Informal Regulation of Pollution in a Developing Country: Empirical Evidence from India

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Abstract

Recent policy discussions recognize the limitations of formal regulations to stem pollution in developing countries. As a result, there is growing interest in the potential of informal regulations to achieve environmental goals. In India, many polluting industries fall under the rubric of the unorganized sector. In such a context, localized pollution may be influenced by discussions and reports on pollution in the vernacular press. This study attempts to test the hypothesis that the press can act as an informal agent of pollution control. This hypothesis is tested using monthly water pollution data from four hotspots in the state of Gujarat, for the period 1996 to 2000. The results show that the press can function as an informal regulator if there is sustained interest in news about pollution. However, not all pollution agents are affected by pollution news. Press coverage appears to mainly influence industrial estates with a mix of small, medium and large industries.

Key words**:** Informal Regulation, Vernacular Press, Industrial Pollution, Developing Country, Small-Scale Industries, India.

JEL Classification Numbers: Q25, P28, K42

Informal Regulation of Pollution in a Developing Country: Empirical Evidence from India

Vinish Kathuria

1. Introduction

The design of policy instruments for industrial pollution is not only complex but also very daunting in the case of developing countries. In principle, the regulator has an array of physical, legal, monetary, and other instruments at his/her disposal (Sterner, 2002). But the presence of a large number of pollution sources in the form of small-scale industries (SSIs) that lack knowledge, funds, technology and skills to treat their effluent frustrates any instrument applied and leads to overall failure. The failure of industrial pollution control is also attributable to rigid command-and-control regulatory approaches. Regulators are constrained by meagre resources, limited authority and political interference. Additionally, low remuneration rates invite corruption. These problems are compounded by *information asymmetries*. For all these reasons, numerous studies in India have concluded that despite a strong legal framework and the existence of a large bureaucracy to manage environmental regulation, implementation is very weak (see, for example, Pargal, *et al*., 1997a; Murty and Prasad, 1999, among others).

The failure of formal regulation to control pollution has highlighted the significance of informal regulation for achieving environmental goals (see, for example, Pargal and Wheeler,1996; Afsah, *et al*., 1996 ; Pargal, *et al*., 1997a ; Tietenberg, 1998 ; Wheeler, *et al*., 2000; Sterner, 2002, among others). There is now considerable interest in "information disclosure" and "rating" as potential tools of industrial pollution control. Sometimes referred to as the "third wave" of environmental policy (Tietenberg, 1998), this approach acknowledges the difficulties of monitoring and enforcement and recognises that there are many more avenues of influence than just formal regulation or fines. Firms are sensitive, for example, about their reputation and the future costs that they may incur as a result of liability or accidents. The emergence of this new paradigm for regulation is also related to advances made in our understanding of asymmetric information (Kathuria and Sterner, 2002).

Anecdotal evidence suggests that when formal regulation is weak or non-existent, informal regulation through local community participation has forced the polluter, especially "visible" ones, to take corrective action. For instance, in 1980, at Banjaran near Jakarta, local farmers burnt a government-owned chemical factory that had been polluting their irrigation channels (Cribb, 1990, qtd. in Wheeler, *et al*., 2000). Similarly, a paper mill in India, after community complaints, had to install pollution abatement equipment and construct a temple as compensation for damage to the community. (Agarwal, *et al*., 1982). Khator (1991, qtd. in Hettige, *et al*., 1996) using several case studies illustrates how polluting plants in India have responded to community pressure.

Pargal, *et al*., (1997b) suggest that informal regulation can take varied forms, including demands for compensation by community groups, social ostracism of the polluting firm's employees, the threat of physical violence, and efforts to monitor and publicise the firm's emissions / discharges. Two "formal" channels of informal regulation are (i) reporting violations of standards to the regulatory agencies (where such standards and institutions exist); and (ii) putting pressure on regulators (through politicians and administrators) to tighten monitoring and enforcement. However, there also exist channels of "informal" regulation, such as public disclosure, ratings, etc., where markets are used to punish polluters. In fact, public disclosures and ratings work when the industrial units are not only relatively large but also in the organised sector and depend on outside markets for their products, finances, etc. However, since a large number of industrial units in India and the rest of the developing world fall under the unorganised sector, the effectiveness of formal channels of informal regulation and public disclosures is limited.

In India, 3.2 million small-scale industries (SSIs) produce about 8,500 products and some of these products are highly polluting. Even a conservative estimate of 10% of the total SSIs as being polluting in nature implies that there are 0.32 million industrial units causing an adverse impact on the environment (CPCB, 2001: 2). The net impact of these units is estimated to be nearly on par with all the large and medium industries put together. SSIs contribute approximately 40% of wastewater generated (among 11 industries, where SSIs have a sizeable presence) (CPCB, 2001: 4). In such a context, the informal pressure has to be highly localised. A proactive vernacular (or local) media is one such localised means of informal regulation. This particular informal channel for regulation is the focus of the present paper.

The paper investigates whether the press has any role to play in pollution control in the second most industrialised and highly polluted state of India, i.e., Gujarat. To answer this question, monthly water pollution data from four water-quality monitoring stations of Gujarat for the period Jan-96 to Dec-2000 is used. The main findings of the paper are that informal regulation, as measured by the number of articles in the vernacular and national press, along with public interest litigation decisions, has worked partly to regulate pollution. Results show that sustained pressure from the press leads to a fall in pollution. However, not all stations are affected equally. It is mainly the monitoring station that receives water from an industrial estate (IE)[1] housing multi-size industrial units that appears to respond to informal pressure. The analysis also reveals that formal regulation, as denoted by the staff allocated to a region, does not have any impact on industrial pollution generation behaviour. In brief, control of pollution from SSIs in Gujarat may still elude policy makers, as these industrial units seem unresponsive to both formal and informal channels of regulation.

The paper is organised as follows. Section 2 summarises the literature on informal regulation in India and elsewhere in the world. Section 3 gives the economics of pollution in a region and how formal and informal regulation facilitates the alignment of behaviour of polluters with that of society. A simple econometric model that looks into the role of informal regulation in controlling pollution is formulated in Section 4. The data and variables are given in Section 5 and Section 6 reports the results. The paper concludes with some policy implications in Section 7.

2. Environmental News, Informal Regulation and Firm Behaviour: A Review of the Literature

Most studies conducted in the developed countries have focused on how capital markets respond to the announcement of adverse environmental incidents (such as violation of permits, spills, court actions, complaints) or positively to the announcement of superior environmental performance. Hamilton (1995) and Konar and Cohen (1997), for example, discuss the reaction of markets to releases of the *Toxics Release Inventory*. Lanoie and Lapante (1994) and Lanoie, *et al*., (1998) have tried to identify the capital market response to environmental accidents. These studies have found that, in general, the announcement of

[1] An Industrial estate (IE) is a large tract of land subdivided and developed for the use of several firms simultaneously. It is distinguished by its shareable infrastructure and the close proximity of firms.

adverse environmental news leads to a decline in the market value of the firms. A summary of studies conducted on this aspect can be found in Wheeler, *et al*., (2000). The summary indicates that negative environmental news has resulted in an average loss of 0.3% to a maximum of 2%, whereas positive environmental performance information resulted in appreciation of the stock by nearly 0.82% as found by Klassen and McLaughlin (1996).

Dasgupta, *et al*., (2001) have tried to gauge the impact of the announcement of environmental news on the capital market in the context of a developing country. The results indicate that capital markets in Argentina, Chile, Mexico and the Philippines do react to the announcement of environmental events, such as superior environmental performance or citizens' complaints. Since the presence of an efficient capital market is more the exception than the rule in most developing countries, other studies, recognising this limitation, have used community specific variables like literacy, the development index, or per capita income as an indicator of informal regulation (Pargal and Wheeler, 1996; Afsah, *et al*., 1996; and Pargal, *et al*., 1997). These studies in general find that community-specific variables are correlated with monitoring / inspection and enforcement.

Most of these studies, however, focus on large size industrial units. An econometric study that has tried to see the role of community pressure in the case of the informal sector is by Blackman and Bannister (1998). The authors find that the local communities exercised considerable leverage in pressurizing traditional small brick making industrial units in Mexico using dirty fuel (tyres, etc.) to shift to propane, a cleaner fuel.

