based instruments) and suggests that provision of information triggers and/or intensifies interactions among firms, workers, community groups, consumers, and financial markets as well as the regulators themselves. It thus increases the expected costs of non-compliance through channels that do not directly involve the regulator. Other non-monetary factors, such as managers' desire to avoid disgrace, probably play an important role.

A feature that has made disclosure schemes very attractive to policymakers is their low cost: a properly managed and relatively small infrastructure for collecting and disseminating information is generally sufficient for implementation. The widely accepted idea of citizens' right to know has both paved the way for the use of these schemes and prompted the authorities to learn about the environmental preferences of

¹ Other important examples include Canada's National Release Inventory (1993–present), the United Kingdom's Pollutant Inventory (1998–present), and Australia's National Pollutant Inventory (1998–present). In the developing world we find several modeled on PROPER, such as the Philippines' Eco-watch (1998–present) and the more ambitious Chinese Green-watch (1999–present). Although the programs vary widely in structure, they share the common principle of information disclosure.

² For a review of the theoretical and empirical economics literature on monitoring and enforcement of environmental policy, see Cohen (1999).

the public.³ Another important aspect is that information collection may be a first step toward the possible introduction of other policies at a later stage.

The empirical evidence on the effectiveness of disclosure programs in reducing pollution—the ultimate goal from an environmental perspective—is still limited, however.⁴ Konar and Cohen (1997) analyze the U.S. TRI scheme and find in a set of 130 firms that bad publicity was correlated with falling stock prices, which in turn were followed by emissions reductions. Furthermore, the greater the fall in stock price, the larger the observed emissions reduction. Because the TRI builds entirely on legal emissions, bad publicity is mainly associated with polluters' relative position in the ranking. Note that the released reports are completely based on self-reported data, allowing for obvious bias. According to Hahn et al (2003), the TRI is claimed to have led to a 45% reduction although there is no analysis that has actually been able to attribute this reduction to the policy itself. Foulon et al. (2002) find that in a set of 15 pulp and paper firms in British Columbia, appearance on the Ministry of Environment's polluters list strengthened the conventional enforcement strategies (fines and penalties) and provided strong incentives for pollution control. The list only discloses the identity of noncompliant firms and firms of concern for the regulator.

In the developing world, where enforcement is generally weak, the evidence on the effectiveness of information strategies is to a large extent anecdotal. Afsah et al. (1997a) and more recently Wang et al. (2002) have reported the success of information disclosure schemes in Indonesia and China, respectively. Their work is mainly descriptive and shows a tendency toward improving environmental indicators among the participating firms. Nonetheless, they do not have the necessary data to analyze in detail whether the programs accounted for the observed improvements. More specifically, would some emissions reductions have occurred in the absence of

³ Portney (2000) identifies disclosure as one of the enduring changes in environmental policy in the world for the period 2000 - 2050.

⁴ Evidence from the empirical literature on stock market reactions to the programs suggests negative effects on stock prices for heavier polluters after information releases. Khanna et al. (1998) and Hamilton (1995) analyze the U.S. TRI Program. Lanoie et al. (1998) study the effects of the list of polluters published by the Ministry of Environment of British Columbia, Canada. Dasgupta et al. (2001) show that stock markets in Argentina, Chile, Mexico, and the Philippines react to announcements of information on environmental events.

the program? If so, how large of a share of the reduction was the program responsible for? It is important to answer these questions now that information disclosure programs are starting to be widely used in poor countries, even though the existing evidence is still fragmentary.

The PROPER program was launched in June 1995 and operated for three years as the first major scheme in the developing world to use information disclosure. At the time, it was considered an inspiring and reasonably cheap experiment and several other countries set off to emulate various aspects (see World Bank 2000).⁵ The PROPER scheme targeted major industrial water polluters and used a five-color scale to grade the environmental performance of different facilities. The grading is primarily built on polluters' compliance status with existing regulation and, unlike the TRI ranking and the British Columbia polluters' list, included both compliant (Gold, Green and Blue grades), and noncompliant firms (Red and Black grades).⁶ Four rounds of evaluations were released to the media over the three years that the program ran. In 1998, Indonesia and other countries of the region were hit by a severe recession coupled with other structural and political problems. This "Asian financial crisis" occasioned considerable political and administrative turmoil, and the PROPER program ceased to function. Currently, however, it is being revived—this time, on a larger scale, making it all the more urgent to analyze the first period and draw lessons for its redesign. We address the effect of the PROPER scheme on actual pollution by analyzing a panel data set of firms that participated in the program and a control group of firms that did not. The use of both ex ante and ex post information allows us to study possible changes in pollution trends due to the policy, and the inclusion of a control group of nonparticipating firms allows us to control for unobserved factors that could have

⁵ The average annual budget of the PROPER program during the period 1995 - 1998 was US\$200,000, which translates into a cost of US\$740 per firm per year. 65% of the budget was allocated to monitoring and inspection activities, 15% to laboratory tests and 20% to information processing and administration.

⁶ Although there is a tendency in the literature to pool disclosure programs in a unique group, it is constructive to recognize the different incentives provided by different schemes. For instance, rankings may trigger more intense competition among firms with respect to pollution abatement than N-tier schemes. We do not yet know whether the performance of programs in terms of emission reductions and costs are influenced by such design details.

affected emissions in the economy as a whole. To the best of our knowledge, there are no other published studies that analyze, econometrically, emissions rates as a function of environmental policy in the developing world. Most studies in this field compare data before and after a program and ascribe observed changes to the program. However, the existence of trends in emissions implies that such evaluations may be biased, thus casting some doubts on the claimed potential of information disclosure to deliver pollution reductions in economies with weak governmental institutions and imperfect markets.

The results of this study show that there was indeed a strong, positive response to the scheme, in particular among firms with poor environmental compliance records; these firms cut their emissions intensity by approximately a third. The response was immediate, and firms pursued further reductions in the following months. We do however not find definitive evidence of further abatement in the firms that were in compliance already at the start of the program.

We also find that self-reported data tend to underestimate actual readings. Although our overall conclusions concerning the estimated effect of PROPER are not sensitive to the use of controls for self-reported data, our results do point to the need for strategies to induce truthful reporting, even among those firms that already have a reputation of being green. This paper proceeds as follows. Section 2 describes information disclosure as a policy instrument, and Section 3 presents an overview of some aspects of environmental management in Indonesia. Section 4 presents the estimation approach, Section 5 reports the data, and Section 6 discusses the results. Section 7 concludes.

2. Public disclosure as a policy instrument

It is curious that economics, the discipline that reminds us there is no such thing as a free lunch, should itself sometimes still assume that information is freely available. Parsimony of information costs is generally accepted as a comparative advantage of the market mechanism, yet we know that the market cannot function at all without information, and we know that the environmental area is very complex. That implies that information demands may be heavy.

Countries such as Indonesia face a tough challenge in choosing and designing policy instruments to deal with industrial pollution. Conventional regulation (such as requirements to use best available technology) is known to be grossly inefficient, since it provides no incentive for firms to innovate. Furthermore, the whole process of setting standards is easily manipulated by powerful industrial lobbies. Indonesia was historically known for a high degree of centralization of both political and economic power in the same closely knit circle, making it hard for understaffed environmental regulators to enforce meaningful and costly requirements. Under such conditions, environmental regulations can even be co-opted to keep new, cleaner entrants out and further solidify the dominance of old, heavily polluting industries.

Other instruments, such as taxes, permits, liability, voluntary agreements, and information disclosure, have been suggested to overcome the difficulties associated with direct regulation; see Sterner (2003). However, none of these solve all the regulator's problems. With the market-based instruments, the regulator faces many of the old problems associated with command-and-control regulation plus new problems specifically related to the complexity of the market instruments themselves (e.g., Bell and Russell 2003; Russell and Vaughan 2003). Information disclosure is of special interest because it is both a prerequisite for other instruments and an instrument in its own right.

A good deal of knowledge is necessary for any form of environmental policy. Environmental protection agencies in developing countries, however, do not usually have the necessary information and cannot collect it easily—especially if it is intended to be used for regulation or taxation. A public disclosure program can provide a useful mechanism for data collection. The fact that the information is disseminated and used for grading makes data quality important and opens up for monitoring and control. The data gathered allows authorities to set priorities and eventually develop the design of policy instruments. It is in this sense a prerequisite for regulation, voluntary agreements, or eco-taxes. The information collection is also a signal that the authorities are becoming more serious, and that signal itself can have important effects.

Somewhat less obvious is the fact that information disclosure can act as an instrument in its own right. We know that bargaining can be a powerful instrument, but naturally

it also requires information. Today, information can be easily compiled, processed, and transmitted, and the U.S. TRI has suggested that the mere public provision of pollution data can trigger strong and sometimes unexpected effects on factor and output markets in addition to more traditional political channels. Public disclosure about a plant's handling of toxic materials can prompt employees to demand higher safety standards or compensatory wages, enable communities to negotiate pollution reductions with local plants, cause environmentally conscious consumers to switch to greener products, and change investors' behavior. The reaction is not limited to agents with "green" preferences. Bankers react not necessarily because they fear pollution but because they fear that others fear it—that is, they fear the market reactions to decreasing sales, liability exposure, declining profitability, falling property values, and so forth. Foulon et al. (2002) look at the effects of appearance on the Ministry of Environment's polluters list in British Columbia and suggest the existence of a certain degree of complementarity between disclosure and conventional enforcement. In fact, a regulator that allocates its budget between monitoring and enforcement may use provision of information to liberate resources to increase monitoring.⁷ Information disclosure can take several forms. Complex information can be interpreted and conveyed through labeling schemes, of which there are several types. Type 1 is certification—of products, firms, processes, or management procedures—by independent agencies. Type 2 is self-certification, without fixed criteria or independent outside review. Type 3 is the provision of raw data, without interpretation or judgment, sometimes in the form of life-cycle analysis.

