INFORMAL REGULATION OF POLLUTION IN A DEVELOPING COUNTRY

– Empirical Evidence from Gujarat, India

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ABSTRACT

Recent literature has not only recognized the implementation limitations of formal regulation, but also appreciated the significance of informal regulation for achieving environmental goals for developing countries. Since most units in developing world fall under unorganized sector, even utility of some of the informal channels like public-disclosures is limited. Under the scenario, a localized channel like vernacular press has greater utility. Present study attempts to see whether this channel has any role to play in pollution control. To test, monthly water pollution data from four hotspots of Gujarat, India for the period Jan-96 to Dec-2000 is used. Analysis shows that informal regulation has worked partly as only sustained pressure leads to fall in pollution. However, not all stations are affected equally. It is mainly the station receiving water from industrial estate and housing somewhat large units respond to the informal pressure.

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1. Introduction

The design of policy instruments for industrial pollution is not only complex but also very daunting especially in the case of developing countries. In principle, the regulator has an array of physical, legal, monetary, and other instruments to use (Sterner, 2002). But the presence of large number of small-scale (SSIs) and unorganised sector pollution sources that lack knowledge, funds, technology and skills to treat their effluent frustrates any instrument applied and leads to overall failure.[1] The failure of industrial pollution control is also attributed to a large extent on the rigid command-and-control (CAC) regulatory approaches. The scattered informal sector units, which are almost *a kin* to non-point source of pollution (NPSP) (Sterner, 2002) aggravates the problems of regulators already constrained by meagre resources[2] and

[1] This is very well substantiated with the ground reality in India. Despite having one of the highest number of legislation to abate pollution, the water quality of major rivers and water bodies is extremely bad in India. The principal cause of this is scattered industrial sources – both SSIs and large units (Kathuria and Haripriya, 2002).

[2] For example, in a Northern state of India – Bihar – the State Government withheld funding to the local EPA (i.e., Bihar Pollution Control Board, BPCB) for several years, restricting BPCB expenditure to less than a third of its modest requisition. Depriving the enforcement agencies of funds means inadequate technical staff and supporting infrastructure for monitoring and control. Ten years after the Indian Parliament enacted the Water Act in 1974, the BPCB did not have a single laboratory or analyst to test effluent samples (Source: B. Desai, 1990, Water Pollution in India, p. 146 as referred in Divan and Rosencranz, 2000: 3).

limited authority – even further marginalised by political interference.[3] Additionally, overall prevailing low remuneration also invites corruption. The problems are compounded by *information asymmetries*. Perhaps that may be the reason why a large number of studies in India concluded that despite a strong legal framework and existence of a large bureaucratic set-up to deal with environmental regulation, the implementation is still weak (see for example, Pargal, Mani and Huq, 1997; Murty and Prasad, 1999 among others).

The situation is not specific to India and is similar in many developing countries. On the flip side, the failure of formal regulation to control pollution has resulted in some fresh thinking in the recent past. The pragmatism has yielded ‘information disclosure’ and ‘rating’ as the tools of industrial pollution control, what is sometimes referred to as the ‘informal regulation’ of pollution or the ‘third wave’ of environmental policy (Tietenberg, 1998). The approach is explicitly acknowledging the difficulties of monitoring and enforcement and recognising that there are many more avenues of influence than just formal regulation or monetary charges. Firms are sensitive, for example, about their reputation and the future costs they may incur as a result of liability or accidents. The emergence of this new paradigm for regulation is also related to the advances made during the past decades in our understanding of *asymmetric information* (Kathuria and Sterner, 2002).

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[3] Following instance reflects the glaring example of this political interference. The local EPA of another Northern state, Haryana PCB was dissolved shortly after it served a prosecution notice on the Chief Minister’s son-in-law, when the unit owned by the latter was found violating the pollution norms in the state (Source: *Haryana Pollution Board Disbanded*, Times of India, Delhi, 13 May 1992).

The recent literature has amply appreciated the significance of informal regulation for achieving environmental goals (see for example, Pargal and Wheeler (1996), Afsah, Laplante and Wheeler (1996), Pargal, Mani and Huq (1997), Tietenberg (1998), Wheeler *et al*. (2000), Sterner (2002) among others). Sufficient anecdotal evidence also exists that when formal regulation was weak or absent, informal regulation through local community participation 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 as mentioned in Wheeler *et al.*, 2000). Similarly, a paper mill in India after being confronted by community complaints had to install pollution abatement equipment and for the remaining damage, the mill compensated the community by constructing a temple (Agarwal *et al.*, 1982). In Rio de Janeiro, Brazil, the protest against a polluting tannery led to its relocation to the outskirts of the city (Stotz, 1993 as referred in Pargal and Wheeler, 1996). Khator (1991 as referred in Hettige *et al.*, 1996) using several case studies illustrates how the polluting plants in India responded to community pressure.

Pargal, Hettige, Singh and Wheeler (1997) suggest that the informal regulation can take varied forms, including demand 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 (1) reporting violations of standards to the regulatory agencies (where such standards and institutions exist); and (2) putting pressure on regulators (through politicians and administrators) to tighten the monitoring and enforcement. However, there also exist "informal" channels of informal regulation – like public disclosure, ratings etc., where use of markets is made to punish polluters. In fact, public disclosures and ratings work when the units are not only relatively large but also in the organised sector and depend on outside markets for their products, finance etc. Since a large number of units in India and other developing world fall under unorganised sector, the utility of formal channels of informal regulation and public disclosures is limited. The data shows that in India 3.2 million SSIs produce about 8,500 products – some of these products are highly polluting. Even a conservative estimate of 10% of the total SSIs being polluting in nature implies that there are 0.32 million units causing adverse impact on the environment (CPCB, 2001: 2). The net impact of these 0.32 million units is estimated to be nearly the same as with all the large and medium industries put together. The share of SSIs in wastewater generation among 11 industries, where they have a sizeable presence, is about 40% with the total volume of wastewater generated by them around 3,881 million liters per day (mld) (*ibid*.: 4). Under the scenario, the informal pressure has to be highly localised. A proactive vernacular (or local) media is one such localised informal means of informal regulation that can easily trigger formal regulation.[4] This particular "informal" means of informal channel is the focus of present paper.

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[4] An example where local (pro-active) press led to prompt High Court (HC) initiative, which finally forced EPA to act, is in the case of gas leakage and foul smell between Sabarmati and Vasna area in Ahmedabad, India on 8th March, 1999. The HC immediately took *suo motu* cognizance and issued notices to the State government, the Gujarat PCB, the Ahmedabad Municipal Corporation (AMC), District Collector, City Police Commissioner, and the Chief Inspector of Factories, when for 3 days consequently, it found extensive press coverage of the gas leak with no government department forthcoming for any clarification (Source: *HC takes note of gas leak*, Indian Express, 12.03.1999).

The paper attempts to see whether this informal channel has any role to play in pollution control in the second most industrialised and highly polluted state of India i.e., Gujarat. The remaining 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 facilitate alignment of behaviour of polluters with that of the 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. Paper concludes with Section 7 with some policy implications.

2. Literature Review

Studies in Developed Countries

In case of developed countries the emphasis of most of the studies is 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. In the case of US, Hamilton (1995) and Konar and Cohen (1997) among other variables also include the reaction of markets to releases of *Toxics Release Inventory*. Lanoie and Lapante (1994) and Lanoie *et al*., (1998) have tried to see the capital market response to environmental accidents. These studies have found that in general, the announcement of adverse environmental news leads to decline in market value of the firms. Wheeler *et al*. (2000) has summarised these and few more studies. The summary indicates that negative environmental news has resulted in an average loss of 0.3% to a maximum of 2%, whereas, a positive environmental performance information resulted in appreciation of the stock by nearly 0.82% as found by Klassen and McLaughlin (1996). The impact of firm-specific environmental news on market value may work its way through various channels: a high level of pollution intensity may signal inefficient production process to the investors; may invite stricter scrutiny by environmental groups or may result in the loss of reputation, goodwill etc. On the other hand, the announcement of investment in cleaner technology or a good environmental performance may have the opposing effect (Dasgupta *et al*., 2001).

Studies in Developing Countries

The only study that has tried to see the announcement of environmental news reaction on the capital market in the context of developing country is by Dasgupta, Laplante and Mamingi (2001). The results indicate that capital markets in Argentina, Chile, Mexico and Philippines do react to the announcements of environmental events, such as those of superior environmental performance or citizens' complaints. Since presence of an efficient capital market is often an exception than a rule in most of the developing countries, recognising this limitation, other studies have used community specific variables like literacy, development index or per capita income as an indicator of informal regulation. These include Pargal and Wheeler (1996), Afsah *et al*. (1996), Pargal *et al*. (1997) among others for countries like Indonesia, Bangladesh, Thailand etc. These studies in general found that the presence of community specific variables in the model(s) showed a direct relation with monitoring / inspection and enforcement. Thus reflecting that the informal regulation has worked.

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

Studies with focus on India

In case of India, there have been four earlier studies to examine the impact of informal regulation on water pollution – three specific to India (Pargal, Mani and Huq, 1997; Murty and Prasad, 1999, and Goldar and Banerjee, 2002) and fourth by Hartman, Huq and Wheeler (1995) is a cross section study on pulp and paper plants of few South and Southeast Asian Countries including India.

Pargal, Mani and Huq (1997) (henceforth PMH) using survey data for 250 medium and large industrial plants located in eight states examined regulatory inspections and water pollution discharges, and investigated whether the monitoring and enforcement efforts of local PCBs are affected by local community characteristics that act as proxies for political power. The two plant level variables used in the study were emissions as measured by bio-chemical oxygen demand (BOD)[5] load and number of inspections each plant was subjected to during 1990-1994. The survey revealed that of the sampled 250 plants, 51 (20.4%) had undertaken abatement in response to non-governmental organisations' (NGOs) pressure and 102 (41%) had done so in response to complaints from neighbouring communities. An important finding of the study with respect to formal regulation is that high levels of

[5] BOD is a commonly used measure of organic pollution and 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.

pollution triggers regulatory response in the form of inspections. Ironically, these inspections have no impact on discharge levels. The authors interpret this as a reflection of bureaucratic or other problems in following through.