In the case of India, four previous studies have examined the impact of informal regulation on water pollution. Pargal, Mani and Huq (1997a), using survey data for 250 medium and large industrial plants located in eight states, examine regulatory inspections and water pollution discharges in order to find out whether the monitoring and enforcement efforts of local PCBs are affected by local community characteristics. Pargal, Mani and Huq find that high levels of pollution trigger regulatory responses in the form of inspections. However, no significant negative relationship is found between informal regulation and pollution discharge. The explanation given by the authors is that community activism could be unrelated to the indicators they use (urbanisation, income, and education), and that the dirty plants may be targeted irrespective of their locations. Community pressure may also be channelled through formal mechanisms rather than through direct negotiation with plants.

Murty and Prasad (1999) undertake analyses that is quite in line with Pargal, *et al*. and use cross-section data from 100 factories belonging to 11 highly water polluting industries in 13 states. They, however, find evidence of significant informal pressure (as represented by district development index and the rate of participation in the previous parliamentary elections). A third study by Goldar and Banerjee (2002) analyses ambient water quality, not the industrial discharge of effluents as such, using annual water quality data for 106 monitoring stations on 10 important rivers for five years. The study attempts to see how secondary education and poll percentage affect pollution levels. The study finds a significant positive relationship between poll percentage and water quality on the one hand and between the proportion of people who have completed school and water quality on the other.

The study by Hartman, *et al*., (1997) uses survey data on 26 pulp and paper plants of four countries, namely, Bangladesh, India, Indonesia and Thailand. The survey covered four Indian states. The study finds that both formal and informal regulatory pressures positively affect abatement effort.

Limitations of previous studies

The studies that have tried to measure the impact of environmental news on the stock-value of firms (e.g., Dasgupta, *et al*., 2001) need to fulfil two conditions. Firstly, capital markets should be perfect and secondly firms need to be listed in the stock exchange. Since the focus of the present work is on a wide range of industries that are rarely listed in the stock exchange, the above-mentioned framework has no applicability to our study. On the other hand, the neglect of SSIs is one of the major limitations of three of the four studies carried out in India as they focus on medium and large size factories. The large plants are more visible and therefore can be targeted more easily using external pressure, but the problem of pollution may still persist. In fact, the *real* challenge for regulators in developing countries is managing SSIs. The study by Blackman and Bannister tests the role of community pressure for the small and informal sector but is concerned with air pollution. The study by Goldar and Banerjee is different as, instead of plant level data, it uses annual ambient pollution level at different locations. However, the use of an annual average has its own problems since the quantity of effluent generated by a firm can vary many times even during a single day (Wheeler, *et al*., 2000).

Further, most studies have used poll percentage as a variable reflecting informal pressure. Given the fact that the polls in India are generally held every five years, the use of the poll percentage has relevance only if the analysis is either cross-sectional, as in the Murty and Prasad study, or if the period of analysis is fairly long. Another limitation is the unpredictability of community characteristics in voting. In the recent past, it has been observed that more literate communities are sometimes not likely to vote given their disenchantment with the political system. Thus, it is not clear that poll percentage truly reflects "informal regulation" as hypothesised by several studies. The use of the index of development as a variable reflecting informal pressure too can be debated, as the two most industrialised states in India—Gujarat and Maharashtra—are also the most polluted. Another important limitation with the Murty and Prasad and Goldar and Banerjee studies is that they have not accounted for formal regulation in their models, which may lead to model mis-specification. Lastly, all the studies for India use education level as a variable for community pressure. This is defensible if the analysis is cross-sectional, which is not the case with the Goldar and Banerjee study. Since the variable hardly changes in a five-year period, it only measures period-specific effects rather than the true effect.

The present study attempts to account for some of the limitations with the previous studies outlined above by focusing on a few industrial hot-spots in Gujarat, where the agents of pollution are not just large and medium industrial units but small-scale industries as well. The study covers both industrial units housed in an IE and industrial units that are dispersed. The present study is also more disaggregated in terms of data use as it employs monthly data on ambient pollution levels and examines whether informal regulation works at the regional level or not. The study also accounts for formal regulation by employing a variable reflecting monitoring.

3. The Economics of Pollution – with formal and informal regulation[2]

The previous literature investigating the impact of informal regulation has looked at "equilibrium pollution" levels in regions that are bereft of any formal regulation (see, for example, Pargal and Wheeler, 1996; Hartman, *et al*., 1997, among others). This may be true for a few developing countries but not for all. Even

[2] Pargal and Wheeler (1996) and Hartman, *et al*. (1997) form the basis of this section.

in India, where regulation failure cases abound, pockets exist where formal regulation has worked. Regulation-induced use of Compressed Natural Gas (CNG) leading to a fall in air pollution of Delhi is one such recent example. Even Pargal, *et al*., (1997a) find wide variation in enforcement across states. In this section, we attempt to incorporate both formal and informal regulation in a model depicting environmental performance in a region comprising mainly of SSIs.

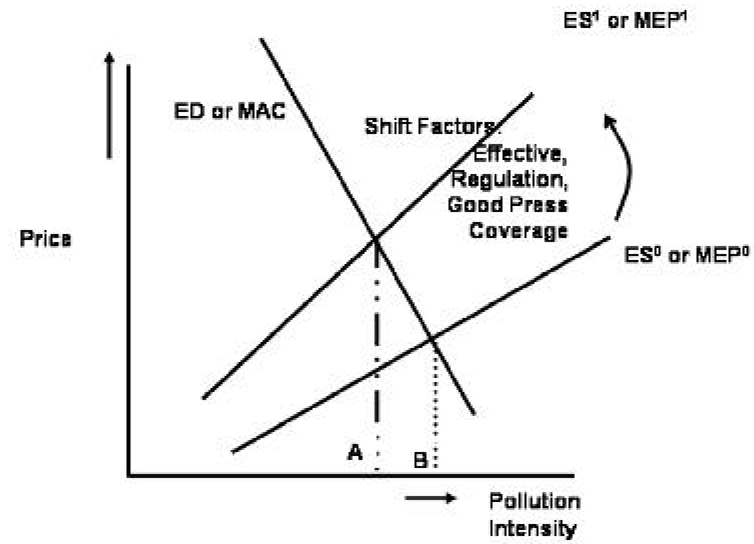
The equilibrium pollution levels in a region are determined by the intersection of a "demand" and "supply" schedule for environmental services. The environment is usually characterised by some carrying or absorptive capacity. Any polluting plant essentially uses this absorptive capacity. Thus, industrial plants have a demand for environmental services. Plants can either use this service completely or reduce emissions by adopting some mitigatory methods. Thus, for a cost minimising plant, the environment demand (ED) schedule reflects its marginal abatement cost (MAC). We could think of this as the firm's marginal willingness-to-pay for abatement. The more the plant abates, the less will be its demand for environmental services. On the other hand, it becomes progressively more expensive for the plant to abate at low pollution levels *a la* the law of diminishing returns. The regional MAC or ED schedule could be crudely approximated as a sum over all the plant-level schedules, which slopes downward to the right. As the price of environmental services rises, the industry would prefer reducing pollution along this schedule (Hartman, *et al*., 1997).

The ED schedule is generally affected by three major factors, namely, (i) external pressure through the factor market or product market, etc.; (ii) economic considerations; and (iii) plant characteristics. All these factors become somewhat irrelevant when the focus is on SSIs. Most SSIs, which are small and which cater to the local market, are indifferent to external pressure. Important plant characteristics like ownership, size, market orientation, human and technical capital, availability of abatement technologies, etc., have less relevance for the SSIs. This implies that for a region comprising mainly of SSIs, the ED schedule will not only be steep (as compared to that of medium and large industrial units) but also discontinuous after a point.[3]

With effective formal regulation, environment services always carry a price for a plant. But for most developing countries including India, the price is too little to impact on pollution at a regional level. This is due both to ineffective formal regulation and the concentration-based standards prevailing in these countries. The price could be augmented if the people affected act in their own self-interest through various "informal" or "quasi-formal" channels. Hartman, *et al*., (1997) argue that in regions devoid of formal regulation, communities confront local polluting plants with their own demands for environmental services. This community demand curve reflects three basic factors: the community's ability to a) monitor emissions; b) assess damages (together a & b indicate information costs); and c) bargain in enforcing (local) pollution norms (reflecting transaction costs). These three aspects reflect the community assessment of social marginal damage (MSD) and get summarised in a locally enforceable environmental supply (ES) schedule. Thus, the ES curve reflects the price the communities require industries to pay for different levels of pollution. With increases in damage, communities impose progressively higher costs on polluting plants. This implies that the ES schedule slopes upward to the right. The equilibrium pollution level in a region is determined at the point where the ED and ES schedules intersect (see Figure 1).

[3] The discontinuity arises because if the price of environmental input is raised beyond a point, many SSIs may go out of business. The reverse is also possible, that is, that they may not abate at all given their infrastructure and resources. The direction of discontinuity is however difficult to predict.