Certification of organic food is widespread and one of the oldest schemes, but the number of new schemes has been increasing rapidly (see Nadaï 1999). Type 1 green labeling of products has become popular in northern Europe; Germany's Blue Angel, started in 1977, was the first national eco-labeling program. Another form of disclosure is environmental certification of firms by ISO 14000 or EMAS standards,⁸ which are oriented toward management: it is the environmental management system that is certified, not the products or processes per se. At least in some markets,

⁷ For an illustration on how this allocation takes place, see Garvie and Keeler (1993).

⁸ ISO 14000 is run by the International Organization for Standardization, and the Eco-Management and Audit Scheme (EMAS) is run by the European Commission.

certification adds value to the firm or product by boosting credibility. Certification can also be an internal management instrument. To deal with inertia against new directives, managers have to fight to get their policies implemented throughout an organization. In this respect, ISO 14000 is akin to quality control (ISO 9000).

Type 3 labeling is fairly common in industry. Volvo, for instance, evaluates its performance according to several criteria and its own internal goals, and the results are published in environmental reports. The U.S. TRI has characteristics of Type 3 programs, except that it is not voluntary. One criticism of these is that the public cannot interpret such information.⁹ The program analyzed here, PROPER, has traits of both Type 3 and Type 1: the information is interpreted through rating and refers to firms or plants rather than products, and the rating—which is not voluntary—is carried out by a ministry rather than by a nongovernmental organization.

3. PROPER and Indonesian environmental management¹⁰

Before the financial crisis began in 1997, the growth of Indonesia's industrial production was impressive. In the 1980s and 1990s, growth rates frequently surpassed 10% per annum, and Indonesia was one of the so-called miracle economies of Asia. Increased prosperity even appears to have benefited the poor. The proportion of people below the poverty line declined from 60% to around 11% from 1970 to 1996. Development was nevertheless uneven, both socially and geographically: 75% of the industrial activity in Indonesia was concentrated in Java. Estimates in 1994 indicated that industrial pollution accounted for 25% to 50% of the total pollution load in rivers of the island (World Bank 1994). Industrial contamination had become a serious health problem and (along with over-fishing) was threatening the coral reef diversity of the archipelago—the most densely populated area on earth.

Despite increasing environmental problems, the environmental protection sector has traditionally been weak in Indonesia. The first serious attempt of the Ministry of Population and Environment to control industrial pollution was the semi-voluntary

⁹ Experience has shown that other organizations will use the information to develop ratings and evaluations for communities, NGOs, investors, and others.

¹⁰ For a detailed description of the PROPER program and the Indonesian regulatory regime in the 1980s and 1990s, see Afsah and Vincent (1997).

Clean River program, begun in 1989. The Clean River program was based on pollution reduction agreements between provincial vice-governors and polluting firms. The agreements were not legally binding, however, and their details were kept secret. In 1990, BAPEDAL, the new environmental authority, took over the program.¹¹ Although it appeared to have some success in reducing pollution, stronger measures were needed.¹²

Faced with the discrepancy between a powerful and expanding industrial sector and its own lack of resources, BAPEDAL decided to tackle industrial emissions control through an information disclosure program. Earlier attempts at regulation had not been very successful, no fines were ever assessed and the authorities lost 90% of cases taken to court. This was the reason why the ministry wanted to try an alternative to regulation. The PROPER program, targeting water pollution, was launched in June 1995. Its distinctive feature was the disclosure of information via a five-color code, in which each participating firm was assigned a color according to its environmental status. The system was designed with considerable care so that it could be readily understood and still convey enough information to influence behavior. The environmental authority's staff understood that disclosing raw data could create interpretation problems among the public, yet a simple binary index—in compliance or out of compliance—would not do justice to all firms, especially those that had an excellent performance record and those that missed compliance by a narrow margin.

As noted earlier, the grading system primarily built on the compliance status of firms with the environmental regulation. The presence of environmental management practices and clean technology were used as secondary criteria. Plants that self-reported information on analysis of the effluent were viewed as cooperative and were, to some limited extent, rewarded in the grading process. Thus, *Black* was awarded to facilities that did not meet the legal standards and made virtually no pollution control

¹¹ In 1991, a ministerial decree (KEP/MEN/03/1991) set effluent discharge standards for the various sectors. Water standards for the sectors analyzed in the paper are given in tables 2a and 2b.

¹² Pargal and Wheeler (1996) suggest that there is some form of informal control of polluting firms in Indonesia. They use plant level data from the period 1989-1990 and find a positive correlation between industrial pollution intensity and surrounding community characteristics (less polluting firms are found in more educated and richer communities).

effort. *Red* facilities had made some effort to reduce emissions but failed to meet legal standards and had insufficient reporting. *Blue* was given to facilities that met legal standards and had reasonably frequent reporting. *Green* was intended for the “proactive” companies and was awarded if pollution was 50% or less the required standards and the firm conducted good equipment maintenance, reporting, and environmental work. *Gold* would reward firms who were below 5% the legal standard and met international standards of environmental excellence,¹³ which in addition to the Green requirements implied the use of clean production technology, waste minimization, and pollution prevention activities. Besides releasing the ratings, BAPEDAL issued a simple one-page checklist on the environmental performance of the participating firms.¹⁴ To achieve the greatest impact on environmental quality, the environmental authority selected major polluters with the highest contributions to rivers’ pollution loads to participate in the scheme.¹⁵

In June 1995, 187 plants were given prior, private notification of their initial ratings and were told that the ratings would be publicly disclosed in December 1995 and at regular intervals thereafter. New firms were gradually included in the program until it reached 324 facilities in June 1998. Participation was compulsory for selected firms but also contained provisions for “opt-ins,” and a small number of additional firms joined the program voluntarily.

BAPEDAL went to great lengths not to alienate or provoke industry but to be constructive and provide accurate and timely advice about what firms had to do to improve their ratings. Since industrial leaders were very influential during this period,

¹³ No Gold ratings were awarded during the period. See Afsah and Ratunanda (1999) for more details on the rankings.

¹⁴ In a survey, managers said the checklist made them aware of their facilities’ environmental shortcomings.

¹⁵ Note that the load distribution (tons/day) does not necessarily track the concentration distribution (mg/L), since water flows (L) are usually the most influential factor of load discharges.

there was also a conscious media strategy for the release of information and other aspects of public relations related to the program (Afsah et al. 1997b).¹⁶

Tables 1a, 1b, and 1c show the evolution of the rankings of those firms that were rated four times from June 1995, when the program started, to June 1998, when the program closed. The tables show that the Black and Red facilities (noncompliance status) make up 65% of the sample in June 1995. This illustrates the lack of stringency in the previous regulatory system, since PROPER did not itself make any changes in emissions requirements. Table 1a shows an immediate positive response within the first six months of the program—even before full disclosure— particularly among Black and Red plants: 83% of the Black plants and 26% of the Red plants improved. One Black plant even managed to turn Blue in this short period. Note, however, that 31% of the Blue plants and 50% of the Green plants could not sustain their ratings.

Table 1b shows a clearer trend of improvement in the longer period between June 1995 and July 1997: not many more firms slipped in performance after that initial six-month period. At the end of the period, the number of Black and Red firms had decreased significantly. We see a larger positive response among those firms that started off with a poor ranking than among those that started off with a good initial ranking. This accords well with the central idea behind the rating program as formulated by the BAPEDAL officer who conceived the program, Nabel Makarim.¹⁷ He had noted that Indonesia has a strong cultural taboo related to the shame of losing face, and thus bad publicity is a much more powerful instrument than good publicity: those firms that were already in compliance would not be heavily affected by the disclosure. The difference in response could also reflect increasing marginal

¹⁶ A limitation of this study that needs to be acknowledged is the lack of information on the possible influence of lobbying and pressure groups in PROPER. In this regard BAPEDAL appeared, at least at the time, to have a reputable name among the regulated community. It seems the designers of PROPER took a number of measures to protect the system from corruption: Information was processed in a sophisticated program that reduced human error and detected data inconsistencies. The staff of PROPER was highly qualified, small in number and closely knitted and inspection group members were constantly rotating.

¹⁷ Nabel Makarim was the Director of the PROPER program during the period studied in this paper and later became the Minister of Environment of Indonesia.

abatement costs: abatement activities are more difficult and expensive at advanced stages of cleanup.

