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Formal and Informal Regulation of Industrial Pollution

Comparative Evidence from Indonesia and the United States

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In both countries the higher the level of community income, the lower the pollution intensity of local plants. This paper provides support for the idea that community-based pressure on plants to abate pollution exists, even in the presence of formal regulation.

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Summary findings

Pargal, Hettige, Singh, and Wheeler start from the premise that governments act as agents of the public in regulating pollution, using the instruments at their disposal. But when formal regulatory mechanisms are absent or ineffective, communities will seek other means of translating their preferences into reality. Recent empirical work suggests the widespread existence of such informal regulation: communities are often able to negotiate with or otherwise informally pressure polluting plants in their vicinity to clean up.

Their thesis is that such informal regulation is likely wherever formal regulation leaves a gap between actual and locally preferred environmental quality. They use plant-level data from Indonesia and the United States — two countries that are very different, both socio-economically and in terms of pollution regulation — to test a model of equilibrium pollution under informal regulation.

Their results suggest three common elements across countries and pollutants:

• Abatement is generally subject to significant scale economies.

• Within-country variations in labor and energy prices have little impact on pollution intensity.

• *Community incomes have a powerful negative association with pollution intensity.*

Their findings on community income are especially important, as they suggest a powerful role for informal regulation whether or not formal regulation is in place. The impact of income disparity on intercounty differences in U.S. pollution intensities seems to match the impact in Indonesia. Undoubtedly, this reflects differences in both preference for environmental quality and ability to bring pressure on polluting factories. The fact that such disparities exist in the United States, even for traditionally regulated pollutants, shows that U.S. regulation has not been able to ensure uniform environmental quality for all citizens regardless of income class.

This paper — a product of the Development Research Group — is part of a larger effort in the group to understand the pollution abatement pressures faced by firms. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Evelyn de Castro, room N10-019x, telephone 202-458-9121, fax 202-522-3230, Internet address edecastro@worldbank.org. July 1997. (21 pages)

FORMAL AND INFORMAL REGULATION OF INDUSTRIAL POLLUTION:
Comparative Evidence from Indonesia and the US

by

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1. INTRODUCTION

This paper starts from the premise that governments act as agents of the public in regulating pollution, using the various instruments at their disposal. However, when formal regulatory mechanisms are absent or ineffective, communities will seek other means of translating their preferences into reality. Recent empirical work has indicated the widespread existence of such 'informal regulation:' communities are often able to negotiate with or otherwise informally pressure polluting plants in their vicinity to clean up.

Formal regulatory mechanisms include both quantity-based instruments (e.g. effluent concentration standards, technology standards) and market-based instruments (e.g. emissions charges, abatement credits, tradable permits). Informal regulation can also take many forms, including demands for compensation by community groups; social ostracism of the firm's employees; the threat of physical violence; boycotting the firm's products; and monitoring and publicizing the firm's emissions.[1] Implicitly, such actions force recognition of the community's property right in the local environment. They frequently work because firms do not operate in a social vacuum. When informal regulation is effective, local factories face a positive expected penalty for polluting.

Informal regulation need not be limited to cases where formal regulation is absent. If formal regulatory standards and institutions exist, the most effective informal regulatory tactic may be reporting the violation of legal standards. This will be easier if information on standards is widespread, monitoring is relatively costless, and violators can be easily identified. A second 'formal' channel for informal regulation is pressure on regulators to tighten local monitoring and enforcement. Profit-maximizing firms will reduce pollution to the point where the marginal cost of abatement equals the expected marginal penalty for noncompliance. Since regulators' resources are limited, many regulatory violations are either undetected or lightly penalized because legal proceedings are costly.[2] In this context, public pressure on regulators can be an important countervailing force.

Our thesis is that such informal regulation will be likely wherever formal regulation leaves a gap between actual and locally-preferred environmental quality. If our hypothesis is correct, we would expect widespread informal regulation in developing countries where formal regulation of pollution is absent or ineffective. However, informal regulation may also be common in industrial countries which have nationally-

[1] For numerous examples, see Pargal and Wheeler (1996).

[2] For recent evidence from North America, see Deily and Gray (1991), Dion, Lanoie and Laplante (1996), Magat and Viscusi (1990), and Russell (1990). Similar evidence for Asia can be found in Dasgupta, Huq and Wheeler (1997), Hartman, Huq and Wheeler (1996), O'Connor (1994), and Wang and Wheeler (1996).

uniform regulatory standards. In the latter case, actual formal and informal pressure on plants to abate may vary significantly with local preferences and organizational capabilities. We would expect informal regulation to be strongest in richer communities, because they will have greater preference for environmental quality and more knowledge of pollutant risks. In addition, such communities are more capable of exerting political, social and economic pressure.