Figure 1. Impact of Formal and Informal Regulation on Equilibrium Pollution Level in a region dominated by Small Scale Units



Source: Adapted from Wheeler et al. (2000)

The ES schedule depends on the perceived risk of pollution, the imputed damage, and the community's ability to act and do something about it. The community's perception of risk is a function of their education level because it depends on deciphering the available information— available through various channels such as official communications, personal observations, experiences and historical evidence. The valuation of damage is highly subjective, because many a times the health impacts are known only after some time has passed. Moreover, valuation of damage often depends on the income of the community. In a labour surplus economy like India, even a high polluting plant may be condoned if it provides significant employment to the local people. Lastly, a community's capacity to impose costs on polluters depends on a number of factors like legal infrastructure, political strength, civil and economic freedom, locally available information, media coverage, presence of NGOs and opportunity cost of time. Hartman, *et al.,* (1997) argue that many of these variables are correlated with income and education across communities.

Effective formal and informal regulations shift the ES schedule to the left (i.e., from ES^0 to ES^1) as shown in Figure 1. This paper examines how shifts in the ES schedule affect equilibrium pollution levels. In particular, we are interested in the impact of informal regulation on pollution behaviour, controlling for other factors that could also induce shifts in the supply schedule.

4. Model specification

The model used here is an extension of the one used by Pargal and Wheeler (1996). Pargal and Wheeler used the model to estimate the firm's equilibrium pollution. The present study modifies the Pargal and Wheeler model to incorporate the effect of formal and informal regulations in order to arrive at pollution level at the *region* instead of at the firm level. Pargal and Wheeler estimated the firm's equilibrium pollution as an intersection of the demand for environmental services by the firm and the supply schedule it faced in an implicit market for environmental services.

According to Pargal and Wheeler, the demand for environmental services for firm i in region j is given by:

$$P_{ij} = f(W_{pij}, s_i, q_i, W_{lj}, W_{ej}, W_{mj}, v_i, f_i, m_i, g_i) \dots\dots (1)$$

Where, P_{ij} is the pollution emitted from plant i in community j; W_{pij} is the expected pollution price for plant i; s_i is the industry/sector to which plant i belongs; q_i is the total output of plant i; W_{lj} is the manufacturing wage in community j; W_{ej} is the energy price index in community j; W_{mj} is the material input price index in community j; v_i is the age of the plant i; f_i is the factor productivity of plant i; m_i is the extent of foreign ownership in plant i; and g_i is the extent of public ownership in the plant.[4]

The environmental supply schedule confronting the firm indicates the expected price it has to pay for each level of pollution (Pargal and Wheeler, 1996: 1319).

$$W_{pij} = f(P_{ij}, y_j, e_j, n_{ij}, a_j, t_j) \dots\dots (2)$$

where P_{ij} is the ith plant's pollution in community j; y_j is the per capita income in community j; e_j is the post-primary schooling rate in community j; n_{ij} is the share of employment of plant i in total manufacturing employment in community j (indicating a plant's visibility and economic attractiveness to the community); a_j indicates urbanization; and t_j is the total pollution load faced by the community.

The firm's equilibrium pollution level is then solved as

$$P_{ij} = f(s_i, q_i, W_{lj}, W_{ej}, W_{mj}, v_i, f_i, m_i, g_i, y_j, e_j, n_{ij}, a_j, t_j) \dots\dots (3)$$

At the regional level, some of the variables found in the Pargal and Wheeler model disappear.[5] Instead, the regional equilibrium pollution level is given by

$$R_j = f(S_j, Q_j, V_j, X_j\,(y_j, e_j, a_j), F_j, RF_j, VE_j) \dots\dots (4)$$

[4] If the expected pollution price (W_{pij}) is more for a firm, it will pollute less. More efficient plants (f_i) are generally better managed and are more equipped to respond to incentives for pollution control, and thus will have less pollution per unit. Similarly, the extent of foreign ownership (m_i) is a reflection of the fact that foreign firms are more conscious of their public image, so will be cleaner compared to local firms. On the other hand, government owned plants (g_i) are generally older and less efficient, but given the fact that they operate under soft budget constraints and are the first to be targeted by the EPA, the net impact will be indeterminable (Pargal and Wheeler, 1996: 1316). The focus of industrial pollution control in a number of developing countries including India is still on end-of-pipe treatment. This is because end-of-pipe treatment is cheaper than retrofitting. This indirectly suggests that plants of older vintage are more polluting. Lastly, materials intensive production tends to be more pollution-generating; however, an increase in material price (W_{mj}) tends to reduce pollution. Similarly, (W_{lj}) an increase in interest rate or price of equipment reduces capital and energy use, which forces the firm to substitute capital and energy with labour and materials in processing. This leads to more pollution.

[5] Firm level variables like foreign equity participation, ownership, etc., lose their relevance at the aggregate level. Similarly variables like manufacturing wage, energy price index, material input price index, etc., have relevance when analysis is across communities unlike in the present case. The share of employment by polluting units in the region also drops. Employment share of units in the region relative to total workforce is more like a static variable, with the changes coming only longitudinally. Given the ground realities, its effect in influencing the supply schedule will be highly restricted for the present study. This is because the industries/regions considered in the analysis mostly fall under the category of the hazardous involving chemicals. Anecdotal and empirical evidence indicates that the local population in these regions flinches from taking such jobs. An earlier survey by the author in one of the study regions also suggests that the share of local employment is abysmally low (Shah and Kathuria, 2001).

where, R_j is the total pollution load in a region j ($\approx \sum P_{ij,\ i = 1, 2 \ldots N}$);[6] S_j is the nature of production activity in the region, i.e., whether the region is dominated by SSIs or large industrial units; Q_j is the total output in region j; and V_j is the average age of plants in the region; X_j is an indicator of informal regulation; F_j reflects formal regulation; RF_j indicates rainfall or meteorological conditions; and VE_j reflects water flow. We hypothesize that increases in S_j, Q_j and V_j, will increase pollution.

Our indicator of informal regulation (X) represents press coverage of pollution in the region. There are several reasons why we choose to use press as an indicator. Many commonly used community indicators of informal regulation (e.g., literacy, per-capita income or urbanization) have relevance for a large cross-section, or when the period of analysis is fairly long as they hardly change in the short run. Moreover, evidence exists that there are potential problems of endogeneity when considering income (and urbanization) and education (Pargal and Wheeler, 1996). In a region where all agents are mobile, location of a polluting unit may trigger locational sorting by income class. This is because wealthier families may relocate to escape the pollution and poor families move in as rents decline. We think that this type of bias in estimation of pollution behavior can be minimized by employing a single variable to represent informal regulation. Thus, X_j represents extensive publicity by the vernacular and regional press or policy pronouncements or any policy decision taken for the region by the local Pollution Control Board. In all probability this indicator is a function of literacy, urbanization and per capita income, i.e., $X_j = f(y_j, e_j, a_j)$, where, y_j is the average per capita income of community j; e_j is the secondary schooling rate in region j; and, a_j is the urbanization. An increase in X_j is likely to decrease pollution.

The Pargal and Wheeler model assumes absence of formal regulation. As mentioned before, pockets exist in India where formal regulation has worked. If the local EPA becomes more vigilant, either by making frequent visits, issuing more notices to the industrial units, or filing cases against the defaulters at regular intervals, it will have sufficient signaling effect and may induce the units to treat the effluent before discharging. Thus the equilibrium pollution level in a region is hypothesized to be a function of formal regulation, F_j, as well.

Since pollution at a regional level is a mix of pollution generation by individual industrial units, the equilibrium level will also be affected by meteorological conditions, especially rainfall, RF_j. Rain scavenges effluent by diluting it.

We also know that when the effluent is discharged in a water body, the pollution level is greatly affected by the total flow of water. A large flow or velocity (VE_j) implies more dilution of the pollutants leading to a fall in overall pollution levels. Recent studies in India however indicate that rivers, where most of the industrial effluent finally gets discharged, do not have sufficient water for dilution of the effluent.[7] In such a case, a high flow can reflect high industrial activity in the region with greater pollution. However, we hypothesize that higher velocity reduces pollution.

[6] R_j is an approximation of the total pollution emitted by different industrial units in the region. This is because there could be other pollution sources in the region – say vehicular pollution or run-off from agriculture or domestic load affecting the total load. Moreover, this assumes perfect mixing of pollutants, which may not be always true.

[7] See CPCB Annual Report (2000-01) and Kathuria and Haripriya (2002).