Table 1a. Change in ratings, June 1995 to December 1995

<i>June 1995</i>	<i>December 1995</i>					Total
	Black	Red	Blue	Green	Gold	
Black	1	4	1	0	0	6
Red	1	75	27	0	0	103
Blue	1	16	37	1	0	55
Green	0	0	2	2	0	4
Gold	0	0	0	0	0	0
Total	3	95	67	3	0	168

Table 1b. Change in ratings, June 1995 to July 1997

<i>June 1995</i>	<i>July 1997</i>					Total
	Black	Red	Blue	Green	Gold	
Black	0	2	4	0	0	6
Red	3	59	40	1	0	103
Blue	0	16	34	5	0	55
Green	0	0	3	1	0	4
Gold	0	0	0	0	0	0
Total	3	77	81	7	0	168

Table 1c. Change in ratings, June 1995 to June 1998

<i>June 1995</i>	<i>June 1998</i>					Total
	Black	Red	Blue	Green	Gold	
Black	0	5	1	0	0	6
Red	1	63	37	2	0	103
Blue	0	22	30	3	0	55
Green	0	1	2	1	0	4
Gold	0	0	0	0	0	0
Total	1	91	70	6	0	168

Note: Tables 1a, 1b, and 1c include data on firms that were rated in each of the following rating rounds: June 1995, December 1995, July 1997, and June 1998.

Table 1c shows the last ratings for 1998, which may reflect the deepening financial crisis. The environmental performance of many firms deteriorated, although not necessarily to the initial levels of June 1995. The chaotic situation in Indonesia in late 1997 and 1998 may have led firms to relax their abatement activities as they probably decided to concentrate on more urgent matters.

4. Testing the policy impact on pollution levels

Although Tables 1a and 1b show a general improvement after implementation of the program, the trend cannot be taken as proof of PROPER's success, since the improvements might have occurred even without the program. We therefore studied emissions before and after the program, using a panel data set of firms that participated in the program and a control group of firms that did not. With panel data we are less worried about heterogeneity of the firms, which is controlled for by firm-specific effects, particularly those characteristics that are constant over time.¹⁸ This approach is rather convenient in our case, where information on individual determinants of pollution is limited and incomplete. The basic model we estimate is as follows:

$$\ln(E_{it}) = \alpha_i + \beta_{1s} * Trend_{it} * Sector_i + \beta_2 * Selfreporting_{it} + \beta_3 * proper1_{it} + \beta_3 * proper2_{it} + \varepsilon_{it} ,$$

where t indicates time, i indicates firm and s indicates sector. E is pollution concentration (mg/L). As stated earlier, firms' fixed effects control for factors that determine pollution and vary across firms. A sector-specific time trend is included to allow for the possibility of separate trends in the pollution intensity of particular industrial sectors. Given that pollution control in Indonesia to some extent has relied on self-reported data, we use a dummy to control for the possibility of underreporting bias. The effect of the PROPER program is assessed through two dummy variables. The first captures the immediate response to the policy, taking the value of 1 one month after a firm joined the program; the second allows for a lagged response, taking the value of 1 six months after entry. Since we do not know of any external factors, such as other changes in environmental regulation that could have affected firms' emissions, our specification does not include any time-specific effects except the time trend. The errors are assumed to be normally distributed.

Note that in the PROPER program, water pollution is measured in terms of concentration (mg/L), rather than in total load (tons/day). For the ecosystem, load would generally be more important and relevant than concentration. Disadvantages of

¹⁸ This includes location characteristics such as surrounding communities' levels of income and education

concentration as a measure include the possibilities that a firm could dilute its effluent to improve its rating, and that increases in production scale involving increased amounts of both pollution load and water could escape detection. The seeming independence of emissions concentration from production scale has allowed regulators around the world to set environmental standards for industrial sectors to make legislation simpler and to facilitate enforcement. Indonesia is not an exception, and the data collected for both the regulations and the color grading system refer to concentration rather than to load.

5. Data

Indonesia's environmental authority, BAPEDAL, provided the information collected for the PROPER program and the earlier Clean River program. The period of analysis is June 1993 through June 1997. We selected this period because we wanted to avoid using information that was affected by the financial crisis, which is reported to have started in July 1997. We focus on emissions concentration as measured by biochemical oxygen demand (BOD) and chemical oxygen demand (COD),¹⁹ which are common water pollution indicators, for which data were available for an adequate number of firms both inside and outside PROPER. We first constructed two panels with monthly data for both pollutants. In the few cases where more than one reading was available for a given month, we selected the median of the readings. Since readings were not available for all 48 months of the period of analysis, we selected only those firms that had at least six readings before and six readings after June 1995. Among the selected firms, none had joined the program voluntarily. Tables 2a and 2b (in next page) present summary statistics of the data on pollution concentration. The BOD panel covers 132 facilities, of which 76 participated in the program. The COD panel covers 138 firms, with 82 being part of the program. In our sample, 34.5% of the BOD and 39.5% of the COD readings were self-reported.

¹⁹ Both indicators are measures of how much oxygen is needed to degrade a certain pollutant. There is no perfect, single indicator for pollution, and these measures may be irrelevant for some types of pollutants. They are nevertheless useful for the analysis of effluents from industries that release large quantities of biodegradable material.

The advantage of our data is that we have a double comparison: *before* and *after* as well as *inside* and *outside* the PROPER program. For the latter comparison to be truly valid, we would need to know how our sample relates to the whole population of polluting firms, since the comparison could be biased if the groups were not representative and comparable. We have used all the data available to us, excluding only polluters with very few readings, and the data set covers a large proportion of the firms that were considered of interest by the environmental authority: these were the significant polluters, particularly regarding water effluents. BAPEDAL had identified, as interesting, 1500-2000 firms most of which were already in the Clean River Program and which accounted for about 80% of total pollution. The plan was to gradually increase coverage to all these firms but BAPEDAL wanted to move carefully to maintain the quality and integrity of the program. They therefore started with a selection of less than 200 firms for the first year. These were chosen on the basis of being important polluters of course but the main criterion at this stage was that firms were located in regional clusters to minimize the travel cost for the inspectors and thus keep within the limited initial budget. As far as we have been able to ascertain, there is thus no other systematic difference between the firms in PROPER and those that participated in the Clean River program but not PROPER (N. Makarim, personal communication, 2006). It appears that PROPER started with a very small budget and simply could not deal with all polluters. In fact, during the period 1995 – 1998 the budget of the program increased by a factor of 2.2 and the number of firms in the program increased by a factor of 1.7.

Table 2a. BOD concentration, summary statistics

<i>Sector</i>	<i>Observations</i>	<i>Environmental standard</i> (mg/L)	<i>Mean</i> (mg/L)	<i>SD</i> (mg/L)
Rubber	631	150	101	66
Plywood	540	100	158	312
Others	633	150	320	567
Pulp and paper	550	150	185	327
Textile	1,041	85	151	204
Total	3,395		180	334

Table 2b. COD concentration, summary statistics

<i>Sector</i>	<i>Observations</i>	<i>Environmental standard</i>	<i>Mean</i>	<i>SD</i>
		(mg/L)	(mg/L)	(mg/L)
Rubber	676	300	142	302
Plywood	607	250	650	121
Others	655	300	1,107	422
Pulp and paper	581	350	534	163
Textile	1,029	250	764	362
Total	3,548		142	314

6. Results

Table 3 presents the regression results for the pollutants BOD and COD. For each pollutant we estimate two models based on specific sub samples. The first sub sample covers firms that had poor environmental compliance records prior to implementation of the policy (and thus risked public embarrassment); the second sub sample covers the firms that exhibited a relatively good environmental record.²⁰ Let us call the former group the initially noncompliant sub sample and the latter the initially compliant sub sample. By splitting the data this way, we acknowledge that pollution trends probably differ between firms that are at different stages of cleanup. Also, the magnitude and timing of the reaction to the policy may differ between the two sub samples. Finally, as discussed below, the incentives to underreport may be different between the two sub samples. In general, the explanatory power of the regressions is satisfactory and the estimations of the policy variables are consistent across regressions, although as expected, a great deal of the explanatory power of the regressions is due to firm-specific effects. Statistical tests show that splitting the data in such a way was appropriate.

We use two PROPER participation dummy variables to capture the immediate and lagged reaction to the program. The first dummy variable takes the value of 1 one

²⁰ If 75% or more of a firm's readings in the June 1993–June 1995 period fell below the environmental standard, it was defined as having a poor environmental compliance record. The 75% figure was not arbitrary but related to the compliance record up to June 1995 of firms rated Blue or Green (compliant) and firms rated Black and Red (noncompliant).

month after a firm joined the program; the second dummy variable takes the value of 1 six months after the entry. For the initially noncompliant firms, the effect of PROPER participation is an immediate reduction in emissions, followed by a further reduction. For the initially compliant sub sample, there is no immediate effect from entering the program, but we do observe a lagged effect. These results are consistent with a more urgent reaction to embarrassing news than to good news, or with an increasing marginal abatement cost function. If a firm has previously made little abatement effort, then simple changes in production processes not requiring capital investments could lead to significant and rapid emissions reductions. Firms in advanced stages of abatement have already achieved the easy reductions, and further reduction is technologically more difficult and expensive.

Robustness

Next we perform a simple robustness test on the PROPER participation variables to the length of the panels. Recall that the duration (48 months) and its close (June 1997) were selected to exclude information from the financial crisis period, and thus the panel covers exactly 24 months before and after the launch of the program. The longer the panel, the more likely it is to include unobserved effects that may affect pollution. We therefore estimated the models for several shorter panels to check the robustness of the PROPER variables. The panels were restricted in three ways, by excluding the first six months, the last six months, and the first and last six months. In the panels of firms with poor compliance histories (regressions 1 and 3 in Table 3), no significant changes in the policy parameters are observed. On the other hand, shortening the panels of firms with good compliance records (specifications 2 and 4 in Table 3) results in an insignificant lagged policy variable in some cases. Nevertheless, the negative sign is always preserved, and we can conclude that the estimations are reasonably robust in this respect.