In this paper, we use plant- and community-level data from the US and Indonesia to test for the effect of informal regulation in a more general model of 'equilibrium pollution.' This model, first developed in Pargal and Wheeler (1996), posits the existence of community-level emissions equilibria at points determined by local environmental demand and supply schedules. Industry's environmental demand (or pollution) schedule reflects the marginal cost of abatement. The position and slope of the schedule will be pollutant-specific and will depend on three sets of variables: the expected cost of pollution, determined by formal and informal regulation; standard economic factors such as abatement scale economies and relative input prices; and a variety of plant and firm characteristics such as equipment vintage, efficiency and ownership. The positions and slopes of environmental supply schedules for specific pollutants will also reflect three sets of factors: community perception of damage; valuation of that damage; and the ability to impose costs on polluting facilities via formal or informal regulatory channels.

The intersection of environmental demand and supply schedules is, of course, a familiar conceptual device in environmental economics textbooks.[3] However, the conventional treatment identifies 'optimal' pollution at the intersection of marginal cost and marginal damage schedules, implicitly assuming transactions costs to be zero for the regulator. By contrast, we assume that formal and informal regulation are affected by the costs of information, organization and enforcement. Thus, local equilibrium emissions may differ significantly from 'optimal' emissions which are derived solely from marginal cost and damage functions. Of course, they may also differ significantly from the emissions which are mandated by formal regulatory standards.

The US and Indonesia provide a good test case, since they are near the opposite ends of the regulatory and socioeconomic spectra. In the US, many air and water pollutants have been regulated at the national level for more than two decades. The US Environmental Protection Agency (EPA) has a large staff, good technical facilities, and a record of tough enforcement action in many cases. Indonesia, by contrast, had no regulatory standards before 1992. At present, enforcement of these standards is mostly limited to a few water pollutants. The monitoring and enforcement capabilities of Indonesia's National Pollution Control Agency (BAPEDAL) are extremely limited;

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3 See for example Tietenberg (1992).

technical staff are almost nonexistent; and there have been very few formal actions taken against noncompliant facilities.

The same extremes apply to socioeconomic data. The US is one of the world's richest, best-educated societies, while Indonesia has only begun to reach lower-middle-income status after three decades of rapid growth and industrialization. Both societies are, however, extremely diverse both geographically and socially. In addition, both have sharply skewed distributions of community income. Thus, it is entirely plausible to assume that informal regulation plays an important, albeit different, role in the two societies.

Across communities, we would certainly expect plant-level equilibrium emissions intensities (or emissions per unit of output) to be higher in Indonesia. However, we would also expect substantial inter-community differentials in both countries and, possibly, an overlap in the tails of the distributions.

In this paper, we compare econometric analyses of plant-level emissions across communities in the two countries. Our geographic units are counties in the US and kabupaten (sub-provincial units) in Indonesia. For the US, we include regressions for emissions of two regulated air pollutants (Total Suspended Particulates (TSP), Sulphur Dioxide (SO_2)); two regulated water pollutants (Biological Oxygen Demand (BOD), Total Suspended Solids (TSS)); and total emissions of toxic compounds, many of which are not formally regulated at present. For Indonesia, we reproduce results for BOD which were previously reported in Pargal and Wheeler (1996). BOD is the only pollutant for which large-sample data are currently available in Indonesia.

The rest of the paper is organized as follows. In the next section, we briefly describe the institutional setting in the US and Indonesia. Section 3 describes our model of equilibrium emissions under formal and informal regulation. Section 4 specifies the regression equation and describes our data. Results and implications are reported in section 5, and a summary and conclusions are presented in Section 6.

2. INSTITUTIONAL BACKGROUND

2.1 Regulation in the US

Criteria air and water pollutants have long been regulated by command-and-control methods in the US. Air pollution control has historically been based on uniform emissions standards, starting with the creation of the EPA and the Clean Air Act Amendments of 1970 (Tietenberg, 1992). EPA regulatory acts have included ambient air quality standards; the designation of areas as non-attainment regions; the application of guidelines for 'prevention of significant deterioration;' and mandated installation of specific control technologies at the plant level. Substantial noncompliance penalties exist, and there is little flexibility in the imposition of environmental regulations under the Clean Air Act.

The control of conventional water pollutants has also been based on national effluent standards at the industry level, which are derived from technological specifications. There is less emphasis on uniform ambient standards than there is for air quality regulation, possibly reflecting the different impacts of pollution in the two media. At present, responsibility for regulating the manufacture and use of toxic substances is shared by several agencies (e.g., EPA, the Food and Drug Administration (FDA), and the Occupational Safety and Health Administration (OSHA)). The handling, shipping, and disposal of hazardous or toxic pollutants in the US are regulated by the EPA. Legal recourse for damage under common law is a valuable complement to these regulations. Some toxics are clearly very dangerous, but many others have uncertain effects on human health and ecosystem functioning. At present, the EPA does not have safety or 'emission/effluent' standards for the majority of toxic pollutants. As an aid to community awareness of exposure risk, however, it has since 1987 published an annual Toxic Release Inventory (TRI). The TRI, which was legislated in 1986,[4] is based on mandated disclosure of toxic releases and transfers by US industrial facilities. Substantial penalties can be imposed for failure to comply with reporting requirements, but the TRI is basically a public information tool. It is up to local governments or community groups to assess the performance of listed firms in their vicinity, and act upon this information as they deem fit - by negotiation, public appeal, citizen suits, etc.

