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Abstract

Environmental problems are typically not addressable by the market and private law to redress harm and regulation by the state is the commonly suggested alternative. The public choice perspective on regulation however points to the possibility of regulation not being effective in the light of political capture and corruption in enforcement. Under such circumstances who regulates the regulator? In India the judiciary seems to have taken on this role through an innovation in procedural law namely Public Interest Litigation (PIL). PIL has been lauded as an effective method of ensuring enforcement of regulatory standards. We test whether this holds true in the case of air pollution in New Delhi. We document evidence of regulatory failure and examine whether the series of supreme-court interventions initiated by a PIL have played a significant role in controlling the pollution levels in the city. Autoregressive distributed lag (ARX) models and univariate structural break analysis show that judicial intervention was effective in containing pollution levels.

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Regulatory Failure and Judicial Intervention: Does Public Interest Litigation Help?

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Environmental problems are typically not addressable by the market and private law to redress harm and regulation by the state is the commonly suggested alternative. The public choice perspective on regulation however points to the possibility of regulation not being effective in the light of political capture and corruption in enforcement. Under such circumstances who regulates the regulator? In India the judiciary seems to have taken on this role through an innovation in procedural law namely Public Interest Litigation (PIL). PIL has been lauded as an effective method of ensuring enforcement of regulatory standards. We test whether this holds true in the case of air pollution in New Delhi. We document evidence of regulatory failure and examine whether the series of supreme-court interventions initiated by a PIL have played a significant role in controlling the pollution levels in the city. Autoregressive distributed lag (ARX) models and univariate structural break analysis show that judicial intervention was effective in containing pollution levels.

Keywords: Public Interest Litigations, Litigation Process, Environmental, Health and Safety Law and Structural Breaks in Time Series

JEL Classification: K32, K41

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Introduction

Environmental pollution is a typical example of a negative externality, which, if left to private rational decision of economic agents, is oversupplied. Correcting for such externalities involves the use of collecting pollution taxes or designing regulatory policies. In situations where polluters are not easily identifiable and damages are diffused overtime, identifying and designing particular tax structures would be difficult. Under these circumstances suggested remedies take the form of regulatory standards that set overall environmental conditions that would have to be adhered to. These regulatory measures are typically enforced through the coercive power of the state and have been considered to be an effective solution to the problem of externalities under the assumption that the state would carry out its duties efficiently in the interests of the people at large.

The literature on the quality of state intervention in economic activities has increasingly questioned this assumption (Buchanan and Tullock, 1962). It has been suggested that the state could be acting to further its own self interest by resorting to vote bank politics and any welfare that results from the action of the government is only a by product (Downs, 1957; Graham, 1998). Typically in developing countries, pressures from the opposition parties or activists for some cause in the public interest create conditions that compel the State to show some visible policy or Act that would be in the interests of the society. However, this creates problems with interest groups who may have a significant influence over the people in power. The typical response is to enact weak legislations that leave large enough loopholes in order that the interest groups are not affected. Corruption in law enforcement leads to the second consequence: weak or nonexistent enforcement of the already weakened legislated regulation.

In India, the concern that such a possibility exists in the field of environmental protection was first voiced by the Supreme Court when it observed, “if enactment of law results in a clean environment India would be the least polluted as there are at least 200 and odd Central and State statutes enacted”. This is indicative of regulatory failure in the

enforcement of the enacted Laws or the standards set. However, as said earlier, regulatory failure can also occur in the standard setting exercise that governments do. Typically such exercises would also involve the stakeholders who can wield significant influence on the regulatory decision if the government is vulnerable to “capture”. Thus regulatory failure can be both *ex post* and *ex ante*. When there is government failure of the kind described the only countervailing force in a democracy would be a strong civil society which acts as a watch dog on government’s actions. If such a mechanism is absent or weak then the government can further its own interest at the cost of people’s welfare.

The response to such failure in India came not from the people but from the judiciary in the form of an innovation in procedural law. This innovation in law, by relaxing the *locus standi*, enables any concerned or public spirited citizen to move the highest court of the land to hold the regulatory authorities concerned accountable for their *inaction* and issue directives to correct for the failure. The PIL filed by MC Metha² in New Delhi on the failure of the government in controlling air pollution in the capital region has been considered to be an important landmark in bringing judicial intervention into matters related to environment.