Table 3. Explaining emissions concentration (log mg/L)

<i>Variables</i>	<i>Dependent variable: Log(BOD)</i>		<i>Dependent variable: Log(COD)</i>	
	<i>(1)</i>	<i>(2)</i>	<i>(3)</i>	<i>(4)</i>
	<i>Sub sample 1</i>	<i>Sub sample 2</i>	<i>Sub sample 1</i>	<i>Sub sample 2</i>
PROPER, 1-month lag	-0.178** (0.084)	0.066 (0.096)	-0.186** (0.090)	-0.017 (0.077)
PROPER, 6-month lag	-0.212** (0.084)	-0.302*** (0.098)	-0.218** (0.090)	-0.194** (0.079)
Self-reported Reading	-0.143*** (0.054)	-0.270*** (0.070)	-0.045 (0.056)	-0.046 (0.059)
Rubber trend	-0.005 (0.004)	0.011** (0.005)	-0.007 (0.004)	0.012*** (0.004)
Plywood trend	-0.014*** (0.004)	-0.003 (0.006)	-0.008* (0.004)	-0.005 (0.005)
Others trend	-0.019*** (0.003)	-0.008** (0.004)	-0.022*** (0.003)	-0.012*** (0.003)
Paper trend	0.009** (0.004)	0.010** (0.005)	0.010** (0.004)	0.012*** (0.004)
Textile trend	-0.017*** (0.002)	0.002 (0.006)	-0.013*** (0.002)	0.007 (0.005)
Constant	5.355*** (0.049)	3.750*** (0.088)	6.112*** (0.054)	4.516*** (0.075)
Observations	2109	1286	2134	1414
Total firms	85	47	86	52
PROPER firms	44	32	45	37
Control group firms	41	15	41	15
R ²	0.60	0.52	0.50	0.52
Test equal parameters	$F(8, 3247) = 6.73$		$F(8, 3394) = 7.80$	

Notes: Regressions include firms' fixed effect dummies. Sub sample 1 (Sub sample 2) cover firms with poor (good) environmental compliance records prior to the PROPER program. "PROPER, 1-month lag" is a policy dummy that takes the value of 1 one month after a firm joined the program. "PROPER, 6-month lag" takes the value of 1 six months after a firm joined. The reported *F*- statistics have *p*-values lower than 0.00005. Standard errors are in parentheses.

* Significant at 10% level; ** significant at 5%; *** significant at 1%

The total estimated reductions in pollution concentrations for the initially noncompliant firms were 32%²¹ and 33%²² for BOD and COD, respectively. In the group of firms with good compliance records, there was no immediate reaction, whereas a lagged reaction shows in some specifications. However, the estimations are strictly speaking, not robust enough to permit definite conclusions.

When evaluating the effectiveness of a program, the question of selectivity bias arises. Would the participating firms have reduced their emissions to the same extent without the policy? To deal with this concern effectively, we have included time trends and included both firms inside and outside the program. The time trends are expected to capture the natural pollution tendency within sectors, leaving the policy dummy to account for the effect of the program. F tests reject the null hypothesis of equal time trends across sectors in the models. This is not surprising, since it is more natural to think of industrial sectors as technologically independent and evolving at independent paces.

The reliability of self-reporting

Our data include both self-reported and external readings. In our sample, 45% and 55% of the BOD and COD readings of the initially compliant firms were self-reported, whereas only 27% and 29% of the readings of the initially noncompliant firms were self-reported. It is natural that the environmental authority would seek to measure emissions of the noncompliant firms directly. The regression results show that self-reported concentration readings (BOD readings in particular) were significantly lower than readings taken by the environmental authorities. It also seems that the tendency for self-reported readings to be low was actually stronger in the initially compliant group (–24% compared with –13%), although the difference was not significant at a reasonable confidence level.²³

²¹ Short-run BOD response = $e^{-0.178} - 1 = -0.163$; lagged BOD response = $e^{-0.212} - 1 = -0.191$. Total BOD response = $e^{-(0.178+0.212)} - 1 = -0.323$.

²² Short-run COD response = $e^{-0.186} - 1 = -0.170$; lagged COD response = $e^{-0.218} - 1 = -0.196$. Total COD response = $e^{-0.186-0.218} - 1 = -0.332$.

²³ Taking the 95% confidence limits underestimation for all firms would have been 4% – 33%.

The self-reporting variable is not significant in the COD panels. One reason may be that BOD standards are relatively tighter than COD standards, and firms find it more difficult to meet them. Another reason could be that the regulator relies more on BOD readings to assess firms' environmental performance. Finally, the main policy variables (response to PROPER) are not particularly sensitive to the presence of the self-reporting dummy in the regressions, and thus our main conclusions still hold.

Our model allows for separate pollution trends for each sector within the two sub samples. We find negative pollution trends in most sectors in the noncompliant group but mixed evidence in the compliant group. F tests reject the hypothesis of equal trends between the two sub samples.²⁴ Thus the noncompliant firms have faster rates of decrease in pollution intensity in addition to their larger reaction to the PROPER program, reinforcing the impression that the main changes in emissions occurred in the initially noncompliant group.

Emission reductions

The analysis above was carried out in terms of emissions concentration—that is, the pollution intensity of effluents. Total pollution loads to the environment also depend on the flow of wastewater. In principle, concentrations can be reduced by increasing water flow. However, most of the plants studied have very large water flows, and further increases would lead to higher pumping and other costs. Data on water flows were somewhat incomplete but did not indicate more than a small increase of 10%, which may have been partly due to increases in production. Using the predicted policy effects on concentration levels and *ex ante*–*ex post* information on water flows for 44 initially out-of-compliance firms in the program (which corresponds to 40% of the total noncompliant firms that were first included in the program), we calculate the effect of the policy on emissions. The estimated reduction in emissions loads due to PROPER participation was 6.2 tons per day for BOD and 11.6 tons per day for COD. These reductions were achieved despite the observed increase in water flows in the period following the policy.

²⁴ More specifically, three out of five sector trends in the compliant group are significantly higher (either less negative or more positive) than the sector trends of the noncompliant group for both pollutants. The remaining two sector trends are not statistically different from each other.

7. Conclusions

This paper has examined the effectiveness of Indonesia's Program for Pollution Control Evaluation and Rating (PROPER) in reducing industrial water contamination. The PROPER program, which ran from 1995 to 1998, was a pioneering scheme in the developing world that used information disclosure to control industrial pollution. The evidence for the effectiveness of such schemes is still very limited, particularly in the developing world. We analyze actual changes in emissions concentrations (mg/L) due to the PROPER program using panel data techniques with plant-level data on a treatment group and a control group.

The main finding of the paper is that the policy was indeed responsible for a reduction in emissions intensity as measured by biochemical oxygen demand and chemical oxygen demand, and that this reduction was particularly rapid and strong for those firms that initially had a poor compliance record. The total estimated reductions in pollution concentration for these firms were approximately 32% in BOD and COD. Further calculations using information on water flows for 44 firms (40% of the noncompliant firms that were initially in the program) show that the estimated reductions in concentration were equivalent to emissions reductions of 6.2 tons per day for BOD and 11.6 tons per day for COD.

The third set of results concerns the importance of underreporting to explain emissions. Self-reported concentration readings, in particular BOD readings, tend to underestimate actual concentration levels. This points to the need for strategies to induce truthful reporting, even among those firms that already have a reputation of being green. Although self-reporting is more common in the (initially) compliant firms, no significant difference in the self-reporting variable was found between the two groups. Our findings are in line with recent evidence that suggests caution in interpreting studies evaluating programs built entirely on self-reporting such as the TRI in the U.S. (De March and Hamilton 2006).²⁵

It may be surprising that mere information disclosure and ratings had such a strong effect. Apparently, reputation is not just a rich-country issue; in fact, it may be more

²⁵ The authors undertook a comparative analysis between TRI data and data from ambient pollution monitors and conclude that plants are not always reporting accurate estimates of their emissions.

important in economies where judicial institutions and insurance markets are weak. We do not know whether the effects depend on the relative ease with which firms that have not previously controlled emissions can achieve abatement, or on firms' perceptions that the rating program signaled tougher regulation ahead. Blackman et al. (2004) find some support for the latter explanation and also attributes the effects to other mechanisms, such as pressure from shareholders and neighbors.

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What kinds of firms are more sensitive to public disclosure schemes for pollution control? The case of Indonesia's PROPER program

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Abstract

This paper analyzes differences in firm responsiveness to PROPER, Indonesia's 1995-98 program for industrial pollution control. The overall effectiveness of this program at achieving emissions reductions, and its low regulatory costs, have earned it a good reputation around the world. PROPER was characterized by the presence of no deterrents or incentives other than those caused indirectly by the public provision of information on the environmental performances of firms. We analyze plant level data to relate short and longer term environmental responses to facility characteristics. The results reveal that foreign-owned firms and firms located in densely populated regions, in particular in Java, were more likely to respond positively to the scheme. Whereas foreign ownership is a determinant of both short and longer term responses, location is only important in the shorter term. Also, facilities that had already taken the first abatement steps found it more difficult to produce further positive responses.

