Environmental fiscal federalism and atmospheric pollution: A tale of two Indian cities

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Abstract:

This paper empirically tests the suitability of local vs state government expenditure in providing an environmental public good, namely airborne pollution control in two municipal areas in India. We employ an innovative methodology where factual and counterfactual state and local expenditure regimes are constructed to capture different degrees of decentralization. Econometric results highlight higher efficacy of state level expenditure (centralization) as spillover/regional effects become important. Particularly, superiority of state expenditure is evident in the control of suspended particulate matter (SPM), which has wide cross-boundary effects. Local expenditure and the counterfactual of local expenditure for uniform provision (both decentralized provision modes) emerge as more effective than state to control point-source local pollutant SO_2. However, they may also supplement the effects generated by state expenditure in the case of NO_2 emissions, which entail spillovers and seem amenable to pressure group influence at local level.

Keywords: Environmental governance; fiscal decentralization; atmospheric pollution; spillover effects; non-point source pollution; India

1. Introduction

In the fiscal federalism literature, local expenditure assignment would depend on heterogeneity of preferences for a public good between local jurisdictions and lack of interjurisdictional spillover of benefits. The proponents of the first-generation theories of fiscal federalism (FGFF) have argued that the decentralized provision of local public goods would lead to potentially large welfare gains (Bradford and Oates, 1974; Rubinfeld, 1987; Oates, 1999). In the second-generation theories of fiscal federalism (SGFT), an alternative way to decentralize public sector is that the central government provides local public services with the help of representation of districts in central legislature and centrally-appointed district officials at the local level (Seabright, 1996; Lockwood, 2002; Besley and Coate, 2003). They however argue that sharing of costs in a decentralized system would create a conflict of interest between different districts both about the level of public spending as well as its allocation between the districts. This political economy dimension would render local legislative assemblies more suitable for local goods provision even if the problem of inter-jurisdictional spillovers remains unresolved. While the supremacy of local government in providing local goods and services in local jurisdictions is established, the issue is whether this tenet would apply to environmental services with lack of benefit heterogeneity in the presence of interjurisdictional spillovers is the concern of this paper. The uncertainty surrounding the interjurisdictional spillover of positive and negative environmental effects may prove to be a barrier to a simple application of the fiscal federalism rules to environmental federalism. Environmental quality, for instance, cannot be taken as a visible and divisible service that is amenable to allocation over local, regional, and national jurisdictions. Moreover, the beneficiaries of the environmental quality provided in a locality may not have the option of exercising heterogeneous preferences in terms of quantity and quality.

We extend the environmental federalism literature by employing an innovative empirical model to examine the relative efficacy of local vs state government expenditure in controlling airborne pollution in a municipal area with Indian subnational data. Environmental problems present themselves differently in different situations, and local government, on the ground of the principle of subsidiarity, may seem to offer a better system of environmental governance for localized pollution. Subsidiarity is one of the features of federalism, which asserts the rights of the parts over the whole. From green-building initiatives to local farmers' markets, local governments have become major players in addressing the most pressing environmental and public health concerns. Local governments have also used their zoning authority to ban or restrict land uses that pose environmental risks. However, allocational issues regarding interjurisdictional environmental governance are complex and have attracted the attention of public policy researchers. It is argued that sub-national governments may have informational advantages regarding local environmental issues, but state and central governments are repository of national and global information, technology, and financial power. It may seem that in very distinct cases local vs non-local role can be specified. For example, the control of pollution due to slaughterhouse in a locality or any other sources of localized pollution can be assigned to a municipal government. Similarly, carbon dioxide (CO_2) emissions would fall in national and international jurisdictions. Other environmental public goods or bads (summarized as environmental quality) would entail varying levels of interjurisdictional spillovers and their provision may necessarily require either centralization or integrated environmental governance across alternative levels of governments. This scenario of environmental governance would also imply that heterogeneity of preferences for environmental quality becomes irrelevant. Nevertheless, for intermediate cases, environmental fiscal assignment of pollution abatement over layers of government is worthy of empirical verification.

The rest of the paper is structured as follows. Section two reviews the relevant empirical literature. Section three documents the nature and trends of three monitored air pollutants with implications for efficacy of environmental governance at more decentralized levels of government. Section four contains model specification, construction of variables, data sources and estimation strategy. Section five discusses the empirical results. Last section concludes with policy implications.

2. Existing Literature on Environmental Federalism and Proposed Extension

The celebrated Tiebout (1956) model of residential location does not discuss the significance of environmental quality of different jurisdiction in his migration model of optimal provision of local public goods. Banzhaf and Walsh (2008) however test the residential location model in the context of changing air quality and find strong empirical support for the notion that households 'vote with their feet' for environmental quality. Millimet (2013) argues that it is not clear from the available literature that individuals sort themselves across jurisdictions according to environmental preferences, although they may matter at the margin.

Oates (2001) presents an empirical literature on the 'race to the bottom' hypothesis and contends that decentralization may result in environmental degradation due to interjurisdictional competition to attract business and industry. He emphasizes that the central government, in addition to setting standards for "national" pollutants, has a fundamental contribution to make in supporting research in environmental science and pollution control technology and in providing needed information and guidance to state and local governments. Millimet (2003) analyzes theoretical models for the effects of decentralized environmental policymaking with predictions ranging from a 'race to the top', a 'race to the bottom', or no effect. His study shows that, by the mid-1980s, US data have been consistent with decentralization leading to a 'race to the top' (improving environmental quality). Anderson and

Hill (1997) argue that most problems can be solved at the state or local level. They consider a wide variety of resource issues, including land, water, wildlife, pesticides, and pollution, and find no evidence that state or local control results in a ‘race to the bottom’ with bad policy driving out good policy. In other words, local intervention may reduce pollution despite externalities. Alm and Banzhaf (2012) argue for local environmental policy and examine the implications of decentralisation for the design of corrective environmental policies, That is, how does one design economic instruments in a decentralised fiscal system in which externalities exist at the local level and in which subnational governments have the power to provide local public services and to choose tax instruments that can both finance these expenditures and correct the market failures of externalities?

Using a detailed simulation model of the US electricity sector, Banzhaf and Chupp (2012) empirically explore the tradeoffs for US air pollution. They find that US states acting in their own interest lose about 31.5% of the potential first-best benefits, whereas the second-best uniform policy loses only 0.2% of benefits. The centralized policy outperforms the state policy for two reasons. First, inter-state spillovers are simply more important that inter-state heterogeneity in this application. Second, because of the convexity of the marginal cost functions (deceasing returns to scale), costs are much lower over the range relevant to the centralized policy, dampening the distortions.