We analyze the impact of the Supreme Court’s (SC) intervention on air pollution in New Delhi. We have chosen Delhi as a test case as there were a number of policy initiatives in the 1990s to assess, monitor and control pollution. In spite of a number of policy initiatives such as committees and regulatory authorities constituted in the 1980’s, Delhi remained among the top ten most polluted cities in the world (Kathuria, 2001). We document both *ex ante* and *ex post* regulatory failure and examine whether the SC intervention had resulted in effecting structural breaks in the pollution levels of Delhi. We statistically test if the directives had any impact on pollution levels of SOX, NOX and SPM using Autoregressive Distributed Lag (ARX) models and univariate structural break analysis.

² Mr.M.C.Mehta, an environmental activist, filed PILs on vehicular pollution (Writ Petition (Civil) No. 13029 of 1985) and industrial pollution (Writ Petition (Civil) No. 4677 of 1985) in Delhi.

The paper is organized as follows. Section II documents the laws and standards set by the authorities on air pollution levels in the city of New Delhi and presents evidence of both ex ante and ex post regulatory failure. Section III describes the PIL that was filed against regulatory authorities and summarizes the directives that the Supreme Court issued in the years that followed. Section IV is concerned with data description and econometric methodology used. Section V contains the results. Concluding remarks are made in section VI.

II

The Delhi Air Pollution Case:

(A) The Law on Books

The Air (Prevention and Control of Pollution) Act 1981 envisaged establishing Pollution Control Boards in the States to monitor and control air and noise pollution level through licensing. The Environment (Protection) Act 1986 included a nation wide strategy for controlling air pollution and was further strengthened in 1994. National Ambient Air Quality Standard for the country (NAAQS) was set through notifications in 1982 and 1994.

Air act like its counterpart Water Act establishes a two-tier system to monitor and enforce the standards. It allows the state and city authorities to decide on demarking pollution free sensitive, residential and industrial areas. The firms then should get a license from the concern state board that their emission levels are well within the limits prescribed. Licensed firms that do not comply with the standards can be closed down or fined by the local pollution control board. In case of serious negligence, the defaulter could be prosecuted in the magistrate court.

There were specific policy initiatives for Delhi state alone. Delhi Development Authority (DDA) was created under Delhi Development Act of 1957 for the planned development of Delhi. The Delhi Master Plan (perspective) 2001 was introduced in the '80s and set out the pollution emission standards in National Capital Region. Different standards have

been specified for industrial, residential and sensitive zones. National Ambient Air Quality Monitoring Program (NAPM) and National Ambient Air Quality Standard (NAAQS) were set up by the Central Pollution Control Board (CPCB) to identify and monitor the pollution level and regularly appraise pollution control programs in the city. The upshot of this is to show that in this case, there is no reason to believe that an absence of law is responsible for the environmental problems since the *law on books* was quite extensive and substantive³. The problem lies with implementation and the dilution of the law on books that seem to be the major obstacles resulting in conventional regulations not being effective.

(B) Regulation:

Regulatory failure consists of two components: a) Capture by ‘influence’ (Stigler, 1971) and b) Corruption. The first is Ex-ante capture and can occur at the time of legislation. The private interest theories of regulation suggest that private interest groups support regulation *only* if they stand to gain from it. Given this the political parties in power is subject to the influence of the interest groups in enacting any legislation. We proceed with the assumption that in the case of environmental legislation, capture of this kind would be reflected in compromising with the stipulations of expert-opinions or standards in the enactment of the law to accommodate private interests. Thus if the standards prescribed by the experts on pollution levels do not get translated into legislation and instead the enacted Law that is agreed upon is set below the recommended one, it can be indicative of capture. The stronger is the influence of interest groups upon the State, the more would be the dilution from the norm that is recommended.

The second aspect of regulatory failure is to do with the implementation of the (possibly diluted) act. This is ex-post failure. There can be many reasons for ex-post failure but the most common is corruption. One can however think of lack of sufficient infrastructure

³ However, the Air Act has a number of shortcomings that require attention. There is no transparency in granting the licenses to the firms to operate within a prescribed area. Moreover, citizens do not have the right to sue the polluting firm or the pollution board for inaction or demand the emission data from the pollution board. This effectively means the corruption at license granting level is unchecked and the aggrieved do not have the right to go to court under the Act.

facilities to monitor violation of norms, laxity in monitoring, or a lack of corresponding legal power in the hands of the monitoring agents to be effective regulators. A well-known version of the private interest theory of regulation is that regulatory agencies typically undergo a life cycle in response to the political environment and as time passes by and the interests of the people shift away from this policy, these agencies become vulnerable to domination by regulated interests (Bernstein, 1955). Many times the lack of public attention, or the lack of expert information being supplied by the party under regulation, or the recruitment of ‘experts’ from the regulated industries can all weaken the regulatory agency and its policy. Which of these factors explains ex-post regulatory failure is an empirical question and would vary with each case.