Key Words: Environmental Policy, Pollution Control, Public Disclosure, Indonesia.
JEL Classification: Q53, Q58, C25

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1. Introduction

Indonesia's 1995-98 Program for Pollution Control Evaluation and Rating (PROPER) was the first major scheme in the developing world that used information disclosure to reduce industrial pollution. Its apparent effectiveness at achieving emissions reductions and its low regulatory costs earned it a good reputation. At the time, the program was viewed as an inspiring experiment and a number of countries set out to emulate it (World Bank, 2000).¹ The early claims of the success of the scheme have however been challenged due to the possibility of other factors, not related to PROPER, being responsible for the observed reductions in emissions. Recently, García et al (2004) addressed this issue and studied the change in emissions before and after the program, using treatment and control groups of firms in side and outside the scheme. The authors concluded that there was indeed a strong, positive response to the PROPER scheme, in particular among firms with poor environmental compliance histories.

In this article we take a step further in an attempt to uncover some of the characteristics of those firms that showed higher susceptibility to PROPER. More broadly, we seek to contribute to the understanding of provision of information programs and the mechanisms through which they work.² It has been argued that disclosure triggers or intensifies interactions among firms, workers, community groups, consumers, and investors, increasing the expected costs of polluting activities through channels that do not directly involve the regulator (Tietenberg, 1998; Sterner, 2003). The empirical literature has however only found a determining role of financial markets in provision of information programs. A number of studies report negative effects on stock prices for heavy polluters following a release of information. Khanna

¹ The U.S. Toxics Release Inventory Program, which has run since 1988, was the first and most notable public disclosure program in the world. However, until PROPER it was not realized that provision of information programs could be successfully implemented in countries with relatively weak governmental institutions and imperfect markets.

² Portney (2000) identifies public dissemination of information as one of the three enduring changes in environmental policy over the 2000 – 2050 period. The other two are the increased use of market-oriented approaches, such as emission fees and tradable emission permits, and the increased decentralization of environmental institutions.

et al. (1998), Hamilton (1995), and Konar and Cohen (1997) analyze the U.S. TRI Program; Lanoie et al. (1998) study the effects of the list of polluters published by the Ministry of Environment of British Columbia, Canada. Dasgupta et al. (2001) show that stock markets in Argentina, Chile, Mexico, and the Philippines react to announcements of information on environmental events. Among these studies, only Konar and Cohen (1997) consider the possible effects on emissions and find that bad publicity is not only followed by falling stock prices but also by emissions reductions; further, the greater the fall in stock price, the larger the observed emissions reduction.

The somewhat robust evidence on the links between financial markets and environmental disclosure contrasts with the apparent lack of studies testing the influence of other channels such as community or worker pressure.³ A paper that looks at the links between communities and environmental outcomes in the context of the U.S. TRI program is Arora and Cason (1999). However, that study does not disentangle the effects of information availability itself on emissions. The unbalance in the current empirical evidence may reflect the difficulties to obtain certain types of data and not necessarily the relative importance of the different channels. It is however important to recognize that stock prices, in principle, reflect the value of the firm and contain information on the present and future stream of net benefits related to the above-mentioned channels.

In this article we analyze differences in firm responsiveness to PROPER (1995-1998). We use a data set collected within PROPER that contains information on facility characteristics and environmental outcomes before and after the disclosure of information. In June 1995, the plants that were selected to participate in the scheme were given prior, private notification of their ratings as of that date. They were also informed that updated ratings would be publicly disclosed in December 1995 and at regular intervals thereafter. We use the first *evaluation* round as a baseline to analyze

³ Blackman et al. (2004) present results of a manager survey carried out within the context of PROPER in 1998. Managers were asked to rank mechanisms that could have been influential in the program. Among the mechanisms most frequently ranked first or second were: the program aroused managers' awareness of environmental problems, bad ratings increased pressure from communities, and bad ratings increased pressure from the news media. Pressure from shareholders also appeared to be important.

the changes in environmental performance observed in the two subsequent *evaluation and disclosure* rounds. We construct two response indexes for the June - December 1995 and the June 1995 – July 1997 periods, and use them as dependent variables in ordered logit models. Lagged firms' characteristics that are correlated with the channels through which disclosure works are implemented as regressors.

Our findings indicate that firms with foreign ownership were more likely to respond positively way to PROPER. This result is somewhat in line with the existing evidence on stock market reaction as it involves pressure from foreign investors, for which a bad environmental reputation is particularly costly. This effect seems quite important in PROPER as it is found in both short and longer run response models. A second finding is that firms located in Java (which concentrates most of Indonesia's population and economic activity) and in other densely populated provinces responded to a larger extent than other firms. This reinforces the impression that one of the key mechanisms in disclosure may be community pressure, which can be stronger in more densely populated areas where more people are negatively affected by pollution. The importance of location variables is only found in the short term response models though. Finally, the results also suggest that the firms that had already taken their first "easy" abatement steps found it more difficult to achieve further improvements. This confirms similar findings reported in García et al. (2004).

This paper proceeds as follows. Section 2 describes information disclosure as a policy instrument and its potential in a developing country context. Section 3 presents an overview of the program to be evaluated. Section 4 presents the empirical approach, Section 5 reports the data, and Section 6 discusses the results. Section 7 concludes.

2. Disclosure as a policy instrument

Garvie and Keeler (1994) argue that the environmental regulator can be viewed as an institution that solves an information asymmetry between polluters and the judiciary. This not only refers to the command-and-control of standards but also to market based instruments, since a reliable monitoring system is a necessary condition for their successful implementation. Typically, the "classical" regulator would allocate the budget in two different activities: (i) monitoring and enforcement, and (ii) actual process of prosecuting firms. However polluting firms face many other costs of

pollution, costs that may be much more important than just environmental fees or fines associated with traditional regulations. Firms have relations with (a) surrounding communities and participate in (b) inputs and output markets, (c) labour markets, and (d) credit markets. Successful experiences like PROPER in Indonesia and the TRI in the U.S. suggest that regulators can help intensify these relations and use disclosure of information as a substitute for enforcement. It is a well-established fact that information plays a determining role in the development of institutions such as markets.

The natural framework of an analysis of the relations between polluters and communities is the Coase theorem (Coase, 1960). Provision of information can reduce transaction costs between communities and neighboring plants, placing the former in a better position to negotiate pollution reductions. This mechanism can be very relevant in the developing world with ill-functioning official institutions and where informal mechanisms are more likely to emerge. The public good nature of information also makes disclosure reach social and economic spheres that stretch beyond neighboring communities (Tietenberg, 1998). In the presence of disclosure, environmentally aware consumers are able to identify and, if preferred, purchase greener products. Probably this mechanism works when the industries produce consumer products, but reputation could be important for firms producing inputs for other firms as well. Employees could also be encouraged to negotiate higher workplace standards after learning the environmental standing of firms. Investors will make decisions based on previous issues and other sensitivities. They will, for instance, worry about hidden liabilities of polluters and loss of goodwill associated with pollution. They could also view excess pollution as a signal of inefficiency. As explained in Section 1, the bulk of the empirical literature on disclosure shows that financial markets do react to bad environmental news.

In the context of Indonesia, and typically of any developing country, pressure from workers and consumers related to the environmental performance seems less likely. Unemployment was still high in the mid 1990s and the economy, although invigorated in the 1980s and 1990s, remained rather poor. Without the possibility of participating in a more competitive job market, workers cannot afford to make high

demands.⁴ Pressure from consumers might not be expected either as most firms participating in PROPER were producers of intermediate goods. Furthermore, green consumerism is not very developed in poorer countries. On the other hand, there are reasons to believe that communities and investors could have played a more important role in PROPER. Pargal and Wheeler (1996) have already provided some evidence on the possible existence of some forms of informal control of polluting firms in Indonesia. Their study suggests that wealthier and more educated surrounding communities can impose higher pressure on polluting firms. As for possible investor reaction, the observed regularity of stock markets being responsive to environmental disclosure suggests that this channel could also have been at work in PROPER. In fact, Dasgupta et al. (2001) show that financial markets do react to bad environmental news in neighboring Philippines. Finally, the answer to the question about whether communities and investors were important forces in PROPER can only be found through an empirical analysis.

3. Indonesia's PROPER program⁵

In the early 1990s the national environmental authority of Indonesia (BAPEDAL) was faced with the discrepancy between an expanding industrial sector and its own lack of resources, and decided to tackle industrial emissions control through an information disclosure program. Earlier attempts at regulation had not been very successful; no fines were ever assessed and the authorities lost 90% of the environmental and health court cases. This was the reason why BAPEDAL wanted to try an alternative to regulation. The PROPER program was launched in June 1995 and aimed to achieve water pollution reductions at minimum regulatory costs. To achieve the greatest impact on environmental quality, BAPEDAL selected the major contributors to river pollution loads to participate in the scheme. The distinctive feature of PROPER was the disclosure of information via a five-color code, in which

⁴ Although the official rate of unemployment was 3% in 1994, the underemployment rate was estimated to be 40%. The latter includes unemployed and those working involuntarily part time for economic reasons or working for poverty-level pay.