To summarize, the US has administered a system of formal, command-and-control regulation of criteria air and water pollutants for over two decades.[5] Analysis of plant-

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[4] The TRI was mandated by the Emergency Planning and Community Right-to-Know Act.

[5] Limited use of market-based instruments has begun, notably in the case of the national trading program for SO_2 emissions permits under the revised Clean Air Act. For the most part, however, the US system continues to rely on command-and-control regulation.

level emissions of these pollutants should therefore provide a good test of the degree to which enforcement of national uniform standards has dominated local environmental demand-supply considerations in pollution control. By contrast, the lack of formal regulation for toxic emissions provides a good case for analyzing the influence of informal regulation.

2.2 Regulation in Indonesia

Indonesia began formal regulation in 1992, with establishment of maximum allowable volumes and concentrations (in kg./ton of output) for emissions of BOD and other water pollutants from 14 broadly-defined industry sectors (e.g. textiles; wood pulping). Although self-reported BOD emissions are now mandated by law, reporting has been extremely sparse until recently.[6] Until 1995, the only consistent program of monitoring and pressure for compliance was a voluntary arrangement instituted in 1989.[7] This PROKASIH or 'Clean Rivers,' program, covers about 5% of Indonesian manufacturing facilities in eleven river basins on the islands of Java, Sumatra and Kalimantan. While it has succeeded in eliciting significant pollution reductions from some of Indonesia's largest polluters[8] PROKASIH represents only the first stage of regulation. Formal regulation of air and toxic pollution has just been introduced. Thus, Indonesia provides a very good test for the significance of informal regulation in a developing country.

3. A MODEL OF EQUILIBRIUM EMISSIONS UNDER INFORMAL REGULATION

3.1 Informal regulation and Coasian economics

Our model of informal regulation has been developed in Pargal and Wheeler (1996), so this paper presents a summary version. The model follows convention in defining emissions as the use of 'environmental services' - an additional production factor in an augmented KLEM (Capital, Labor, Energy, Materials) framework. The implicit 'price' of pollution is the expected penalty or compensation exacted by the affected community. It is different from other input prices in that it may be plant-specific. Optimizing

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[6] Expansion of self-reporting has recently begun under the PROPER program for rating and publicly disclosing the environmental performance of industrial facilities. For further discussion, see Afsah and Wheeler (1996).

[7] As noted above, the PROPER program is now providing additional pressure for compliance. The program is still in its introductory phase, but has recently expanded to coverage of approximately four hundred major polluters.

[8] See Afsah, Laplante and Makarim (1996) for a detailed analysis of the PROKASIH program.

communities may tolerate polluting factories when they provide a lot of jobs, local contracts or tax revenues. Conversely, they may pay particular attention to plants whose location makes them easy to monitor (e.g., large, isolated facilities) or particularly damaging to the local environment (e.g. pulp mills immediately upstream from local fisheries or irrigated fields).

There is clearly a relationship between the concept of informal regulation and the Coasian view of environmental economics. Both consider the process by which externalities are internalized in the absence of regulatory agents, and both acknowledge that an externality can be reciprocal (i.e., due to the polluter, the pollutee or both[9,10]). However, the traditional Coasian solution remains dependent on a well-defined legal and institutional environment even when regulatory agents are absent. Efficient outcomes require accurate information about pollution problems, clear delineation of environmental property rights, and courts which are able and willing to enforce legal agreements.

We do not question the relevance of these conditions in many cases, but our view of informal regulation extends the Coasian interpretation in two ways. First, community pressure clearly affects polluters' behavior, even where there is little accurate information, no explicit agreement about environmental property rights, and no court system able to adjudicate settlements. Secondly, our research and other studies have suggested that the conceptual distinction between Coasian arrangements and traditional regulation is often blurred in practice. Regulators must confront strategic behavior by polluters and frequent renegotiation of compliance schedules and penalties. Community pressure may significantly affect these interactions, creating de facto informal regulation even in countries where information is plentiful, formal regulations are clearly defined, and the legal system functions effectively.

3.2 Environmental supply

Informal regulation reflects local factories' acceptance of the community's property right in the environment. Communities use their leverage to impose penalties (costs) on firms whose emissions are judged unacceptable. As factories use up more local environmental quality, affected communities will impose higher costs. From the viewpoint of industry, the result of informal regulation is an 'environmental supply schedule', which shifts inward as average community income increases.[11] However, this

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9 In some cases an externality is generated when a household or firm moves into proximity with a polluter. In the law, this is called "coming to the nuisance". See Cooter and Ulen (1988), p. 181.