Documentation of regulatory failure of both kinds can be done by analyzing the legislative process that led to the enactment of particular acts and to compare the norms that the act was based on (expert committee recommendations) with the final Act that was legislated. If there were no good reasons given for any dilution of the committee recommendations then one can conclude the presence of interest groups at work. Secondly, if data on the actual harm levels were obtained *after the Act comes into effect*, a consistently higher level of harm as compared to the standard set by the act would be an indicator of regulatory failure of the second kind. In some cases, the number of *executive petitions filed* (i.e. petitions that are filed by victims in the event enforcing agents fail to comply with the enforcement of the legislated standard) can also be an indicator of failure at the level of implementation⁴.

C) Evidence of Capture: Dilution of Standards

A committee under H.B. Mathur of Indian Institute of Technology, New Delhi was set up to recommend vehicular emission norms for New Delhi for the period 1995-2000. There were specialized sub-committees under S. Raju of the automotive research association of India to recommend on petrol cars and B.P Pundit of Indian institute of petroleum for diesel vehicles. These two committees set the pollution standards for industrial and

⁴ However, data on this was not available for this study.

vehicular pollution in the capital territory of Delhi. Industrialists protested against the Mathur committee recommendations and Ministry of Environment And Forest (MoEF) opted for a softer version of the recommendation in 1993. The committee had set 2.0 to 4.0 gm/km for NO_x emissions according to the reference weight of the vehicle but the adopted figure was 3.0 to 4.36 gm/km according to the cubic capacity of the vehicle (Divan and Rozencranz, 2001). Further, these standards were set for cold start conditions when the emissions are at their maximum. However, the same standards were adopted for warm start conditions where the emissions are relatively low. Further, the lobby group succeeded in postponing the date of the enforcement of the committee recommendations by one year from April 1995 to April 1996. By softening the standards, changing the reference point and postponing the commencement date the lobby group had considerably reduced the original standards recommended by the committee.

D) *Ex post* Regulatory Failure

The second type of regulatory failure refers to the inability of enforcement authority to bring about compliance with the recommended standards. Comparing the recommended standard with actual pollution levels will substantiate evidence of this. If the records show that pollution levels were consistently higher than the recommended levels in the years subsequent to the enactment of the Acts, this would be indicative of *ex post* failure.

Ambient air quality is measured in term of three components of pollution namely Oxides of Sulphur (SO_x), Oxides of Nitrogen (NO_x) and Suspended Particulate Matter (SPM). The regulatory authorities have set up three different standards of the levels each these components depending upon the area viz, industrial area, residential area and sensitive areas are designated as those which house schools and hospitals. A perusal of city map of Delhi shows that both residential and sensitive areas are intermixed and one cannot differentiate them from each other. Hence through out this study we use the standard set for the sensitive areas as the “city standard”. Thus we are left with two standards for purposes of comparison that is the industry standard and the city standard.

As is evident in the pollution data of the early 90's, the pollution level of SO_x, NO_x and SPM had been on the rise in the early 90's. Figures 1A, B, C indicate that the statues enacted, standard set and government machinery responsible for pollution control did not succeed in effectively controlling air pollution in Delhi by bringing the ambient air quality to the set standard. Particularly Suspended Particulate Matter is phenomenally high (average of 400) compared to the Indian standard of 360 for industrial areas, and 140 for city standard⁵. SO_x and NO_x are also much above the city standard prescribed. The most disturbing factor is that the gap between actual level of pollution and the standards had been widening over time. The reason could be laxity in enforcement as enforcement agencies were not accountable to any higher authority.

[Insert Figures 1A, B and C here]

To summarize pollution control boards are seen to be ineffective and the political willingness to curb pollution were minimal. There was no evidence of any outcry in the media or otherwise, in terms of citizen protests, prior to the PIL case. One major reason for public apathy could be the lack of information on pollution levels and enacted standards. This in turn creates conditions under which civil society's strength to act as a watchdog on government's actions or inactions is considerably weakened. Corrupt practices thrive when there is lack of information or when the information is not easily verifiable. The workings of pollution control boards and other regulatory bodies seldom catch the attention of media and are therefore removed from the public knowledge domain. In most cases it is extremely difficult for the private citizens to verify independently on the workings of such agencies. Under such conditions regulatory failure goes unchecked.