⁵ This section builds on García et al. (2004). For a detailed description of the PROPER program and the Indonesian regulatory regime in the 1980s and 1990s, see Afsah et al. (1997) and Afsah and Vincent (1997).

each participating firm was assigned a color according to its environmental status. The scale built primarily on the compliance status with existing pollution standards.⁶ Implementation of environmental management practices, such as the existence of flow meters and self reporting of reliable data, was also considered. The environmental authority understood that disclosing raw data could create interpretation problems among the public. Yet a simple binary index—in compliance or out of compliance—would not do justice to all firms, especially not to those that had an excellent performance record and those that missed compliance by a narrow margin.

Black meant that the facilities did not meet the legal standards and made virtually no pollution control effort. *Red* facilities had made some effort to reduce emissions but failed to meet legal emissions standards and had insufficient reporting. *Blue* was given to facilities that met legal emissions standards and had reasonably frequent reporting. *Green* was intended for the “proactive” companies and was awarded if pollution was 50% or less than the required standards and the firm conducted good equipment maintenance, reporting, and environmental work. *Gold* was awarded to firms that were below 5% of the legal standard and met international standards of environmental excellence, which in addition to the green requirements implied the use of clean production technology, waste minimization, and pollution prevention activities.⁷

BAPEDAL identified 1,500-2,000 firms that accounted for about 80% of total pollution. The plan was to gradually increase the coverage to all these firms, but BAPEDAL wanted to move carefully in order to maintain the quality and integrity of the program. They therefore started with a selection of firms in the first year. These were of course chosen on the basis of being significant polluters, but another important criterion at this stage was that the firms had to be located in regional clusters to minimize the travel cost for the inspectors and thus keep within the limited initial budget. In June 1995, 187 large polluting plants were notified of their initial ratings and were told that full disclosure of the ratings would be made in December 1995. New firms were gradually included in the program until it reached 324 facilities

⁶ In 1991, a ministerial decree (KEP/MEN/03/1991) set effluent discharge standards in terms of concentration (mg/L) for a number of industrial sectors.

⁷ See Afsah and Ratananda (1999) for more details on the rankings.

in June 1998. The program collapsed in 1998 with the Asian financial crisis, but is currently being currently revived. Participation was compulsory for the selected firms but ratings for “opt-ins” were as well made, and a small number of additional firms joined the program voluntarily. Initial ratings indicated that two-thirds of the companies were noncompliant and were given Red or Black ratings. In December 1995, full disclosure of all the ratings started, industry by industry, to receive maximum press coverage during a fairly extended time period. The changes in rankings, for the 145 firms used in the empirical exercise of this paper, from June 1995 to December 1995 and July 1997 are shown in Tables 1A and 1B. No Gold ratings were awarded during the period. Table 1A shows an immediate, positive response during the first six months of the program particularly among Black- and Red-rated plants. All but one of the Black ratings improved and moved up. More firms adjusted and improved in the longer run. Note that a fairly similar number of firms declined in their environmental performance in both the short and longer terms.⁸

Table 1A Change in ratings June 1995 vs. December 1995

Rating June 1995	Decline	No change	Improve	Total
Black	–	1	4 (1)	5
Red	1	66	23	90
Blue	13	32	1	47
Green	1 (1)	2	0	3
Gold	0	0	–	0
Total	16	101	28	145

Notes: Tables 1A and 1B include the 145 firms that are used in the empirical analysis done in this paper. The numbers in parentheses indicate the number of firms that improved or decline two ratings with respect to their initial rating in June 1995. For instance, in December 1995 four firms improved from black to red and one from black to blue.

⁸ As mentioned earlier, PROPER has been considered a reasonably cheap experiment. The average annual budget of the program during the 1995 - 1998 period was US\$200,000, which translates into a cost of US\$740 per firm per year. Sixty-five percent of the budget was allocated to monitoring and inspection activities, 15% to laboratory tests and 20% to information processing and administration. During the 1995 – 1998 period the budget increased by a factor of 2.2, whereas the number of firms in the program increased by a factor of 1.7.

Table 1B Change in ratings June 1995 vs. July 1997

Rating June 1995	Decline	No change	Improve	Total
Black	–	0	5 (4)	5
Red	3	50	37 (1)	90
Blue	13	29	5	47
Green	2	1	0	3
Gold	0	0	–	0
Total	18	80	47	145

4. Empirical approach.

We use the first round of PROPER in June 1995, where facilities were evaluated but information was not disclosed, as a benchmark. The changes in the environmental performance of firms after implementing of the program can be analyzed in a number of different ways. One way is to focus on emissions themselves, which would be the ultimate goal for a policy maker. However, for the firms operating under this labeling scheme, and for most other stakeholders, it is reasonable to think that their main focus of attention is related to the rating itself, and therefore our empirical approach concentrates on these ratings. The ratings are of course based on emissions but also on the implementation of some environmental management practices. Note that the ratings are based on wide emission intervals, which means that the goal of the firm may not be so much a general reduction of emissions but rather to get just below a certain limit that corresponds to the desired rating (perhaps with some margin to hedge against any uncertainty of emission metering).

Let E_{it} be a continuous variable that measures the environmental performance of firm i at time t . Higher values of E_{it} indicate better performance. We are primarily interested in changes of this variable that could be attributed to information provision. Thus, the change in environmental performance between $t = 0$, without disclosure, and $t = 1$, some time later with disclosure, can be represented as $\Delta E_i = E_{i1} - E_{i0}$. Note that this can be positive or negative. Some firms may actually increase emissions and decrease their environmental performance as a response to other (unobserved) factors. Let R_{it} be a PROPER rating variable that takes discrete consecutive values for each color category: 1 for Black, 2 for Red, up to 5 for Gold. R_{it} will be a reflection of the

underlying variable E_{it} , but the latter may change without a change in rating. There will be a change in rating only if the change in emissions is sufficiently large. Our empirical model assumes that the response to the policy, ΔE_i , depends on a number of exogenous variables, X_i , related to firm characteristics and the different channels through which disclosure works. Also, we include the initial environmental performance E_{i0} in order to control for increasing marginal abatement costs effects. The structural model in our specification is thus given by:

$$\Delta E_i = \beta' X_i + \gamma E_{i0} + \varepsilon_i, \quad (1)$$

where the vector β and the scalar γ represent the parameters, and ε_i is the error term.⁹ We devise the change in rating ΔR_i as a reflection of the change in environmental performance ΔE_i . As discussed in the previous section, facilities participating in PROPER can typically be classified into three groups: those that improved their ratings, those that did not change it and those whose ratings declined. We maintain this classification to define the dependent variable of our econometric specification. Thus:

$$\Delta R_i = \begin{cases} -1 & -\infty \leq \Delta E_i \leq \mu_1 \\ 0 & \text{if } \mu_1 < \Delta E_i \leq \mu_2 \\ +1 & \mu_2 < \Delta E_i \leq \infty \end{cases}, \quad (2)$$

where μ_1 and μ_2 are threshold parameters to be estimated along with β and γ in equation (1). Note that the coding of ΔR_i is irrelevant as long as the order of the three outcomes is preserved. The coding we use in equation (2) is meant to remind the

⁹ A model that has sometimes been used within the context of public disclosure programs is:

$$E_{it} = \beta' X_i + \varepsilon_i$$

See for instance Arora and Cason (1999). Note that the dependent variable is given by the absolute level of emissions in period $t = I$, when information has already been provided. This specification, although useful for several purposes, does not permit inferring the incremental contributions of the different factors associated with information provision. Disentangling the informational effects requires data on the environmental performance of firms under non-disclosure.

reader of the directions of the changes in ratings. The error term is assumed to have a standard logistic distribution across observations. The probabilities of observing the three different outcomes are given by:

$$\begin{aligned} \Pr(\Delta R_i = -1 \mid X_i, E_{i0}) &= F(-\beta' X_i - \gamma E_{i0}) \\ \Pr(\Delta R_i = 0 \mid X_i, E_{i0}) &= F(\mu_1 - \beta' X_i - \gamma E_{i0}) - F(-\beta' X_i - \gamma E_{i0}) \\ \Pr(\Delta R_i = +1 \mid X_i, E_{i0}) &= 1 - F(\mu_2 - \beta' X_i - \gamma E_{i0}) \end{aligned} \quad , \quad (3)$$

where F is the cumulative logistic distribution function. These probabilities are used to construct the likelihood function and carry out the estimation.

5. Data

The local Environmental Authority BAPEDAL provided the information collected within the PROPER program. We use data on 145 firms that were rated in the first (June 1995), second (December 1995), and forth (July 1997) rounds of the program. The third round of evaluation (June 1996) only included a small number of firms; we were not able to use the data in the analysis. Note also that the Asian financial crisis is reported to have started in July 1997. Since the information used to construct the ratings is typically collected in advance, the data set is not contaminated by this event.

Table 2 presents the specification and descriptive statistics of the variables included in the analysis. The upper and lower panels include information on the dependent and independent variables respectively. We construct two dependent variables, ΔRating_6 and ΔRating_{25} , based on the reported changes in ratings in the first six and the first 25 months of the program (June 1995 - December 1995 and June 1995 - July 1995). The difference in means indicates a higher positive response in the longer term.