Bahl (2013) examines three basic approaches to metropolitan governance, namely jurisdictional fragmentation, functional fragmentation, and governance emphasizing coordination and internalizing externalities. In the context of the latter, he argues that while advocates of metropolitan government make the case for combination of scale economies and elimination of duplication, they miss the advantages that might come from competition in a fragmented government setting. In other words, the problem would hinge around how to design greater local involvement in fiscal decision making while expanding jurisdictional boundaries to capture economies of scale and deal with inter-jurisdictional externalities.

In his review of the literature, Millimet (2013) finds no empirical evidence to support the (intuitive) notion that subnational jurisdictions are better able to act on community preferences for environment than the central government. Moreover, the empirical evidence concerning the importance of inter-jurisdictional externalities is compelling, particularly as it relates to transboundary pollution and strategic policymaking. In this line of research, jurisdictional differences would have implications for cost and benefit of a project and the nature of these effects may limit the scope of fiscal federalism. In a study of nutrient control for the Neuse River in North Carolina, Smith *et al*., (1997) develop area-specific measures of the benefits and costs of regulations and illustrate 'how changes in the composition of the areas allowed to "count" for policy design can affect decisions about the levels of control judged to meet the net benefit test'. This shows the difficulties in arriving at optimal solutions under an environmental policy. van't Veld and Shogren (2012) find that decentralizing the choice between these regimes does not, in general, induce the socially optimal outcome as some regions may choose negligence and others strict liability. It is only by combining negligence with a Pigouvian tax, or strict liability with a bonding requirement that harmonized regional and central environmental policies can be designed. Coria, & Hennlock, & Sterner (2018) analyze the effects of the interaction between national and local initiatives designed to reduce emissions that causes environmental damages both nationally and locally. Their analytical findings with Swedish data suggest that local regulators are not able to impose emissions standards stringent enough and that most emissions reductions can be attributed to the national tax, which supports the case for inter-governmental environmental policy.

Sigman (2014) empirically examines control of the two public bads, namely a pollutant with inter-jurisdictional spillovers and a pollutant with more local effects. The evidence points to higher levels of a regional pollutant with more decentralization. In this case, decentralization may provide more opportunities for free riding in regional pollutants. The research nevertheless provides limited support for more general problems from decentralization, such as destructive regulatory competition or greater sensitivity of local governments to interest group politics. As regards a pollutant with more local effects, decentralization is shown to be welfare improving. In addition, his results suggest higher inter-jurisdictional variations in pollution in countries with federal systems. Such variations in pollution over regions may support the traditional view that decentralization would allow better tailoring of policies to local conditions. Two noteworthy studies on India by Lovo (2018) and Kattumuri and Lovo (2018) empirically examine the decentralization of environmental impact assessment (EIA) in 2006 from Center to state level, later extended to districts in 2016. They find that decentralization of EIA from Center to states has improved enforcement and reduced pollution through comparatively fewer firm being born in states with stricter environmental law enforcement. Their findings emphasize the significance of proactive implementation at the subnational level of a regulatory policy designed at the national level. In a recent study, Steurer and Clar (2018) analyze the role played by federalism in Austria in greening the decentralized building sector (relevant for mitigation), on the one hand, and in improving regional flood risk management (relevant for adaptation), on the other. They show that federalism appears more appropriate for regional flood protection than for mitigating climate change. The latter require higher level governmental intervention. Chen and Liu (2020) capture both fiscal expenditure decentralization and fiscal revenue decentralization in China and show that the impact of fiscal decentralization on environmental pollution is positive and appears the phenomenon of "race to bottom." This research supports the case for limited role of local government in pollution control.

The upshot of the literature review with mixed results is that in the presence of negative externalities, borderless benefit areas of environmental quality, and limitations of environmental policy instruments, the design of environmental quality governance would remain a challenge for researchers and policymakers. The literature reviewed here is highly skewed towards findings emanating from developed countries. For instance, the suitability of local versus state governance in the context of addressing atmospheric quality has not been analyzed using developing country experiences. This study attempts to fill this gap by analyzing air pollution control in urban environments of Mumbai and Delhi in India.

3. Air pollutants in India's mega-cities – with focus on Delhi and Mumbai

We propose to analyze the relative efficiency of alternative government levels, more specifically, state vs local in alleviating air quality degradation measured by three air pollutants, namely sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and suspended particulate matter (SPM). These municipal areas would entail pollution ranging from localized slaughterhouse gases to global CO_2 emissions. Our analysis does not consider carbon dioxide emissions for which information is not available in terms of municipal area. Moreover, CO_2 is considered a uniformly mixed air pollutant whose extent of damage (e.g. climate change) depends on total emissions worldwide. This is unlike SO_2, NO_2 and SPM which have characteristics of non-uniformly mixed pollutants and tend to be localized in regions close to the site of emissions, with high incidence particularly in cities and urban areas (Guttikunda *et al.*, 2014). This section looks at the nature, impact area and trends of these three air pollutants emphasizing implications on probable efficacy of decentralized environmental governance approaches.

3.1 Nature of pollutants

Table 1 attempts characterization of these atmospheric pollutants in terms of their nature, possible sources and range of impact with implications for the efficacy of control measures by different levels of government. SO_2 and NO_2 are gaseous in nature while SPM can be microscopic solid or liquid matter suspended in the earth's atmosphere (except pure water). These particles can be of various sizes, the upper limit being 50-100μm (micrometer) in diameter (CPCB, 2010). Our analysis focuses on particulate matter of size less than 10μm (also called PM_{10}), which is regularly monitored by the Central Pollution Control Board (CPCB) in India since 1999.

While all three are non-uniformly mixed air pollutants, SO_2 and NO_2 are primary pollutants, that is, they are composed of material in the same chemical form as when they were emitted into the atmosphere. NO_2 however can act as precursor for formation of secondary pollutants including secondary SPM. Examples of primary SPM are windblown dust, sea salt, road dust, mechanically generated particles and combustion-generated particles such as fly ash and soot. Secondary particles are formed from condensable vapors generated by chemical reactions of gas-phase precursors. Secondary processes can result in either the formation of new particles or the addition of PM to pre-existing particles. Primary SPM, unlike secondary particles, can be correlated more straightforwardly to sources of emissions while secondary formation is a function of many factors like concentrations of precursors, concentrations of other gaseous reactive species (e.g. ozone), atmospheric conditions, and cloud or fog droplet interactions.