III

PIL as an Alternative form of Control

Brief description of PIL

⁵ International standards are much more stringent than Indian standards where SPM is 60-90 mg/m³ (World Bank, 1995)

The procedure for judicial review of administrative actions in India was revolutionized when *locus standi* was relaxed and courts sought only “sufficient interest” of the litigant as against “person aggrieved⁶”. A concerned citizen (or a voluntary organization) may sue, not as representative of others but in her *own right* as a member of the citizenry to whom a public duty is owed. By relaxing *locus standi* the Supreme Court (SC) opened its doors by empowering any concerned citizen to voice in the court on behalf of the public and made the judicial process more participatory (Cunningham, 1987). It was thought to be a step towards checking the abuse of executive authority.

From a law and economics perspective, PIL cuts short the procedure of redress by bypassing the lower courts. As the Supreme Court’s verdict binds all other courts and pollution board, replication of similar cases that would have gone to lower courts i.e. magistrate courts is largely reduced. This would save a lot of scarce judicial time. Another advantage of PIL is that it attracts a lot of media coverage and checks corruption by making the matter public. Thus PIL could be seen as a mode for the civil society to make regulatory authorities’ inaction public and eventually move the Court to urge the executive to act swiftly.

Supreme Court Directives

Supreme Court of India in 1990, replying to a PIL filed in 1985 by M.C.Mehta, demanded the city administration to submit a complete list of action taken against the environmental tort feasons, mostly industries, and also directed the state to explore the possibilities of reducing pollution⁷. Subsequently the Court asked the government to form a high-powered committee, the K.N.Saikia Committee, to assess the low cost

⁶ The Supreme Court of India has clearly delineated the role of court in Sheela Barse case (Sheela Barse v. Union of India, 1988 4 SCC 226, 234, 1988 AIR (SC) 2211, 2214) that purpose of public interest litigation is “in a Public Interest Litigation, unlike traditional dispute resolution mechanisms, there is no determination or adjudication of individual rights. While in the ordinary conventional adjudications the party structure is merely bi-polar and the controversy pertains to the determination of the legal consequences of past events and the remedy is essentially linked to and limited by the logic of the array of the parties, in a public interest action the proceedings cut across and transcend these traditional forms and inhibitions”.

⁷ Writ Petition (Civil) No. 13029 of 1985, order dated 14 November 1990

technological alternatives and new legal solutions⁸. The Court was active through out this period as it was concerned with carrying out the prosecution of defaulters⁹. The first concrete order given by the SC to reduce pollution was issued to the Delhi Transport Corporation buses ordering them to change from gasoline to natural gas¹⁰. The Division Bench of Supreme Court consisting of Justice Kuldip Singh and Justice S Saghir Ahamad in 1995 directed the Delhi Government to set up a committee to study industrial concentration in non-conforming areas such as colonies and other residential pockets.

In May 1992 SC had ordered all stone crushers along Delhi-Faridabad boarder close or shift away from Delhi as they were polluting Delhi air. In 1995, as per the Court order, individual notice had been sent to 8378 industries asking them to relocate or stop functioning as they are polluting industries and or functioning in non-conforming areas specified in Delhi Master Plan. In the subsequent notifications SC had made its point clear that forms that are noxious and hazardous particularly industries that fall under the category of 'H(a)' and 'H(b)' should be relocated in a stipulated time of three years and other not noxious but nuisance causing units should move out in four years¹¹. More than 1,300 industrial units have been closed.

Regarding vehicular pollution the Court came out with a series of orders that directs the pollution control authorities to execute the standards set by various committees and boards¹². As an affidavit filled by the CPCB attributes more than 2/3 of the pollution to vehicles particularly the diesel run two wheeler, the Court had ordered all the new diesel vehicles to be registered after June 1999 in Delhi should abide to Euro-1 emission norms

8 Writ Petition (Civil) No. 13029 of 1985, order dated 19 February 1991

9 1991 (2) SCC 137

10 Writ Petition (Civil) No. 13029 of 1985, order dated 3 October 1991 and 25 October 1991; it was extended to all public buses (Writ Petition (Civil) No. 13029 of 1985, order dated 8 January 1992) and all government vehicle were ordered to shift CNG (26 April 1996).

