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Evidence from India's Green Rating Project

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Abstract

Public disclosure programs that collect and disseminate information about firms' environmental performance are increasingly popular in both developed and developing countries. Yet little is known about whether they actually improve environmental performance, particularly in the latter setting. We use detailed plant-level survey data to evaluate the impact of India's Green Rating Project (GRP) on the environmental performance of the country's largest pulp and paper plants. We find that the GRP drove significant reductions in pollution loadings among dirty plants but not among cleaner ones. This result comports with statistical and anecdotal evaluations of similar disclosure programs. We also find that plants located in wealthier communities were more responsive to GRP ratings, as were single-plant firms.

Key Words: public disclosure, pollution control, India, pulp and paper

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Contents

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1. Introduction

Programs that collect and disseminate information about firms' environmental performance have been characterized as the "third wave" in environmental regulation, after command-and-control and market-based approaches [1]. Two types of national public disclosure programs have emerged over the past two decades [2]. So-called pollutant release transfer registries simply report emissions or discharge data without using them to rate or otherwise characterize environmental performance. More than 20 countries have set up such registries.[1] Like the seminal U.S. Toxic Release Inventory, most focus on toxic pollutants not covered by conventional regulations.

The second type of national public disclosure program both reports emissions or discharge data and uses them to rate plants' environmental performance. These programs are confined to developing countries and focus mostly on conventional pollutants. Examples include Indonesia's Program for Pollution Control, Evaluation, and Rating (PROPER), which was the first such program to appear and is the best known; India's Green Rating Project; the Philippines' EcoWatch program; China's GreenWatch program; and Vietnam's Black and Green Books initiative. These programs have been touted as a means of circumventing perhaps the most daunting obstacle to pollution control in developing countries: weak environmental regulatory institutions. Public disclosure does not necessarily require an effective enforcement

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[1] Countries that have at least the inception of a web-accessible pollution release transfer registry include Austria, Australia, Canada, Chile, the Czech Republic, Denmark, England, France, Germany, Hungary, Italy, Japan, Mexico, the Netherlands, Norway, Scotland, South Korea, Spain, and Sweden [2,33].

capability or even a well-defined set of environmental regulations. Furthermore, the costs of the administrative activities it does require—data collection and dissemination—are declining thanks to new information technologies [2].

Notwithstanding the promise and growing popularity of public disclosure, we know little about whether it actually improves environmental performance, in either industrialized or developing countries. As discussed in the next section, most evaluations to date have been anecdotal, and only a few rigorous analyses have appeared.

To help fill this gap, this paper evaluates the impact of India's Green Rating Project (GRP) on the environmental performance of the country's largest pulp and paper plants. To our knowledge, it is the first rigorous analysis of the GRP's environmental impact and only the second such evaluation of a developing country public disclosure program.[2] To identify the effect of the GRP, we control for other factors that drive cross-sectional and intertemporal variations in pollutant discharges using exceptionally detailed plant-level data, including both primary survey and secondary census data.

Our analysis suggests that the GRP drove significant reductions in pollution loadings among dirty plants but not among cleaner ones. This result comports with statistical and anecdotal evaluations of similar disclosure programs [2,3,4]. We also find that plants in wealthier communities were more responsive to GRP ratings, as were single-plant firms.

The remainder of the paper is organized as follows. Section 2 reviews the literature on public disclosure and presents a conceptual framework for our empirical analysis. Section 3 provides background information on the GRP and the Indian pulp and paper industry. Section 4 describes the empirical framework and the data used in the regression analysis. Section 5 presents our econometric results, and Section 6 concludes.

2. Literature Review and Conceptual Framework

This section briefly reviews the empirical literature on public disclosure programs, focusing on two questions: do they improve environmental performance, and if so, how? Then, drawing on the literature, it presents a heuristic graphical model of public disclosure to underpin the econometric analysis.

[2] To the best of our knowledge, the only other developing country program that has been rigorously evaluated is the PROPER program; see Garcia et al. [3] and Garcia et al. [4] for details.

2.1. Does public disclosure improve environmental performance?

Only a few papers have evaluated environmental performance rating programs like the GRP, but all have concluded that the programs have generated environmental benefits. Of these papers, to our knowledge, only two—García et al. [3] and Garcia et al. [4]—present a rigorous statistical analysis. Using panel data on both participants and nonparticipants, the authors test whether Indonesia's PROPER drove reductions in water pollution. They find that the program in fact spurred significant emissions reductions, particularly among plants with poor compliance records. Dasgupta et al. [2] present a largely qualitative evaluation of performance rating programs in Indonesia, the Philippines, China, and Vietnam. In each program, the authors find that a large number of plants initially rated "noncompliant" improved to "compliant" over time (although plants rated "flagrant violators" and "compliant" tended to remain in these categories). Without additional statistical analysis, however, one cannot determine whether public disclosure or exogenous changes in technological, regulatory, or market conditions were responsible for the apparent increase in compliance. Wang et al. [5] provide a more detailed but still primarily anecdotal evaluation of the Chinese performance ratings program that suggests it succeeded in improving environmental performance.

Several recent papers evaluate public disclosure initiatives other than environmental performance rating programs and also find significant impacts on environmental performance. Bennear and Olmstead [6] find that a 1996 amendment to the U.S. Safe Drinking Water Act, mandating that community drinking water systems publicly report regulatory violations, reduced the incidence of subsequent violations. Similarly, Delmas et al. [7] find that regulations requiring U.S. electric utilities to mail bill inserts to consumers reporting the extent of their reliance on fossil fuels led to a significant decrease in fossil fuel use. And Foulon et al. [8] find that a policy of publicly disclosing the identity of plants that are noncompliant or "of concern" spurred emissions reductions in a sample of pulp and paper plants in British Columbia.

Finally, a number of papers have examined the U.S. Toxic Release Inventory [9,10,11,12]. Since the program began in 1986, total reported releases of the toxics it covers have fallen by at least 45 percent. However, it is not clear that public disclosure has been responsible for this decline. Data on toxic releases are not available for the period preceding the program, or for plants that fall outside the program, and as a result the usual means of estimating releases absent the program are not available [6].[3]

2.2. How might public disclosure improve environmental performance?

Tietenberg [1] identifies seven "channels" through which public disclosure may motivate improved environmental performance. To simplify the exposition, we group these channels into four broad categories.

Output market pressures. Disclosure may affect the demand for firms' goods.

Input market pressures. Disclosure may affect the demand for firms' securities and the firms' ability to hire and retain employees.

Judicial pressures. Disclosure may encourage private citizens to initiate tort law actions against polluters, motivate private suits to force firms to undertake abatement, and give rise to judicial actions in countries whose constitutions guarantee citizens the right to a healthy environment (as in India).

Regulatory pressures. Disclosure may build support for new pollution control legislation or better enforcement of existing legislation.

Based on the literature discussed below, we add two more mechanisms.

Community pressures. Disclosure may enhance pressures that community groups and nongovernmental organizations place on polluters to cut their discharges.

Managerial information. Disclosure may provide new information to managers about their plants' discharges and options for reducing them.