5. Data and Variables

5.1 Pollution data and Selection of Estates/Monitoring Stations

In Gujarat, monitoring of surface water is done through 39 stations — 7 of which come under the Global Environmental Monitoring System (GEMS) on 4 major rivers, and 32 stations are under the Monitoring of Indian National Aquatic Resources System (MINARS), which are on both major and minor rivers, creeks, etc.[8] Water quality readings are taken once a month generally during the first week of the month. Data is available on different indicators of water quality including chemical oxygen demand (COD). Appendix 2 gives the quality of water at the 7 most polluted stations in Gujarat from 1996-97 to 1999-2000. It is to be noted from Table A1 that all the places where parameters are much higher than the standards are on the "golden corridor"— a stretch of 400 km in Gujarat that is famous for its chemical and petrochemical industries.

In this study, we use COD as an indicator of pollution. COD is the most relevant parameter since the industries in the study area are mainly chemical in nature. It is defined as the amount of oxygen required to degrade the organic compounds of wastewater. A higher COD value indicates more oxygen demanded from water bodies.

Monthly data on COD from four monitoring stations for the period 1996 to 2000 is used in the present study. These are stations where pollution parameters exceed standards. Of the four monitoring stations, two, that is Khari and Amla Khadi, can be categorized as Type 1 monitoring stations, which receive effluent from industrial estates (IEs) while the other two, V.N. Bridge and Vautha on river Sabarmati, can be categorized as Type 2 stations, which receive water from scattered and dispersed industrial units. The V.N. Bridge monitoring station is in Ahmedabad itself, whereas Vautha is a place near Dholka (nearly 60 km from Ahmedabad), where the River Sabarmati meets River Vatrak. Figure A1 in Appendix 3 locates these stations on the map of Gujarat.

5.2 Definition and Measurement of Informal and Formal Regulation

How to define and measure informal regulation is a key issue for the present study. It is hypothesized that whenever any news item appears in the press (especially the vernacular press) denouncing industrial units, each such event has a considerable signaling effect within the IE or for other industrial units in the region. Similarly, since industrial estates tend to be a close-knit community, the issuance of a notice or press release by the local PCB will be immediately known to all industrial units. In the days immediately following the highly publicized issuance of notices, plants will be reminded of possible increased PCB monitoring efforts and will thus be more cautious with their effluent generation. Also, if the local PCB plans to be more vigilant, the press will immediately report it. Similarly, any public interest litigation (PIL) filed against industrial units for causing pollution or any decision taken by the High Court or Supreme Court (SC) will find coverage. Any effort of the local EPA, or policy decision by the Central or State government, to reduce pollution resulting in policy promulgation will also be reported immediately. And,

[8] India currently has 507 monitoring stations under the Monitoring of Indian National Aquatic Resources System (MINARS) and Global Environmental Monitoring System (GEMS). The quality of water is monitored for 25 physico-chemical and biological parameters like dissolved oxygen (DO), BOD, chemical oxygen demand (COD), pH, total dissolved solids (TDS), faecal coliform, turbidity, conductivity, etc. Appendix 1 presents the legislative provisions for the regulation of water pollution in India.

lastly, any instance of discharging untreated effluent (or solid waste) will not go unreported at least by the vernacular press.

Thus, our indicator of informal regulation (X) is rather broad measure and is being captured as the number of articles published in the vernacular (and leading national) newspapers relevant to industrial water pollution in Gujarat. In addition, any decision on PIL[9] or *suo motu* notice by the High Court is also included. The press releases by the GPCB and any important decision taken by the board during its meetings, which has a direct bearing on pollution generation by the industrial units, also has been accounted for in the study.

For the study, articles were collected from all local, regional and national newspapers for the period 1995 to 2001.[10] The articles are from newspapers such as the *Times of India, Indian Express, Financial Express, Economic Times, Business Line, Sandesh, Observer of Business and Politics, Gujarat Samachar, Loksatta Jansatta, The Hindu,*[11] and other publications like *Gujarat Law Herald, Gujarat Law Reporter,* press notifications by GPCB, Annual reports of GPCB, Divan and Rosencranz (2000), etc. Table 1 gives the articles published in these sources year-wise. Figure A2 in Appendix 4 shows the monthly variation in articles published from January 1995 onwards. From the table and the figure, it is evident that barring 1998, more than three-fourth articles published were against the industry, which thereby may have shifted the ES schedule. This shift in the ES schedule could have raised the MEP of the industrial units leading to changes in the quality of effluent generated.

Table 1: Articles and Court Rulings pertainingto Industrial Water Pollution in Gujarat

	Year (1)	Total Articles/ Decisions (2)	Articles/ Decisions on Gujarat	%Against Industry (4)	% Against Industry (5)
1	1995	28	15	13	86.67
2	1996	53	21	16	76.19
3	1997	68	23	17	73.91
4	1998	94	37	23	62.16
5	1999	95	73	57	78.08
6	2000	31	26	22	84.62
7	2001	31	31	27	87.10
8	**Total**	**400**	**226**	**175**	**77.43**

Source: Gujarat Law Reporter (various issues), Gujarat Law Herald (various Issues), GPCB Annual Reports (various years), Different Newspapers, Divan and Rosencranz (2000).

[9] Not all PILs and PIL hearings could be included. The author contacted the Gujarat High Court for the number of PILs filed that had to do with water pollution for the period 1996-2000 and the court hearings and decisions on these cases. However, the officer on special duty (OSD) refused to part with the data citing confidentiality (Visit to the High Court, Ahmedabad on September 12 and 13, 2002).

[10] The analysis is for post-1995 because it is only from the middle of 1995 that endeavours were made to punish polluters and intensify monitoring in Gujarat. The GPCB entered its most critical period during this time as it had to face several PILs (GPCB, 1995-96).

[11] Of these, *Sandesh*, *Gujarat Samachar, Loksatta Jansatta* are in the vernacular languages. The vernacular dailies are included because though high-profile cases get reported in the regional or national dailies, more subtle pressure is exerted through the vernacular press only.

Another important variable in the present study is accounting for formal regulation. Compliance hinges on the periodicity and effectiveness of monitoring and enforcement — that is, how frequently industrial units are monitored and, then, if found violating the norms, fines are imposed and collected. The ideal variable here would have been the units' estimate of the perceived likelihood of being caught and fined / closed. In the absence of firm-specific information, aggregate data has been used to construct the formal regulation variable. We construct this variable by first identifying the number of monitoring staff allocated to different IEs in Gujarat. We then adjust the number of staff by a factor that reflects polluting industrial units in the study area. Thus, the formal regulation variable is given by the total technical staff of GPCB multiplied by the ratio of total polluting units in the estate/area to the total polluting units in the state.[12] [13]

The variables 'F' and 'X' have been constructed based on the assumption of adaptive expectations. Given the fact that the readings are usually taken in the first week of every month, it is the previous month's proactivism (i.e., the number of articles covering pollution issues in the last month) that would affect the behavior of industrial units and hence the level of pollution generation. It is to be noted that the informal regulation variable constructed is the same for all the monitoring stations. Since the monitoring stations analysed in the study are from the same state and are thus equally affected by events within the state, use of the same variable can be justified.

5.3 Other Data Variables

Given below are the definitions of the remaining variables along with the sources of data:

- Rainfall: average rainfall for the day and the preceding day, when the reading was taken[14] (Source: Meteorological Department, Ahmedabad).
- Velocity: velocity of water at different stations measured by the GPCB (Source: GPCB/CPCB).
- Activity: no data was available for the level of activity / production from these estates / region. In its absence, the Monthly Index of chemical production for the country as a whole has been taken. Since Gujarat produces nearly one-fourth of India's chemical output (Kathuria and Sterner, 2002), the index of Gujarat's chemical production will be highly correlated with the present variable.[15]
- Year dummies: this variable accounts for any technical change in abatement technology.
- Month dummies: this variable accounts for any monthly variation in production or any unaccounted variable.
- Station dummies: these variables account for whether the flow is from IEs, or dispersed industrial units and any other station-specific effects.

[12] One can argue that the way the variable has been constructed, it represents only the number of polluting industrial units in the region rather than the monitoring staff. The conjecture may be valid if the monitoring staff remains constant over the period, and only the polluting units increase. However, that was not the case as the technical staff strength has increased during the study period while the proportionate increase in polluting units has not been that much. A low correlation coefficient of 0.33 also reflects this independence.

[13] Besides this variable, a number of other variables accounting for Formal Regulation were constructed. However, they yielded inferior results compared to the monitoring staff allocated to a region. These include the number of court cases filed by the PCB; the number of notices issued to units by the board; the amount spent by the board in monitoring different regions; the number of cases that went against the industry, etc. For a discussion on how each such variable was constructed, please refer Kathuria (2004).