11 Delhi Master Plan has categorized the industries in Delhi into A to H. of that H category has been subdivided into 'H(a)', which include noxious and hazardous industries such as Cellulosic Products, Cement and Refractories, Explosive and Ammunition, Fertilizers, Inorganic and Organic Chemical Industries, Leather and Other Animal Products, Metallurgical Industries, Paper and Paper Products, Poison, Radioactive Elements and Rubber Industries and 'H(b)', heavy and large industries.

12 1998 (6) SCC 63 and AIR 1999 SC 291

and vehicles to be registered after 2000 April should abide to EURO II emission norms¹³. Environment Pollution (Prevention and Control) Authority for the National Capital Region states in a report on clean fuels that Sulphur content in diesel and petrol was ordered to be reduced to a maximum of 0.25% and 0.10% respectively and steps were taken to control Benzene and lead in petrol (EPCA, 2001). All vehicles that are 15 years and older were phased out. All government vehicles were asked to convert to CNG. In the light of the above directives, the next section is concerned with testing the hypothesis that the Supreme Court intervention was effective in improving the Law enforcement and controlling pollution in Delhi.

IV

The Data, Descriptive Statistics and Econometric Methodology

Annual average of Oxides of Sulphur (SO_x), Oxides of Nitrogen (NO_x) and Suspended Particulate Matter (SPM) for the years from 1987 to 2004 were collected from the reports of Department of Environment, Government of Delhi & Central pollution Control Board. All these pollution series are measured in $\mu\text{g}/\text{m}^3$ and SPM is total suspended particulate matter in the ambient air with the diameter larger than 0.25. Data on Index of Industrial Production, number of industrial units functioning in Delhi and the number of vehicles registered in Delhi are also obtained from the reports of Department of Environment, Government of Delhi & Central pollution Control Board.

Simple plotting of the pollution series at their absolute levels show that SPM is fluctuating around its mean value of 400, whereas NO_x showed consistent increase over the period considered. Levels of SO_x exceeded the city standards although the levels were well within the limits industrial areas. SPM was consistently above specified maximum ambient quality standard of 360 for industrial areas. It is extremely high when compared to the standard for residential areas (140), and sensitive areas (70).

13 1999 (6) SCC 12

The growth in the number of vehicles registered in Delhi was enormous in the period considered. Given the moderate increase in the number of industrial units coupled with vehicle growth, it is expected that the ambient air quality would worsen overtime. When the data is corrected for these increments, all pollution series considered show consistent *reduction* implying that per vehicle and per industrial unit pollution has gone down¹⁴. This reduction is prominent for pollution corrected for number of vehicles. This simple plotting of corrected data lends credence to our hypothesis that the SC intervention has helped in moderating pollution level in Delhi. By this we mean the Court's intervention helped keep the ambient air quality from further deterioration.

In figure 2.A we have plotted actual level of SPM corrected for increment in number of vehicle and ought-to-be per vehicle standard in order to maintain the ambient air quality within the prescribed limits. The difference between these two would show the effectiveness in implementation. The gap seems to be narrowing in the case of SPM or moderated over time, whereas SOX shows a phenomenal reduction as the actual level of pollution has gone below the standard. However, NOX shows consistent increase.

[Insert Figures 2 A, B and C here]

As the corrected data show some kind of moderation over years, we use a number of techniques to statistically prove that this moderation is due to the SC intervention in the 1990's. Measuring the impact of policy and institutional changes such as the SC intervention on resultant variables has been the occupation of recent research in econometric modeling (Fomby & Lin, 2003; Freeman, 2005). There are a number of empirical studies that take the fundamental changes in institutions, policy and other social changes into account¹⁵.

The Policy Variable (SCI)

¹⁴ Pollution series corrected for number of vehicles go with a subscript v (e.g. SPMv, NOXv and SOXv), series corrected for number of industrial units go with a subscript u (e.g. SPMu).

¹⁵ For a recent survey of the structural break literature see Maddala & Kim (2000) chapter 13, Perron (2005).

Using year wise SC directions to the concerned authorities in Delhi, we generate a variable called “Supreme Court Intervention (SCI)”. We club all the directives¹⁶ into three broad categories. (i) Directives that have only indirect effects, e.g. to set up fuel testing labs etc., the variable will carry a weight of 1, (ii) Directives that are of local importance such as restrictions on the plying of heavy vehicles will carry a weight of 2, whereas (iii) The directives that would impact the pollution in a big way such as switch to CNG by all public transport vehicles and the phasing out of old vehicles will carry the maximum weight of 3. The index shows that the SC intervention peaked in the late 1990’s especially there were 10, 8 and 6 directives in 2000, 1998 and 1996 respectively.