Empirical analysis aimed at determining which of those six mechanisms explain how various public disclosure programs have their effect is limited. To our knowledge, only a few empirical papers have examined this issue as it relates to performance rating programs, like the GRP and PROPER. Gupta and Goldar [13] test whether GRP ratings affect the stock prices of Indian companies in the pulp and paper, chlor alkali, and automobile sectors (three of the four sectors rated by the GRP, the other being cement, which was rated after 2005). They find that

[3] Moreover, several papers propose alternative explanations for the observed reductions in toxic releases, including the imposition of more stringent conventional regulation [11]; plants' practice of substituting unlisted toxics for listed ones [34]; and simple underreporting of emissions [12].

poor GRP ratings led to significant negative abnormal returns. These results suggest that GRP may have an important effect on environmental performance through capital markets. Blackman et al.'s [14] survey of managers of plants participating in PROPER generated data suggesting that an important means by which the program spurs abatement is improving managerial information. Garcia et al. [4] identify characteristics of Indonesian plants that were more responsive to PROPER ratings and find that foreign-owned plants, those in more densely populated areas, and those with low initial ratings were more responsive, all other things equal.

The empirical literature on the workings of public disclosure initiatives other than performance rating programs has focused mainly on capital markets. Although this research clearly shows that public disclosure can affect stock prices [15,16,17], it does not establish that the changes in stock prices have, in turn, affected firms' pollution control activities. However, Konar and Cohen [9] and Khanna et al. [18] find evidence suggesting that this can occur.

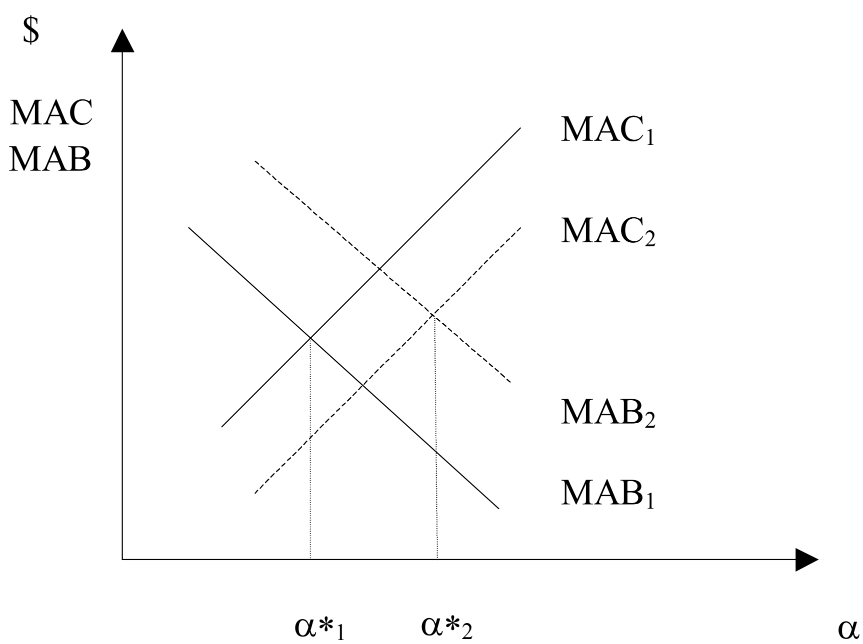
Beyond the studies cited thus far, empirical research on how public disclosure per se has an impact is quite limited. However, the literatures on "voluntary regulation" and "informal regulation" are relevant. The literature on voluntary regulation examines pressure to overcomply with mandatory regulations generated by regulators, markets, and courts (see Lyon and Maxwell [19] and Khanna [20] for reviews). For example, Segerson and Miceli [21], Maxwell et al. [22], and Glachant [23] present analytical models in which firms voluntarily overcomply to preempt more stringent mandatory regulation; some empirical research supports this approach [24,25]. Arora and Gangopadhayay [26] hypothesize that firms overcomply with environmental regulations to attract "green" consumers. Some empirical evidence also supports this proposition. Finally, empirical research by Videras and Alberini [24], Sam and Innes [25], and Vidovic and Khanna [27] suggests that judicial pressure can also drive voluntary overcompliance.

The literature on informal regulation focuses on pressures to abate generated by private sector agents in developing countries where state regulation is weak or effectively nonexistent (see World Bank [28] for a review). For example, Pargal and Wheeler [29] examine the environmental performance of plants in Indonesia at a time when regulatory enforcement was negligible (and before the PROPER program was initiated); they find that emissions were lower in communities with higher per capita income and higher levels of education, implying that such communities effectively pressure plants to abate (see also Blackman and Bannister [30]).

2.3. Conceptual framework

This section presents a heuristic graphical model of public disclosure to underpin the econometric analysis (see Appendix 1 for an analytical version of the model). It draws upon the standard representation of a plant's abatement decision in the environmental economics literature (see, e.g., World Bank [28]). We assume marginal abatement costs (MAC) are increasing in abatement while (private) marginal abatement benefits (MAB) are decreasing in abatement (Figure 1). The plant chooses the level of abatement, α^*, such that MAC equals MAB.

Figure 1. Marginal abatement cost (MAC) and marginal abatement benefit (MAB) schedules; optimal abatement level, α*



Drawing on the literature surveyed in Section 2, we define six channels through which public disclosure might affect the firm's abatement decision. The first five channels have to do with the costs that can be imposed on dirty firms by green consumers (g), input (capital and labor) markets (k), courts (j), regulatory authorities (r), and communities (c). The sixth channel is related to the costs of pollution abatement arising from the plant's need to acquire information about abatement technologies and its own pollutant discharge (t). We use Figure 1 to illustrate how each channel might affect the firm's abatement decision. First, public disclosure could either reduce or enhance consumers' demand for the firm's output, depending on whether the firm is relatively clean or dirty (g). Either effect, in turn, implies the marginal benefit to the firm of cutting discharge will be greater regardless of the actual level of abatement. For a clean firm, disclosure enhances its demand, but for a dirty firm, disclosure decreases its demand. Graphically, in either case, the MAB curve shifts up and in equilibrium the firm chooses a higher level of abatement. Similarly, depending on whether the plant is dirty or clean, public disclosure could either raise or lower costs imposed by regulators (r), input markets (k), communities (c), and courts (j). Once again, regardless of whether the plant is clean or dirty, each of these effects shifts the MAB curve up and results in a higher equilibrium level of abatement. Finally, public disclosure could reduce the cost to firms of acquiring information about abatement (t), lowering the marginal cost of abatement at every level of abatement. In this case, graphically, the MAC curve shifts down, and the end result is a higher level of abatement.

3. Background

3.1. Green Rating Project

The Centre for Science and Environment (CSE), one of India's best-known and most influential environmental nongovernmental organizations, began work on the GRP in 1997. According to CSE background materials, the program was urgently needed to shore up India's weak environmental regulatory institutions and was inspired by the Council on Economic Priorities, a now-defunct U.S. nongovernmental organization that provided investors with annual ratings of the environmental performance of U.S. companies.

To date, the GRP has rated the environmental performance of large plants in four pollution-intensive industrial sectors: pulp and paper, chlor-alkali, cement, and automobiles. Plants in the pulp and paper sector have been rated twice (once in 1999 and again in 2004); plants in the other three sectors have been rated just once. In each rating, plants are assigned a numerical score from 0 to 100 and are awarded symbolic "leaves" depending on their score: five leaves for scores of 75 and above, four for 50–74, three for 35–49, two for 25–34, one for 15–24, and none for 14 and below. The GRP scores are based on an evaluation of the plant's life-cycle environmental impacts, from the sourcing and processing of raw materials to the manufacture, use, and disposal of products. The exceptionally detailed data needed to conduct this cradle-to-grave analysis are collected from questionnaires administered to participating plants, along with secondary data provided by local environmental regulatory institutions and other sources. Both the questionnaires used to collect the data and the methodology used to analyze them were designed by a panel of leading technical experts in each rated sector. In addition, to ensure objectivity and transparency, the entire GRP program is supervised by a panel comprising high-level representatives of industry, government, the judiciary, academia, and nongovernmental organizations. Lastly, self-reported data from the firms are carefully checked by GRP inspectors and compared with the secondary data.