10 For further discussion, see Brown (1973); Calabresi (1970); Coelho (1975); Coase (1960); Demsetz (1963,1967,1972); Diamond (1974); Hartman (1982); McKean (1970).

11 Field survey evidence from Southeast Asia suggests that this schedule will depend on several factors: the level of community organization, information, legal or political recourse, media coverage, NGO

supply schedule is expected to be flat with respect to income if formal regulation is successful in equalizing emissions across locations.

3.3 Environmental Demand

Faced with an environmental supply schedule, each plant adjusts pollution to the optimal point along its pollution demand schedule, derived from its cost minimization exercise. As noted in Pargal and Wheeler (1996), potentially-significant determinants of the environmental demand schedule include sector, output, relative input prices, vintage, productive efficiency and, in the case of Indonesia, ownership. The latter variable is not a significant source of variation in the US data, given the preponderance of domestic, private firms in the economy. However, in Indonesia we might expect the partial effect on pollution intensity to be positive for state ownership and negative for multinationals.

Pollution seems likely to be complementary to material inputs, but its cross-price relationships with labor, capital and energy are not clearly signed. For this study, we have been able to construct local labor and energy price indices for both the US and Indonesia, and a proxy for materials price variation across regions in Indonesia. The absence of capital price information is not a major concern, since both of our samples are cross-sectional and we would not anticipate much within-country variation in the price of this factor.

Well-managed plants should generate fewer waste residuals per unit of output and respond more readily to incentives for pollution control. To the extent that profitability reflects efficiency, well-run plants should also have more discretionary funds available to respond to demands for cleanup. Profitability, however, is a double-edged sword in this context, since firms which have avoided pollution abatement should have lower operating costs, ceteris paribus. Thus, while efficient management should have an unambiguously negative effect on a plant's pollution intensity, proxies based on measures of profitability might have a 'perversely' positive effect in regressions if the cost-saving component were dominant.

3.4 Equilibrium Pollution

Following the supply/demand derivation in Pargal and Wheeler (1996), we solve for the following reduced-form equation which characterizes a plant's equilibrium pollution:

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presence, the efficiency of existing formal regulation, and the opportunity cost of time. Many of these factors are correlated with community income levels. For more detailed discussion, see Huq and Wheeler (1993), Hartman, Huq and Wheeler (1996) and Hettige, Huq, Pargal and Wheeler (1996).

(1) $P_{ij} = f(W_{lj}, W_{ej}, W_{mj}, Q_i, s_i, v_i, f_i, m_i, g_i, n_i, a_j, y_j)$

Righthand variables for the regression equation are defined as follows, with expected signs of estimated parameters:[12]

Standard demand variables

?	W_{lj}	=	Manufacturing wage in county j
?	W_{ej}	=	Energy price index in county j
-	W_{mj}	=	Material input price index in county j
+	Q_i	=	Total output of plant i [0 < elasticity < 1]
?	s_i	=	Sector of plant i

Firm-specific variables

+	v_i	=	Age of plant i
?	f_i	=	Factor productivity of plant i
-	m_i	=	Multinational status of plant i (1 if multinational)
?	g_i	=	Public/private status of plant i (1 if public)

Informal regulation variables:

?	n_i	=	Share of plant i in county j's manufacturing employment
?	a_j	=	Population density in county j
-	y_j	=	Per capita income in county j

3.5 The Roles of Sector and Location

As previously mentioned, broadly-defined industry sectors differ greatly in average pollution intensity of production (see Hettige, et. al. (1994)). However, even in sectors with high pollution potential, emissions can be substantially reduced through process modification or installation of end-of-pipe abatement equipment. Investors make simultaneous choices of products, processes and abatement levels, taking relative prices at different locations into account. In general, we would expect emissions per unit of output to be relatively elastic with respect to the local 'price of pollution.'

[12] See Pargal and Wheeler (1996) for a detailed discussion.

3.5.1 Possible Endogeneity of Income

Our model employs community mean income as an exogenous variable, but we recognize the risk of endogeneity. Within an urban region, where residential mobility is comparable to factory mobility, an increase in pollution-intensive manufacturing in some areas may induce a decline in their average income as richer people move away and lower property prices attract poorer people. This may well have been a significant factor in some US metropolitan areas. If so, the result would be an upward-biased estimate of the impact of informal regulation (proxied by community income) on plants' abatement decisions. However, our results (Section 5) suggest that simultaneity bias is not a significant problem for our US regressions.