In the discussion in Section 3, two factors, namely community groups and investors, were identified as potential drivers of the general positive response to the scheme. We use two proxies to capture these two channels. The first one is a location variable that measures the population density in the provinces where the firms were located. This, we believe, is a reasonable way to look at the effects of community pressure, since highly populated areas are usually the most affected by pollution. We built a set of three dummy variables: The first one accounts for one for provinces with more than 500 persons per square kilometer, which corresponds to provinces in Java, Indonesia's

main island and one of the most densely populated places on earth.¹⁰ The second and third dummy variables are for firms located in provinces with population densities between 100 and 500 persons per square kilometer and less than 100 persons per square kilometer, respectively.

Table 2. Variable specification and descriptive statistics.
Number of firms = 145

Variable	Mean	S. Dev.	Description
<u>Reaction to PROPER</u>			
ΔRating6	0.08	0.548	Change in rating between June 1995 and December 1995. The coding is: 1=improve;0=nochange;-1=decline
ΔRating25	0.20	0.640	Change in rating between June 1995 and July 1997. The coding is: 1=improve;0=nochange;-1=decline
<u>Explanatory variables</u>			
Initial_rating	0.655	0.477	1=black or red; 0=no
Employment	1299	1933	Number of employees
Ownership			
Public	0.176	0.382	1=yes; 0=no
Private (local)	0.693	0.462	1=yes; 0=no
Foreign	0.129	0.336	1=yes(with foreign share); 0=no
Sector			
Sugar	0.102	0.303	1=yes; 0=no
Rubber	0.170	0.376	1=yes; 0=no
Plywood	0.149	0.357	1=yes; 0=no
PalmOil	0.081	0.274	1=yes; 0=no
PulpPaper	0.122	0.328	1=yes; 0=no
Textile	0.231	0.423	1=yes; 0=no
Other	0.142	0.351	1=yes; 0=no
Population density			
High (Java)	0.524	0.501	1=yes(high popul density); 0=no
Medium	0.117	0.322	1=yes(medium popul density); 0=no
Low	0.358	0.483	1=yes(low popul density); 0=no

We use an ownership variable as a proxy for investor pressure. The hypothesis is that firms that are, for instance, state-owned as opposed to private-owned, are less likely to

¹⁰ The population of Indonesia in the mid-1990s was around 200 million making it the fourth most populated country in the world. Around 35% of the population lived in urban areas. The Indonesian archipelago comprises approximately 17,500 islands, of which only 6,000 are inhabited. The four major islands are Java, Sumatera, Kalimantan, and Sulawesi (Central Bureau Of Statistics (CBS) [Indonesia] et. al, 1998)

face pressure from shareholders, namely the government. We construct three dummy variables: one for state owned firms, one for local private owned firms and one for firms with some share of foreign ownership. We acknowledge that our measure of investor pressure is not necessarily perfect since firm abatement costs, and therefore responsiveness ability to the program, may also have been determined by ownership.¹¹ On the other hand, it is not clear that foreign-owned firms would have lower abatement costs at the margin, especially if they had already undertaken the first abatement steps.

Other explanatory variables are initial rating, employment, and industrial sector. The initial rating variable is a dummy variable that takes the value of one if a firm was rated either Black or Red in the first PROPER round in June 1995. Tables 1A and 1B show that only 3 (2%) and 5 (3%) were given black and green colors in that round, respectively; therefore we decided to put them in the same categories with Red-rated and Blue-rated firms, respectively. This environmental performance dummy variable actually indicates whether a firm was initially in or out of compliance. The industrial sector dummy is mainly included to control for possible differences in abatement costs and reaction capabilities across sectors. Note though that the need to control for such factors, although necessary, is less important in our model. The reason is that in Indonesia emission standards are stated in concentrations (mg/L) and differ across sectors in such a way that the difficulties to comply are somewhat evened out. Employment is included as a measure of firm size. Larger firms could be more likely to be affected by bad publicity. It is difficult to argue that this variable measures possible economies of scale in abatement since pollution intensity (mg/L) is a measure that controls for firm size.

¹¹ Takii (2002) finds that foreign-owned firms in Indonesia had higher technology levels than local owned firms in 1995. Bernard and Sjöholm (2003) report higher levels of (labor) productivity of foreign firms compare to local enterprises in the country in the 1975 - 1989 period. Apparently this gap in productivity increased over time.

6. Results

Table 3 presents full information maximum likelihood estimates for both the six and 25e month response ordered logit models. Using a threshold probability value of 0.5, the estimated models correctly predict 72% and 62% of the short and longer term responses, respectively. Explicitly, the observed actions and predicted actions are (prediction in brackets):

6 month response: decline 16 (9), no change 101(126), and improve 28(10).

25 month response: decline 18(7), no change 80(90), and improve 47(48).

Table 3. Ordered logit estimates

VARIABLE	6 month response		25 month response	
	Coefficient	SE	Coefficient	SE
Initial_rating	4.393 ***	0.861	2.608 ***	0.512
Log_employment	0.044	0.202	0.019	0.186
Ownership				
Public	1.325	0.869	0.218	0.718
Foreign	1.894 ***	0.685	1.551 **	0.629
Density				
High (Java)	2.439 ***	0.950	0.219	0.819
Medium	1.676 **	0.837	-0.308	0.697
Sector				
Sugar	0.459	1.334	1.226	1.159
Rubber	1.833 *	1.088	1.724 **	0.852
Plywood	3.347 **	1.315	1.207	1.031
PulpPaper	0.031	1.306	0.699	1.101
Textile	0.779	1.236	-0.124	1.057
Other	1.079	1.092	0.662	0.909
U_1	2.802	1.584	0.290	1.338
U_2	8.682	1.918	3.936	1.388
Sample size		145		145
Log_likelihood		-84.54		-111.79
Pseudo R2		0.283		0.190

Notes: The omitted dummy variables are: Private (local) in the ownership set of variables, Low in the population density variables, and PalmOil in the sector variables. Pseudo R2 is the likelihood ratio index $1 - \ln L / \ln L_0$, where L and L_0 are the log likelihoods with and without regressors .

* Significant at the 10% level; ** significant at 5%; *** significant at 1%

These predictions should be read with some reservation given that a majority of the observations in our sample fall in the no-change category. In this case, prediction of the other two outcomes is less likely than in a balanced data. While the no-change

outcome is pretty well predicted by the two models, as expected, the improvement category is much better predicted in the 25 month response model. The seemingly poor predictability of the decline category in the two models may be related to unobserved factors and the randomness embedded in this outcome. Firms that have some financial or technological problems, or that must meet a peak of demand for their product, may increase pollution intensity despite the incentives given by PROPER.

The ordinal regressions estimates of Table 3 provide a general idea of the direction of the effects of the different variables. Positive estimates invariably indicate a higher likelihood of a positive response;¹² that is, a higher probability of improving, $\Delta R = +1$, and a lower probability of declining, $\Delta R = -1$. Some regularities can be identified between the two regressions.¹³ Firms that were initially out-of-compliance and have foreign shares, as opposed to being national private, were more likely to respond positively. Also, most sector dummies are positive but rarely significant in our regressions. The two location variables were positive and significant in the first model, but not in the second model, signifying a stronger short-term positive response of those firms situated in densely populated areas. The two location dummy variables of the 6 month response model, although not significantly different from each other, suggest a larger effect of Java.¹⁴

¹² The signs of the coefficients of ordinal regression models only give unambiguous information on the changes in probabilities in the two extreme categories (Greene, 2003). No inference about the intermediate outcomes can be made. Note though that our model has only three categories and the in-between category is, by construction, directly associated with the initial environmental states of the firms. This allows us to read the estimates in terms of contributions to the likelihood of observing positive responses, as compared to the initial environmental state.

¹³ Direct interpretation of the magnitude of the parameters across the two regressions is not possible due to probable differences in the variances of the latent variables, which might be represented as ΔE_{i6} and ΔE_{i25} .

¹⁴ It should be acknowledged that the estimates of the longer-term response model are more likely to be affected by noise and unobservable factors. For instance, Garcia et al. (2004) find evidence on the existence of negative trends in industrial water emissions in Indonesia in the same period of analysis.

Since our model is of probability, the sizes of the estimates of the ordinal regressions are difficult to interpret in terms of stimulus to the “unobserved” latent variables ΔE_{i6} and ΔE_{i25} . We thus turn to study estimated marginal effects which, ultimately, break down the regression estimates into contributions to each one of the response probabilities (see Table 4). The marginal effects related to the improvement (decline) outcome indeed have the same (opposite) signs as the ordinal regression estimates in Table 3. For our only continuous variable, namely employment, the marginal estimate measures a partial increase in the “absolute” probability of observing a given outcome due to a percentage change in the number of employees. Employment, however, appears non-significant throughout the analysis. For dummy variables, the marginal effects are calculated as differences in probabilities of a given outcome for the two possible values of the variables.

All but one of the marginal effects (that of the initial rating) of the no-change category have the same signs as those of the decline outcome. This suggests similar roles of the determinants of both these categories. Note however that the significance levels of some variables vary widely across categories.

It is found that the initial rating has a very large and significant effect on both the probabilities of observing improvements and declines. Being rated Black or Red in June 1995, as opposed to Blue or Green, increases the likelihood of improvement by 29.2% in December 1995 and by 40.6% in July 1995. Accordingly, the probability of observing a decline is reduced by 34.0% and 25.5%, respectively. The initial rating also has a negative significant effect on the probability of observing the no-change outcome in the 25 month response model, whereas no significance is found in the shorter term period of six months. This reinforces the idea that the inertia that tends to keep firms at their initial performance levels becomes less pressing over time. As Tables 1A and 1B show, both non-compliant firms (Red and Black) and compliant ones (Blue and Green) were more likely to improve in the longer time period. Non-compliant firms appeared to have been relatively more responsive as time passed.¹⁵

¹⁵ The decline outcome is not observable for firms with initial black ratings. Note that the proportion of black firms in our sample is very small (5.02% of total firms rated black or red). Their inclusion in the analysis does not bias the econometric results.