In addition to informing the public about plants' environmental performance, the GRP also informs plants about their pollution and pollution abatement options. The program uses the primary and secondary data it collects to construct a detailed environmental profile of each plant and sends it to the facility for review before releasing the ratings to the public. The program also publishes specific recommendations for improving environmental performance in each sector. Finally, the ratings are released at a high-profile public event by leading public figures. For example, some ratings were released by the late Dr. K.R. Narayanan, India's former president.

3.2. Pulp and paper sector

Pulp and paper is a notoriously dirty industry worldwide. The environmental performance of mills in North America and Scandinavia, which tend to be much larger and more modern than their developing-country counterparts, has improved considerably over the past few decades. Indian mills lag behind, with per unit measures of industrial pollution 5 to 10 times higher than those of Western plants [31].

Making paper involves four main steps, all of which generate water pollution: raw material processing, pulping, bleaching, and papermaking.[4] To reduce pollution loadings, plants undertake both pollution control and prevention. All the plants rated by the GRP have wastewater treatment plants. In addition, to prevent pollution, mills have eliminated particularly dirty inputs, adopted good "housekeeping" measures, improved chemical recovery systems, and modified the pulping process.

As previously mentioned, the pulp and paper sector is the only sector that has been rated twice. As a result, survey data on environmental impact indicators and other relevant variables are available for several years before and after the first rating. This allows us to construct a counterfactual—that is, an estimate of what pollution would have been absent the program—needed to identify the impact of the GRP. Because the necessary data on environmental

[4] See CSE [31] or Schumacher and Sathaye [35] for more detail.

indicators and firm behavior are not available after the second rating, we can analyze the effectiveness of only the first rating.

The first rating included all 28 plants in the pulp and paper industry with a production capacity exceeding 100 tons per day in fiscal year 1998[5] (India's fiscal year ends on March 31; all years referred to in this paper and accompanying figures are fiscal years). Collectively, these plants were responsible for 59 percent of pulp and paper production in India. They were contacted for the survey in January 1998, toward the end of fiscal year 1998, and asked to provide data (that they normally track and record anyway) for 1996 through 1998. The ratings for these plants were released by Dr. Manmohan Singh, India's current prime minister, on July 18, 1999. All major Indian daily newspapers covered the event. Of these 28 plants, 22 were rated a second time in 2004 and responded to questionnaires for 1999–2003.[6] Again, the data were reported retroactively. For the remainder of the paper we will refer to years 1996–1998 as predisclosure and 1999–2003 as postdisclosure.

3.3. Trends in pollution indicators

Average annual discharge data for 1996–2003, as shown in Figures 2 and 3, suggest that the environmental performance of particularly dirty plants—those that received one leaf in the 1999 rating—did in fact improve significantly during 1999, the year of the first GRP rating. Figure 1 shows trends in chemical oxygen demand (COD), and Figure 2 shows trends in total suspended solids (TSS)—two common measures of water pollution.[7] Both pollutants declined dramatically after 1998 for plants that received a one-leaf rating, but not for plants with higher ratings.

[5] By way of comparison, the average plant in the United States has a capacity of nearly 600 tons/day [31]. GRP's size criteria excluded more than 500 smaller plants.

[6] Of the six plants that were rated in the first period but not the second, five were permanently closed and one was temporarily closed after the first rating.

[7] COD is a measure of the amount of oxygen needed to fully oxidize the organic compounds in water to carbon dioxide; it is a linear function of the chemical composition of the organic pollutants in a sample of water. TSS is even more straightforward: it is the dry weight of particles suspended in a sample of water and, like COD, is typically expressed in mg/L. To properly scale for water use, we convert both measures and express them as kg/bdmt of product. This is done by multiplying first by a constant, then by the amount of water used to produce a bone dry metric ton of product.

Figure 2. Annual unweighted average discharges of chemical oxygen demand (COD) from 22 pulp and paper plants participating in India's Green Ratings Project, by performance rating

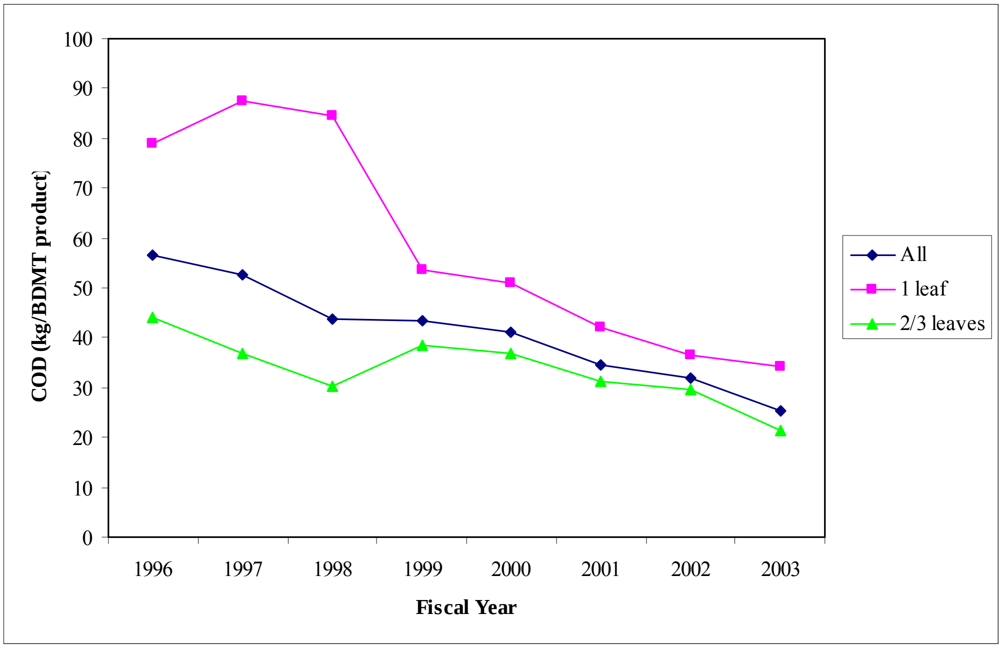
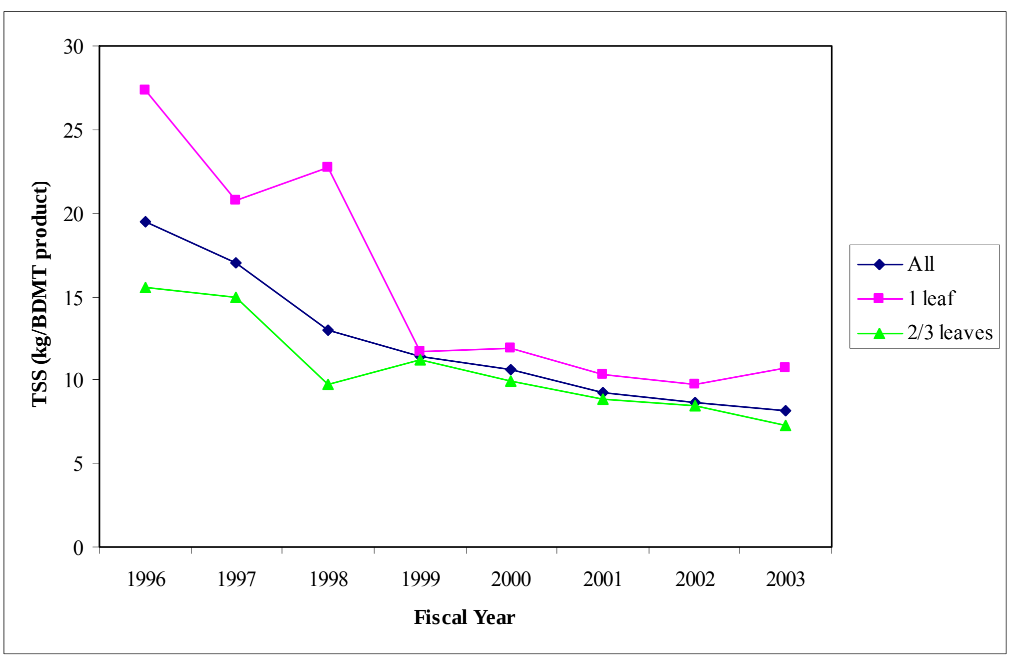