Methodology

We first test for structural breaks in the time series data. Structural breaks in univariate time series are usually caused by an exogenous change in surrounding conditions that would result in a break in the conditional mean and the variance of the series. In the conventional time series analysis, to account for this kind of structural breaks, a change point dummy variable is specified *a priori* to capture the mean shift between two periods. The shortcoming of this method is that it cannot detect the time of policy intervention when there are significant implementation lags. One would end up overestimating or underestimating the significance of break point due to this data dredging, more so when the point of intervention or policy change is not clear. When the change point is not known *a priori* or implementation lags are not cognizable, diagnostic methods or non-parametric methods are used to locate the time and the number of change points in the series endogenously. In our case the Supreme Court intervention was over a period of time and there was no objective *a priori* method to state a single break point.

To overcome this difficulty, we have used a number of unit root techniques such as Andrews and Zivot (1992) and Clemente, Montanes and Reyes (1998) to identify the breaks in the individual time series endogenously. These techniques are meant to test for unit root in a time series accounting for structural break. If an optimal break point is identified endogenously then conventional regression models could make use of this

¹⁶ Refer to Rathinam and Raja (2006) for a detailed list of Supreme Court interventions.

information to test if these breaks are associated with policy changes or known exogenous shocks.

Andrews and Zivot (1992) have developed a procedure to identify a single break point in the intercept and/or the trend in the series. The obvious weakness of this test is that it cannot identify when there is more than one break point especially when the shock is innovational rather than a one-shot exogenous shock. To overcome this shortcoming Clemente, Montanes and Reyes (1998) have developed a procedure allowing for a gradual shift in the mean to test more than one break point. In Clemente *et.al* there are two different ways a shock could affect a series i.e. an additive outlier where break is assumed to be instantaneous and an innovational outlier where the break is gradual. In our case there are a series of interventions by the court in the form of directives issued at different points of time, so we expect the impact to be gradual.

We further specify autoregressive and distributed lag models, where each pollution series is modeled as a linear function of its own and lagged values of SCI. We used information criteria such as Akaike information criterion (AIC) and Schwarz criterion (BIC) to identify the number of lags in the model. As it is common for the time series regression to suffer from serial correlation, we have used Feasible Generalized Least Squares (GLS) estimator, and heteroskedasticity and autocorrelation consistent (HAC) standard errors.

IV

Econometric Models and the Results

The results of Clemente, Montanes and Reyes (1998) test for multiple endogenous structural break points in single series show that all the pollution series have a break in the mid 1990's. Especially SPM and SPM corrected for vehicle and industrial activities show a break in the later half of 1990s however, SOX series shows in the first half with high level of significance.

The optimal break identified by the above unit root tests could be used to examine whether the SC intervention had any impact of pollution levels. We specify a dynamic

linear regression model where SCI is run against all of corrected pollution series. We consider the date of commencement as the date of directive. Due to implementation and response lags, we expect pollution levels would react to these changes with some lags. The autoregressive and distributed lags are decided using information criteria such as AIC and BIC. To identify the impact of SCI on each pollution series we run the following regression with a number of SCI lags and the own lagged value of the pollution series.

$$Y_t = \alpha + \delta_1 Y_{t-1} + \beta_1 \text{SCI}_{t-1} + \beta_2 \text{SCI}_{t-2} + \dots + \beta_n \text{SCI}_{t-n} + \varepsilon_t \quad (1)$$

Where Y_t stands for the pollution series Y_{t-1} is the first lag of pollution series and SCI_{t-1} stands for the lags of Supreme Court intervention. The results show the presence of a strong negative persistence in the all the pollution series as the first lagged values introduced is negative and highly significant in all the models (see Table-I in Appendix-I). The contemporaneous effect of SCI in all the models have turned out to be insignificant and were dropped. SCI with some lags however has turned out to be significant in all the series except SPM corrected for number of vehicles in Delhi. The over all results suggest that SC's intervention is substantial in reducing pollution. More importantly, SCI against all the pollution series corrected for number of vehicles and industrial activities has the right sign i.e. SCI has a dampening effect on pollution. This only establishes that SCI is significant in explaining the reduction in pollution level. As expected, the impact of SCI is considerably lagged in the case of SOXv and SOXu as much as four to five years from the date of directive. On the other hand, NOXu, SPMv and SPMu show relatively immediate impact of court intervention. Even though Breusch-Godfrey test for autocorrelation suggests no serial correlation in the regression, Newey-West heteroskedasticity and autocorrelation consistent (HAC) standard errors show that the results are consistent.