[14] The reason for taking an average for two days is because the time of day when the sample is taken is not fixed.

[15] The model was also estimated using the Index of total production, but the results hardly change. Given the fact that the focus is on industrial water pollution, the use of an index of chemical production seems more appropriate.

Table 2 summarizes all the independent variables, their measurement and the expected sign.

Table 2: Independent Variables, their measurement and expected sign

	Variable (1)	Measurement (2)	Expected Sign (3)
1	Informal Regulation (X_{t-1})	No. of articles/ decisions against the industry pertaining to water pollution	–
2	Formal Regulation (F_{jt})	No. of staff allocated by the EPA in the area	–
3	Rainfall (RF_{jt})	Rainfall during and the preceding day	–
4	Velocity (VE_{jt})	Velocity of water in the river/creek where the effluent is being discharged	–
5	Region's Output (A_{jt})	Index of Chemical Production	+
6	Nature of the region (RD_j)	Dummy for each monitoring station	?

5.4 Econometric Specification

For j^{th} monitoring point, the econometric model is specified as:

$$\text{Log}(R_{jt}) = b_0 + (-)b_1{*}X_{t-1} + (-)b_2{*}F_{jt} + (-)b_3{*}RF_{jt} + (-)b_4{*}VE_{jt} + (+)b_5{*}A_{jt} + (?)b_{6\text{-}8}{*}RD_j + (?)b_{9\text{-}12}{*}YD_t + (?)b_{13\text{-}23}{*}MD_k + u_j \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where X_{t-1} and F_{jt} reflect informal and formal regulation, RF_{jt}, rainfall, reflects the meteorological conditions in the region; the total output in the region (Q_j) is represented by A_{jt}, the activity variable. RD_j (regional or station dummy) captures the nature of production (S_j) and average age of plants (V_j) in the region. VE_{jt} represents the velocity of the water and $YD_{t = 1..4}$ and $MD_{k = 1...11}$ capture the year and month dummies. Lastly, the expected pollution price at an aggregate level is captured by community specific characteristics represented by X_t. Equation 5 is estimated for COD or Chemical Oxygen Demand. Thus, R_{jt} as given in equation 5 is the log of COD.

To test the hypothesis that informal regulation leads to a fall in pollution generation, we pooled the monthly data for all four stations for the five-year period, i.e., for 60 months from January 1996 to December 2000. Pooling can be done in various ways depending upon whether the data has auto-correlation or not and if it is homoscedastic. Thus, we first tested for autocorrelation and heteroscedasticity. The Cook-Weisberg test gives the χ^2 value of 5.49, which is significant at less than 5% indicating that the data has heteroscedasticity. The autocorrelation coefficient shows that the value is fairly high for three of the total four panels. This prompted us to use the panel corrected standard error model given by Praise and Winsten (PW).

In the PW model, disturbances are assumed to be heteroskedastic and are contemporaneously correlated across panels while computing the standard errors and the variance-covariance estimates. The model also assumes that there is first-order autocorrelation and that the coefficient of the AR (1) process is specific to each panel. The PW estimator is a generalized least squares estimator (for details, refer Judge, *et al.*, 1985).[16]

[16] The PW method is a modification of the Cochrane-Orcutt (CO) method, as the first case gets explicit treatment. There is another benefit with PW, that is, that for the high value of ρ, there is some difficulty in converging in CO process, but not with PW method (STATA, 2001).

Table 3 gives the station-wise descriptive statistics for some of the variables.

Table 3: Descriptive Statistics – Mean and Standard Deviation

S.No.	Variable	Monitoring Stations at				Overall
		V.N. Bridge (1)	Vautha (2)	Amla Khadi (3)	Khari (4)	
1	COD (mg/l)	273.78 (170.94)	326.53 (456.99)	3497.7 (4118.8)	1094.3 (493.27)	1298.1 (2456.0)
2	Discharge (m3) @	–	–	17.19 (21.3)	–	–
3	Velocity (m/sec)	0.227 (0.292)	0.281 (0.33)	0.51 (0.517)	0.357 (0.281)	0.344 (0.38)
4	Rainfall (mm)	1.36 (6.61)	0.81 (2.25)	1.89 (7.23)	1.12 (3.57)	1.3 (5.31)
5	Informal Regulation (no)	2.15 (2.18)	2.15 (2.18)	2.15 (2.18)	2.15 (2.18)	2.15 (2.18)
7	Formal Regulation (no)	20.62 (4.77)	20.62 (4.77)	10.63 (5.49)	41.23 (9.54)	23.27 (12.65)

Note: Figures in parentheses are standard deviation. @ - Discharge volume is given only in the case of Amla Khadi. For the other monitoring station, no readings have been given. This could be due to the low volume of water in those places.

6. Results

6.1 Basic Pooled Model

Table 4 gives the results for the pooled model. Column 1 of the table gives results when neither year nor month dummies is included in the model. Columns 2 and 3 report the results with the inclusion of month and year dummies. Since any increased coverage by the vernacular or other media should spur local monitoring, an interaction term (between informal regulation and the formal regulation variable) is included with the results given in Column 4.

As expected, the rains dilute the pollution concentration. The variable is negative and highly significant for all the variants of the model (row 1).[17] The coefficients on Velocity are insignificant.[18]

In the current specification, informal regulation does not have a significant influence on pollution. Even though the variable (row 3) has the correct sign, it is not significantly different from zero in statistical terms in any variants of the model. Similarly, the interaction term is not significant in statistical terms.[19]

[17] It could be argued that the previous day rainfall may not truly capture the dilution effect. Rather it is the rain during the past week or the past month that may explain the dilution better due to below ground percolation. Although the model was re-run with the variable calculated as the rainfall during the week and the month, it did not come out to be significant. One probable reason is that the regions covered are not high rainfall areas, so no such long-term percolation may be occurring.

[18] The positive sign on the coefficient is perhaps explained by the fact that most of the rivers, where industrial effluent finally gets discharged, do not have sufficient water for dilution of the effluent (CPCB Annual Report, 2000-01, and Kathuria and Haripriya, 2002). In such cases a high flow is a reflection of high activity in the region, which implies more production by the industrial units.

[19] Since the interaction term is insignificant, it is dropped from the subsequent analysis.

Table 4: Impact of informal regulation on pollution: Results of the pooled model

S.No.	Explanatory variables	Estimates of the Model			
		Without Year and Month dummies (1)	Without Month dummies (2)	With Year and Month dummies (3)	With dummies and Interaction term (4)
1	Rainfall during the day	-0.041* (-5.5)	-0.038* (-5.03)	-0.0273* (-3.47)	-0.0269* (-3.42)
2	Velocity	0.093 (0.81)	0.079 (0.68)	0.116 (1.01)	0.109 (0.95)
3	Informal Regulation (no. of articles published last month)	-0.011 (-0.43)	-0.003 (-0.61)	-0.012 (-0.44)	-0.008 (-0.32)
4	Formal Regulation (monitoring staff allocated to the area)	-0.022* (-2.29)	0.005 (0.31)	-0.015 (-0.96)	-0.01 (-0.59)
5	Interaction Term	-	-	-	-0.2×10^{-3} (-0.92)
6	Index of (Chemical) Industrial Production	0.016* (4.23)	0.013* (2.56)	0.02* (3.26)	0.021* (3.82)
7	Year dummy '97	-	-0.253 (-1.08)	-0.034 (-0.15)	-0.077 (-0.33)
8	Year dummy '98	-	-0.542* (-2.38)	-0.4* (-1.82)	-0.45* (-1.97)
9	Year dummy '99	-	-0.412* (-2.0)	-0.308* (-1.68)	(-1.45)
10	Significant month dummies	-	-	(-) July, August, September, October	(-) July, August, September, October
11	V.N. Bridge dummy	-1.91* (-8.60)	-1.36* (-4.04)	-1.77* (-5.17)	-1.73* (-4.93)
12	Vautha dummy	-2.23* (-6.73)	-1.69* (-4.13)	-2.1* (-5.31)	-2.07* (-5.12)
13	Amla Khadi dummy	0.18 (0.56)	0.997* (2.04)	0.369 (0.73)	0.43 (0.83)
14	Constant	5.43* (11.68)	5.03* (10.72)	4.84* (10.3)	4.74* (9.92)
15	R-squared	0.83	0.81	0.82	0.82
16	Wald Chi-square	475.41	525.19	589.49	593.48
17	Rho for each panel	0.05, 0.57, 0.35, 0.14	0.06, 0.54, 0.23, 0.20	0.03, 0.48, 0.25, 0.19	0.039, 0.48, 0.25, 0.21
18	No. of observations	240	240	240	240

Note: Figures in parentheses are t-ratios. * indicates statistically significant at minimum 10% level. Different variants of formal regulation variable were tried, but the model gives the best results with “monitoring staff allocated” variable only.