Figure 3. Annual unweighted average discharges of total suspended solids (TSS) from 22 pulp and paper plants participating in India's Green Rating Project, by performance rating



The fact that the most dramatic reductions in discharges took place in 1999, the year that the ratings were released, suggests that the rating prompted improvements in the environmental performance of poorly performing plants. These reductions, however, could have been caused by contemporaneous changes in technological, market, and regulatory conditions that influence the plants' pollution loadings. For example, they could have been caused by reductions in the relative price of cleaner inputs that happened to coincide with the release of the GRP ratings. To identify the impact of the GRP, we develop an econometric model that can control for such confounding factors.

4. Empirical framework

The first goal of our empirical analysis is to determine whether the drops in COD and TSS levels depicted in Figures 2 and 3 were caused by the GRP and not by confounding factors. In addition, if we find that the GRP was, in fact, responsible, we seek to identify the channels through which it had this effect.

4.1. Econometric model

4.1.1. GRP's impact

To isolate the impact of the GRP, we run separate fixed-effects ordinary least squares (OLS) panel-data models for COD and TSS of the form

$$\begin{aligned} (1) \quad y_{it} = \alpha_i + \beta_1 \mathrm{TREND} + \beta_2 \mathrm{POSTGRP}_t + \beta_3 \mathrm{TREND} * \mathrm{ONELEAF}_i \\ + \beta_4 \mathrm{POSTGRP}_t * \mathrm{ONELEAF}_i + \beta_5 \mathbf{x_{it}} + u_{it} \end{aligned}$$

where α_i is the plant fixed effect, TREND is a linear time trend, $\mathrm{POSTGRP}_t$ is a dummy variable that takes the value one for the postdisclosure period (1999–2003) and zero otherwise, $\mathrm{ONELEAF}_i$ is a dummy variable for plants that received a one-leaf rating, and $\mathbf{x}_{it}$ is a vector of confounding factors including plant characteristics, input prices, and measures of regulatory pressure (Table 1).[8] TREND allows us to control for exogenous improvements in technology that could affect pollution levels prior to and after the information disclosure.[9] TREND*ONELEAF allows exogenous improvements in technology (both before and after the disclosure) to differ between dirtier plants and relatively clean plants. $POSTGRP_t$ is included to capture the impact of the ratings on firm behavior. Finally, $POSTGRP_t$ *ONELEAF allows the effect of $POSTGRP_t$ to differ between dirty and clean plants.[10] To allow for heteroskedasticity across plants and arbitrary serial correlation within each plant, we report standard errors that are clustered by plant [32].[11]

4.1.2. GRP channels

To analyze the channels through which the GRP potentially affects firm behavior, we run separate models for COD and TSS of the form

$$(2)\quad \begin{aligned} y_{it} &= \alpha_i + \beta_1 \mathrm{TREND} + \beta_2 \mathrm{POSTGRP}_t + \beta_3 \mathrm{TREND} * \mathrm{ONELEAF}_i \\ &+ \beta_4 \mathrm{POSTGRP}_t * \mathrm{ONELEAF}_i + \beta_5 \mathbf{x_{it}} + \beta_6 \mathrm{TREND} * \mathbf{z_i} + \beta_7 \mathrm{POSTGRP}_t * \mathbf{z_i} + u_{it} \end{aligned}$$

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[8] Although we expect the error terms in the COD and TSS regressions to be correlated, we do not use a seemingly unrelated regression (SUR) approach because there is no reason, a priori, to omit any explanatory variables from either of the two regressions. When the same explanatory variables appear in both regressions, SUR is equivalent to OLS [36, p. 343] and yields no efficiency gain. The only advantage of SOLS in this case is that it allows for joint hypothesis testing across the two regressions. The disadvantage is that SOLS routines in standard statistical packages do not allow for clustered standard errors. SOLS results (available from the authors upon request) comport with the OLS results presented in Tables 2 and 3: although the individual coefficients of interest are not always significant, they have the same sign, and testing the joint significance of these coefficients in both equations rejects the null hypothesis that they are jointly zero.

[9] The choice of a linear trend term, as opposed to other functional forms, is based on preliminary regressions using predisclosure data. In these regressions, available from the authors upon request, the addition of a quadratic term adds little explanatory power.

[10] We also experimented with the possibility that the disclosure program induced a persistent increase in the rate of environmental progress (which would be consistent with a change in the slope of the trend term) rather than in a one-time shift of the equilibrium path (consistent with a one-time decrease in the intercept term). The most obvious way to identify such an effect would be to include an additional trend term that takes only positive values after disclosure. However, given the sample size and a high degree of multicollinearity between the postdisclosure trend term and the original trend term, this renders identification difficult. Furthermore, regression results (available from the authors upon request) suggest that the one-time drop is more consistent with the data than is a change in the trend. Accordingly, we proceed without the postdisclosure trend variable.

[11] Although the inclusion of fixed plant effects allows for heterogeneity in the form of a mean plant-specific unobservable component, we still need to allow the variance to differ across plants. Also, although it is reasonable to assume independence of the error terms across plants, we cannot, a priori, rule out persistence in the error term within a plant.

where $\mathbf{z_i}$ is a vector of time-invariant plant and community variables, such as whether the plant is part of a conglomerate and the level of community wealth. This specification allows us to determine whether plants with certain characteristics and in certain communities responded differently to the program. This in turn sheds light on the channels through which GRP has an effect. Note that because these community and plant variables are time-invariant, we cannot identify their effect on pollution intensity independent of the plant fixed effect. This does not pose a major problem, however, since unlike Pargal and Wheeler [29], we are not interested in the coefficients on these variables per se. Rather, we are interested in determining whether these characteristics have any additional effect once the disclosure program changes the institutional landscape.