With respect to informal regulation, the results indicate a positive relationship between district development index, DDI (chosen as a proxy for informal regulation) and the number of inspections, but no significant negative relationship is found between DDI and BOD discharge. The possible explanation given by authors is that the community activism could be unrelated to levels of urbanisation, income, and education, and the dirty plants are targeted irrespective of their locations. Another inference drawn by the authors is that the community pressure presently is probably being channelled through the formal mechanism rather than through direct negotiation with plants.

Murty and Prasad (1999) (henceforth MP) carried out an analysis for the period 1994/95, quite in line with that of PMH, using cross-section data for a sample of 100 factories belonging to 11 highly water polluting industries in 13 states. They however find evidence of significant informal pressure (as represented by DDI and the rate of participation in the previous parliamentary elections) on an index of the reduction in pollution due to firm’s efforts. The index of reduction is constructed as the ratio of BOD concentration in effluent to that of influent. The estimation shows a significant negative relationship of the DDI and political participation on the BOD ratio. This implies that higher levels of development are associated with greater abatement of pollution and the more active the local people politically, the higher is the extent of pollution abatement done by the factories located in that area.

The third study by Goldar and Banerjee (2002) (henceforth GB) analyses the ambient water quality not the industrial discharge of effluents as such, and uses the annual water quality data for 106 monitoring stations on 10 important rivers for five years. The study attempts to see how the secondary education and poll percentage of the area (proxies for informal regulation) affect the pollution level. The study finds a significant positive relationship between poll percentage and water quality, and also between the proportion of people who have completed school education in a state and the water quality in rivers flowing through the state. Based on the signs and significance the study concludes that a significant favourable effect of informal regulation exists on river water quality in India.

The last study by Hartman, Huq and Wheeler (1995) uses survey data on 26 pulp and paper plants (mainly of large size) of four countries namely Bangladesh, India, Indonesia and Thailand. The sample was chosen to maximise variation in location- and ownership related variables within these countries. In India, the survey covered four states. Besides other variables, index for formal and informal regulations were used. An index of strength of formal regulation was constructed based on units' perception on a 5-point scale. Informal regulation was represented by a dummy, based on consideration of strong pressure by the community to abate during the last two years. The study finds that both formal and informal regulatory pressure positively affect the abatement effort. When the authors replace informal pressure by per capita income and visibility of plant as denoted by nearness to the city, the results hardly change except that the overall fit of the model drops slightly.

Limitations of previous studies

The studies that have tried to see the impact of environmental news on stock-value of firms (e.g., Dasgupta *et al.*, 2001) need to fulfil two conditions – the capital markets should be perfect and the firms should be listed in the stock exchange. Since the focus of the present work is on SSIs – both scattered and housed in Industrial Estates (IEs), the framework has no utility. This is also one of the major limitations of three of the four studies carried out in case of India as their focus on medium and large size factories. Since, large plants are more visible and can be targeted using external pressure also, the problem of pollution may still persist. In fact, the regulator's problem in developing countries is essentially managing SSIs. The study by Blackman and Bannister though tests the role of community pressure for small and informal sector but is concerned with air pollution. The study by GB is different, as instead of plant level data it uses annual ambient pollution level at different locations. However, the use of annual average conceals important differences for the period as will be evident from Section 5.

Further, most of the studies have used poll percentage as a variable reflecting informal pressure. Given the fact that polls in India are generally held after five years, the use of poll percentage has relevance if the analysis is either cross-sectional as in MP study or the period of analysis is fairly long, which incidentally is not always the case. Another limitation is the unpredictability of community characteristics in voting. In the recent past, it has been observed that sometimes more literate communities do not go for voting due to their disenchantment with the political system. Under the scenario, whether poll percentage can truly reflect 'informal regulation' as hypothesised by several studies is any body's guess. Use of index of development as a variable reflecting informal pressure can easily be debated, as the two most industrialised states in India – Gujarat and Maharashtra are also the most polluted. Even within industrialised states (e.g., Gujarat), it is the highly urbanised and industrialised districts (i.e., Ahmedabad and Surat) which are the most polluted. Another important limitation with the MP and GB study is that they have not accounted for formal regulation in their models, implying the estimated model could be mis-specified. Lastly, all the studies for India have used education level as a variable for community pressure. The use is defensible if the analysis is cross-sectional, which is not the case with the GB study. Since the variable hardly changes in five-year period, it only measures period-specific effect rather than the true effect.

The present study attempts to account for some of these limitations by focusing on few industrial hot-spots in Gujarat, where the pollution is caused by not merely large and medium units, SSIs also have a major contribution. The study intends to cover both categories of hotspots – category one where units are housed in an IE and category two where units are dispersed. The present study is also more disaggregated in terms of data use, as it employs monthly data on ambient pollution level and attempts to examine whether informal regulation works at the regional level or not. The construction of informal regulation variable itself is quite broad in coverage, as we shall see in Section 5. The study also accounts for formal regulation by employing a variable reflecting the monitoring aspect.

3. Economics of Pollution – with formal and informal Regulation[6]

The previous literature investigating the impact of informal regulation has looked 'equilibrium pollution' level in a region, which are bereft of any formal regulation (see for example, Pargal and Wheeler, 1996; Hartman *et al.*, 1996 among others). This may be true for few developing countries but not for all. Even in India, where regulation failure cases abound, pockets exist where formal regulation has worked. Regulation induced use of Compressed Natural Gas (CNG) leading to fall in air pollution of Delhi is one such recent example. Even Pargal *et al*. (1997) 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 SSIs.

The equilibrium pollution level in a region is determined by the intersection of 'demand' and 'supply' schedule for environmental services. Environment is usually characterised by some carrying or absorptive capacity. Any polluting plant essentially uses this absorptive capacity. This is nothing but the demand for environmental services by a plant. Plants can either use this service completely or can reduce the emissions by adopting some mitigatory methods. The latter can be achieved by diverting the resources. Thus, for a cost minimising plant, this environment demand (ED) schedule reflects its marginal abatement cost (MAC) schedule. This implies more the plant abates, lesser is its demand for environmental services. On the other hand, it becomes progressively expensive for the plant to abate at low pollution levels *a la* law of diminishing returns. The regional MAC or ED schedule can

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

be crudely approximated as a sum over all the plant-level schedules, which slopes downward to the right. As the price of the environmental services rises, industry would prefer reducing pollution along this schedule (Hartman *et al*., 1996).

With an effective formal regulation, the environmental services always have a price for a plant. But the widespread ineffective formal regulation accentuated by the concentration-based standards prevailing in developing countries including India, this price becomes too little to impact on pollution at a regional level. The price can be augmented if the people affected act in their own self-interest through various ‘informal’ or ‘quasi-formal’ channels. Hartman *et al*. (1996) argue that in the absence of formal regulation, communities confront local polluting plants with a supply schedule for the environmental services that reflects three basic factors: their ability to a) monitor emissions; b) assess damages (together they indicate information costs); and c) bargain in enforcing (local) pollution norms (reflecting transaction cost). These three aspects mirror the community assessment of social marginal damage (MSD) and get summarised in a locally enforceable environmental supply (ES) schedule. With increase in damages, the 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 (Figure 1).

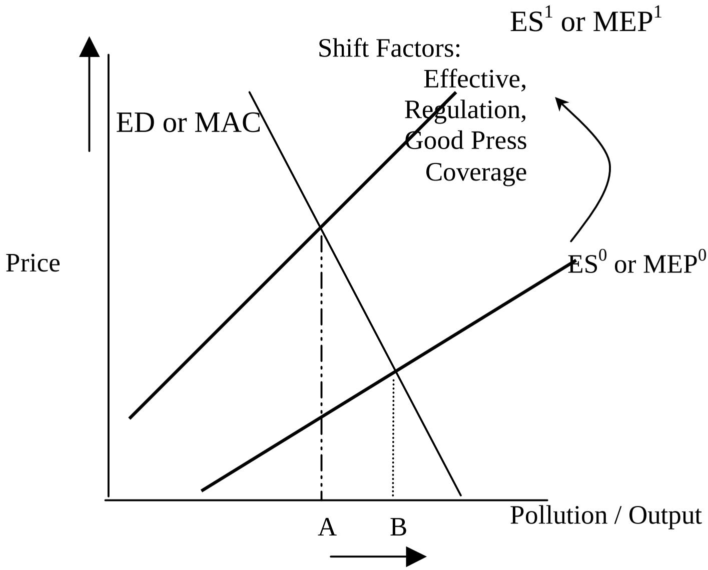

Figure 1. Impact of Formal and Informal Regulation on Equilibrium Pollution Level in a region dominated by Small Scale Units

The discussion suggests that the slope and position of the ES schedule depend on the perceived risk of pollution, the imputed damage and the community's ability to act and do something about it, besides the formal factors. The community's perception of risk is a function of their education level and depends on deciphering the information, which is available through various channels like official communications, personal observations, experiences and historical evidence. The valuation of damage is highly subjective, because many a times the health impacts are known after certain period.[7] The evidence also exists that valuation of damage often depends on the

[7] The Love Canal in US where the impact of dumping toxic waste got detected only after two decades when the dumping had already ceased clearly points (Sterner, 2002) towards subjective valuation of damages.

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.* (1996) argue that many of these variables are correlated with income and education across communities. Additionally, this ES schedule is strengthened by the effectiveness of formal regulation in the region. Effective formal regulation not only facilitates change in the slope, but also shifts the schedule to the left (i.e., from ES^0 to ES^1) as shown in Figure 1.