Table 1: Nature, probable sources and range of impact of SO_2, NO_2 and SPM

Nature / Characteristic	**SO_2**	**NO_2**	**SPM**
Non-uniformly mixed pollutant (subject to spatial concentrations)	Yes	Yes	Yes

Primary vs secondary pollutant	Primary	Primary - Can be a precursor for formation of secondary pollutants like ozone, and photochemical smog	Primary Also secondary pollutant formed as a result of complex reactions with atmospheric constituents and other pollutants (precursors)
Point source	Yes (predominantly) - Mainly localized e.g. SO_2 emissions from a power plant. Also possible: long range impacts like acid rain	No Pollution comes from multiple sources (e.g. vehicular emissions, power plants). Difficult and /or impractical to pinpoint specific local sources.	Not straightforward – Particles may be formed due to local pollutants and precursor pollutants that can cross boundaries
Range of impact	Mainly local as the effects/ concentrations get dissipated in the air with distance. In the case of acid rain, effects may be transboundary.	Mostly localized as concentrations get quickly dissipated in the air. However, formation of secondary pollutants may have spill over effects.	Mainly localized but with source being local and regional
Continuous pollutant	Yes	Yes	Yes But with seasonal peaks. E.g., in Delhi, peak is experienced during winters due timing of regional crop fires that coincide with the period of temperature inversion and clear sky in the city.

Source: Authors using information from CPCB (2010, 2016) and National Research Council (2010).

From Table 1, SO_2 is a point source pollutant whose emitters are identifiable whereas NO_2 and SPM are predominantly non-point source air pollutants due to widespread sources and impact area. Apportionment of sources of pollutants, particularly in case of secondary particles, is a daunting task due to mixture of activities in urban centers like industrial, commercial, transport, residential and slums. Shifting industries, land use patterns and changes in combustion practices increase the difficulty of source profiling. Moreover, heterogeneity of modes of transport, large number of vintage vehicles complicates estimation of vehicular emissions. While more localized and point source pollutants may be tackled at the local level, non-point source pollutants would require coordinated policies between decentralized and higher levels of government due spillover effects and opportunities for free riding.

3.2 Trends in air pollution and source apportionment

Over the period 1996 to 2016, SO_2 levels in Delhi and Mumbai cities have complied to NAAQS (national ambient air quality standards) set by the CPCB, that is, not exceeding 50 µg/m^3 (CSO, 2017). Particularly, Delhi records 10.1±4.9 µg/m^3 and Mumbai, 9.9±6.1 µg/m^3. A declining trend in SO_2 emissions is observed over this timeline, which is more pronounced in Mumbai (-66.7%) than in Delhi (-59.5%). The reduction would be explained by the phasing out of diesel driven buses and implementation of clean fuel standards, particularly Bharat 4 diesel (50 ppm Sulphur) and Bharat Stage–III norms to commercial vehicles (CPCB, 2016). Moreover, relocation or refurbishing of industries consuming coal and diesel with better efficiency norms have led to this compliance.

As regards NO_2 levels, a steadily increasing trend over years 1999-2016 is observed in Delhi where emissions have exceeded NAAQS and WHO 2005 standards of 40 µg/m^3 post year 2000, with a spread of 47.4±14.2 µg/m^3. Delhi is found to rank second after Kolkata in terms of NO_2 emissions in past ten years. Mumbai, conversely, displays significantly lower levels of NO_2 emissions (25.8±8.3 µg/m^3) than Delhi emissions, and has experienced a 15% decline. Delhi on the other hand witnessed a growth rate of 66.2% in NO_2 levels.

Coming to SPM, data published by the CPBC extends from years 1999 to 2016. SPM levels in the two mega-cites are found to exceed WHO 2006 standards of 20 µg/m^3 as well as national NAAQS limit of 60 µg/m^3. Delhi city is the largest emitter of SPM in India with levels (200.8±44.6µg/m^3) almost double that of Mumbai (104.1±21.9 µg/m^3). Moreover, the growth rate of particulate matter has been higher in Delhi at 40.1% than in Mumbai (31.3%).

The most commonly and identified sources of airborne pollution in India's mega-cities are vehicles, manufacturing, construction, road dust, waste burning, and combustion of oil, coal and biomass in households. From Sindhwani and Goyal (2014), 72% of the total air pollution load in Delhi can be attributed to vehicular pollution. A multi-city study by the CPCB reveals that in Delhi and Mumbai, vehicular contribution to total air pollution load is about 5-12% for SO_2, 66-74% NOx (nitrogen oxides), and 3-12% for SPM (CPCB, 2010). According to this study, vehicular pollution in Delhi contributes 67% of the total air pollution load, dust and construction 45%, waste burning 17%, and transport 14%. For Mumbai, contribution of dust, transport and waste burning are respectively 35%, 17% and 16%.

CPCB (2010) and NEERI (2010a, 2010b) also categorize sources of pollutants as area source, industrial source and line source as displayed in Table 2. Detailed categorization for Delhi (NEERI, 2010a) comparable to that of Mumbai (reported in Table 2) is however not available. SO_2 pollution is shown to emanate predominantly from industrial source – 93.8% in Mumbai and 98.8% in Delhi (NEERI, 2010a). As suspected, the impact area of this air pollutant appears localized with identifiable and relatively few emitters (relative to NO_2 and SPM), namely power plants and industries. Hence, control of the pollutant may be feasible to address by local level government.

Coming to NO_2, from Table 2, emissions in Mumbai appear mainly distributed across industrial sector (47.5%) and area source (40.8%) - with the majority being emitted by locomotives (61% of area source) and the domestic sector. Only 11.7% is attributed to line source. By contrast, in Delhi, principal contributors of NO_2 load are industrial sector (78.4%) and vehicular emissions (18.3%) (NEERI, 2010a). While the fleet of vehicles in Delhi has been increasing tremendously over the years leading to rise in NO_2 emissions, installed air pollution devices in many industries are in idle conditions, resulting in emission of pollutants directly into the atmosphere without any filtration (CPCB, 2016). Further, construction of short chimneys also restricts the polluting gases to escape into the upper layers of the atmosphere. In a nutshell, the greater number of NO_2 emitters (relative to SO_2) makes targeting of emission control at point source an impractical task. Moreover, numerous sources of NO_2 emissions in Delhi may imply higher dispersion leading to spillover to (and from) regions in the periphery and outside the municipal areas warranting intervention from higher levels of government. Nevertheless, lax regulations of industries in Delhi may imply political economy dimensions such as pressure from industrial groups at local government level so that state regulation may emerge as more effective than local.