4.2 Data

As discussed above, most of our data come from GRP surveys. In addition, we used data from the 2001 Indian census to construct proxies for several community characteristics; data from Prowess, an on-line business database, to construct company-level (versus plant-level) variables and a regional energy price index; and finally, data from Indiastat, an on-line database of Indian statistics, to construct price indices for a number of inputs.[12] The independent and dependent variables used in the regressions are described below. See Table 1 for summary statistics.

[12] For information on Prowess, see http://www.cmie.com/database/?service=database-products.htm, and for information on Indistat, see http://www.indiastat.com.

Table 1. Variables in econometric analysis and descriptive statistics

Variable	Description	Mean	S.D.	Min.	Max.
COD	Natural log of chemical oxygen demand (kg/bdmt)	3.37	0.90	0.04	5.43
TSS	Natural log of total suspended solids (kg/bdmt)	2.10	1.07	-2.74	4.08
POST-GRP	1999 or later (0/1)	0.72	0.45	0	1
ONELEAF	Received one leaf in 1999 grp rating (0/1)	0.31	0.47	0	1
TREND	Linear time trend term (1996 = 1, 1997 = 2, … 2003 = 8)	4.74	2.23	0	8
SCALE	Natural log of output (kg/bdmt)	11.19	0.55	9.84	12.21
FINALGOOD	Percentage of output that is final (vs. intermediate) product	0.62	0.35	0	1
PCTBAMBOO	Percentage of fiber inputs from bamboo	0.29	0.34	0	1
PCTGRASSES	Percentage of fiber inputs from grasses	0.02	0.08	0	0.56
PCTRECYCL	Percentage of fiber inputs from recycled materials	0.12	0.22	0	1
PCTPULP	Percentage of fiber inputs from market pulp	0.10	0.22	0	1
FORSHARE	Percentage of sales derived from exports	0.05	0.05	0	0.20
PRICE_WAGES	Inflation-adjusted national avg. daily wages for nonagricultural unskilled workers	0.35	0.02	0.32	0.39
PRICE_CL	Inflation-adjusted national avg. price of chlorine	1.01	0.12	0.83	1.25
PRICE_NAOH	Inflation-adjusted national avg. price of sodium hydroxide	0.83	0.13	0.68	1.08
PRICE_WOOD	Inflation-adjusted national avg. price of wood	1.17	0.15	0.96	1.41
PERMIT	Water effluent permit (0/1)	0.87	0.34	0	1
EFFRIVER	Percentage effluents discharged into a river (vs. land, etc.)	0.68	0.42	0	1
WEALTH	Percentage households in subdistrict that own moped	0.41	0.20	0.12	0.79
SINGLE	Stand alone plant (0/1)	0.45	0.51	0	1

4.2.1. Environmental performance

Because all 22 plants in the sample have effluent treatment plants, COD and TSS measurements reflect posttreatment or "end-of-pipe" quantities. In India, as in most countries, regulatory standards for these pollutants are specified in milligrams per liter of effluent. In India, however, where water is inexpensive, the use of this metric creates an incentive for plants to dilute their liquid discharges. To control for this effect, we measure COD and TSS in kilograms (kg) per bone-dry metric ton (bdmt) of pulp and paper product. Our resulting measure, kg/bdmt, gives water pollution per unit of product produced. Finally, because we are interested in the responses of both clean and dirty plants, we use logged values of both dependent variables so that our coefficient estimates measure the relative change in the dependent variable for a given absolute change in the values of the respective explanatory variables.

4.2.2. Confounding factors

We use a broad set of regressors to control for factors other than public disclosure that affect pollution loadings, including variables related to plant characteristics, input prices, and interactions with regulators. Unless otherwise indicated, these data were derived from GRP survey data. Among the plant characteristics, SCALE is the log of the amount of final product produced by a given plant in a given year (measured in bone dry metric tons because moisture content can vary between different classes of products). FINALGOOD is the proportion of a plant's output that represents final products (such as writing and tissue paper) used directly by consumers. This variable is meant to proxy for consumer pressure for environmental quality. PCTBAMBOO, PCTGRASSES, PCTRECYCL, and PCTPULP measure the proportion of fiber inputs derived from bamboo, grasses, recyclables, and market pulp, respectively (wood is the omitted category, and agroresidues are also dropped, because these are collinear with plant fixed effects). FORSHARE is the share of sales derived from exports, a firm-level variable derived from the Prowess database. This variable is meant to capture pressure for improved environmental performance generated by foreign investors and consumers.

Among the input price variables, PRICE_NAOH and PRICE_CL are inflation-adjusted country-wide price indices for sodium hydroxide and chlorine, the major chemicals used in the pulping and bleaching processes. PRICE_WOOD is an inflation-adjusted national price index for wood. This serves as a proxy for fiber input prices.[13] Finally, PRICE_WAGES is an inflation-adjusted national price index for average daily wage rates for nonagricultural, unskilled workers.

Two variables are used to proxy for changes in regulatory pressure. PERMIT is a dummy variable that takes the value one if the plant has been granted a water effluent permit by its state pollution control board and zero otherwise. EFFRIVER is the percentage of the plant's effluent discharged into a river (versus on land or in the sea) in a given year. Effluent discharged into a river must, by law, be cleaner, so it is important to control for shifts in the discharge destinations of effluents.

4.2.3. Channels

We use two variables to establish possible channels of influence, WEALTH and SINGLE. We experimented with several other variables that could conceivably be related to the

[13] We were unable to find sufficient data to construct similar indices for any of the other fiber inputs—bamboo, grasses, agro-residues, recycled paper, and market pulp. However, these prices will generally be related to wood prices in India where the fiber inputs are substitutable [31, p. 40]. Also we do not include a variable measuring water costs because the price industrial users pay for water is minute and there was no variation over time in the water prices for period in question.

level of plant response.[14] However, to keep the exposition manageable, we present (in Section 5.2) only those models in which interaction terms are significant. WEALTH is the percentage of households in the plant's subdistrict (similar to a U.S. county) that own mopeds.[15] SINGLE is a dummy variable that takes the value one if the plant is the unique establishment owned by the company, and zero otherwise. This variable serves as a proxy for organizational differences that could affect the way different plants respond to the GRP ratings. Any plant for which SINGLE equals zero is either part of a larger pulp and paper company or part of a diversified conglomerate.

5. Results

5.1. GRP's impact

As previously noted, Figures 2 and 3 suggest not only that COD and TSS levels are lower after disclosure but also that reductions were greatest among the worst-performing plants. The first objective of our empirical analysis is simply to test whether these results are statistically significant. Two specifications for each dependent variable are presented in Table 2; Model 1 (for COD) and Model 2 (for TSS) include only regressors related to the disclosure program: TREND, POST-GRP, and ONELEAF, along with interaction terms for ONELEAF. Models 3 and 4 include all time-varying covariates as well.

[14] These include LITERACY, the percentage of the population that is literate in the municipality where the plant is located; CASTE, the percentage of the municipal population that belongs to a scheduled caste or scheduled tribe; AGLABOR, the proportion of the workers in the municipality who are either cultivators or agricultural laborers; URBANPCT, the proportion of the population in the subdistrict who live in municipalities that are classified as urban; and COMPTOWN, the percentage of nonagricultural laborers in a subdistrict who work for the plant. We also investigated whether interaction terms involving variables that proxy for other channels were significant. These include ENFWATER, a dummy variable that equals 1 if the plant had been fined or faced some other enforcement action from the regional pollution control board for water pollution prior to disclosure; COMWATER, a dummy variable that equals 1 if the plant had been the subject of registered complaints about water pollution prior to disclosure; and GOV, a dummy variable that equals 1 for government-owned plants.