Given the regional ES schedule, a unit's equilibrium emissions would be determined by the position and slope of the ED schedule (refer Figure 1). The ED schedule is generally affected by three major factors, namely, (i) external pressure; (ii) economic considerations; and (iii) plant characteristics. All these factors become irrelevant when the focus is on SSIs. Most SSIs being small and catering to the local market are indifferent to the external pressure. Important plant characteristics like ownership, size, market orientation, human and technical capital, availability of abatement technologies etc. have hardly any meaning for the SSIs, thus ED schedule will be rather steep (Figure 1). This implies, it is only the community induced ES schedule augmented by effective formal regulation[8] has a potential to change the

[8] Though it is the effectiveness of the formal regulation that may shift the ES schedule, but sometimes increased visits by the PCB official can also facilitate shift in ES. This is because such visits are usually very distracting and cause disruption in production. This is even true for SSIs forcing them to look for options outside. Evidence exist that in a number of places one of the reasons cited by the SSIs to join common effluent treatment plant (CETP) club is anticipation of reduced visits by the PCB official. See Shah and Kathuria

equilibrium level of pollution in the region. The potency of this shifting of ES by formal and informal regulation has been looked into in this paper.

4. Model specification

The model used here is an extension of the one used by Pargal and Wheeler (1996). Pargal and Wheeler (henceforth, P&W) estimated the firm's equilibrium pollution as an intersection of demand of environmental services by the firm and the supply schedule it faced in an implicit market for environmental services. The expected signs of partial derivatives are given in the parenthesis.

According to P&W, the demand for environmental services for firm i in region j is given by

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

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.

The environmental supply schedule faced by the firm indicates the expected price it has to pay for each level of pollution.

(2001: 134) for the case of Ankleshwar. A recent survey by the author in Kundli IE, Haryana also reinforces this (Kathuria, 2003).

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

where P_{ij} is the i^{th} 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 (+)plant's visibility and (-)economic attractiveness to the community); (?)a_j is the urbanization; and (+)t_j is the total pollution load faced by the community.

The firm's equilibrium pollution level is then solved as

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

At a regional level, this equilibrium pollution level will be given by

$$R_j = f(W_{pj}, S_j, Q_j, V_j, y_j, e_j, N_j, a_j, t_j) \qquad (4)$$

where R_j is the total pollution load in a region j ($\approx \sum P_{ij,\ i = 1, 2 \ldots N}$),[9] (+)$Q_j$ is the total output of units in region j; (?)S_j is the nature of production in the region i.e., whether the region is dominated by SSIs, or large units and among large units - the type of ownership; (-)y_j is the average per capita income of community j; (+)V_j is the average age of plants in the region, (-)e_j is the secondary schooling rate in region j; (+)N_j is employment share of units in the region to the total workforce in region j (indicating industry's economic attractiveness to the community),

[9] Rj will be an approximation of the total pollution emitted by different 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.

(?)a_j is the urbanization and (+)t_j is the total pollution load faced by the community.

As mentioned in previous section, many of these community specific variables (say literacy, per-capita income or urbanization) (i.e., indicators of informal regulation) 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 is potential endogeneity of 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. Even if industrial location dynamics dominates residential location dynamics, the bias in the estimates can be minimized by employing a single variable. The present study uses an indicator of informal regulation (X) as represented by extensive publicity by the vernacular and regional press or policy pronouncements or any policy decision taken for the region by the local PCB, etc. In all probability this indicator will be a function of literacy, urbanization and per capita income i.e., $X_j = f(y_j, e_j, a_j)$

Similarly, share of employment by polluting units in the region is also more like a static variable, the changes come 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 are mostly chemical involving some hazardous work and anecdotal and empirical evidence indicates that local population in these regions flinch 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). This implies N_j will be insignificant and can be ignored in the analysis. Any reduced value of N_j also implies that communities may have less toleration of the pollution and polluting factories.

Lastly, the P&W model assumes absence of formal regulation. As mentioned, pockets exist in India where formal regulation has worked. If the local EPA becomes more vigilant – either by making frequent visits or issuing more notices to the 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 will be a function of both formal (F) and informal regulation (X).

There exists another difference when the analysis is at a regional level. Since pollution at a regional level is a mix of pollution generation by individual units, the equilibrium level will also be affected by the meteorological conditions in the region (M_j), especially rainfall. The rain scavenges effluent by diluting it, but rain usually has a pH of 5.0. This implies that higher rainfall may also lead to increase in acidity.[10] Thus at a region level, the equilibrium pollution level will be given by

$$R_j = f(W_{pj}, S_j, Q_j, V_j, M_j, X_j, F_j, t_j) \qquad (5)$$

[10] This implies that rain need to be included as a quadratic variable while explaining variation in pH (acidity).

Econometric Specification

Since the basic pollution demand equation in P&W model is at a firm level given by $P = f(W_p, W_l, W_e, W_m, Q)$, which can be estimated along with other input demand equations from a generalized cost function under the assumption of cost minimization. The present study being aimed at finding equilibrium pollution at a region perceives finding input demand equations rather too cumbersome. Moreover, the estimation of the same will look inappropriate for the following reason – W_p is endogenous and has many determinants, sample size not high and there could be measurement error for the left-hand side variable (refer Pargal and Wheeler, 1996: 1320 for details). P&W also consider the estimation of demand equation not very efficient. In a similar fashion as proposed by P&W, we also propose to estimate a log-linear model with dummies for categorical variables.[11]

We 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 implies more dilution of the pollutants leading to fall in overall pollution level. 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.[12] In that case a high flow is mainly a reflection of high activity in the region, which implies more production by the units. This may aggravate the pollution problem. Further variables like average age of plants and nature of firms in the region will be region-specific and are static in the short-

[11] Pargal and Wheeler (1996) estimated a log-log model.

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

run. Region dummies can be employed to capture any region-specific attribute. Thus for j^{th} monitoring point, the econometric model will be:

$R_{jt} = b_0 + b_1*X_{jt-1} + b_2*F_{jt-1} + b_3*Rfall_{jt-1} + b_4*Activity_{jt} + b_5*Flow_{jt} + b_6*Region\_dmy_j + u_{jt}$ (6)

The estimates are panel corrected standard error (PCSE) for linear cross-sectional time-series models, where the parameters are estimated by Prais-Winsten regression. However, in the model, while computing the standard errors and the variance-covariance estimates, the disturbances are, by default, assumed to be heteroskedastic and contemporaneously correlated across panels. 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 Prais-Winsten (PW) estimator is a generalized least squares (GLS) estimator (for details refer Judge *et al.*, 1985). The method is a modification of Cochrane-Orcutt (CO) method, as the first case gets explicit treatment.

$$y_t = a + \sum_{t=1}^{p} b_i x_{ti} + u_t \quad (7)$$

$$u_t = \rho u_{t-1} + e_t \quad (8)$$

where e_t are independent and identically distributed as $N(0, \sigma^2)$. The error term u_t follows a first-order autoregressive process.

$$y_t - \rho y_{t-1} = a(1-\rho) + \sum_{t=1}^{p} b_i (x_{ti} - \rho x_{(t-1)i}) + \varepsilon_t \quad (9)$$

Defining $y_t^* = y_t - \rho y_{t-1}$ and $x_{ti}^* = x_{ti} - \rho x_{(t-1)i}$, above equation can be rewritten as

$$y_t^* = a(1-\rho) + \sum_{t=1}^{p} b_i x_{ti}^* + \varepsilon_t \qquad (10)$$

In PW method, one more equation is added by putting t = 1, so as not to lose any observation:

$$y_1(1-\rho) = a(1-\rho) + \sum_{t=1}^{p} b_i x_{ti}(1-\rho) + (1-\rho)\mu \qquad (11)$$

There is another benefit with PW that for high value of ρ, there is some difficulty in converging in CO process, but not with PW method (STATA, 2001).

5. Data and Variables

The testing of impact of informal regulation as formulated above in equation 6 requires resolving two choice issues: (1) which regions to be looked into? and (2) how to measure informal regulation?

5.1 Selection of Estates / Monitoring Stations

Before venturing into the selection of estates/regions, it is necessary to deliberate briefly about water quality monitoring in India in general and Gujarat in particular. Appendix A1 gives the legislative provision of regulation of water pollution in India. The water quality monitoring program was initiated by the CPCB in 1976 with 18 stations on river Yamuna. The program was gradually extended over time. At present, there are 507 monitoring stations in the country under Monitoring of Indian National Aquatic Resources System (MINARS) and Global Environmental Monitoring System (GEMS) and spread over all important water bodies. Out of these 507 stations, 414 (81.6%) are on rivers, 38 (7.5%) on lakes, 25 (4.9%) on ground water and 30 (5.9%) on canals, creeks, drains, ponds etc. covering a total of 126 different water bodies. 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. Five classes, A to E, in decreasing order are used for water quality. At certain stations, the water quality is even below E. In Gujarat monitoring of surface water is done through 39 stations – 7 of which come under GEMS and are on 4 major rivers and 32 stations under MINARS are on both major and minor rivers, creeks etc. The readings are taken once in a month and are generally during the first week of the month.

Table 1 gives the quality of water at seven most polluted stations in Gujarat from 1996-97 to 1999-2000. From the table it is apparent that the quality is consistently bad at (1) V.N. Bridge on river Sabarmati (units/estates in Ahmedabad); (2) Lali on river Khari (Vatva, Odhav and Naroda IEs – outskirts of Ahmedabad); (3) Atul on river Par (Atul IE); (4) Kalkada Khadi at Kachigram (Kachigram IE); (5) Ankleshwar on Amla Khadi (Ankleshwar IE); and (6) Bill Khadi at Vapi (Vapi IE) (Source: GPCB Annual reports, various years). It is to be noted that all the places where parameters are much higher than the standards are on ‘golden corridor’.[13]

[13] ‘Golden Corridor’ is the name given to a stretch of 400 Km from Vapi in South of Gujarat to Mehsana in the North of Gujarat. The region has acquired the name because it has generated a lot of wealth from chemical and petrochemical industries.