With respect to formal regulation, in model 1 the results indicate that if more people were devoted to monitoring, it results in a fall in pollution (row 4). However, the impact of monitoring gets marginalised with the inclusion of month or year dummies (columns 2 and 3). In fact, higher monitoring is one thing and monitoring efficiency is another. It is quite possible that inspectors may be visiting the estates/units, but perhaps not to nab culprits but to engage in something not quite so above-board such as taking graft. Thus, we think that the lack of significance of the formal regulation variable may have something to do with not having the correct indicator.[20]

Row 6 gives the coefficient for Index of chemical production, which comes out to be positive and highly significant indicating that a higher chemical production leads to high pollution generation.

Row 10 identifies significant month dummies. As expected, pollution is lower during the rainy months, i.e., July to October. Rows 11 to 12 give the monitoring station dummies. As shown in Table A1, the quality of water is comparatively better at V.N. Bridge and Vautha, where the water is from dispersed SSIs. On the other hand, at Amla Khadi and Khari, which receive water from Ankleshwar and Naroda, Odhav and Vatva IEs, the quality is extremely bad. This is well supported by the sign and significance level of coefficients.

6.2 Cumulative and Lagged Effects of Informal Regulation

It is possible that informal regulation has a lagged effect on pollution behaviour. In the previous section, informal regulation is modelled with a one month lag. Policy pronouncements or a High Court decision or PCB initiatives leading to a fall in pollution generation may require better housekeeping or a change in the production process or some investment in treatment. Thus, the one-month lag may not be adequate. We therefore re-estimated our results after constructing the informal regulation variable with a longer lag.

Furthermore, informal regulation may need to be sustained in order to have any meaningful impact on the behaviour of the firms. To see whether sustained informal regulation has any impact, the model is run with the variable calculated as the sum of articles published in the last two months to last one year respectively.

Table 5 reports the results when a lagged effect of news reporting on pollution is assumed and when the cumulative effect of news reporting is checked. We re-run model 3, which has month and year dummies. The results in Table 5 are reported for only the regulation variables (both formal and informal).

Rows 1 to 7 report the results when the regulation pressure variable is constructed with different lags rather than a month lag. From the table, it can be seen that though the formal regulation variable has come up with the right sign, it is not significant in any variant of the model. The probable reasons for the variable not being significant could be: a) poor implementation of formal regulation in the area; and b) the way the informal regulation variable has been constructed, which might be capturing the formal regulation impact as well. On the other hand, with respect to informal regulations, it is mainly press coverage accorded in the not too distant past (i.e., two months ago) to the polluting activities of the firms that seems to have led to a fall in pollution generation. However, when the individual lag is increased to more than 2 months, the impact vanishes.

[20] The monitoring effectiveness could not be used as the variable came out to be highly correlated with other explanatory variables.

Rows 8 to 16 report results when the information regulation variable is cumulated over different months. It is interesting to note that the cumulative press coverage, given in the previous two months from the period when water quality samples were taken, has a significant impact on pollution behaviour. The effect then becomes insignificant but gains in importance after five months but then again peters off beyond eight months of the cumulative impact. From the table, one can see that the coefficient is negative in all the cases. However, the significance level increases as the cumulative coverage increases, and the optimum seems to be six to seven months of sustained information regulation pressure. After the threshold, the impact decreases.

Table 5: Estimates of the pooled model – Checking for lag and sustained pressure

S.No.	Informal Regulation with	Coefficient for	
		Formal Regulation (1)	Informal Regulation (2)
1	1 month lag	-0.015 (-0.96)	-0.012 (-0.44)
2	2 month lag	-0.016 (-1.0)	-0.067* (-2.93)
3	3 month lag	-0.015 (-0.94)	0.019 (0.81)
4	4 month lag	-0.016 (-0.96)	0.0036 (0.16)
5	5 month lag	-0.014 (-0.89)	-0.023 (-0.98)
6	6 month lag	-0.015 (-0.95)	-0.02 (-0.85)
7	7 month lag	-0.015 (-0.92)	-0.012 (-0.52)
8	2 months' cumulation	-0.015 (-0.92)	-0.042* (-2.45)
9	3 months' cumulation	-0.016 (-0.97)	-0.023 (-1.55)
10	4 months' cumulation	-0.014 (-0.9)	-0.015 (-1.22)
11	5 months' cumulation	-0.013 (-0.82)	-0.017 (-1.6)
12	6 months' cumulation	-0.0127 (-0.78)	-0.018* (-1.83)
13	7 months' cumulation	-0.0114 (-0.69)	-0.0187* (-2.00)
14	8 months' cumulation	-0.013 (-0.81)	-0.0089 (-1.05)
15	9 months' cumulation	-0.013 (0.8)	-0.01 (-1.33)
16	12 months' cumulation	-0.016 (-0.97)	0.0007 (0.10)

Note: Same as Model 3 of Table 4—all other variables retain almost the same sign and significance level.

6.3 Impact of Informal Regulation—Is it different across institutional set-up?

The analysis so far does not take into account possible differences in the impact of informal regulation on different types of industries. As mentioned in sub section 5.1, two of these four monitoring stations, referred to as Type 1 stations (Amla Khadi and Khari), are directly on the mouth of industrial estates. However, the other two stations, that is, Type 2 stations, (V.N. Bridge and Vautha), receive water from dispersed industrial units. Consequently, the monitoring requirement and pollution problem in these two types of stations are likely to differ. The monitoring of units in Type 1 stations is more *a kin* to monitoring a point source of pollution, whereas in Type 2 stations it is essentially monitoring non-point sources of pollution (Kathuria and Sterner, 2002). This implies that the industrial units in these two types of monitoring stations are subject to two different types of institutional set-up with respect to monitoring. Thus, the impact of informal regulation on effluent generation cannot be identical at these two institutional set-ups. This section tries to separate the effect of informal regulation pressure on these two station types.

Table 6 gives the results of the impact of informal regulation on Stations receiving effluents from industrial estates (Type 1) and Stations receiving effluents from diverse industrial sites (Type 2) separately. The Informal Regulation variable has been constructed as an interaction variable. For the Type 1 station, it is interaction of X (informal regulation) with the dummy variable for stations 1 and 2. Similarly, for Type 2 monitoring stations, we interact X (informal regulation) with the dummy for stations 3 and 4. Thus, for Type 1 stations, the variable is constructed in the following manner:

Informal Regulation for Type 1 = X * Station dummy for Amla Khadi and Khari

The Informal Regulation variable now looks like a dummy variable except that instead of value 1 and 0, it has a value of informal regulation and zero. This way of constructing the informal regulation variable can retain the advantage of pooling, but allows us to check whether coefficients for Informal Regulation vary across monitoring stations or not. Columns 1 and 2 of Table 6 report results when the model is estimated with one month lag and 2 months lag respectively. Rows 3 and 4 give the coefficient for the informal regulation variable for the two types of monitoring stations. From the sign and significance level of the coefficients, it seems that informal regulations have a significant impact on Type 1 monitoring stations, i.e., on stations that receive pollutants from industrial estates. However, they do not appear to have any significant effect on Type 2 stations or stations that receive effluents from dispersed industries.

To test whether there is a significant difference between these two coefficients, we undertook a Wald test. It is a chi-square test, which tests for the equality of variables. If the test statistics, i.e., χ^2 is significant, this implies that the coefficients are unequal. Table 7 gives the test statistics for both the models. The test statistics show that the two coefficients (i.e., informal regulation variable for Type 1 and Type 2 monitoring stations) are different, as the χ^2 value is significant. Thus, informal regulation has a differential impact on the two different station types.