Table 4. Estimated marginal effects

VARIABLE	Decline	No change	Improve
	$\Delta R = -1$	$\Delta R = 0$	$\Delta R = 1$
6 month response model			
Initial_rating	-0.340 ***	0.048	0.292 ***
Log_employment	-0.001	-0.002	0.003
Ownership			
Public	-0.026	-0.122	0.148
Foreign	-0.031	-0.227	0.258 *
Population density			
High (Java)	-0.087	-0.116 *	0.204 **
Medium	-0.028 *	-0.191	0.219
Sector			
Sugar	-0.011	-0.031	0.041
Rubber	-0.033 *	-0.202	0.234 **
Plywood	-0.045	-0.521 **	0.566
PulpPaper	-0.001	-0.002	0.002
Textile	-0.018	-0.055	0.073
Other	-0.022	-0.0942	0.116
25 month response model			
Initial_rating	-0.258 ***	-0.148 **	0.406 ***
Log_employment	-0.001	-0.002	0.003
Ownership			
Own_Public	-0.013 ***	-0.030	0.043
Own_Foreign	-0.063	-0.289 **	0.353 **
Population density			
High (Java)	-0.014	-0.028	0.042
Medium	0.021	0.034	-0.056
Sector			
Sugar	-0.052	-0.225	0.278
Rubber	-0.072 **	-0.316 *	0.388 **
Plywood	-0.054	-0.215	0.270
PulpPaper	-0.035	-0.114	0.150
Textile	0.008	0.015	-0.023
Sect_Others	-0.034	-0.106	0.141

Notes: Marginal effects are estimated at the means of other dependent variables. The omitted dummy variables are: Private (local) in the ownership set of variables, Low in the population density variables, and Palm Oil in the sector variables.

* Significant at the 10% level; ** significant at 5%; *** significant at 1%

Foreign ownership, as opposed to private local ownership, explains the improvement but not the decline in the short and longer term models. The importance of ownership in explaining the improvement category is more significant and apparently stronger in the 25 month response model; being foreign-owned increases the probability of improvement by 25.8% in the June-December 1995 period and by 35.3% in the June 1995 – July 1997 period. Although these estimates are consistently higher than those of the public ownership dummy variable, no statistical difference between the two is found. Foreign ownership exhibits a large, negative, and significant effect for the no-

change category in the 25 month response model whereas no significance is reported in the 6 month response model. Also, public-owned firms appear less likely to decline in their performance than private-owned firms in the longer term. However, the associated marginal effect is almost negligible, 1.3%.

As for the location variables, significant effects are only found in the six month period model. The significant results show that whereas being located in Java increases the probability of observing an improvement outcome by 20.4% (and reduces the probability of a no-change outcome by 11.6%), being in less populated islands decreases the probability of decline outcomes by 3.8%. The reported loss in significance of these variables in the 25 month response model could be due to either a fallback in performance of those firms located in the most densely populated provinces or to improvements made by firms located in less densely populated provinces. Since environmental performances improved over time, the most likely explanation is that firms located in less populated provinces caught up in the longer term period.

7. Conclusions

The reported success of public disclosure programs at inducing industrial pollution reductions has made this approach increasingly popular among policy makers around the world. Early experiences show that a small and properly managed infrastructure for collecting and disseminating information is sufficient for implementation. Our understanding of the different mechanisms through which provision of information works is however still limited. In this article we set out to unveil some of the characteristics of those firms that showed higher susceptibility to the provision of information in the context of Indonesia's PROPER program, 1995–1998. The local Environmental Authority BAPEDAL sought to reduce industrial water emissions by a system of environmental rating. It had few instruments other than the mere public disclosure of the environmental ratings of firms. The program lasted for only a few years before the Asian crisis swept it away. However in that brief interlude it was rather successful and a number of countries set to emulate its design.

Although the data set used in this study is one of the more comprehensive emission and rating data sets available in the developing world, it is still fairly limited in scope.

We are nevertheless able to identify a number of interesting findings: Firstly, foreign-owned firms were consistently most responsive to the program, which can be interpreted as managers of polluting firms facing higher pressure from foreign investors. This is consistent with findings of the stock market literature that report that stock prices do react to bad environmental news. Note that foreign-owned firms are more sensitive to media and other attention. Also this types of firm could be more responsive since it may be expected to have lower emissions abatement costs.

We also found that in the shorter term, firms located in the most densely populated areas responded better to the program. In particular being located in Java, Indonesia's main island, seemed to be important in determining the extent to the response. Java is the most densely populated island on Earth, has higher incomes, better media coverage, access to political arena, and a greater potential for community pressure.

Our results provide a general indication of the possible mechanisms at work in schemes such as PROPER. However, and as suggested earlier, in order to provide a more compelling picture of the role of different channels in disclosure programs, more detailed data is required. We have, for instance, argued that consumer and worker pressure seemed less likely in PROPER. Firms in PROPER were typically producers of intermediate goods far from the final consumer and, on the other hand, green consumerism does not appear to be well established in developing countries anyway. Also, workers in poor countries are not in the position to demand high work standards. Our data however did not allow us to test the importance of possible product and job markets interactions. Finally, it would be interesting to have more concrete information to analyze, for instance whether legal or informal actions undertaken by communities against polluters were intensified following information releases and, most importantly, whether these actions translated into emission reductions.

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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 lead to EP implementation.

Key Words: Environmental Management, Bivariate Analysis, Central and Eastern Europe.
JEL Classification: Q53, Q58, C25

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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. SO₂ emissions per capita were on average twice that of the EU countries (OECD, 1999). Compared with Western Europe, the CEE countries produced 30% more SO₂ 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 were 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% had 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)				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%)

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 rate 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:

$$y_{ij} = \begin{cases} 1 & \text{if } \pi_{ij}^* > 0 \\ 0 & \text{if } \pi_{ij}^* \leq 0 \end{cases}.$$

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:

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

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:

$$\Pr[ED_i = 1] = \Phi_1(\beta_1 x_i), \quad (2)$$

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

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

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

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

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 (Wooldridge, 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	<u>Cross tabulation of EP and ED.</u>		
Rho	0.5280 *** (0.0444)	Fitted values in brackets		
Log likelihood	-1347.71	ED= 0	ED=1	
Pseudo R2	0.22	EP= 0	658	199
			[894]	[48]
		EP=1	235	284
			[178]	[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	$\Delta\text{Prob}[\text{ED}=1 \mid \text{EP}=1]$	$\Delta\text{Prob}[\text{ED}=1 \mid \text{EP}=0]$	$\Delta\text{Prob}[\text{EP}=1 \mid \text{ED}=1]$	$\Delta\text{Prob}[\text{EP}=1 \mid \text{ED}=0]$
	Δx	Δx	Δx	Δx
BULGARIA ^d	-0.2772 *** (0.0593)	-0.1728 *** (0.0305)	-0.0914 (0.0635)	-0.0928 *** (0.0356)
HUNGARY ^d	-0.6159 *** (0.0473)	-0.319 *** (0.0291)	0.3469 *** (0.0619)	0.1925 *** (0.0677)
LITHUANIA ^d	-0.5990 *** (0.0367)	-0.2894 *** (0.0269)	0.1944 *** (0.0626)	0.0062 (0.0433)
POLAND ^d	-0.5872 *** (0.0376)	-0.2982 *** (0.0257)	0.3143 *** (0.0479)	0.1633 *** (0.0497)
SLOVAKIA ^d	-0.5154 *** (0.0603)	-0.2082 *** (0.0208)	0.3684 *** (0.1004)	0.2753 (0.2494)
AGE	-0.0006 (0.0012)	-0.0005 (0.0008)	-0.0004 (0.0011)	-0.0003 (0.0008)
EMPLOYEES (log)	0.0171 (0.0163)	0.0143 (0.0116)	0.0287 ** (0.0139)	0.0230 ** (0.0101)
PRIVATE	0.0005 (0.0005)	0.0004 (0.0004)	-0.0006 (0.0005)	-0.0004 (0.0004)
FOREIGN OWNER ^d	-0.0444 (0.0574)	-0.0298 (0.0381)	0.0286 (0.0486)	0.0188 (0.0365)
EXPORTSHARE	0.0006 (0.0007)	0.0005 (0.0004)	0.0021 *** (0.0006)	0.0017 *** (0.0005)
DISCLOSURE ^d	0.0915 ** (0.0437)	0.07356 ** (0.0357)	0.0394 (0.0396)	0.0363 (0.0308)
WARNINGS ^d	0.1959 *** (0.0531)	0.1637 *** (0.0541)	-0.0655 (0.0470)	-0.0401 (0.0322)
ORDERS ^d	0.0998 (0.0638)	0.08407 (0.0561)	0.0702 (0.0520)	0.0626 (0.0446)
FINES ^d	0.0793 (0.0511)	0.0632 (0.0419)	0.0152 (0.0480)	0.0163 (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 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. 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 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).

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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