V

Summary and Conclusions

We have shown in the paper that the PIL filed in New Delhi has played a lead role in enforcing the environmental standards. Despite strict environmental standards and the presence of regulatory authorities, air pollution level in Delhi was exceeding the acceptable levels. It was quite evident in this case that regulation has failed due to *ex ante* and *ex post* captures. The government has softened the standards set by committees and even these diluted standards were not implemented effectively.

PILs and Supreme Court's environmental activism have resulted in *moderating* ambient air quality in Delhi. SPM and SO_x corrected for number of vehicles registered and number of industrial units in Delhi, have shown reducing trend in the late 90s and stabilized due to court orders such as redeploying non-conforming polluting industrial units, adopting stringent vehicular emission standards and shift to CNG. The impact becomes clearly discernible when the data is corrected for increased number of industrial units and the number of vehicles in Delhi vis-à-vis the original series. Structural break unit root tests show that all the components of pollution data considered i.e. SO_x, NO_x and SPM showed a considerable shift in the mean value between early 1990s and late 1990s. This clearly coincides with the years when the SC issued largest number of directives to the authorities to enforce standards.

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Appendix I

Figure 1.A

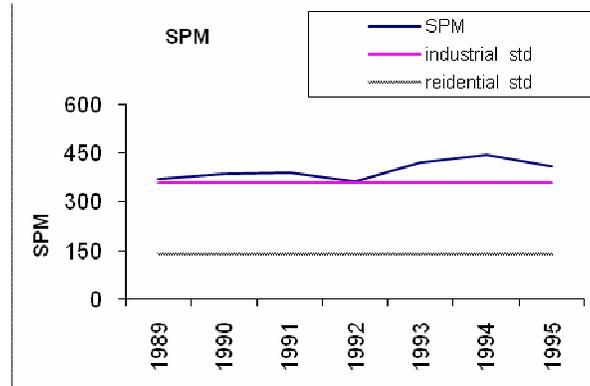


Figure 1.B & C

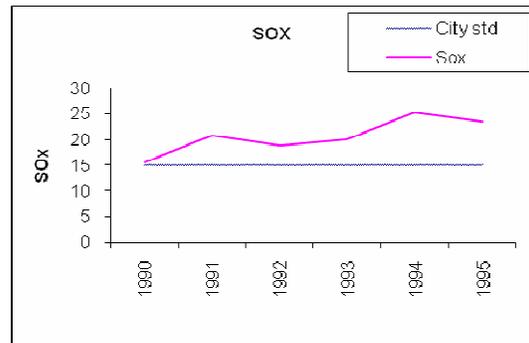
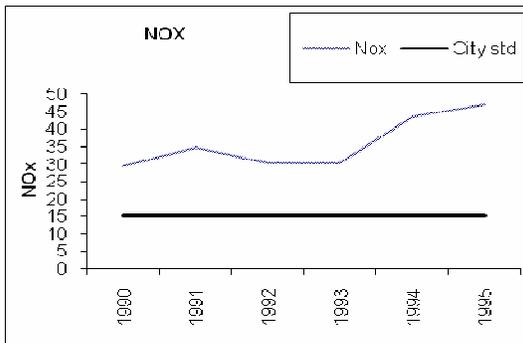