[15] The census data provide alternative measures of wealth, all involving the percentage of households owning a particular asset (or employing banking services). These measures are all highly correlated, and our regression results using other wealth measure are qualitatively identical.

Table 2. OLS regression results: Green Ratings Project impact
(clustered standard errors in brackets; all regressions include plant fixed effects)

Model number	1	2	3	4
Dependent variable	COD	TSS	COD	TSS
TREND	-0.136	-0.12	-0.124	-0.154
	[0.025]**	[0.026]**	[0.039]**	[0.032]**
POST-GRP	0.308	0.021	0.201	0.087
	[0.107]**	[0.109]	[0.129]	[0.111]
ONELEAF*TREND	0.043	0.064	0.014	0.066
	[0.038]	[0.043]	[0.033]	[0.046]
ONELEAF*POST-GRP	-0.446	-0.445	-0.411	-0.527
	[0.142]**	[0.154]**	[0.185]*	[0.215]*
SCALE			0.051	-0.274
			[0.229]	[0.146]+
FINALGOOD			-0.453	-0.242
			[0.296]	[0.260]
PCTBAMBOO			-0.529	-0.336
			[0.357]	[0.344]
PCTGRASSES			0.545	-0.906
			[1.247]	[1.377]
PCTRECYCL			-0.492	-0.927
			[0.511]	[0.369]*
PCTPULP			-2.081	0.736
			[1.524]	[0.911]
PRICE_WAGES			1.648	4.033
			[1.262]	[1.769]*
FORSHARE			-0.473	-2.252
			[0.639]	[0.727]**
PRICE_NAOH			0.028	-0.874
			[0.527]	[0.361]*
PRICE_CL			-0.191	-0.489
			[0.220]	[0.238]+
PERMIT			-0.061	-0.133
			[0.088]	[0.077]+
EFFRIVER			-4.399	-4.551
			[1.444]**	[0.790]**
PRICE_WOOD			-0.186	-1.093
			[0.503]	[0.363]**
Constant	3.85	2.695	6.89	10.577
	[0.066]**	[0.080]**	[3.321]+	[1.981]**
Observations	155	153	154	152
R-squared	0.49	0.58	0.56	0.64
Wald statistic	-1.46	-3.90	-1.10	-2.09

+ significant at 10%; * significant at 5%; ** significant at 1%

In Models 2, 3, and 4, the POST-GRP dummy is not significant. In Model 1 it is positive and significant, although this significance disappears when all covariates are included in Model 3. We conclude that the 1999 GRP rating did not have a significant pollution-reducing impact *on the average plant*, including both good and poor environmental performers.

The interaction terms in Table 2—ONELEAF*TREND and ONELEAF*POST-GRP—allow us to test a second hypothesis suggested by Figures 2 and 3: following the first rating, one-leaf plants improved their environmental performance more than two- and three-leaf plants. The negative and statistically significant coefficients on ONELEAF*POST-GRP in all four models in Table 2 suggest that this hypothesis is correct.

The important question that follows from this pair of findings is whether the net effect of GRP on one-leaf plants was significant. A simple Wald test of the sum of the coefficients on POSTGRP and ONELEAF*POSTGRP allows us to test this hypothesis. The results, reported in the bottom row of Table 2, suggest that GRP did drive reductions in TSS by one-leaf plants. The net effect for COD was not significant, however.

In all regressions TREND is negative and significant, suggesting that exogenous technological improvements in the pulp and paper industry, independent of the GRP, are also responsible for declines in pollution loads. The results for the other covariates unrelated to the GRP rating shown in columns 3 and 4 are largely consistent with stylized facts about the determinants of water pollution in the pulp and paper industry. In Model 4 (for TSS), SCALE, PCTRECYCL, FORSHARE, PRICE_NAOH, PRICE_CL, PERMIT, EFFRIVER, and PRICE_WOOD are negative and significant, and PRICE_WAGES is positive and significant. In Model 3 (for COD), EFFRIVER is negative and significant. These results comport with the conventional wisdom that pollution abatement entails economies of scale (SCALE); pollution loadings are decreasing in the share of nonwood inputs (PCTRECYCL); plants that export are subject to more pressure to improve their environmental performance (FORSHARE); pollution loadings are decreasing in the price of polluting inputs (PRICE_NAOH, PRICE_CL, and PRICE_WOOD); regulatory pressure spurs abatement (EFFRIVER and PERMIT); and labor and pollution abatement are substitutes in production (PRICE_WAGES). It is encouraging that coefficients on these regressors have the same sign, if not significance, in Models 3 and 4.

To assess the economic significance of the estimates, we analyze the effect of disclosure on a hypothetical plant that received one leaf in the first rating and had mean values for all other covariates, using the estimation results from Models 3 and 4. With GRP disclosure, such a plant's COD discharges would decrease by 63 percent between 1996 and 2003. However, absent disclosure, the plant's COD discharges would have decreased by only 54 percent. The effect of the disclosure program is stronger when we focus on TSS. The plant's emissions would decrease 65 percent with the disclosure program but only 46 percent without it.

Finally, it is important to note that of the six pulp and paper plants that participated only in the first round of the GRP, five—those ranked 5th, 17th, and 24th–26th of the 28 plants evaluated in the first round—went out of business before the second round was initiated. In at least two cases, environmental protests were an important reason.[16] Although we do not have enough observations to formally model these closures (using a Heckman selection approach), they suggest that, if anything, our econometric results probably understate the impact of the 1999 ratings.

5.2. GRP channels

The regressions presented in Table 3 explore whether certain types of plants were more responsive to GRP disclosure. We use an identification strategy similar to that employed to test whether one-leaf plants were more responsive: we create variables that interact various time-invariant plant or community characteristics with POSTGRP.[17] In addition, we control for the possibility that these characteristics affect the slope of the trend term using a second set of variables that interact the time-invariant plant or community characteristics with TREND. Instead of including all interaction terms in a single model, we include pairs of interaction terms corresponding to a single characteristic (e.g., TREND*WEALTH and POSTGRP*WEALTH) in separate models. There are three reasons: several of the interaction variables formed are highly collinear (in part because all take a value of zero for the three predisclosure years); including several sets of these interaction variables simultaneously poses a degrees-of-freedom problem; and we are more interested in identifying channels by which disclosure has an effect than in identifying the strongest among several closely related channels. To make the exposition manageable, we present only those models in which interaction terms are significant.

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[16] Personal communication, Monali Zeya Hazra, Center for Science and the Environment, March 13, 2007.

[17] Some of the characteristics we use to construct these interaction terms, such as EFFRIVER, display some minor variation over time. For these, we calculate the predisclosure average and interact it with the postdisclosure dummy to create the corresponding interaction term.