The data given in the Annual Reports is annual yearly average. Since the pollution parameter varies greatly across the months due to natural (like rainfall etc.) and seasonal (caused by slump in production during few months of the year) factors, the averaging does not reveal the true picture. For instance, for the year 1996, the average COD at Amla Khadi was 1626 (Table 1), however, the actual COD had varied between 885 to 2326 with standard deviation of 552.6.

Thus, for the present study, monthly data is collected from the CPCB for most of the monitoring stations in Gujarat for the period 1995 to 2000. Since pollution parameters exceed for only few monitoring stations, the analysis is done for some of these stations. Though Vautha is not shown in the Table (as it is not being reported in the Annual report since 1996-97 onwards), it is also included in the analysis. The analysis is carried out for four monitoring stations belonging to two types. Type 1 monitoring stations comprise of Khari and Amla Khadi receiving effluent from IE only, and Type 2 receiving water from scattered and dispersed industrial units – V.N. Bridge and Vautha on river Sabarmati. V.N. Bridge monitoring station is in Ahmedabad itself, whereas Vautha is a place near Dholka (nearly 60 km from Ahmedabad), where river Sabarmati meets river Vatrak. Figure 2 gives the location of these stations on the map of Gujarat.

5.2 Definition and Measurement of Informal Regulation

The other important issue is defining and measuring informal regulation. The present study hypothesizes that whenever any news item appears in the press (especially vernacular) denouncing units – each such event has a considerable signaling effect within the IE or for other units in the region. Similarly, since the estate is a close-knit community, the issuance of a notice or press release by the local PCB will be immediately known to all units. In the days immediately following the highly publicized issuance of notices, the plants will be reminded of possible increased PCBs monitoring efforts and thus be more cautious with their effluent generation.

Thus, the informal regulation can be proactive (vernacular) press or anticipated enhanced monitoring. The vernacular press plays a much bigger role. For example, if local PCB plans to be more vigilant – press will immediately report it. Similarly any public interest litigation (PIL) filed against units for causing pollution or any decision taken by the High Court (HC) or Supreme Court (SC) will find coverage. Any effort of local EPA or policy decision by the Central or State government to reduce pollution resulting in policy promulgation will also be reported immediately and lastly, any instance of discharging untreated effluent (or solid waste) will not go unreported by the vernacular press at least. Thus, informal regulation (NP) as measured is rather broad and is being captured in the present study as the number of articles published in vernacular (and leading national) newspapers relevant to industrial water pollution in Gujarat. Besides these any decision on the PIL[14] or *suo motu* notice by the HC is also being covered. The press releases by the GPCB and any important decision taken by the board during its meetings, which has a direct bearing on

[14] Not all PILs and PIL hearings could be included. The author contacted the Gujarat HC for the number of PILs filed and hearing on these PILs in the past five years pertaining to industrial pollution and the decisions given by the court on these. However, the officer on special duty (OSD) refused to part with the data stating that it is highly confidential (Visit to the HC, Ahmedabad on September 12 and 13, 2002).

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. The articles covered are from newspapers like Times of India, Indian Express, Financial Express, Economic Times, Business Line, *Sandesh*, Observer of Business and Politics, *Gujarat Samachar*, *Loksatta Jansatta*, Hindu,[15] and other publications like Gujarat Law Herald, Gujarat Law Reporter, press notifications by GPCB, Annual reports of GPCB, Divan and Rosencranz (2000) etc. Table 2 gives the year-wise articles published in these sources. Figure 3 shows the monthly variation of 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, thereby may have shifted the ES schedule. This shift in ES schedule could have raised the MEP of the units leading to change in quality of effluent generated.

It is to be noted that the period of analysis is after 1995. This is because it is only from the middle of 1995, the endeavours were made to punish polluters and intensified monitoring exercise took-off in Gujarat. According to GPCB itself – the board entered its most critical period, as it had to face several PILs (Source: GPCB, Annual Report, 1995-96). The main challenge came in Special Civil Application No. 770 of 1995 – *Pravinbhai Patel v State of Gujarat and others*. The judgement on August 5, 1995 laid the 'polluter pays principle' and

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[15] Of these *Sandesh*, *Gujarat Samachar*, *Loksatta Jansatta* are vernacular. The reason for including vernacular dailies is because though the extreme cases are usually cited in Regional or National dailies, but more subtle pressure is through the vernacular press only.

more than 400 industries were ordered to be closed in three IEs – Naroda, Odhav and Vatva – falling under AMC. Besides these, units were asked to pay 1% of their maximum turnover in the past three years as a compensation to clean-up the environment. Similarly PILs with regard to the pollution prevailing in other areas of the State mainly Vapi, Sarigam, Jetpur etc. were before the Gujarat HC during this period. One of the suggestions of the HC was to strengthen the GPCB. The state government immediately sanctioned 169 technical, scientific and other posts to comply with HC directive. Recruitment undertook on a priority basis. Besides these, Pollution Awareness and Assistance Centre (PAAC) was set up at Headquarters of the Board with effect from January 1996 to receive and look into the complaints of the general public (Source: GPCB, Annual Report, 1995-96). All these events occurred in 1995 itself.[16]

5.3 Definition and Measurement of Formal Regulation

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 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. We do not have information on individual monitoring and even less on expectations. But have data on some aggregate variables such as

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[16] The description suggests that there was a structural change in the monitoring in Gujarat in 1995. Since formal regulation was highly ineffective before 1995, any fall in pollution during that period would be due to informal regulation pressures only. However, due to non-availability of data (pertaining to monitoring etc.) the analysis could not be extended to include years before 1995.

number of court cases filed by the PCB[17] or the number of notices issued to units by the board or the amount spent by the board in monitoring different estates etc. reflecting formal regulation. The annual report of GPCB gives the total number of cases filed by the board and the number of notices issued, but not by estate or region. Same figures are taken as a measure for formal regulation (FORM) under the assumption that total number of such cases filed has signaling effect on all the units in the estate or a region irrespective of their location.

Since there exists more than 160 working IEs in Gujarat and not all are chemical, it was not easy to find the budget allocated for each of these estates. Moreover, each Regional office[18] caters to four to five major IEs besides monitoring small estates and scattered SSIs. As a result, no one could tell how much is spent on monitoring of units on these four estates and areas surrounding the other two monitoring stations. An alternate scheme was devised, where the total budget amount is apportioned based on share of polluting units in the district. Inventorization of hazardous waste by CPCB and National Productivity Council gives number of polluting units in different districts for two different years. These have been intrapolated to get a rough estimate of the polluting units in these four areas. It is then assumed that the whole

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[17] The number of cases filed is certainly better than the number of visits made where no samples are taken. This is because in that case, the inspector would rely on the data given by the plant, which could be concocted. The conjecture arises from the fact that a survey done in four countries including India by Hartman *et al.*, (1995) find that on some occasions units were maintaining two sets of books – one for regulatory authority and other for plant's use (referred in Hettige *et al.*, 1996). And quite obviously plants were meeting norms in the former case.

[18] GPCB has six regional offices in the state.

of plan expenditure is spent on monitoring mainly these polluting units.[19] The amount is then divided between different districts and IEs.

Two more variables have been constructed to account for formal monitoring. First variable is the number of water cases filed in the HC by the GPCB. Another variable is the allocation of monitoring staff to different IEs. Under the assumption that the staff caters to mainly polluting industries in the estate,[20] the variable reflecting formal monitoring in the estate would be given by 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.[21] The data shows that the number of cases filed by GPCB is highly correlated with this variable (correlation coefficient = 0.41). Moreover, it is the effectiveness of monitoring which is more relevant. This prompted us to construct another variable called monitoring effectiveness denoted by number of cases in which decision went against the units (either through injunctions or the unit was convicted) to the total number of cases

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[19] The use of only plan expenditure is under the assumption that the non-plan expenditure may not be related to monitoring and it may be taking care of staff other than involved in monitoring i.e., non-technical staff.

[20] The assumption seems quite tenable since the frequency of monitoring depends on the category of units. The units in Gujarat and elsewhere in India have been classified into three categories based on their pollution potential – Red, Orange and Green. ‘Red’ industries are required to be monitored once in a month to three months (based on size), followed by once in two to six months for ‘Orange’ and once in three months to a year for ‘Green’ industries.

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

disposed by the HC during the year. Table 3 gives the summary of different parameters used to construct formal regulation variable.

The table reveals that the HC directive has been followed in Gujarat as the GPCB recruited large number of people after the 1995 judgement. The share of technical staff, which was one-third before the directive, increased to one-half next year. However, it has hovered around 50% thereafter.

Following are the definitions of the remaining variables along with the sources from where data has been collected:

Rainfall - Average rainfall for the day and the preceding day, when the reading was taken[22] (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.[23] In absence, monthly Index of chemical production of the country as a whole has been taken.[24]

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

[23] Despite approaching different organizations – Industries Commissionerate, Industrial extension bureau (iNDEXTb), Gujarat Industries Development Corporation (GIDC) etc., none could provide how many factories are working in these IEs and what is the chemical production from these estates/regions.

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

Year dummies – To account for any technical change in abatement technology.

Month dummies – To account for any monthly variation in production or any other unaccounted variable.

Station dummies – To account for whether the flow is from IEs or dispersed units and any other stations specific effect.

Thus the final Model to be estimated is:

$$R_{jt} = b_0 + b_1 * NP_{t-1} + b_2 * Form_{jt} + b_3 * Rfall_{jt} + b_4 * Velocity_{jt} + b_5 * Production\_Index + b_{6-9} * Year\_dmy + b_{10-20} * Month\_dmy + b_{21-23} * Station\_dmy + u_j \quad (12)$$

The model is estimated for one of the important pollution parameters i.e., COD. Chemical Oxygen Demand (COD) is most important pollution parameter when the industries are chemical in nature as in the present case. COD is defined as the amount of oxygen required to degrade the organic compounds of wastewater. The higher the COD value of wastewater, the more oxygen the discharges demand from water bodies. Thus, R_{jt} is log of COD. As mentioned, the variable ‘FORM’ or ‘NP’ has 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 pro-activism (i.e., the number of coverage given to the pollution issues in last month) that would affect the behavior of units and hence the level of pollution generation. Similarly, in absence of actual visits made by the board’s official to a region or IE, last year values of formal regulations have been used. The model is in linear form and is estimated by pooling for all the four monitoring stations. The model has been estimated using

STATA 7.0 econometric package. Table in the Appendix A2 gives the station-wise descriptive statistics for some of the variables.