In the Indonesian case, the prior argument for endogeneity is far less compelling. The units of analysis are kabupaten drawn from a broad spectrum of urban and rural areas in Java, Sumatra and Kalimantan; their relative social and economic status has changed little since 1975. However, most of Indonesia's manufacturing has developed during the past two decades. Therefore *industrial location clearly dominates residential migration in the Indonesian case.* If there is any bias in our estimates, we are confident that it is small.

3.5 Econometric Specification

We have no strong prior views on appropriate specification of the estimating equation for equilibrium pollution. Since our theory of informal regulation has not been extensively tested, it would seem better to start with a relatively simple and tractable empirical exercise. The pollution price variable (W_p) is endogenous, with many determinants, and there many plant-specific demand-shift variables in the model. We therefore limit ourselves to estimation of log-log regressions, using dummies for categorical variables.

Heteroscedasticity across observations, often a problem with cross section analyses, is not a significant problem in our US data. For Indonesia, we have reported White heteroscedasticity-consistent results. Although there is fairly significant correlation between different groups of variables in our Indonesia dataset, multicollinearity does not appear to have been a problem for estimation.

4. THE DATA

For the US, the data used for this study were obtained by merging together establishment level manufacturing data from the US Census Bureau's Longitudinal Research Database (LRD), county income and population data from the Census Bureau's 'USA counties on CD ROM' (COSTAT) and EPA data from various sources: the TRI for toxics, the Aerometric Information Retrieval System (AIRS) for air emissions, and the National Pollutant Discharge Elimination System (NPDES) for water pollutant discharges.

Indonesian manufacturing and socio-economic census data have been combined with observations on plant-level water pollution measured as part of the Environment Ministry's PROKASIH (Clean Rivers) Program during the period 1989-1990. Our plant-level emissions data have been provided by BAPEDAL, Indonesia's National Pollution Control Agency in the Ministry of Environment. Data on plant characteristics and socioeconomic characteristics of communities have been provided by BPS (Indonesia's Central Statistics Bureau), and are described in Pargal and Wheeler (1996).

4.1 US Variables

For the US case the dependent variables in our analysis include two air pollutants (SO_2 and TSP), two water pollutants (BOD and TSS) and the total quantity of toxic releases. We measure emissions volume in kg/day for both BOD and Total Suspended Solids (TSS); toxics are measured in pounds per year, as are SO_2 and TSP.

Our data on US plant characteristics, drawn from the LRD and COSTAT, include measures of output value, age and county-level employment share. As in the Indonesian case, we have used value added per employee as a proxy for productive efficiency. We have also included dummy variables for all nine two-digit US SIC manufacturing sectors.

Data for our US energy price index were obtained for each state for 1987 from the State Energy Price and Expenditure Report of 1991, published by the Energy Information Administration. This is a composite index for the industrial sector created from coal, natural gas, petroleum, and electricity prices, in dollars per million BTU. The local manufacturing wage in the US was computed from the LRD as the mean plant wage for each county. We lack direct measures of relative materials prices by sector, and have excluded them from the US regressions.

4.2 Data Description

The US data set used for toxics is the largest, with 12,005 observations common to the LRD and TRI. The characteristics of over 2,000 matching counties cover a wide distribution, with first and third quartiles of population density and per capita income ranging from 109 to 1403 people per square mile, and $10,000 to $13,075 respectively. Plant characteristics for the toxics sample are represented by a mean age of 25 years, mean wage of $22,000 per annum and a mean local employment share of 5.6%.

The air pollution data for the US include 1987 emissions information from 878 plants in the AIRS database which could be matched with the LRD. The matching community characteristics are less widely distributed, ranging between 139 and 1281 persons per square mile for first to third quartiles of population density and between $10,000 and $12,500 for per capita income. Plants in this sample have a mean age of 27 years, mean wage of $26,000 a year and mean local employment share of 8.5%.

The US water pollution data come from a sample of 1,368 plants in EPA's NPDES database which could be matched with the LRD. Here the matching counties are less densely populated: First and third quartiles range between 74 and 742 people per square mile. Per capita income is similar to the other data sets, with an interquartile range of $9,607 to $12,168. The plants have a mean age of 27 years, and employ a mean of 4.1 % of county workers at a mean annual wage of $26,000.

For Indonesia, out of a total sample of 253 plants, we have exact ownership information on 246: of these 3 are wholly foreign owned, 13 are completely owned by the government and 178 are private domestic firms. Factory age ranges from 0 years (2 firms) to 90 years (2 firms), with the median age of firms being 10 years. The geographic spread of the data is restricted to three islands - Java (189 plants), Sumatra (40 plants), and Kalimantan (24 plants) - and 8 provinces. Forty one ISIC codes or sectors are represented in the dataset, and firms range in size from 22 to 41,821 employees, with share in kabupaten employment varying from 0.02% to 91%. The kabupatens represented in the data are quite varied as well: 1990 population density ranges from 3.4 to 53,876 persons per square km., the proportion of the population with more than a primary education varies between 6.85% and 48.5%, and mean annual per capita expenditure varies from Rp. 256,447 to Rp. 837,277 (1990 Rp.).