Table 3. OLS regression results: Green Ratings Project channels
(clustered standard errors in brackets; all regressions include plant fixed effects)

Model number	5	6	7	8	9	10	11	12
Dependent variable	COD	TSS	COD	TSS	COD	TSS	COD	TSS
TREND	-0.104	-0.146	-0.13	-0.164	-0.102	-0.162	-0.128	-0.17
	[0.042]*	[0.029]**	[0.034]**	[0.031]**	[0.048]*	[0.039]**	[0.038]**	[0.035]**
POST-GRP	0.214	0.384	0.21	0.15	0.252	0.471	0.233	0.192
	[0.205]	[0.156]*	[0.164]	[0.136]	[0.228]	[0.169]*	[0.164]	[0.129]
ONELEAF*TREND					0.014	0.064	0.007	0.042
					[0.036]	[0.046]	[0.037]	[0.035]
ONELEAF*POST-GRP					-0.379	-0.44	-0.349	-0.329
					[0.182]*	[0.176]*	[0.211]	[0.211]
SCALE	0.067	-0.336	0.02	-0.343	0.03	-0.383	0.035	-0.35
	[0.249]	[0.173]+	[0.263]	[0.186]+	[0.234]	[0.157]*	[0.269]	[0.189]+
FINALGOOD	-0.22	0.013	-0.362	-0.224	-0.39	-0.105	-0.475	-0.286
	[0.334]	[0.240]	[0.354]	[0.263]	[0.304]	[0.223]	[0.300]	[0.239]
PCTBAMBOO	-0.281	-0.055	-0.462	-0.364	-0.405	-0.175	-0.551	-0.416
	[0.399]	[0.319]	[0.393]	[0.363]	[0.354]	[0.299]	[0.354]	[0.351]
PCTGRASSES	0.653	-0.249	0.262	-1.048	0.964	-0.408	0.53	-1.054
	[1.115]	[1.331]	[1.182]	[1.363]	[1.296]	[1.388]	[1.247]	[1.386]
PCTRECYCL	-0.292	-0.291	-0.603	-0.977	-0.248	-0.251	-0.501	-0.916
	[0.504]	[0.369]	[0.484]	[0.369]*	[0.581]	[0.343]	[0.539]	[0.333]*
PCTPULP	-1.903	1.461	-2.1	0.799	-1.846	1.779	-2.107	0.951
	[1.602]	[0.903]	[1.620]	[1.032]	[1.653]	[0.816]*	[1.634]	[0.989]
PRICE_WAGES	1.334	3.568	1.473	3.948	1.332	3.562	1.602	3.964
	[1.262]	[1.652]*	[1.294]	[1.827]*	[1.226]	[1.659]*	[1.262]	[1.815]*
FORSHARE	-0.38	-2.105	-0.365	-2.181	-0.263	-1.962	-0.422	-2.135
	[0.723]	[0.573]**	[0.756]	[0.700]**	[0.621]	[0.509]**	[0.677]	[0.671]**
PRICE_NAOH	0.021	-0.893	0.005	-0.92	0.05	-0.906	0.028	-0.917
	[0.530]	[0.383]*	[0.535]	[0.387]*	[0.524]	[0.370]*	[0.531]	[0.379]*
PRICE_CL	-0.169	-0.441	-0.184	-0.465	-0.171	-0.462	-0.184	-0.48
	[0.197]	[0.232]+	[0.203]	[0.237]+	[0.204]	[0.228]+	[0.221]	[0.233]+
PERMIT	0.018	-0.052	-0.005	-0.083	-0.041	-0.09	-0.054	-0.113

	[0.072]	[0.105]	[0.069]	[0.108]	[0.082]	[0.093]	[0.084]	[0.097]
EFFRIVER	-2.059	-2.412	-3.52	-4.409	-4.014	-3.304	-4.53	-4.857
	[1.212]	[0.829]**	[1.261]*	[1.207]**	[1.610]*	[0.993]**	[1.657]*	[0.941]**
PRICE_WOOD	-0.209	-1.08	-0.203	-1.092	-0.154	-1.053	-0.174	-1.078
	[0.467]	[0.361]**	[0.469]	[0.359]**	[0.489]	[0.360]**	[0.494]	[0.356]**
WEALTH*TREND	-0.13	0.058			-0.136	0.053		
	[0.193]	[0.169]			[0.203]	[0.185]		
WEALTH*POST-GRP	-0.631	-2.607			-0.288	-2.398		
	[1.033]	[0.812]**			[1.030]	[0.928]*		
SINGLE*TREND			0.02	0.079			0.018	0.064
			[0.038]	[0.041]+			[0.043]	[0.031]+
SINGLE*POST-GRP			-0.292	-0.576			-0.132	-0.446
			[0.189]	[0.198]**			[0.198]	[0.229]+
Constant	4.919	9.449	6.638	11.241	6.742	10.688	7.172	11.673
	[3.430]	[2.373]**	[3.832]+	[3.095]**	[3.298]+	[1.858]**	[4.081]+	[2.886]**
Observations	154	152	154	152	154	152	154	152
R-squared	0.54	0.67	0.54	0.65	0.57	0.69	0.57	0.66

+ significant at 10%; * significant at 5%; ** significant at 1%

Table 3 presents results from 10 models intended to identify channels through which GRP operates. Model 5 (for COD) and Model 6 (for TSS) include WEALTH interaction terms, and Model 7 (for COD) and Model 8 (for TSS) include SINGLE interaction terms. As discussed below, we include additional models with ONELEAF interaction terms to disentangle the effects of baseline environmental performance from other plant and community characteristics: Model 9 (for COD) and Model 10 (for TSS) include WEALTH interaction terms along with ONELEAF interaction terms and Model 11 (for COD) and Model 12 (for TSS) include SINGLE interaction terms along with ONELEAF interaction terms. Finally, Model 13 (for COD) and Model 14 (for TSS) include all available regressors.

Turning to the results, first note that even with the inclusion of these additional interaction terms, there is virtually no change in the qualitative results on the controls discussed in the previous section.

In both Models 5 and 6, WEALTH*POSTGRP is negative, and it is significant in the TSS model. This result suggests that plants in wealthier communities were more responsive to disclosure than those in poorer communities. Several explanations are possible. Residents of relatively wealthy communities may have been more likely to pressure plants to improve their performance following a GRP rating. Alternatively, or perhaps as a result, regulators in such communities may have been more ready to crack down on poorly performing plants following disclosure.

Turning to Models 7 and 8, the interaction term SINGLE*POST-GRP is negative and significant in the TSS model, implying that plants that are part of a conglomerate or multiplant firm were less responsive to GRP ratings than standalone plants. Again, several explanations are possible. Plants that are part of a conglomerate may have better access to the human capital needed for environmental management, be better informed because they share best practices with other plants in the same firm, and/or have better access to the financial capital needed for pollution control.

Though those explanations appear plausible, it is also possible that plants in wealthier communities and plants that are not part of a conglomerate were more responsive to disclosure because they were dirtier to begin with. Simple correlation coefficients suggest that this may be true in the case of standalone plants; the evidence is less clear that dirty plants were located in wealthier communities. In Models 9 through 12, we add the ONELEAF interaction terms (ONELEAF*TREND and ONELEAF*POST-GRP) to disentangle the effects of baseline environmental performance from other plant and community characteristics. In these regressions the WEALTH and SINGLE interaction terms remain significant, although levels of significance are attenuated. These results suggest that the channels proxied for by WEALTH and SINGLE interaction terms facilitate environmental improvement above and beyond that driven by the simple fact that plants in wealthy communities and those that are not part of conglomerates tend to be dirtier.