6. Estimation Results

The above equation (eq. 12) involves pooling monthly data for all the four stations for the five-year period i.e., for 60 months from January 1996 to December 2000. Table 4 gives the results for the pooled model with panel corrected standard errors. 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 successive inclusion of month and year dummies. Since any increased coverage by the vernacular or other media should spur the local monitoring, to see whether such an interaction exists, an interaction term (between informal regulation pressure and the formal regulation variable) is included with the results given in Column 4 of the table.

As expected, the rains dilute the pollution concentration. The variable is negative and highly significant for all the variants of the model (row 1).[25] Surprisingly higher the velocity, more is the pollution, though the impact is not statistically significant (row 2). As mentioned earlier 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

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[25] It can 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. The model was re-run with the variable calculated as the rainfall during the week and the month, however, 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. This is well supported by the data, which shows that the region experienced a paltry average monthly rainfall of 2.36 mm for the entire period.

that case a high flow is a reflection of high activity in the region, which implies more production by the units.

With respect to the formal regulation – the results indicate that if more number of people are devoted to monitoring, it results in 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 may not be nabbing the culprit and the visit may be mainly for executing some clandestine deed like taking graft etc. Though there does not exist any concrete evidence as such, but the perception among the people is that poor implementation of environmental laws in India is because the inspectors can be tempted to corruption.[26] Under these circumstances, the variable may not come out to be significant. Instead if monitoring effectiveness variable is taken, that should show a discouraging impact on the units to discharge untreated effluent, as it shifts the ES schedule by raising the MEP for the units. Thus having the right signalling effect on them forcing to carry out some treatment before discharging any effluent.[27]

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

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[26] To give an example, the Punjab PCB was superseded in 1996 after the state government received complaints regarding mal-administration and harassment. An enquiry revealed that some of the board decisions were ‘highly suspect’ - *G.S. Oberoi v State of Punjab*, AIR 1998, P& H 67 (Source: Divan and Rosencranz, 2000: 3).

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

mentions about the significant month dummies. As expected, the pollution is lower during the rainy months, i.e., July to October. Rows 11 to 12 give the monitoring station dummies. As we have seen earlier in Table 2, of the seven most polluted stations, quality of water is comparatively better at V.N. Bridge (and Vautha), where the water is from dispersed units. On the other hand, at Amla Khadi and Khari, which receive water from Ankleshwar and Naroda, Odhav and Vatva IEs, quality is extremely bad. This is well supported by the sign and significance level of coefficients.

With respect to 'informal regulation' variable (row 3), though the variable has correct sign, it is not significantly different from zero in statistical terms in all the variants of the model. Similarly, the interaction term though has the correct sign, is not significant in statistical terms.[28] One can argue that informal regulation needs to be sustained so as to have any meaningful impact on the behaviour of the firms. Sustained regulation means that such reporting should not be an isolated event, rather continuously bring the nefarious activities of the units to the public notice. In order 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. Alternatively it can also be argued that the way informal regulation variable has been constructed may not be the appropriate one. At present it is the activism in the last month. Since any policy pronouncement or the HC decision or the PCBs initiatives leading to fall in pollution generation may require either better house-keeping or change in production process or some investment in treatment. This

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

implies one month lag may not be the ideal one. Thus variable need to be constructed with a longer lag. Table 5 reports the results for both the modifications. The results are given for only regulation variable (both formal and informal). Column 1 reports the results for formal and column 2 reports for informal regulation.

Rows 1 to 7 report the results when informal regulation pressure variable is constructed with different lags rather than a month lag. From the table it can be seen that the formal regulation variable though has come up with right sign but is not significant in any variant of the model. The probable reasons for variable not coming out significant could be either due to poor implementation of formal regulation in the area or alternatively it is possible that the way informal regulation variable has been constructed, it may be capturing formal regulation impact too.

On the other hand, with respect to informal regulation, it is mainly the coverage accorded in the not too distant past (i.e., two months ago) to the nefarious activities seems to have led to fall in pollution generation. However, when the individual lag is increased to more than 2 months, the impact vanishes. Why the individual lag effect has not come out significantly? In fact, informal regulation pressure can have relevant impact if there is substantial coverage each month. The distribution of coverage / policy pronouncements shows that of the total 60 months for which analysis has been carried out, in nearly three-fifth time (i.e., 35 months), twice or less than twice any such event occurred which denounced the industries for causing pollution (Figure 4). This may not be high given a high level of pollution generated by the industries in the region.

Rows 8 to 16 report results when the information regulation variable is cumulated over different months. It is interesting to note that the cumulative coverage given in the last two months from the period when water quality samples were taken, has a significant impact on the behaviour of units. The effect then becomes insignificant but gains importance after five months and then again petering off beyond eight months of 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 sustained information regulation pressure. After the threshold, the impact starts falling.

The analysis so far has been done by pooling data for all the four stations. In fact, two of these four monitoring stations (Type 1) – Amlakhadi and Khari – are directly on the mouth of IEs, but the other two (Type 2) – V.N. Bridge and Vautha – receive water from dispersed industrial units. Consequently, the monitoring requirement and hence the pollution problem in these two types of areas feeding to the stations will be entirely different. The monitoring of units in the former stations is more *akin* to monitoring point source of pollution, whereas in the later it is essentially monitoring of NPSP (Kathuria and Sterner, 2002). If that be the case, the impact of informal regulation on effluent generation should not be identical at these two institutional set-ups. The next part of the paper tries to segregate the effect of informal regulation pressure on these two station types.

6.1 Impact of Informal regulation – Is it different across two institutional set-ups?

Table 6 gives the results where informal regulation for Type 1 and Type 2 monitoring stations is considered separately and reports the results in both the cases i.e., excluding and including month and year dummies. As found in the previous subsection, it is the two months lagged informal regulation pressure that has the most significant effect in reducing the pollution level. The model is estimated with two-month lag also. Columns 1 and 2 report results when the model is estimated with one month lag and columns 3 and 4 report when informal regulation variable is introduced with 2 months lag.

Rows 3 and 4 give the coefficient for the informal regulation variable for the two types of monitoring stations. With respect to the variable, as predicted earlier, the two stations adjoining the IEs are behaving identically. The last month's informal regulation pressure has a significant negative impact on the effluent generation by the units in these estates. Is the difference statistically significant? In order to investigate this, Wald test is carried out. 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 the coefficients are unequal and vice versa. Table 7 gives the test statistics for both the models – model 1 and 2. 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. The difference however reduces when one considers the informal regulation pressure with two months lag. Thus, the informal regulation has differential impact for two different station types. Though, at V.N. Bridge and Vautha (row 4) impact is perverse but insignificant.

With respect to formal regulation – increased monitoring leads to fall in pollution generation, but once month and year dummies are taken into account, the impact collapses. Other variables retain the same sign and significance level as obtained earlier (refer Table 4).

Thus the analysis indicates that informal regulation has worked differently depending upon the institutional set-up, in which the units are located. The possible explanation for 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 estate, as local industries association itself may be doing policing job.[29] However for the dispersed units, such increase in MEP is rather unlikely, due to the very nature of their location.

The analysis so far finds that the Type 1 and Type 2 monitoring stations behave differently with respect to informal regulation. Given the profile of units in each type of monitoring stations, it is still possible that they may not respond identically to informal regulation pressure, especially in Type 1 station. For instance, as the units in Ankleshwar are both small and medium & large including MNCs, they may be more responsive to the negative publicity and hence experience a greater shift in ES schedules compared to Khari where units are predominately small in nature. In order to see the differential impact of informal regulation, the model is run with the variable assumed differently for all the four monitoring stations. Table 8 reports the results.

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

It can be seen from the table that the coefficients for Type 2 monitoring stations (i.e., V.N. Bridge and Vautha) are somewhat identical, but for Type 1 monitoring stations (i.e., Amlakhadi and Khari) they are entirely different. Table 9 tests for significance of these differences using Wald test.

It can be seen from Table 9 that the informal regulation pressure is same for the monitoring stations having dispersed units (i.e., V.N. Bridge and Vautha) irrespective of the way the informal regulation variable is constructed. On the other hand, Type 1 monitoring stations have a varied response to the informal regulation pressure, as indicated by the significant value of χ^2. The difference is more pronounced when the two month lag is used to construct the informal regulation variable.

Based on the coefficients and significance levels, it can be inferred that it is mainly the units in Ankleshwar that have responded to informal regulation pressure (row 5) as the variable is not only negative but is highly significant in both the models. Whereas despite having similar institutional set up, the informal regulation pressure effect becomes insignificant for units discharging in Khari (row 6). Since Khari is behaving more like Type 2 stations, we tested whether the coefficient of informal regulation at Khari is similar as obtained for V.N. Bridge and Vautha. The test statistics (rows C and G of Table 9) indicate that irrespective of the way informal regulation variable is constructed and whether month and year dummies are included, Khari (a Type 1) station is behaving identically as that of other Type 2 stations. This implies it is behaving more like a sink for scattered /

dispersed units and the informal regulation is not showing any impact in affecting the behaviour of polluting units.

It is worth exploring why informal regulation pressure failed to impact the units in Khari. This can be probably explained by looking into the extent of formal regulation implementation in the region. Analysis of some of the HC rulings indicates that the HC has repeatedly passed strictures against industries in Vatva, Naroda and Odhav, in general and some of the erring industries in particular. But every time, the local PCB derelicted and seems to have failed to take necessary action. In fact in one of the recent rulings the Gujarat HC has lamented about the failure of the Gujarat PCB to carry out its duties and rushing to HC for all the things.[30] Once the units in these estates find that despite successive violations, the local PCB is as dormant as earlier, even the units, which were treating the effluent earlier, would have lost the interest leading to the Nash equilibrium of not treating the effluent by most of the units.