5. RESULTS

The econometric results for Indonesia from Pargal and Wheeler (1996) are reproduced in Table 1, while comparative results for the US are reported in Table 2. Since we regress log (emissions) on log (output), the regression coefficients should be interpreted as partial effects on pollution intensity. The single exception is the result for log (output) itself, which should be reduced by 1 for interpretation in emissions-intensity form.

5.1 Standard Demand Variables

Among the standard demand variables, only scale economies emerge consistently in our results. In all cases except SO_2 in the US, the output elasticity of emissions is significantly less than one. Thus, emissions intensity generally declines with plant output, reflecting scale economies of abatement.

The input price results show no consistent pattern of complementarity or substitutability with labor and energy across pollutants. For Indonesian BOD emissions, only the crude materials price proxy is significant. In the US, there is evidence of significant emissions-labor substitutability for TSS and toxic emissions; emissions-energy substitutability for US SO_2 and emissions-energy complementarity for US TSS. Otherwise, cross-price effects are not significant. Within countries, labor and energy price variation seems to have had little effect on emissions intensity.

5.2 Firm- and Plant-Specific Variables

Except for sectoral differences, plant and firm characteristics show little evidence of consistent and significant impacts in these regressions. Value added per worker does have a negative, significant association with emissions intensity for the two variables which are not formally regulated: US toxics and Indonesian BOD. For the formally-regulated US pollutants, however, the results for this variable are inconsistent. We find no effect for water pollutants, but strong and significant positive associations for both air pollutants. These results suggest a different balance in air and water emissions between pure efficiency effects and profitability from lower abatement costs

Significant vintage effects are observable only for water pollution in Indonesia. This may not be too surprising, since even older US facilities have operated under strict regulation for a long time.

Our results for sectoral dummy variables are generally consistent with expectations about relative pollution intensity. In the case of Indonesia, where five sectors are amply represented in the data set, our results show that four are more BOD-intensive than other manufacturing sectors: Textiles, Leather Tanning, Food Products and Pulp and Paper. The BOD intensity for Wood Products is not significantly different from the average for other manufacturing. In the US case, we have included dummy variables for all two-digit SIC sectors, using Food Products as the excluded sector. This sector is known to have high intensity in organic water pollution (BOD), and relatively low intensity in toxics and standard air pollutants. Our results follow this pattern, and indicate the following relative intensities for other sectors (ceteris paribus): Textiles and Leather, Pulp and Paper, Chemicals and Metals have the highest intensity in toxics, while Food Products have the lowest; Textiles, Non-Metallic Minerals (principally cement) and Metals are most intensive in TSP, while Machinery and Miscellaneous Manufacturing are least intensive; Textiles and Leather and Chemicals are the most SO_2-intensive, while Machinery is least intensive. Not surprisingly, only Pulp and Paper is significantly more intensive in organic water pollution (BOD) than Food Products, although Textiles and Leather Tanning are also relatively BOD-intensive, as in the Indonesian case; Metals and Machinery are least BOD-intensive. Pulp and Paper and Miscellaneous Manufacturing are most intensive in TSS (total suspended solids), while Machinery is least intensive.

To summarize, our results suggest that plant and firm characteristics are more important determinants of emissions intensity in weakly-regulated economies. In the US we find strong scale and sectoral effects, but no consistent effect for vintage and efficiency. However, the Indonesian results for vintage, efficiency and public ownership are consistent with results obtained for Bangladesh, India and Thailand in other studies (Huq and Wheeler, 1993; Hartman, Huq and Wheeler, 1997).

5.3 Informal Regulation Variables

Our results suggest that informal regulatory forces are pervasive, even when strong formal regulation is in place. In both the US and Indonesia, the elasticity of all emissions intensities with respect to community income is negative, large, and generally highly significant (the only exception is US BOD). The estimated elasticity for the regulated US air pollutants is approximately equal to the Indonesian elasticity for BOD; US water pollutants and toxic emissions have lower, but still substantial, elasticities. As previously noted, these results may reflect income-related differences in both preferences and power.

The income result is critical for our central hypothesis, and there is some risk (see Section 3.5.1) of upward bias in the estimated impact when per capita income is used as a proxy for local informal regulation.[13] However, the argument for endogeneity is based on co-location of poor communities with pollution-intensive industry sectors. By introducing sectoral dummy variables, our equations measure the impact of income on pollution intensity *after dirty-sector location decisions have already been made*. As we noted in the previous discussion, our results confirm what is generally known about the relative pollution intensity of industry sectors. With the sector controls in place, our regressions allow us to focus on determinants of within-sector pollution abatement.