Table 6: Impact of informal regulation on pollution for monitoring stations with different institutional set-up (N = 240)

S.No.	Explanatory variables	Estimates of the Model	
		Model 1 - One month lag (1)	Model 2 - Two months lag (2)
1	Rainfall during the day	-0.026* (-3.38)	-0.0248* (-3.25)
2	Velocity	0.11 (0.97)	0.084 (0.75)
3	Informal Regulation - (For ESTATE - Type 1 stations)	-0.049* (-1.72)	-0.061* (3.41)
4	Informal Regulation - (For non-ESTATE - Type 2 stations)	0.022 (0.60)	-0.024 (-1.02)
5	Monitoring staff allocated for the area	0.013 (0.83)	-0.013 (-0.78)
6	Index of (Chemical) Industrial Production	0.02* (3.69)	0.022* (4.06)
7	Year dummy '97	-0.052 (-0.23)	-0.04 (-0.19)
8	Year dummy '98	-0.42* (-1.93)	-0.44* (-2.07)
9	Year dummy '99	-0.32* (-1.67)	-0.16 (-0.84)
10	Significant month dummies	July, August, September, October	July, August, September, October
11	V.N. Bridge dummy	-1.88* (-5.43)	-1.88* (-5.21)
12	Vautha dummy	-2.22* (-5.52)	-2.22* (-5.35)
13	Amla Khadi dummy	0.43 (0.85)	0.45 (0.86)
14	Constant	4.91* (10.47)	4.75* (10.27)
15	R-squared	0.834	0.83
16	Wald Chi-square	659.81	648.36
17	Rho for each panel	0.04, 0.48, 0.24, 0.18	0.048, 0.49, 0.24, 0.23

Note: Same as Table 5.

Table 7: Wald (χ^2) test for equality of coefficients for two different institution types

Model	Informal regulation (1)	Identical Monitoring Stations (2)	Chi-square (3)
1	As one month lag	Type 1 (1,2) and Type 2 (3,4)	3.61* (0.0575)
2	As two months lag	Type 1 (1,2) and Type 2 (3,4)	2.38* (0.1226)

Note: Figures in parenthesis are significance levels. * indicates coefficients are significantly different from each other at minimum 15%.

Thus the analysis indicates that informal regulation works differently depending upon the institutional set-up. The possible explanation for the differential response can be given from the ES schedule or MEP of units in the two areas. The expectation of increase in MEP rises for the firms in an industrial estate, as the local industries association itself may be doing a policing job.[21] However, for the dispersed industrial units, such increase in MEP is unlikely.

Given that there are different types of industries that release effluents at each of the monitoring stations, an interesting question is whether these industries respond differently to informal regulations. The Type 1 stations, for instance, reflects pollution from industrial units in Ankleshwar and Khari. Ankleshwar has small, medium and large industries, including MNCs that may be more responsive to the negative publicity. Khari, on the other hand, is made up mainly of small industrial units. In order to examine the differential impact of informal regulation, the model was run with the informal regulation variable constructed differently for each station. The informal regulation variable for a station is an interaction variable between X (informal regulation) and the dummy for that station.

Informal Regulation for a station = X * Dummy for the station

Table 8 reports the results, which show that informal regulations have a significant effect on pollution associated with only one monitoring station only, i.e., Amla Khadi, which is fed by pollution from the Ankleshwar industrial estate. The interaction coefficient between informal regulation and Amla Khadi (row 5) is negative and significant in both the models. However, despite having a similar institutional set up, the informal regulation pressure effect is insignificant for units discharging into Khari (row 6).

Since Khari appears to behave more like Type 2 stations, we tested to examine whether the coefficient of informal regulation at Khari is similar to coefficients obtained for V.N. Bridge and Vautha. A Wald test was conducted and reported in Table 9. It can be seen from Table 9 that the informal regulation pressure is the same for the monitoring stations having dispersed industrial units (i.e., V.N. Bridge and Vautha). That is, coefficients of the interaction term between informal regulation and monitoring stations are not significantly different from each other in the case of V.N. Bridge and Vautha. The test statistics (rows C and G of Table 9) indicate that Khari (a Type 1 station) is behaving identically to Type 2 stations. On the other hand, as shown in Row F, the two Type 1 monitoring stations, Amla Khadi and Khari, differ in their response to the informal regulation pressure when a two-month lag is used.

[21] In the recent past, GPCB as well as High Court rulings have directed the industries associations to do monitoring in their respective estates. After a 1995 ruling by the High Court, monitoring by the Industries Association has become a regular feature in Ankleshwar, Vapi, etc.

Table 8: Impact of Informal regulation on pollution for each monitoring station

S.No.	Explanatory variables	Estimates of the Model	
		Model 1 - one month lag (1)	Model 2 - two months lag (2)
1	Rainfall during the day	-0.026* (-3.34)	-0.025* (-3.37)
2	Velocity	0.11 (0.96)	0.096 (0.87)
3	Informal Regulation - (V.N. Bridge station)	0.034 (0.88)	-0.024 (-0.99)
4	Informal Regulation - (Vautha station)	0.011 (0.20)	-0.024 (-0.61)
5	Informal Regulation - (Amla Khadi station)	-0.081* (-1.89)	-0.097* (-3.58)
6	Informal Regulation - (Khari station)	-0.014 (-0.44)	-0.025 (-1.18)
7	Monitoring staff allocated for the area	-0.017 (-1.08)	-0.021 (-1.34)
8	Index of (Chemical) Industrial Production	0.021* (3.85)	0.023* (4.38)
9	Year dummy '97	-0.018 (-0.08)	-0.041 (-0.18)
10	Year dummy '98	-0.39* (-1.77)	-0.37* (-1.70)
11	Year dummy '99	-0.31* (-1.64)	-0.11 (-0.60)
12	Significant month dummies	July, August, September, October	July, August, September, October
13	V.N. Bridge dummy	-1.92* (-5.61)	-1.9* (-5.58)
14	Vautha dummy	-2.21* (-5.33)	-2.25* (-5.20)
15	Amla Khadi dummy	0.45 (0.90)	0.48 (0.97)
16	Constant	4.83* (10.16)	4.65* (9.9)
17	R-squared	0.835	0.83
18	Wald Chi-square	665.87	654.02
18	Rho for each panel	0.05, 0.48, 0.22, 0.19	0.048, 0.49, 0.24, 0.23
19	No. of observations	240	240

Note: Figures in parentheses are t-ratios. * indicates statistically significant at minimum 10% level.

Table 9: Wald (χ^2) test for equality of coefficients for each monitoring station

Model			Monitoring Stations (1)	Identical Monitoring Stations (2)	Chi-square (4)
1	Informal regulation as one month lag	A	1, 2	V.N. Bridge and Vautha	0.16 (0.69)
		B	3, 4	Amla Khadi and Khari	1.86 (0.17)
		C	1, 2, 4	V.N. Bridge, Vautha and Khari	1.33 (0.504)
		D	1, 2, 3, 4	All the stations	6.99* (0.0304)
2	Informal regulation as two months lag	E	1, 2	V.N. Bridge and Vautha	0.0 (0.999)
		F	3, 4	Amla Khadi and Khari	5.04* (0.025)
		G	1, 2, 4	V.N. Bridge, Vautha and Khari	0.0 (0.999)
		H	1, 2, 3, 4	V.N. Bridge, Vautha and Khari	6.43* (0.0402)

Note: Figures in parenthesis are significance levels. * - indicates coefficients are statistically different across monitoring stations.

Why is informal regulation pressure not working in industrial units in Khari? This is may be partly because of weak formal regulation in the region. Analysis of some High Court rulings indicates that the Court has repeatedly passed strictures against industries in the Khari region. But the local PCB seems to have failed to take necessary action each time. Once the industrial units find that the local PCB is dormant, even the units treating effluents may stop, which would lead to a Nash equilibrium of not treating the effluent by most of the units. Further, as stated previously, industrial units in Khari are small while those in Ankleshwar are a mix of small, medium and large. Thus, our analyses suggests that small units, even if they are part of an industrial estate, are less likely to respond to informal pressure.

Thus, based on the above analysis, we conclude that informal regulation of pollution seems to work only partially in Gujarat. Further, formal regulations seem to have little or no effect on polluting behaviour. With respect to informal regulation pressure, the impact is not immediate. Only sustained publicity of polluting activities leads to some fall in pollution generation. The effect is also not uniform: industrial units discharging effluent in Amla Khadi are found to be more responsive to informal regulation than units elsewhere. Despite having the same institutional set up, industrial units in Khari behave differently.

7. Concluding Remarks

The design of policy instruments for monitoring industrial pollution in the case of developing countries is a challenging task. In principle, the regulator has an array of physical, legal, monetary, and other instruments. But the presence of a large number of SSIs and informal sector pollution sources that lack knowledge, funds, technology and skills to treat their effluent, makes a mockery of any instrument applied and leads to overall failure. The literature in the recent past has not only recognised the implementation limitations of formal regulations but has also appreciated the significance of informal regulation in achieving environmental goals.