The sign and significance of formal regulation variable indicates that increased monitoring staff allocated in an area (row 7) lead to fall in pollution generation. However, the fall is not significant when month and year dummies are included. With respect to other variables, they retain same sign and significance level.

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[30] In *Suo Motu v Vatva Industries Association Ahmedabad and Others,* AIR 2000, the HC directive stated that "the court observed that it was the function of the Board and its officers to take action under the Act when they noticed huge quantities of hazardous waste dumped and they were not required under the statute to bring it to the notice of the HC for seeking directions on the units to stop unauthorized movements and/or disposal of waste. Otherwise such nefarious activities by the polluting units would continue unabated under the pretext of pendency of the matter before the court" (Source: CEERA Newsletter, Vol. 3 Issue 3, July 2000).

Thus, based on the above analysis, it can be concluded that both formal and informal regulation of pollution seems to have worked only partially in Gujarat. The formal regulation as represented by the extent of monitoring though leads to fall in pollution generation, the effect is not statistically significant. With respect to informal regulation pressure, the impact is not immediate. Only the sustained publicity of the nefarious activities leads to some fall in pollution generation. Still the effect is not uniform – units discharging effluent in Amla Khadi are found to be more responsive to informal regulation than units elsewhere. Despite having same institutional set up of Khari and Amla Khadi, the response of the units to informal regulation pressure varies. In Khari, weak formal regulation seems to have militated against the informal regulation.

7. Concluding Remarks

The design of policy instruments for industrial pollution in the case of developing countries is very challenging. In principle, the regulator has an array of physical, legal, monetary, and other instruments. But the presence of large number of SSIs and informal sector pollution sources that lack knowledge, funds, technology and skills to treat their effluent mocks any instrument applied and leads to overall failure. The literature in the recent past has not only recognised the implementation limitations of formal regulation, but has also appreciated the significance of informal regulation for achieving environmental goals in the case of developing countries. Since a large number of units in India and other developing world fall under small and unorganised sector, the utility of some of the informal channels like public disclosures or ratings is limited. Under the scenario, the other means like localised press coverage can easily induce compliance. The efficacy of press coverage increases if units are part of IE. The present study has attempted to see whether this 'informal channel' 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, the study used monthly water pollution data collected by the local PCB under MINARS/GEMS from the four hot spots of Gujarat for the period January 1996 to December 2000. The analysis shows that both formal and informal regulation of pollution seems to have worked only partly in mitigating the pollution in these areas. The extent of monitoring (as measured by staff allocated) though leads to fall in pollution generation, the effect is not statistically significant. One probable reason for the variable not coming out to be significant is that monitoring as such does not have any impact, but it is usually the targeted monitoring, that leads to fall in pollution generation.

With respect to informal regulation as represented by the press coverage, HC rulings and PCB policy announcements etc., the impact is there but not immediate. Only the sustained publicity of the nefarious activities leads to significant fall in pollution generation. Individual station-wise coefficient yields a slightly different picture – where units discharging at Amla Khadi seem to have responded to the informal regulation pressure, at Khari they have not. Why is this differential response? This can be easily explained by looking at the formal regulation in these two areas. The HC rulings in some of the cases have denounced local PCB for being highly ineffective in Khari region.

Another factor that can explain the differential response is the different economic considerations, which a unit may be facing, besides the usual plant characteristics. This could be input prices, market characteristics, availability of information on abatement technology, and sources of financing. Since units in Ankleshwar are of both categories – units which are extremely large and units which are very small. In fact, few of the large units have foreign ownership and few of them are Indian MNCs – they not only have larger resources at their disposal, but also will be more susceptible to buyer or investor pressure than the units at Vatva, Naroda and Odhav, which are predominantly small in size.

The study has a wide policy implication for other developing countries, as it has demonstrated that informal regulation works to some extent in a developing country setting, especially when the units are located in an IE. One of the limitations of the present work is the use of monthly pollution data. It is quite possible that the units may be responding rather immediately to the policy promulgation or vernacular media pressure or after any HC judgement and so on. The feedback mechanism may be working without much lag than the one assumed here. Use of daily pollution level data (which unfortunately at present is not available) can, in fact, truly reflect the role of informal regulation. Thus the study can be extended using daily ambient water quality data. Another limitation of the study is that it does not differentiate between the severity of the violation or the punishment meted out by the HC for violations. One of the measures indicating the gravity of the problem is whether news finds coverage in national as well as vernacular press. In that case, it should have a stronger impact on the behaviour of units. Thus the study can be extended accordingly.

Table 1

Yearly Average of Pollution Parameters at few Most Polluting Stations in Gujarat

		1996-97			1997-98			1998-99			1999-00		
River	**Location**	**DO**	**BOD**	**COD**	**DO**	**BOD**	**COD**	**DO**	**BOD**	**COD**	**DO**	**BOD**	**COD**
Sabarmati	V.N. Bridge	1.16	82	229	1.2	82	179	4.8	74	239	4	114	260
Sabarmati	Miroli	0.02	61	221	0.02	62	151	2.4	57	182	2	65	187
Khari	Lali	0	271	1046	0.2	171	246	0	263	1033	0	77	259
Par/Atul	Rly.Br.Pardi	3.7	65	351	6.7	25	51.3	6.8	25	510	5	7	39
Amla Khadi	Ankleshwar	1.2	8	1626	0.5	71	191	0.2	575	1425	0	1039	2717
Kalkada Khadi	Kachigam	..	805	1393	5.6	56	99	ND	9	108	0	31	131
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; Figures are rounded off; For definitions of DO, BOD, COD – see text.

Table 2

Articles and Court Rulings pertaining to Industrial Water Pollution in Gujarat

Year	Total Articles / Decisions	Articles / Decisions on Gujarat	Against Industry	% Against Industry
1995	28	15	13	86.67
1996	53	21	16	76.19
1997	68	23	17	73.91
1998	94	37	23	62.16
1999	95	73	57	78.08
2000	31	26	22	84.62
2001	31	31	27	87.10
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).

Table 3

Summary Table of Monitoring and Effectiveness of Monitoring

		Mar-96	Mar-97	Mar-98	Mar-99	Mar-00
1	**Total Staff (GPCB) (No.)**	342	442	489	484	479
2	**Technical Staff (GPCB) (No.)**	113	223	253	253	250
3	**Technical staff ratio (%)**	33.04	50.45	51.74	52.27	52.19
4	**Budget (constant prices) (Rs. Lakhs)**	31.85	168.50	299.77	203.21	166.82
5	**Water Related cases filed in the HC (No.)**	245	108	20	1	19
6	**Water Related Cases Disposed by the Court (No.)**	42	13	65	75	94
7	**Total Cases filed in the HC (No.)**	252	120	20	21	48
8	**Total Cases Disposed by Court**	56	15	78	79	106
9	**Effectiveness of Monitoring (%)**	51.79	66.67	20.51	5.06	16.98

Source: GPCB Annual Reports (various years)

Table 4
Does informal regulation work? Estimates of the pooled model – PW Estimator

SNo.	Explanatory variables	Estimates of the Model			
		Without Yr & Month dummies (1)	**Without Month dummies (2)**	**With Yr & Month dummies (3)**	**With dummies & 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 - Articles published last month (No.)	-0.011 (0.43)	-0.003 (0.61)	-0.012 (-0.44)	-0.008 (-0.32)
4	Monitoring staff allocated for the area	-0.022* (2.29)	0.005 (0.31)	-0.015 (0.96)	-0.01 (0.59)
5	Interaction Term				$-0.2\text{x}10^{-3}$ (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		-0.54* (2.38)	-0.4* (1.82)	-0.45* (1.97)
9	Year dummy '99		-0.41* (2.0)	-0.308* (1.68)	-0.28 (1.45)
10	Significant month dummies			July, Aug, Sep, Oct	July, Aug, Sep, Oct
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	0.04, 0.48, 0.25, 0.21
18	No. of observations	240	240	240	240

Notes: 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 best results with 'monitoring staff allocated' variable only.

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)

Notes: Same as Table 4; All other variables retain almost the same sign and significance level.

Table 6
Informal regulation – Is it different across different institutional set-ups?

S. No.	Explanatory variables	Estimates of the Model			
		Without Year & Month dummies (1)	With Year & Month dummies (2)	Without Yr & Month dummies (3)	With Year and Month dummies (4)
		Model 1 – 1 month lag		Model 2 – 2 months lag	
1	Rainfall during the day	-0.040* (5.41)	-0.026* (3.38)	-0.04* (5.47)	-0.0248* (3.25)
2	Velocity	0.0816 (0.72)	0.11 (0.97)	0.06 (0.54)	0.084 (0.75)
3	Informal Regulation - (For ESTATE – Type 1 stations)	-0.046* (1.95)	-0.049* (1.72)	-0.048* (3.05)	-0.061* (3.41)
4	Informal Regulation – (For non-ESTATE – Type 2 stations)	0.021 (0.58)	0.022 (0.60)	0.012 (0.49)	-0.024 (1.02)
5	Monitoring staff allocated for the area	-0.021* (2.32)	0.013 (0.83)	-0.021* (2.1)	-0.013 (0.78)
6	Index of (Chemical) Industrial Production	0.016* (4.32)	0.02* (3.69)	0.018* (4.66)	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, Aug, Sep, Oct		July, Aug, Sep, Oct
11	V.N. Bridge dummy	-2.04* (9.01)	-1.88* (5.43)	-2.04* (8.19)	-1.88* (5.21)
12	Vautha dummy	-2.36* (7.0)	-2.22* (5.52)	-2.36* (6.75)	-2.22* (5.35)
13	Amla Khadi dummy	0.198 (0.63)	0.43 (0.85)	0.217 (0.65)	0.45 (0.86)
14	Constant	5.48* (12.06)	4.91* (10.47)	5.29* (11.08)	4.75* (10.27)
15	R-squared	0.85	0.834	0.83	0.83
16	Wald Chi-square	527.47	659.81	522.52	648.36
17	Rho for each panel	0.07, 0.58, 0.33, 0.09	0.04, 0.48, 0.24, 0.18	0.08, 0.57, 0.30, 0.18	0.05, 0.49, 0.24, 0.23
18	No. of observations	240	240	240	240

Notes: Same as Table 4. Figures in parentheses are t-ratios. * indicates statistically significant at minimum 10% level.