In a second, independent check for significant bias, we have analyzed the relationship between county income per capita and the location of the most highly-polluting US industry sectors. Using very different criteria, several empirical studies (Robison, 1988; Tobey, 1990; Mani, 1996; Hettige, Martin, Singh and Wheeler, 1994; Mani and Wheeler, 1997) have identified the same five 3-digit SIC sectors as large outliers in air, water and toxic pollution intensity: Iron and Steel (SIC 371); Non-Ferrous Metals (372); Industrial Chemicals (351); Pulp and Paper (341); and Non-Metallic Mineral Products (369). For the year 1987 (the same year as our plant sample), we have estimated a log-log function which relates per capita income in all US counties to the

[13] As might be expected, community income is highly correlated with community education in both countries. After controlling for income, education does not emerge as significant in either set of results. We reproduce the estimated coefficient for schooling in Indonesia, but have dropped education from the final US regressions.

ratio of value added in 'dirty' production (our five outlier sectors) to value added in other manufacturing activities.

In this context, there can be a serious problem of simultaneity bias only if the estimated effect of income on dirty-sector share is large and negative. However, our results (Table 3) show no relationship at all. They reinforce our view that the econometric result in Table 2 reflects the impact of income (and informal regulation) on *in situ* abatement, not location.

Results for our other two community-related variables -- plant share of local employment; population density -- are mixed. Under informal regulation, there may be a significant 'visibility effect' when polluting facilities can hide among other plants in urban/industrial areas. If this effect dominates, population density should be positively associated with emissions intensity. When formal regulation ensures visibility by requiring emissions reports, however, another effect should dominate: More densely-populated areas should exert pressure for greater cleanup because more people are adversely affected. The latter effect should be particularly strong for conventional air pollutants. In the US, our results are consistent with this interpretation for TSP, the most visible air pollutant. However, no other US pollutant has a significant relationship with population density. In the case of Indonesia, the significant, positive association between BOD intensity and population density is consistent with the dominance of the 'visibility effect' in an unregulated economy.

Our results for plants' local employment share are also mixed and have no ready interpretation. Under informal regulation, the estimated impact of relative size will reflect two considerations: the visibility of the plant as a polluter, and the benefits it brings to the community as an employer. Again, emissions reporting under formal regulation should reduce or eliminate the visibility effect. For regulated US pollutants, we might therefore expect the employment benefit effect to dominate, with larger employers having greater emissions intensity, ceteris paribus. This is indeed the case, although the effect is generally weak, except for the most visible pollutant, airborne TSP. This has a marginally-significant negative association, as does informally-regulated BOD in Indonesia.

6. SUMMARY AND CONCLUSIONS

In this paper, we have used plant-level data from the US and Indonesia to test a model of equilibrium pollution under informal regulation. The model yields a reduced form in which emissions intensity is related to variables in three categories: standard demand variables (scale, input prices); plant and firm characteristics (sector, efficiency, vintage, ownership); and informal regulatory variables (community income, population density, plant size relative to local economy). We have estimated emissions regressions for four formally-regulated US pollutants (TSP, SO_2, BOD, TSS); toxic pollution from US factories; and BOD emissions from Indonesian factories. Thus, the full set of regressions also includes implicit controls for formal regulation and level of economic development.

Our results suggest three common elements across countries and pollutants: Abatement is generally subject to significant scale economies; within-country variations in labor and energy prices have little impact on pollution intensity; and **community incomes have a powerful negative association with pollution intensity.** Although the plant and firm characteristics we have measured seem important in Indonesia (and other Asian developing economies we have studied), only scale and sector have consistent, significant effects in the US.

Our findings on community income are particularly important, since they suggest a powerful role for informal regulation whether or not formal regulation is in place. The impact of income disparity on inter-county differences in US pollution intensities seems to match the impact in Indonesia. Undoubtedly, this reflects differences in both preference for environmental quality and ability to bring pressure on polluting factories. The fact that such disparities exist in the US, even for traditionally regulated pollutants, shows that US regulation has not been able to ensure uniform environmental quality for all citizens regardless of income class.

Table 1 - INDONESIA (t-statistics in parentheses)

DEPENDENT VARIABLE:	LOG OF BOD EMISSIONS
INTERCEPT	17.479 (2.38)**
ECONOMIC VARIABLES	
Log [OUTPUT]	0.712 (3.78)***
Log [WAGE]	-0.316 (0.52)
Log [FUEL PRICE]	-1.267 (0.52)
D [JAVA]	-1.530 (2.98)***
PLANT/FIRM VARIABLES	
Log [VA/WORKER]	-0.312 (1.79)*
Log [AGE]	0.179 (1.07)
FOREIGN OWNERSHIP	0.0004 (0.06)
STATE OWNERSHIP	0.021 (2.91)***
COMMUNITY VARIABLES	
Log [LOCAL EMPLOYMENT SHARE]	-0.313 (1.84)*
Log [INCOME PER CAPITA]	-2.811 (3.02)***
Log [% GT PRIMARY EDUCATION]	-0.668 (1.17)
Log [POP. DENSITY]	0.128 (0.62)
D [TEXTILES]	1.247 (3.41)***
D [LEATHER TANNING]	1.961 (3.14)***
D [FOOD]	2.480 (4.52)***
D [PULP, PAPER]	2.265 (3.98)***
D [WOOD PRODUCTS]	-0.930 (1.02)
OBSERVATIONS	250
ADJUSTED R^2	.3805

a: White heteroscedasticity consistent standard errors in parentheses; *H_O: =0 rejected with 90% confidence (2 tail);