The present study attempts to see whether "informal channels" or local press as a form of informal regulation has any role to play in pollution control in the second most industrialised and polluted state of India, i.e., Gujarat. In order to test this hypothesis, the study uses monthly water pollution data from four hot spots of Gujarat for the period January 1996 to December 2000.

The analysis shows that local news coverage of pollution does have an influence on polluting behaviour. However, the effect of informal regulation on polluting behaviour is not immediate. Only sustained publicity about polluting activities of industrial units appears to lead to a significant fall in pollution generation. Further, informal regulation seems to work best on pollutants from industrial estates with a mix of small, medium and large industries.

The study identifies important policy and practical implications for regulating pollution. Our analysis suggests that lobbying efforts through the media by environmental activists and NGOs may be quite effective in influencing industry behaviour.

However, we cannot answer the larger policy question about which regulation is more cost effective, formal or informal. This is due to the kind of data used. For such a policy prescription, one needs more detailed analyses covering all the monitoring stations in Gujarat, if not the whole country.

There are many ways in which this study can be extended to obtain a better understanding of the effect of informal regulation on industrial pollution. One of the limitations of the present work is the use of monthly pollution data. It is quite possible that industrial units respond more immediately to policy promulgations or media pressure. Use of daily pollution level data would help assess this. Also pollution behaviour may respond differently to local versus national press coverage. Another possible extension of the study is to see whether informal regulation is causing a change in pollution or whether higher pollution rates and associated health impacts cause more media coverage. However, this type of detailed analyses would require time-series data, which is currently unavailable.

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Appendix 1

Legislative provision of regulation of Water Pollution in India[22]

The Water (Prevention and Control of Pollution) Act (1974) and the Environment (Protection) Act (1986) are the two main legal provisions that empower the Indian government to enforce environmental regulations. The Water Act prescribes both general and industry specific standards for the discharge of wastewater into water bodies. The discharge of wastewater carrying pollutants beyond the specified standards is prohibited into surface waters, public sewers, coastal waters and on land for irrigation. The Act also lays down penalties for non-compliance. These standards uniformly apply to all firms within an industry or to all firms in general (where specific standards do not exist). The standards differ according to the class of water bodies into which the wastewater is discharged. For example, the standards are relatively less strict for disposal on land for irrigation but are most strict for discharge into surface water bodies. The pollution standards are concentration based, i.e., they are specified as milligrams (mg) of pollutant per litre (mg/l) of wastewater discharged. The Environment Act, which is also an umbrella act, provides the Central Government with greater powers to set and enforce environmental standards than what was provided in the Water Act. The basic features pertaining to industrial pollution abatement, however, remain the same.

There is a basic division of power between the centre and the states in India with regard to environmental regulation, reflecting the federal nature of the Indian Constitution. The mandate of the Central Pollution Control Board (CPCB) is to set environmental standards for all the plants in India, lay down ambient standards and co-ordinate the activities of the state PCBs. The State PCBs (SPCBs) can set even stricter standards depending upon the carrying capacity of the region.[23] The implementation and enforcement of environmental laws, however, are decentralised, and are the responsibility of the SPCBs. Evidence suggests wide variations in enforcement across the states (Pargal, Mani and Huq, 1997)—a result of prevailing differences in local political, economic and environmental conditions (Hettige, *et al.*, 1996).

The SPCBs have the legal authority to conduct periodic inspections of factories to check whether they have the appropriate consent to operate, have effluent treatment plants (ETPs), take periodic samples for analysis, etc. Some of these inspections are sometimes programmed in response to public requests and litigation (Goldar and Banerjee, 2002). There are penalties for non-compliance. Until 1988, the enforcement authority of the SPCBs was very weak. But now the SPCBs have the power to close non-compliant factories or cut-off their water and electricity by administrative orders.

[22] This borrows heavily from Goldar and Banerjee (2002).

[23] This is similar to the "subsidiarity" principle followed by EU member countries with regard to setting of environmental standards.

Appendix 2

Table A1: Yearly Average of Pollution parameters at the Most Polluting Stations in Gujarat

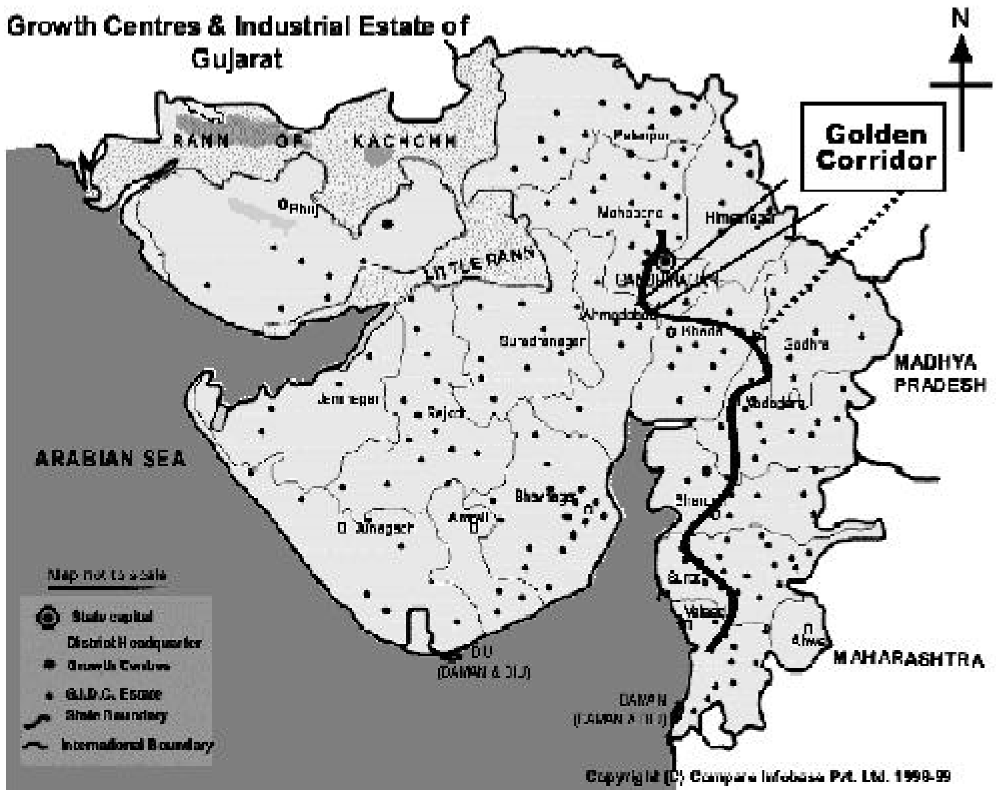
S.No.	River / Location	1996-97			1997-98			1998-99			1999-00		
		DO (1)	BOD (2)	COD (3)	DO (4)	BOD (5)	COD (6)	DO (7)	BOD (8)	COD (9)	DO (10)	BOD (11)	COD (12)
1	Sabarmati / V.N. Bridge	1.16	82	229	1.2	82	179	4.8	74	239	4	114	260
2	Sabarmati / Miroli	0.02	61	221	0.02	62	151	2.4	57	182	2	65	187
3	Khari / Lali	0	271	1046	0.2	171	246	0	263	1033	0	77	259
4	Par/Atul / Rly. Bridge Pardi	3.7	65	351	6.7	25	51.3	6.8	25	510	5	7	39
5	Amla Khadi /Ankleshwar	1.2	8	1626	0.5	71	191	0.2	575	1425	0	1039	2717
6	Kalkada Khadi /Kachigam	–	805	1393	5.6	56	99	ND	9	108	0	31	131
7	Bill Khadi / Vapi	–	392	1136	2.9	61	88	ND	18	168	0	130	586

Source: GPCB, Annual Reports (various years)

Note: All the figures are in mg/l and are rounded off; BOD, COD and DO are commonly used parameters to measure pollutants in water. Bio-chemical Oxygen Demand (BOD), a measure of organic pollution, is defined as the amount of oxygen used by micro-organisms per unit of volume of water at a given temperature for a given time. Chemical Oxygen Demand (COD) is an alternative measure of the oxygen equivalent of the organic content of a sample that is susceptible to oxidation by a strong chemical agent whereas Dissolved Oxygen (DO) is the concentration of oxygen dissolved in water.

Appendix 3

Figure A1: Location of Monitoring Stations



Source: Downloaded from www.gidc.gov.in in July 2000.

Notes: Red line indicates the Golden Corridor—a stretch of 400 Km from South Gujarat to Mehsana where most of the (chemical) industrial development has taken place. Arrows in bold indicate the location of the four monitoring stations analysed in the present study.

Appendix 4

Figure A2: Informal Regulation Pressure in Gujarat