Table 7

Wald (χ^2) test for equality of coefficients for two different institutions

Model	**Informal regulation**	**Monitoring Stations**	**Identical Monitoring Stations**	**Without month and year dummies**	**With month and year dummie**
1	**As one month lag**	(1,2) & (3,4)	Type 1 and Type 2	3.81 (0.0701)	3.61 (0.0575)
2	**As two months lag**	(1,2) & (3,4)	Type 1 and Type 2	2.07 (0.1503)	2.38 (0.1226)

Note: Figure in parenthesis are significance levels.

Table 8
Informal regulation – Is each monitoring station different?

S. N.	Explanatory variables	Estimates of the Model			
		Without yr & month dummy (1)	With year & month dummy (2)	Without yr & month dummy (3)	With year & month dummy (4)
		Model 1 – 1 month lag		Model 2 – 2 months lag	
1	Rainfall during the day	-0.039* (5.25)	-0.026* (3.34)	-0.04* (5.52)	-0.025* (3.37)
2	Velocity	0.077 (0.67)	0.11 (0.96)	0.066 (0.59)	0.096 (0.87)
3	Informal Regulation - (V.N. Bridge station)	0.026 (0.69)	0.034 (0.88)	-0.013 (0.56)	-0.024 (0.99)
4	Informal Regulation - (Vautha station)	0.017 (0.31)	0.011 (0.20)	-0.01 (0.24)	-0.024 (0.61)
5	Informal Regulation - (Amlakhadi station)	-0.078* (2.01)	-0.081* (1.89)	-0.087* (3.47)	-0.097* (3.58)
6	Informal Regulation - (Khari station)	-0.016 (0.57)	-0.014 (0.44)	-0.013 (0.68)	-0.025 (1.18)
7	Monitoring staff allocated for the area	-0.023* (2.36)	-0.017 (1.08)	-0.024* (2.35)	-0.021 (1.34)
8	Index of (Chemical) Industrial Production	0.017* (4.33)	0.021* (3.85)	0.019* (4.76)	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, Aug, Sep, Oct		July, Aug, Sep, Oct
13	V.N. Bridge dummy	-2.03* (8.51)	-1.92* (5.61)	-1.94* (7.79)	-1.9* (5.58)
14	Vautha dummy	-2.32* (6.55)	-2.21* (5.33)	-2.27* (5.98)	-2.25* (5.20)
15	Amla Khadi dummy	0.28 (0.83)	0.45 (0.90)	0.44 (1.23)	0.48 (0.97)
16	Constant	5.42* (11.46)	4.83* (10.16)	5.18* (10.79)	4.65* (9.9)
17	R-squared	0.839	0.835	0.83	0.83
18	Wald Chi-square	532.53	665.87	534.69	654.02
18	Rho for each panel	0.087, 0.57, 0.30, 0.15	0.05, 0.48, 0.22, 0.19	0.08, 0.57, 0.29, 0.18	0.05, 0.49, 0.24, 0.23
19	No. of observations	240	240	240	240

Notes: 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	Identical Monitoring Stations	Without month and year dummies	With month and year dummies
1	**Informal regulation as one month lag**	A	1, 2	V.N. Bridge and Vautha	**0.02** (0.8781)	**0.16** (0.69)
		B	3, 4	Amla Khadi and Khari	1.68 (0.195)	1.86 (0.17)
		C	1, 2, 4	V.N. Bridge, Vautha and Khari	**0.94** (0.625)	**1.33** (0.504)
		D	1, 2, 3, 4	All the stations	5.67 (0.0587)	6.99 (0.0304)
2	**Informal regulation as two months lag**	E	1, 2	V.N. Bridge and Vautha	**0.0** (0.944)	**0.0** (0.999)
		F	3, 4	Amla Khadi and Khari	5.63 (0.017)	5.04 (0.025)
		G	1, 2, 4	V.N. Bridge, Vautha and Khari	**0.0** (0.997)	**0.0** (0.999)
		H	1, 2, 3, 4	All the stations	6.4 (0.0408)	6.43 (0.0402)

Notes: Figures in parenthesis are significance levels. Bold means coefficients are same.

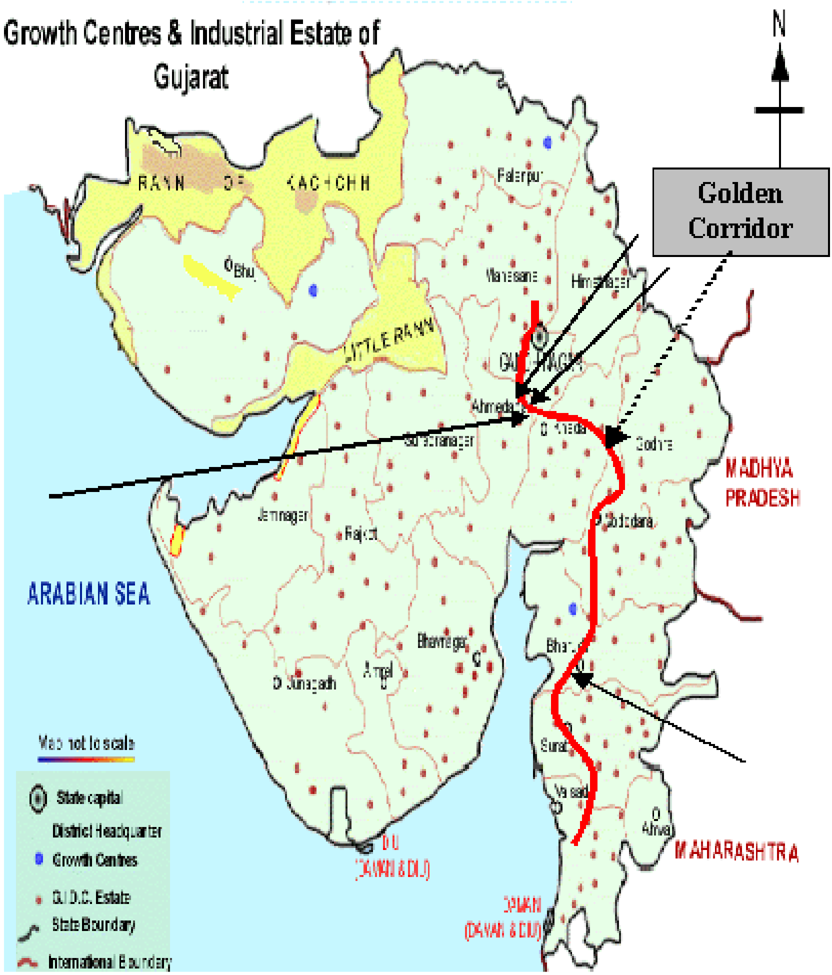


Figure 2: Location of Monitoring Stations

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

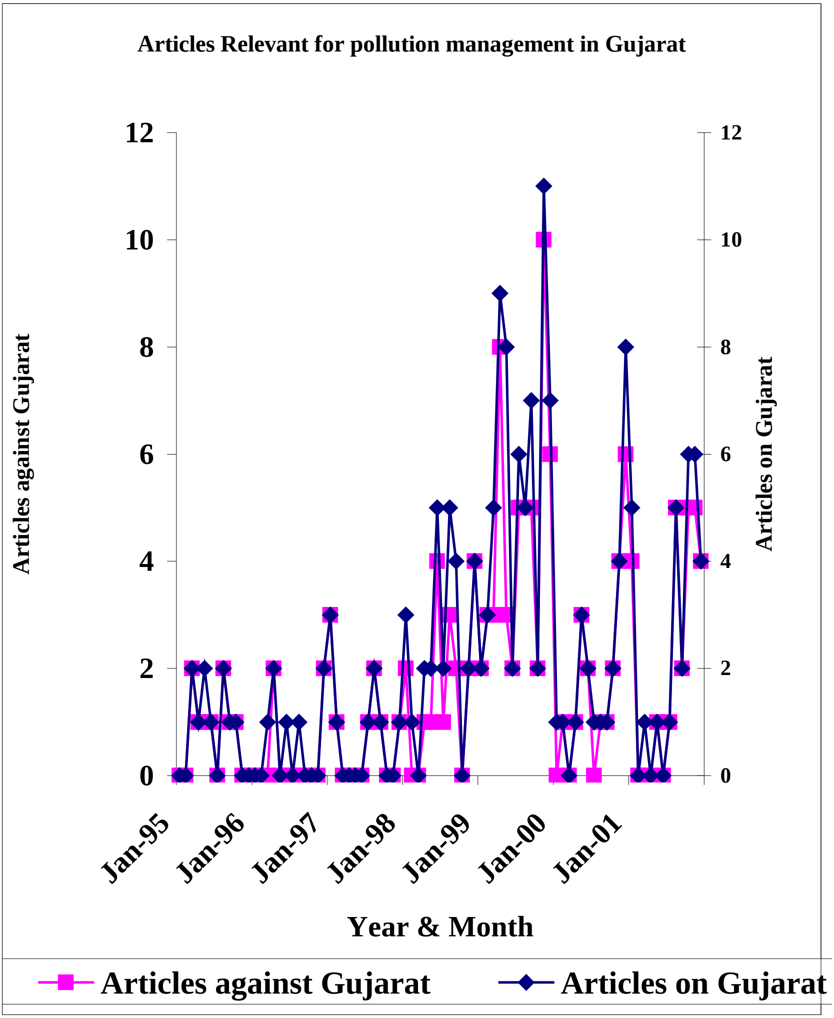
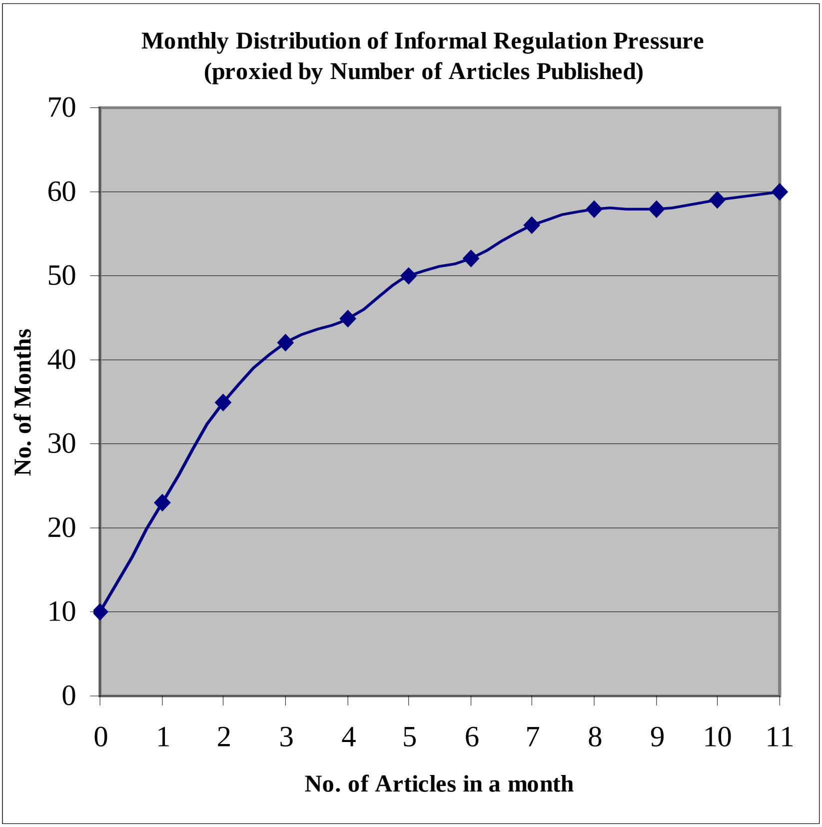