Figure 2.A & B

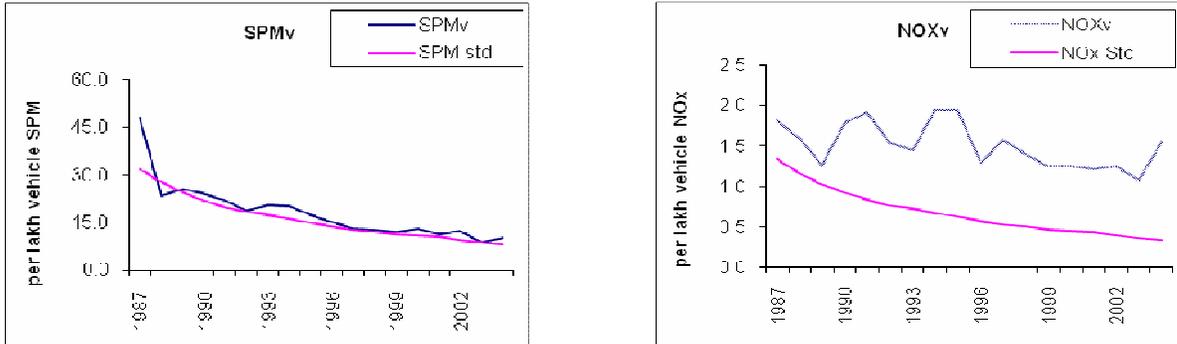
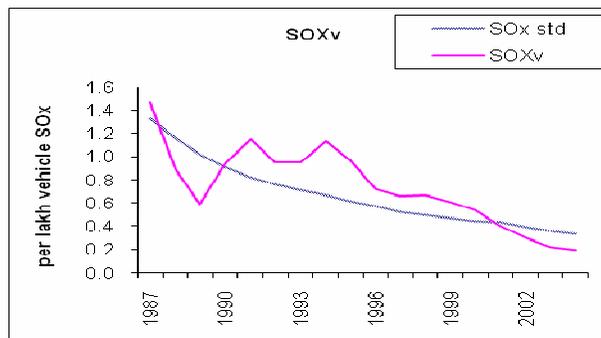


Figure 2.C



Appendix II

Table I: Regressing SCI on pollution variables

Independent variables	Dependant variable					
	model-1 SOX _v	model-2 SOX _u	model-3 NOX _v	model-4 NOX _u	model-5 SPM _v	model-6 SPM _u
SOX _{v,t-1}	-.554 (-2.88)					
SOX _{u,t-1}		-.573 (-2.97)				
NOX _{v,t-1}			-.747 (-3.26)			
NOX _{u,t-1}				-1.196 (-2.63)		
SPM _{v,t-1}					-.601 (-5.75)	
SPM _{u,t-1}						-1.108 (-7.48)
SCI _{t-1}			-.031 (-1.52)		-.358 (-1.18)	-1.512 (-2.26)
SCI _{t-4}	-.029 (-2.37)	-.094 (-2.36)		.180 (1.73)		
SCI _{t-5}	-.035 (-2.30)	-.132 (-2.70)				
Cons	0.510 (2.55)	2.18 (2.85)	1.192 (3.25)	7.53 (2.58)	9.822 (3.87)	77.91 (6.97)
R-squared	0.491	0.552	0.445	0.431	0.713	0.800
LM test ⁺	0.795	0.937	0.603	0.746	0.323	0.122
DW-Alt [@]	0.838	0.951	0.647	0.784	0.374	0.144

+ Breusch-Godfrey LM test for autocorrelation.

@ Durbin's alternative test for autocorrelation

t-values are given in the parenthesis. All the series except SPM_v and SPM_u are non-stationary at levels and stationary in first difference.

Table II: Regression with Newey-West HAC standard errors

Dependant variable	Dependant variable					
	model-1 SOX _v	model-2 SOX _u	model-3 NOX _v	model-4 NOX _u	model-5 SPM _v	model-6 SPM _u
SOX _{v,t-1}	-.555 (-2.74)					
SOX _{u,t-1}		-.575 (-3.34)				
NOX _{v,t-1}			-.747 (-3.90)			
NOX _{u,t-1}				-1.196 (-3.65)		
SPM _{v,t-1}					-.311 (-4.78)	
SPM _{u,t-1}						-1.108 (-6.48)
SCI _{t-1}			-.031 (-1.89)			-1.512 (-2.44)
SCI _{t-3}					-.421 (-2.98)	
SCI _{t-4}	-.029 (-2.07)	-.091 (-2.17)		.180 (1.16)		
SCI _{t-5}	-.035 (-2.37)	-.133 (-3.82)				
Cons	.510 (2.20)	2.18 (2.85)	1.191 (3.64)	7.53 (3.66)	5.290 (3.28)	77.91 (6.19)

t-values are given in the parenthesis. All the series except SPM_v and SPM_u are non-stationary at levels and stationary in first difference.

Table III: Clemente-Montañés-Reyes Unit Root Test for Structural Break

Pollution series	Year of break
SOX	2000
NOX	1992
SPM	1993
SOX _v	1997
SOX _u	1999
NOX _v	1997
NOX _u	-
SPM _v	1993
SPM _u	1995

Graph I: Clemente-Montañés-Reyes Test for Structural Break in SOX, NOX and SPM