Table 2: Source apportionment of air pollutants in Mumbai city (2010)

	SO_2		NO_2		SPM	
	(T / yr)	% Total	(T /yr)	% Total	(T/ yr)	% Total
A. Area source	3266	5.8	32144.2	40.8	9815.3	36.6
Bakeries	*n.*		*n.*		*15.8*	
Hotels & restaurants	*n.*		*n.*		*6*	
Open burning	*n.*		*n.*		*7.5*	
Land fill open burning	*n.*		*n.*		*29.6*	
Construction activities					*23.3*	
Domestic sector	*38.6*		*30.9*		*5.8*	
Locomotive	*44.4*		*61.3*		*5.2*	
B. Industrial source	52983.5	93.8	37379.7	47.5	7526.3	28.1
Power plant	*46.2*		*77.4*		*74.8*	
Stone crushers					*18.5*	
Industries	*53.8*		*22.6*		*6.7*	
C. Line source	229.7	0.4	9169.2	11.7	9469.2	35.3
Vehicular						
2 wheeler	*n.*		*5.9*		*n.*	
3 wheeler	*n.*		*4*		*n.*	
Car diesel	*38*		*11.6*		*n.*	
car petrol	*n.*		*3.4*		*n.*	
HMV	*55.2*		*75*		*9.7*	
Taxis	*n.*		*n.*		*n.*	
Road dust						
Paved Road dust	*Nil*		*Nil*		*33.4*	
Unpaved Road dust	*Nil*		*Nil*		*50.3*	
Total (A+B+C)	56479.2	100	78693.1	100	26810.8	100

Source: Computed from NEEC (2010a) and NEEC (2010b). Figures in italics show percentage in respective sources of pollution, namely area, industrial and line. T/year: tons per year; n: negligible percentage (< 5%).

As regards SPM, emissions in Mumbai are spread amongst the three sources: 36.6% for area emissions predominantly from open burning and construction activities; 28.1% from industrial sources and 35.3 % from line sources mainly road dust (Table 2). In Delhi, line source contributes 59.1% of SPM (88.8% being from road dust) (NEERI, 2010a). Next is industrial source at 22% and area source, 18.8% – predominantly the domestic sector (44% of area source) and locomotives (43%). For Delhi, in residential locations, the major contributors of SPM (PM_{10}) are construction activities and transportation; in kerbside locations, road side dust and construction activities; and at industrial locations, road dust, garbage burning, and construction activities (CPCB, 2016). Source apportionment of SPM depicted in Table 2 is however not totally comprehensive as both local and regional (transboundary) emissions are responsible for most particulate concentrations that exceed air quality standards in the city. For instance, regional agricultural emissions like stubble burning from neighboring state (Punjab) and industrial emissions from uncontrolled sources in Delhi's surrounding perimeter (where city regulations do not apply and those that apply are not followed stringently) contribute to secondary and primary SPM formation within Delhi city (Kumar *et al.*, 2015).

To compound the problem, geography has a role to play regarding concentrations of pollutants. Delhi is landlocked, while Mumbai, a coastal city would have the opportunity to clean its pollution with the flow of sea breeze. Dense smog formation during winter months in Delhi can be attributed to vehicular pollution as well as the prevailing meteorological conditions in the months of December and January. Delhi and Northern India face temperature inversion in Winter, which creates a layer that traps pollutants, causing higher pollution concentrations in the city. Similarly, wind pattern also affects the weather conditions. According to a study, during the autumn and winter months, approximately 500 million tons of crop residues are burnt in Indo-Gangetic plains. With wind blowing from north and north-west to the east direction during winters, pollution levels in Delhi are significantly impacted (Sharma *et al.*, 2010). While geography cannot be controlled by the government, mitigation measures particularly to reduce transboundary impacts on city level SPM would necessitate higher level interventions and coordination at regional and peripheral levels.

4. Modelling Efficacy of Air Pollution Mitigation by State and Local Expenditure

The upshot of the previous discussion is that while SO_2 levels have been declining, NO_2 and SPM emissions are cause for concern. Our postulations of higher or lower regulatory efficiency of state and local expenditures in mitigating the above pollutants constitutes the central research enquiry in the empirical part of the paper. The dispersion or spread of the pollutants implied by high number of (identifiable) sources of emissions will have repercussions on feasibility and effectiveness of pollution mitigation by different levels of government.

We expect higher efficacy in controlling air borne pollution at local level for SO_2, need for coordination between government at different levels for NO_2 control specially in presence of local interest groups, and higher-level government intervention for SPM mitigation due to wide transboundary effects and its nature as a secondary pollutant.

The sample in our study consists of municipal jurisdictions of Delhi and Mumbai. Municipal Corporation of Greater Mumbai is the financial capital of India and located in the big state of Maharashtra. Delhi Municipal Corporation falls in the State of Delhi, which is much smaller in area and population, but it is in the heart of national capital region (NCR). While the states of Maharashtra and Delhi are not comparable on several counts, the selection of the two major municipal corporations is based on the premise that besides facing high incidence of air pollution, these local bodies are major and most resourceful in terms of finance and human resource. Thus. the performance of these institutions can be compared with state government intervention in environmental quality control. The other important dimension is the geographical location of these municipal jurisdictions. Bombay municipal corporation covers a coastal city whereas Delhi is a landlocked city. The pollution levels in coastal locations are supposed to be lower than the levels obtained in landlocked area because of sea wind sweeping away a good part of pollution. In other words, these two corporations are characterized by climatic differences, the influence of which would need to be accounted for in any comparative analysis.

4.1 The model and construction of counterfactuals

We extend the models of Brueckner (1979, 1982) and Nath and Schroeder (2007) by replacing maximization of local property value with minimization of local pollution level through local and state government expenditure activity. Unlike direct interventions, it is assumed that state and local government expenditure on regulation through policies, institutions and projects would reduce pollution levels in cities. Three local air pollution abatement functions are specified as follows:

- SO_2 = f (NSDP, SE, LE*) (1)
- NO_2 = f (NSDP, SE, LE*) (2)
- SPM = f (NSDP, SE, LE*) (3)

In equations (1)-(3), NSDP (net state domestic product) is included as a control variable, capturing dual aspects of income on pollution, namely, an output effect resulting in increase in pollution due to production activities; and a capacity effect leading to decrease in pollution through enhanced investment in environmental protection. SE denotes state environmental expenditure, proxied by state revenue expenditure (due to unavailability of such information). LE*, the variable of interest, is measured as factual expenditure of municipal corporations on pollution abatement and, alternatively, as counterfactual local expenditure as if incurred by the state government on behalf of local government.