H_O: =0 rejected with 95% confidence (2 tail); * H_O: =0 rejected with 99% confidence (2 tail)

Source: Pargal and Wheeler (1996)

Table 2 - US (t-statistics in parentheses)

DEPENDENT VARIABLE:	LOG OF POLLUTION INTENSITY				
	TOXICS	BOD	TSS	SO_2	TSP
INTERCEPT	6.18 (4.58)***	3.38 (0.85)	5.54 (1.21)	21.73 (1.78)	16.77 (1.56)
ECONOMIC VARIABLES					
Log [OUTPUT]	0.69 (25.76)***	0.37 (4.86)***	0.50 (5.68)***	0.91 (3.64)***	0.88 (4.04)***
Log [WAGE]	0.84 (4.18)***	0.21 (0.39)	2.28 (3.60)***	-3.03 (1.56)	1.39 (0.81)
Log [FUEL PRICE]	-.012 (0.10)	-0.09 (0.27)	-0.96 (2.52)**	4.48 (2.69)**	-0.13 (0.09)
PLANT/FIRM VARIABLES					
Log [VA/WORKER]	-0.16 (4.51)***	-0.03 (0.31)	-0.14 (1.20)	0.94 (2.91)**	0.39 (1.38)
Log [AGE]	0.05 (0.83)	-0.11 (0.50)	-0.17 (0.66)	-0.31 (0.50)	0.42 (0.76)
COMMUNITY VARIABLES					
Log [LOCAL EMPLOYMENT SHARE]	0.08 (3.28)***	0.04 (0.58)	0.10 (1.17)	0.27 (1.10)	-0.34 (1.56)
Log [INCOME PER CAPITA]	-0.59 (3.58)***	-0.51 (1.08)	-1.27 (2.35)**	-2.85 (1.90)**	-2.69 (2.03)**
Log [POP. DENSITY]	0.02 (0.54)	-0.04 (0.54)	-0.03 (0.35)	0.13 (0.56)	-0.43 (2.02)**
D [TEXTILES, LEATHER]	1.77 (13.16)***	0.58 (1.53)	1.41 (3.24)***	2.11 (1.72)*	3.26 (3.02)***
D [WOOD PRODUCTS]	0.99 (7.67)***	-0.10 (0.16)	-0.02 (0.03)	-1.69 (1.57)	1.14 (1.20)
D [PULP, PAPER]	1.78 (14.76)***	2.98 (11.54)***	2.93 (9.85)***	0.78 (0.92)	-0.99 (1.32)
D [CHEMICALS]	1.44 (16.01)***	-0.53 (2.57)**	0.16 (0.66)	1.62 (2.18)**	1.03 (1.58)
D [NON-METALLIC MIN.]	0.51 (3.50)***	-1.64 (4.15)***	-0.48 (1.05)	1.01 (1.09)	3.53 (4.36)***
D [METALS]	1.50 (13.02)***	-2.03 (8.13)***	0.11 (0.39)	-0.05 (0.06)	2.04 (2.69)**
D [MACHINERY]	1.03 (11.78)***	-1.87 (8.54)***	-1.55 (6.14)***	-3.39 (4.49)***	-3.04 (4.58)***
D [MISC. MANUFACTURING]	0.92 (4.29)***	-1.33 (1.37)	3.38 (3.01)***	-1.10 (0.39)	-3.33 (1.35)
OBSERVATIONS	11,827	1,343	1,343	869	869
ADJUSTED R^2	.196	.315	.273	.211	.205

* H_O: = 0 rejected with 90% confidence (2 tail); ** H_O: = 0 rejected with 95% confidence (2 tail); *** H_O: = 0 rejected with 99% confidence (2 tail)

Table 3: Location of Pollution-Intensive Production vs. Income Per Capita: US Counties, 1987

DEPENDENT VARIABLE:	LOG (VA_D / VA_O)[a]
INTERCEPT	-1.199 (0.66)
LOG (INCOME PER CAPITA)	-0.17 (0.88)
OBSERVATIONS	2,464
ADJUSTED R^2	-.0001

[a] VA_D = Value Added in the five most pollution-intensive three-digit sectors

VA_O = Value Added in all other manufacturing sectors

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