Figure 3: Articles/decisions/notifications relevant for pollution management in Gujarat

Figure 4: Monthly Distribution of No. of Articles published by Vernacular, Regional and National press pertaining to Industrial Pollution in Gujarat



Appendix A1
Legislative provision of regulation of Water Pollution in India[31]

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, on land for irrigation and marine coastal waters. 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 in regard to environmental regulation, reflecting the federal nature of Indian Constitution. The mandate of the Central Pollution Control Board (CPCB) is to set environmental standards for

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

all the plants in India, lay down ambient standards (though State PCBs can set even stricter standards depending upon the carrying capacity of the region),[32] and co-ordinate the activities of the SPCBs. 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.

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[32] This is similar to the 'subsidiarity' principle followed by EU member countries in regard to setting of environmental standards.

Appendix A2

Table A1

Monitoring Station-wise Descriptive Statistics – Mean & Standard Deviation

S. No.	Variable	Monitoring Stations at			
		V.N. Bridge	**Vautha**	**Amla Khadi**	**Khari**
1	COD (mg/l)	273.78 (170.94)	326.53 (456.99)	3497.7 (4118.8)	1094.3 (493.27)
2	pH	7.26 (1.06)	7.66 (0.89)	4.64 (1.86)	6.9 (1.32)
3	Discharge (m^3)	@	@	17.19 (21.3)	@
4	Velocity (m/sec)	0.227 (0.292)	0.281 (0.33)	0.51 (0.517)	0.357 (0.281)
5	Rainfall (mm)	1.36 (6.61)	0.81 (2.25)	1.89 (7.23)	1.12 (3.57)

Notes: Figures in parenthesis are standard deviation. Discharge volume is given only in the case of Amla Khadi.

REFERENCES

Afsah, S., B. Laplante and D. Wheeler (1996) “Controlling Industrial Pollution: A New Paradigm”, *Policy Research Working Paper* #1672, Policy Research Department, Environment, Infrastructure and Agriculture Division, World Bank, Washington, DC.

Agarwal, A. *et al*. (1982) *The State of India’s Environment – First Report*, Centre for Science and Environment, N. Delhi.

Blackman, A. and G.J. Bannister (1998) “Community Pressure and clean technology in the informal sector: An econometric analysis of the adoption of propane by traditional Mexican brickmakers”, *Journal of Environmental Economics and Management*, **35**(1), 1-28.

Central Pollution Control Board (2000-01) Annual Report, CPCB, Ministry of Environment, N.Delhi.

Central Pollution Control Board (2001), Clean Technology Options in Small Scale Industries, *Parivesh: Newsletter*, July, CPCB, Ministry of Environment and Forests, Delhi.

Cribb, R. (1990), “The Politics of Pollution Control in Indonesia, *Asian Survey*, **30**, 1123-35.

Dasgupta, S., B. Laplante and N. Mamingi (2001) “Pollution and Capital Markets in Developing Countries”, *Journal of Environmental Economics and Management*, **42**, 310-35.

Divan, S. and A. Rosencranz (2000) *Environmental Law and Policy in India*, Oxford University Press, N. Delhi.

Goldar, B. and N. Banerjee (2002) “Impact of Informal Regulation of Pollution on Water Quality in Rivers in India”, Paper presented at the Second World Congress of Environmental and Resource Economists, Monterey, California, June 24-27, 2002.

Gujarat Pollution Control Board (various years) Annual Reports, GPCB, Gandhinagar.

Hamilton, T. (1995) “Pollution as News: Media and stock market reaction to the Toxic Release Inventory data”, *Journal of Environmental Economics and Management*, **28**, 98-113.

Hartman, R., M. Huq and D. Wheeler (1995) “Why Paper Mills Clean-up: Results from a four-country survey in Asia”, *Policy Research Department Working Paper*, Development Research Group, World Bank, Washington, DC.

Hettige, H., M. Huq, S. Pargal and D. Wheeler (1996) “Determinants of Pollution Abatement in Developing Countries: Evidence from South and Southeast Asia”, *World Development*, **24**(12), 1891-1904.

Judge, G.G., W.E. Griffiths, R.C. Hill, H. Lutkepohl and T.C. Lee (1985) *The Theory and Practice of Econometrics*, 2nd Edition, John Wiley & Sons, New York.

Kathuria, V. (2003) “Failure of Collective Action as an institution – Lessons from Kundli, Haryana”, Institute of Economic Growth, Working Paper No. 230/2003.

Kathuria, V. and G. S. Haripriya (2002) “Industrial Pollution Control – Need for Flexibility”, Parikh K.P. and R. Radhakrishna (eds.) *India Development Report - 2002*, Oxford University Press, Delhi, 140-56.

Kathuria, V. and T. Sterner (2002) “Monitoring and Enforcement – Is Two Tier Regulation Robust?” Resources for the Future, Discussion Paper 02-17, April, RFF, Washington D.C.

Khator, R. (1991) *Environment, Development and Politics in India*, University Press of America, Lanhmam, MD.

Klassen, R.D. and C.P. McLaughlin (1996) “The impact of environmental management on firm performance’, *Management Science*, **42**, 1199-214.

Konar, S. and M.A. Cohen (1997) “Information as Regulation: The effect of community right to known laws on toxic emissions”, *Journal of Environmental Economics and Management*, **32**, 109-24.

Lanoie, P. and B. Laplante (1994) “The market response to environmental incidents in Canada: A theoretical and empirical analysis” *Southern Economics Journal*, **60**, 657-94.

Lanoie, P., B. Laplante and M. Roy (1998) “Can capital markets create incentives for pollution control?”, *Ecological Economics*, **26**, 31-41.

Murty, M.N. and U.R. Prasad (1999) “Emissions Reduction and Influence of Local Communities in India”, in M.N. Murty, A.J. James and Smita Misra (eds.), *Economics of Industrial Pollution Abatement: Theory and Empirical Evidence from the Indian Experience*, Delhi: Oxford University Press.

Pargal, S. and D. Wheeler (1996) “Informal Regulation of Industrial Pollution in Developing Countries: Evidence From Indonesia”, *Journal of Political Economy*, **104**(6), 1314-27.

Pargal, S., H. Hettige, M. Singh, and D. Wheeler (1997) “Formal and Informal Regulation of Industrial Pollution: Comparative Evidence from Indonesia and the United States”, *World Bank Economic Review*, **11**(5), 433-50.

Pargal, S., M. Mani and M. Huq (1997) “Inspections and Emissions in India: Puzzling Survey Evidence on Industrial Water Pollution”, *PRD Working Paper* #1810, Development Research Group, World Bank, Washington, DC, August.

Shah, A. and Kathuria, V. (2001) Impact of Industrialisation in Peripheral Economy: A Case study of Ankleshwar Industrial Estate in Gujarat, project report, GIDR, Ahmedabad, March.

STATA (2001) *Stata Reference Manual*, Reference 7, Vol. 2, H-P, Stata Press, College Station, Texas.

Sterner, T. (2002) *The Selection and Design of Policy Instruments*: *Applications to environmental protection and natural resource management*, Resources for Future and the World Bank.

Stotz, E. N. (1993) "Luta pela saude ambiental: A AMAP contra cortume carioca, S.A., una experiencia vitoriosa", in V.V. Valla and E.N. Stotz (eds.) *Participacao popular, educacao e saude*, Rio de Janeiro: Editora Relume Dumara.

Tietenberg, T. (1998) "Disclosure Strategies for Pollution Control", *Environmental and Resource Economics* **11**, 587–602.

Wheeler, D. *et al*. (2000) *Greening Industry: New Roles for Communities, Markets and Governments*. World Bank Policy Research Report, New York: Oxford University Press.