While designing counterfactual local expenditure, we use the scenarios discussed in the first- and second-generation theories of fiscal federalism (see Box I). The measures of alternative local environmental governance are constructed in two ways: (i) as counterfactual state assembly (counterfactual 1 or CF1) providing uniform local goods, and (ii) as counterfactual state assembly with representation of local representatives in state assembly (counterfactual 2 or CF2) using inputs provided by local assemblies.

Box I: Construction of alternative governments as counterfactual

- LE: Local factual to capture decentralized provision (Oates, FGFT)
- SE: State factual to capture uniform provision without consultation with local governments
- LEav (CF1) is a counterfactual of LE when expenditure decisions are taken by the state but in consultations with locally elected representatives in local assemblies. It represents average of LE of Bombay and Delhi municipal corporations to provide uniform environmental quality.
- LEg (CF2) represents a counterfactual of LE when decisions are taken by the State government in consultation with locally elected representatives in the state assembly to provide differentiated local service (Besley and Coate, SGFT). This counterfactual is constructed using amounts of grants to local bodies. The contention is that differential grants to local bodies would carry information about differential need of different localities.

4.2 Sources of data

Local and state expenditure data are taken from Municipal Budgets and RBI (2016), respectively. Local municipal revenue expenditure figures are available over years 1981 to 2009 for the Municipal Corporation of Delhi (MCD), and years 1981 to 2013 for the Municipal Corporation of Greater Mumbai (MCGM). Moreover, published information on state level expenditure data for Delhi spans over years 1994 to 2016 while a longer series is obtained for the State of Maharashtra covering years 1981 to 2016. Net State Domestic Product (NSDP) at constant prices is reported in the Handbook of Statistics on Indian States (RBI, 2016) Monitored average annual level of SO_2, NO_2 and SPM emissions are compiled by CPCB (also reported in CSO (2017) and are available from 1996-2016 for SO_2, 1996-2016 for NO_2 and 1999-2016 for SPM. In the absence of comparable and reliable data on expenditure on pollution abatement at state and local levels, total state expenditure and total local expenditure, respectively are taken to represent environmental expenditure at alternative levels. The use of aggregate municipal expenditure data in the empirical analysis to determine efficiency may be justified to satisfy the scale of local expenditure operation against the state level environmental programs. Since the pollution abatement programs will be implemented by state and municipal governments in the municipal jurisdictions of Delhi and Bombay, it is assumed that both governments would face similar labor, capital and technological cost opportunities.

4.3 Estimation strategy

The crux of our empirical exercise hinges around testing the differential effectiveness of centralized state expenditure (SE(factual)) on air pollution control as against different modes of decentralized provision (LE(factual), CF1 and CF2) as illustrated by the matrix in Figure 1. LE(factual) is at one extreme involving fully decentralized/municipal provision using local expenditure to satisfy the heterogenous demands of the local population for air quality (locality-specific decentralization). The other extreme is centralized state provision to provide uniform services. The two counterfactuals, LEav(CF1) and LEg(CF2), may be viewed as intermediate decentralization models. More specifically, LEav(CF1) is constructed by averaging municipal expenditures of Mumbai and Delhi to provide uniform services within municipal jurisdiction In other words, two municipal corporations decide to undertake similar steps to achieve uniform service (Inter-locality decentralization). Conversely, LEg(CF2) represents state provision of differentiated services by consulting locally elected representatives in state assembly (Besely and Coate approach) though grant finance. The local machinery is however used to implement aided expenditure projects. We can call it centralized decentralization or de-concentration.

Figure 1: Decentralization regimes across uniform vs. heterogenous provision

	State	Municipal
Uniform	SE(factual)	LEav(CF1)**
Heterogenous	LEg(CF2)*	LE(factual)

Source: Authors' postulations. *: Average of municipal expenditure; **: Grant financed municipal expenditure.

Models are first estimated with state expenditure (SE) and actual local expenditure (LEfactual) as represented in equations (1), (2) and (3). Subsequently, the equations are also estimated using LE_{AVG} (CF1) in place of LE to provide uniform local services and using LE_{G} (CF2) to capture the decentralized provision of local service by the state government.

Due to constrained sample size for individual municipalities, we use pooled data arrangement to conduct the empirical analysis. Models (1)-(3) are estimated individually using pooled ordinary least squares (POLS) technique. Moreover, SURE (seemingly unrelated regression equations) and IV (instrumental variable) methodologies are also employed as robustness checks.

The attractiveness of the SUR strategy is that it produces more precise estimators than POLS in the event of contemporaneous correlation across equations in the system (Greene, 2012). If the errors however are not correlated, SURE estimators would reduce to OLS. It is good to note that SURE technique looks appropriate from significant Breusch-Pagan test statistics for serial independence of errors between pollution equations (1)-(3) (see Appendix Table A.2). Thus, estimation of these equations as a system rather than individually (as does POLS) seems preferred. Nevertheless, the interpretations remain constrained by small degrees of freedom. Addressing the problem of endogeneity of NSDP is also essential as, in a recent study, Hao et al. (2018) find that an increase in air pollution ($PM_{2.5}$ concentration) in cities in North and East China has a significant negative impact on GDP per capita. We employ IV to addresses potential endogeneity between the air pollutants and income (NSDP), which would render POLS estimates biased and inconsistent Empirical findings from the different estimation approaches are presented in Appendix Tables A.1-A.3. As additional sensitivity check, we report results without and with Delhi climate dummy in Panels A and B of each Appendix Table, respectively. The climate dummy captures the climate as well as locational differences (coastal vs landlocked) between the two municipal corporations.

5. Empirical Results and Discussion

The results are discussed according to factual and counterfactual state and local expenditure, respectively. In Table 3, effectiveness of these alternate forms of governance in terms of air pollution control is inferred when the coefficient on the respective expenditure variable is significantly negative (detailed results reported in Appendix Tables). From Panel A, in the case of a more localized pollutant like SO_2 whose major emitters are relatively few and easily identifiable, control policies at the local level ($LE_{factual}$) or in consultation with local representatives in local assembly (LE_{AVG}) appear successful in reducing the problem. This is facilitated as enforcement costs as well as administrative costs would be lower relative to more dispersed pollutants NO_2 and SPM. SE, on the other hand, seems to have limited role in SO_2 control. When we control for Delhi climate (Panel B), however, it now appears that both SE and LE_{AVG} would have some significant role in pollution control whereas $LE_{factual}$ is now less important (insignificant). These findings may highlight success of well-designed and coordinated efforts at both local and state level for achieving reduced SO_2 emissions.