5.3 Robustness checks[18]

In this subsection we address some possible robustness issues. First, with an unbalanced panel covering at most 22 plants over eight years, we have a limited number of observations. Therefore, we need to make sure that our regression results are not being driven by outliers. To that end we performed an outlier check. We repeated each regression in Tables 2 and 3 22 times, omitting one plant in each regression. The ONELEAF, WEALTH, and SINGLE interaction terms are significant in each regression.

A second concern is that several of our regressors, including the composition of fiber inputs, as well as SCALE and FINALGOOD, could be endogenous if abatement decisions and production decisions are made simultaneously. However, these variables display only minor temporal variation, so any endogeneity should be minimal. As a robustness check, we reestimated all regressions presented in Tables 2 and 3, omitting the potentially endogenous regressors PCTBAMBOO, PCTGRASSES, PCTRECYCL, PCTPULP, SCALE, and FINALGOOD. In all cases, our results are qualitatively unchanged, and in Model 13, ONELEAF*POST-GRP becomes more negative and marginally significant. We conclude that endogeneity is not an important practical concern in this context.

Finally, note that in the interest of preserving degrees of freedom and concise exposition, we have omitted regressors whose inclusion had no effect: real price of coal, vintage of the plant, other types of regulatory permits, share of sales spent on R&D, and diversity of the product mix produced by each plant.

6. Conclusion

We have used eight years of exceptionally detailed survey data on 22 of India's largest pulp and paper plants to evaluate the Green Rating Program, an Indian environmental

[18] These results are available from the authors upon request.

performance public disclosure program. We sought to determine whether a 1999 GRP rating caused plants to reduce their water pollution loadings. We have also attempted to shed light on the mechanism by which the rating may have done this. We found that the GRP drove significant reductions in pollution loadings among dirty plants but not among cleaner ones. This result comports with Dasgupta et al.'s [2] finding that performance ratings programs in Indonesia, Philippines, China, and Vietnam all led to improvements among plants with moderately poor performance records, but not among those with either very bad or good records.

We also found that pulp and paper plants located in wealthier communities were more responsive to GRP ratings, as were stand-alone plants. We hypothesized that the former result suggests that environmental performance ratings programs may have an effect by mobilizing local communities and/or regulators to exert pressure for reductions in discharges. We hypothesized that the latter result implies that performance rating programs are more effective when targeted at plants with better access to human and financial capital for pollution abatement.

This study adds to a thin but fast-growing body of evidence that public disclosure programs can be an effective environmental management tool, even in developing countries where weak regulatory institutions, limited political will, and other problems hamstring conventional pollution control policies. Although an analysis of the costs of administering the GRP is beyond the scope of our study, we suspect it has been less expensive than conventional policies that involve standard setting and enforcement. If that is indeed the case, then our findings indicate that public disclosure programs may be an efficient as well as effective environmental management strategy.

Finally, we note that whereas virtually all national-level performance ratings programs in developing countries are administered by state environmental regulatory agencies, the GRP is run by a nongovernmental organization. To the extent the GRP is replicable, it suggests that even in countries where institutional and political constraints preclude state-run initiatives, public disclosure may offer a means of making progress.

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Appendix 1. Analytical model

This appendix presents a simple analytical version of the graphical model of public disclosure in Section 3. To keep the model as simple as possible and focus attention on pollution abatement, we assume that the firm makes production and abatement decisions sequentially. First it chooses a level of output, q, and a vector of levels of financial and human capital, **k**. Subsequently, it chooses a level of abatement, α, treating both q and **k** as fixed. We model the firm's second-stage abatement decision only. Note that abatement here may also include pollution prevention. The firm chooses α to maximize profit, π, given by

$$\pi = P[g(\alpha, d)]q - C[\alpha, t(d)] - \mathbf{W}(\alpha, d)\mathbf{k} - H(\alpha, d)$$

where

$$H(\alpha, d) = r(\alpha, d) + c(\alpha, d) + j(\alpha, d)$$

and

$P(\cdot)$	is the equilibrium price of output;
g	is an index of green consumerism—the sensitivity of P to the plant's discharges;
d	is a measure of the public disclosure of information about the plant's discharges;
q	is the quantity of output;
$C(\cdot)$	is the cost of abatement;
t	is the plant's information about abatement technologies and its own discharges;
$\mathbf{W}(\cdot)$	is a vector of the costs of two types of capital, financial and human;
k	is a vector of two types of capital, financial and human;
$H(\cdot)$	is the total cost of the plants' discharges generated by external agents;
$r(\cdot)$	is costs generated by formal regulatory authorities;
$c(\cdot)$	is costs generated by communities; and
$j(\cdot)$	is costs generated by courts.

Following the literature discussed in Section 2, we make the following assumptions about the price and cost functions:

- the stronger is green consumerism, the lower is the equilibrium price the plant receives for its output (P is decreasing in g);[19]
- the less the plant abates and the more the public knows about its discharges, the stronger is green consumerism (g is decreasing in α and increasing in d), the higher are the costs of financial and human capital (**W** is decreasing in α and is increasing in d), and the greater are the costs imposed on the plant by external agents (r, c, and j are all decreasing in α and increasing in d); and
- the less the plant abates and the more information it has about its discharges and abatement technologies, the lower is the marginal cost of abatement (C is increasing in α and decreasing in t).

Finally, we make the reasonable assumptions that

- abatement has a diminishing marginal impact on green consumerism, capital costs, and costs imposed by external agents; and an increasing marginal impact on abatement costs (g, W, H, and C are all convex in abatement).

The first-order condition for the choice of the optimal level of discharges, α*, is[20]

$$\text{(A1)}\quad \left\{\frac{dP}{dg}\frac{\partial g}{\partial \alpha}q-\frac{\partial W}{\partial \alpha}k-\frac{\partial H}{\partial \alpha}\right\}-\frac{\partial C}{\partial \alpha}=0$$

The first term in braces represents the marginal benefit of abatement due to an increase in the equilibrium price of output (the first term in braces); a reduction in the costs of labor and capital (the second term); and a reduction in costs imposed by formal regulatory authorities, communities, and the courts (the third term). We will refer to the sum of these three terms as the

[19] To keep the exposition simple, we implicitly assume that the plant is an inherently dirty one—for example, an aged coal-fired power plant—so that regardless of its choice of α , green consumerism always reduces equilibrium price. We could just as easily assume that the plant is an inherently clean one whose equilibrium price is always increased by green consumerism. Allowing green consumerism to increase or decrease equilibrium price depending on the plant's choice of α makes the model needlessly complex given our limited goal of illustrating how various channels discussed in the literature operate.

[20] The convexity of g(·), C(·), W(·), and H(·) guarantee that the second-order condition is met.

marginal abatement benefit (MAB). The last term in (A1) is the marginal abatement cost (MAC). The plant chooses α^* such that MAB is equal to MAC.

Using (A1), it is straightforward to show that the total derivative of α^* with respect to d is unambiguously negative. Therefore, public disclosure will increase abatement. Figure 1 makes this point graphically. Given our assumptions on $P(\cdot)$, $C(\cdot)$, $W(\cdot)$, and $H(\cdot)$, the MAC schedule is increasing in α and the MAB schedule is decreasing in α. The plant chooses the level of discharges where these schedules intersect. An increase in d will cause $t(\cdot)$ to increase and the MAC schedule to shift down. It will also cause $g(\cdot)$, $W(\cdot)$, and $H(\cdot)$ to increase and the MAB schedule to shift up. Each of these shifts will cause α^* to increase.