Table 3: Summary of results on effectiveness of expenditure measures

Expenditure Variables	**SO_2 control** POLS	SURE	IV	**NO_2 control** POLS	SURE	IV	**SPM control** POLS	SURE	IV
PANEL A: Without Delhi climate dummy									
SE (factual)	No (except with LE_G)	No (except with LE_G)	Yes (except with $LE_{factual}$)	Yes	Yes	Yes	Yes (except with LE_G)	No	No
$LE_{factual}$	Yes	Yes	Yes	No	No	No	No	No	No
CF1: LE_{AVG}	Yes	Yes	Yes	No	No	No	No	No	No
CF2: LE_G	No	No	No	No	No	No	No	No	No
PANEL B: With Delhi climate dummy									
SE (factual)	No (except with LE_G)	Yes (except with LE_{AVG})	Yes (except with LE_{AVG})	Yes (except with LE_{AVG})	Yes	Yes (except with LE_{AVG})	No	No	No
$LE_{factual}$	No	No	No	No	No	No	No	No	No
CF1: LE_{AVG}	Yes	No	Yes	No	No	No	No	No	No
CF2: LE_G	No	No	No	No	No	No	No	No	No
DL Climate	-ve sig (except with LE_{AVG})	-ve sig (except with LE_{AVG})	-ve sig (except with LE_{AVG})	+ve sig (except with $LE_{factual}$)	+ve sig	+ve sig (except with $LE_{factual}$)	+ve sig	+ve sig	+ve sig

Source: Estimated.
SE: Stated revenue expenditure; $LE_{factual}$: Municipal corporation revenue expenditure or local expenditure by local assembly; LE_{AVG}: Counterfactual 1 of Mumbai and Delhi municipal corporations to provide uniform environmental quality; LE_G: Counterfactual 2 constructed using amounts of grants to local bodies. POLS: robust Pooled OLS estimates; SURE: Seemingly Unrelated Regression Equations estimates; and IV: Instrumental Variable estimates.

As regards NO_2, emitters are many (mainly vehicles and industries) so that the air pollutant is expected to be more dispersed than SO_2. Externalities may also be higher with impacts spilling outside the municipal region. POLS and IV results in Table 3 indicate that the spillover effects are significant, state control is overwhelmingly warranted. This result is robust to the inclusion of Delhi climate dummy (favouring NO_2 accumulation) in our models. State level interventions would be more effective in addressing the free riding problem by spreading regulatory and abatement costs to beneficiaries outside the municipal area. Moreover, lax environmental regulations in cities and their periphery (CPCB, 2016) may imply pressure group influence, particularly from the polluting industrial sector, on local governments rendering them unsuccessful in implementing regulations as opposed **to** state government.

Coming to SPM, which is both a primary and secondary air pollutant, sources of pollution appear more difficult to identify than in case of NO_2 and secondary effects would imply cross boundary effects of higher magnitude in and out of the municipal area. Thus, reduction of the pollutant is not solely in the control of local bodies. While POLS in Panel A demonstrate some success of state intervention in reducing SPM levels, this result just disappears when we use alternate estimation methods and control for Delhi climate (Panel B). Moreover, all localized interventions also emerge as unsuccessful. Delhi climate would appear to be a major culprit for SPM emission levels. If we believe POLS results, then state level effort would have potential in reducing yearly SPM emissions. Nevertheless, in the light of these results, it can be conjectured that the situation would have worsened in both the cities due to lack of (any or) sustained efforts at the state level and coordination with sub-urban and other regional bodies in addressing the problem. For instance, in Delhi, major sources of SPM pollution include road dust, but also industrial activities, construction and thermal power plant emissions located mainly outside the city boundaries (including nearby states). Road dust, which is also significantly felt in Mumbai would largely be attributed to vehicular concentration, network of unpaved roads as well as ongoing construction work. Expansion in the fleet of vehicles in these megacities over the sample period would have more than offset any power of regulations, worsening (or least not alleviating) the SPM problem. Ex post, the (occasional) shutting down of thermal plants such as National Capital Power Station NTPC Dadri (located outside Delhi state) and Badarpur Thermal Plant (in Delhi State), did not reduce severity of SPM pollution. The important pressure groups such as from industry and construction activities located in and outside the megacity (including other states) would imply constraint on any efforts by state government in designing regulations and performing effective monitoring and implementation. We conjecture that for a complex pollutant like SPM crossing city and state boundaries would involve more powerful players that may render even state officials less willing to regulate.

To be specific, LE(factual) addressing localised effects and CF1(inter-locality uniform provision) appear to be effective for SO_2 regulation due to minimal interjurisdictional spill overs. SE seems to be instrumental in reducing NO_2 levels on the grounds of uniform provision and interjurisdictional spill overs. As regards, SPM, with larger impact area covering the state and beyond would appear to work against decentralised intervention, rendering both local and state interventions ineffective. Nevertheless, CF2 (centralised decentralisation or de-concentration) as mode of environmental governance is found to be generally ineffective.

The coefficients on net state domestic product (NSDP) are usually positive but not always significant (Appendix Tables A.1-A.3). The impact of NSDP entails two dimensions: an output effect that is higher output produces higher pollution and a capacity effect that increases the fiscal resources to invest in technology and meet higher expenditure needs to alleviate pollution. Significantly positive coefficient would indicate the polluting nature of production process overpowering the capacity effect. In some cases, negative and significant coefficients would convey a rise in the fiscal capacity factor as NSDP increases that would act as pollution reducing channel. Where insignificant, we may conjecture that the two effects (output and fiscal) cancel each other.

6. Conclusion and Emerging Policy Issues

Recent advances in environmental governance literature concentrate on comparing the relative efficacy of central vs sub-national government involvement in environmental abatement strategies. It is argued that sub-national governments may have informational advantages as regards regional and local environmental issues, however central government is a repository of national and global information, technology development and financial power. An attempt is made in this paper to extend the above arguments at the subnational level, that is, between state/regional and local government. We test the efficacy of local government (municipal) expenditure and state level expenditure in alleviating air pollution in the municipal jurisdiction of Bombay and Delhi due to SO_2, NO_2 and SPM (PM_{10}). The empirical exercise however does not yield any straightforward result in support of local intervention except in the case of SO_2, which is mainly localized. Thus, whereas a strong case is made for decentralization in the fiscal federalism literature, our results do not support environmental federalism to control borderless airborne pollutants, namely SPM and NO_2. Our findings highlight the difficult task of determining the benefit area of environmental quality and employing policy instruments by different levels of government to correct negative externalities.

Our empirical results can be summarized as follows. Local municipal expenditure and decentralized provision measured by counterfactual CF1 are effective in reducing the more localized point source pollutant SO_2, but not in case of the dispersed non-point source pollutants, NO_2 and SPM. In these cases, the spill over effects from and outside the municipal jurisdiction are significant, which implies that higher information costs (including on polluters/beneficiaries outside the locality), transaction costs and enforcement costs required for effective pollution control. Moreover, pressure group influence, for example, from industries in neighbouring areas or in the city may deepen the ineffectiveness of local interventions. State level expenditure thus emerges as overwhelmingly successful in controlling these two pollutants as opposed to other decentralised expenditure regimes. Nevertheless, in the case of NO_2, which seems more localized relative to SPM, results display some scope for success of coordinated efforts of local and state level to control these emissions.

These findings may be taken as exploratory due to restricted sample size and small stock of fiscal and real data available. However, this exercise provides a new framework to examine the issues underlying the allocation of pollution abatement functions across different layers of government. In the local context, the role of municipal expenditure in pollution mitigation should not be underplayed. Our findings point towards the possibility that, with proper monitoring from higher level governments, local governments can significantly contribute to environmental governance efforts of state and central governments. It is however important to note that the success of state level environmental policy in addressing pollution underlies the notion that national level centralization may not be ideal. As Ryan (2015) puts it very aptly, environmental federalism is lighting a path away from the old “zero-sum” model of federalism (which treats every assertion of authority at one jurisdictional level as a loss of authority for the others), and pushes toward a model of negotiated federalism emphasizing consultation, compromise, and coordination.

An alternate counterfactual that is not explored in our empirical exercise is public-private partnership (PPP) whereby local governments may partner with private operators for example in attempts to (i) reduce number of private car commuters on the road such as by increasing the flight of public/private bus or other vehicular transport; (ii) help to finance develop clean modes of transport such as electric buses or vehicles running with fuel cells; and (iii) support to develop alternate modes of clean energy for industries. This partnership mode may constitute an important further research issue involving environmental managers of big cities.

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Appendix Tables

Appendix Table A.1: Pooled OLS results: Local vs. state expenditure – SO_2, NO_2 and SPM emissions control

	Dependent variable: Pollution emissions (ln)								
	ln(SO2)			ln(NO2)			ln(SPM)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Without Delhi Dummy									
ln(NSDP)	0.306	0.170	1.916**	1.372**	1.373**	1.302*	-0.047	0.082	-1.030**
	(0.555)	(0.378)	(2.347)	(2.404)	(2.644)	(2.033)	(-0.162)	(0.400)	(-2.295)
ln($LE_{factual}$)	-1.315***			0.506			0.487***		
	(-4.596)			(1.460)			(4.236)		
ln(LE_{AVG})		-0.819***			0.404*			0.345***	
		(-7.012)			(1.873)			(5.555)	
ln(LE_G)			0.183*			0.077			-0.121*
			(2.033)			(0.974)			(-1.730)
ln(SE)	0.281	-0.139	-1.420**	-1.305***	-1.081***	-0.941**	-0.401*	-0.277**	0.459*
	(0.627)	(-0.451)	(-2.750)	(-2.817)	(-3.052)	(-2.339)	(-1.915)	(-2.095)	(1.734)
Const	7.617***	8.878***	0.882	1.738	0.357	2.364*	6.076***	5.026***	9.465***
	(5.283)	(7.978)	(0.578)	(1.265)	(0.216)	(1.976)	(8.345)	(8.680)	(8.733)
N	32	28	27	32	28	27	28	28	24
adj. R^2	0.739	0.801	0.597	0.361	0.360	0.363	0.787	0.839	0.748
Panel B: Without Delhi Dummy									
ln(NSDP)	0.0758	0.153	0.613	1.477**	1.610***	1.857**	0.117	0.128	-0.223
	(0.133)	(0.331)	(1.054)	(2.717)	(3.683)	(2.803)	(0.808)	(0.955)	(-0.711)
ln($LE_{factual}$)	-0.244			0.0136			-0.164		
	(-0.637)			(0.0305)			(-1.115)		
ln(LE_{AVG})		-0.754**			-0.540			-0.169	
		(-2.119)			(-1.289)			(-1.277)	
ln(LE_G)			0.123***			0.103			-0.074
			(4.097)			(1.109)			(-1.168)
ln(SE)	-0.556	-0.184	-1.041***	-0.920*	-0.434	-1.102**	0.154	0.138	0.179
	(-1.017)	(-0.454)	(-3.012)	(-1.750)	(-1.017)	(-2.748)	(0.799)	(1.104)	(0.872)
DL	-1.237***	-0.121	-1.388***	0.569	1.736**	0.591**	0.839***	0.978***	0.605***
	(-3.611)	(-0.221)	(-5.742)	(1.384)	(2.142)	(2.158)	(4.607)	(5.134)	(5.700)
Cons	9.576***	8.970***	7.859***	0.837	-0.958	-0.607	4.253***	4.307***	5.685***
	(7.394)	(8.124)	(6.061)	(0.527)	(-0.477)	(-0.341)	(10.84)	(11.36)	(7.934)
N	32	28	27	32	28	27	28	28	24
adj. R^2	0.835	0.793	0.851	0.373	0.431	0.448	0.882	0.883	0.858

Source: Estimated. t-statistics in parentheses * p<0.10, ** p<0.05, *** p<0.01
Linear interpolation has been used to address missing observations; N: no. of obs.; NSDP: Net state domestic product; LE_{AVG}: Average of local (municipal) revenue expenditure of Municipal Corporation of Delhi (MCD) and Municipal Corporation of Greater Mumbai (MCGM); LE_G: Grants to municipal corporations; $LE_{factual}$, SE: Local and state revenue expenditure, respectively.

Appendix Table A.2: SURE results on pollution control: Local vs. state expenditure (Dependent variables: SO_2, NO_2, and SPM emissions)

	ln(SO2)			ln(NO2)			ln(SPM)		
	(1a)	(1b)	(1c)	(2a)	(2b)	(2c)	(3a)	(3b)	(3c)
Panel A: Without Delhi Dummy									
ln(NSDP)	0.804	0.654	1.524**	0.943*	1.008**	0.851	-0.451+	-0.362	-0.647**
	(1.449)	(1.488)	(2.039)	(1.806)	(2.145)	(1.434)	(-1.623)	(-1.489)	(-2.071)
ln($LE_{factual}$)	-0.426**			0.090			0.078		
	(-2.095)			(0.836)			(1.018)		
ln(LE_{AVG})		-0.376***			0.107			0.090**	
		(-3.936)			(1.612)			(2.115)	
ln(LE_G)			0.098			-0.006			-0.026
			(0.967)			(-0.120)			(-0.665)
ln(SE)	-0.461	-0.529*	-1.121**	-0.769**	-0.781**	-0.664*	0.078	0.048	0.238
	(-1.149)	(-1.832)	(-2.410)	(-2.192)	(-2.552)	(-1.755)	(0.402)	(0.307)	(1.226)
Cons	4.152***	5.546***	1.361	3.031***	2.519***	3.434***	7.669***	7.190***	8.315***
	(3.793)	(5.632)	(0.856)	(3.473)	(2.887)	(3.243)	(14.32)	(13.55)	(12.90)
N	23	23	23	23	23	23	24	24	24
R^2	0.577	0.697	0.497	0.382	0.440	0.352	0.759	0.794	0.754
B-P test: chi2(3)		30.528			54.728			46.286	
p-val		[0.00]			[0.00]			[0.00]	
PANEL B: DELHI Dummy included									
ln(NSDP)	0.082	0.153	0.192	1.662***	1.678***	1.659***	0.132	0.133	0.095
	(0.152)	(0.325)	(0.339)	(3.594)	(3.782)	(3.416)	(0.507)	(0.511)	(0.365)
ln($LE_{factual}$)	-0.048			-0.014			-0.003		
	(-0.325)			(-0.194)			(-0.108)		
ln(LE_{AVG})		-0.321			-0.068			-0.008	
		(-1.394)			(-0.505)			(-0.166)	
ln(LE_G)			0.021			-0.001			-0.007
			(0.463)			(-0.043)			(-0.513)
ln(SE)	-0.701**	-0.502	-0.797**	-0.776***	-0.738**	-0.787***	-0.006	-0.002	0.011
	(-2.037)	(-1.543)	(-2.452)	(-2.772)	(-2.639)	(-2.777)	(-0.039)	(-0.017)	(0.079)
DL	-1.376***	-0.784	-1.395***	1.095***	1.217***	1.082***	0.665***	0.677***	0.656***
	(-4.030)	(-1.476)	(-4.531)	(3.929)	(3.271)	(3.889)	(4.350)	(3.849)	(4.544)
Cons	9.459***	8.920***	9.107***	-1.909	-2.020	-1.882	4.486***	4.476***	4.616***
	(5.571)	(5.829)	(4.961)	(-1.306)	(-1.425)	(-1.217)	(5.174)	(5.141)	(5.327)
N	23	23	23	23	23	23	24	24	24
R^2	0.727	0.759	0.733	0.649	0.656	0.647	0.868	0.868	0.871
B-P test: chi2(3)		51.420			63.187			65.340	
p-val		[0.00]			[0.00]			[0.00]	

Source: Estimated. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.
t-statistics in parentheses adjusted for small sample size and low degrees of freedom.
Notes: As for Table A.1. BP test: Breusch-Pagan test of independence of equations in systems 1, 2, 3.

Appendix Table A.3: Robustness test: IV results – SO_2, NO_2, and SPM emissions control

	ln(SO)$_2$			ln(NO_2)			ln(SPM)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Without Delhi Dummy									
ln(NSDP)	1.039**	0.813*	2.832***	1.456*	1.781***	1.312+	-0.282	-0.0335	-1.394**
	(2.541)	(1.846)	(3.492)	(2.006)	(3.023)	(1.648)	(-0.790)	(-0.132)	(-2.635)
ln($LE_{factual}$)	-1.194***			0.520			0.432***		
	(-2.802)			(1.500)			(3.664)		
ln(LE_{AVG})		-0.757***			0.444**			0.328***	
		(-6.820)			(2.163)			(5.110)	
ln(LE_G)			0.223**			0.077			-0.162*
			(2.336)			(1.014)			(-1.891)
ln(SE)	-0.254	-0.562*	-1.994***	-1.367**	-1.349***	-0.947*	-0.222	-0.201	0.680**
	(-0.611)	(-1.880)	(-3.963)	(-2.496)	(-3.472)	(-1.912)	(-0.862)	(-1.243)	(2.170)
Cons	6.316***	7.627***	-0.650	1.588	-0.437	2.348+	6.562***	5.295***	10.25***
	(3.367)	(8.223)	(-0.386)	(0.997)	(-0.277)	(1.651)	(7.895)	(7.750)	(7.895)
N	32	28	27	32	28	27	28	28	24
R^2	0.751	0.806	0.621	0.422	0.422	0.437	0.806	0.856	0.770
Panel B: With Delhi Dummy									
ln(NSDP)	0.604*	0.816*	1.262**	1.648**	2.215***	2.098**	0.033	0.023	-0.325
	(1.710)	(1.885)	(2.097)	(2.290)	(3.864)	(2.465)	(0.160)	(0.132)	(-1.030)
ln($LE_{factual}$)	-0.194			0.030			-0.175		
	(-0.366)			(0.066)			(-1.120)		
ln(LE_{AVG})		-0.786*			-0.568			-0.179	
		(-1.951)			(-1.427)			(-1.402)	
ln(LE_G)			0.151***			0.113			-0.084
			(3.389)			(1.283)			(-1.354)
ln(SE)	-0.908**	-0.540	-1.411***	-1.034+	-0.760	-1.240**	0.209	0.203	0.231
	(-2.100)	(-1.312)	(-3.768)	(-1.669)	(-1.422)	(-2.556)	(0.869)	(1.572)	(1.158)
Delhi	-1.196***	0.052	-1.274***	0.582	1.893**	0.634*	0.828***	0.970***	0.579***
	(-2.994)	(0.083)	(-5.835)	(1.438)	(2.476)	(2.060)	(4.745)	(5.103)	(4.720)
Cons	8.587***	7.596***	6.378***	0.517	-2.211	-1.157	4.445***	4.555***	5.992***
	(8.912)	(9.192)	(5.184)	(0.274)	(-1.062)	(-0.502)	(11.24)	(10.29)	(7.519)
N	32	28	27	32	28	27	28	28	24
R^2	0.850	0.806	0.864	0.453	0.496	0.530	0.899	0.899	0.882

Source: Estimated. + $p<0.12$, * $p<0.10$, ** $p<0.05$, *** $p<0.01$

t-stats in parentheses are heteroscedasticity robust and corrected for first-order autocorrelation. Stats adjusted for small sample size. Notes: As for Appendix Table A.1. Instruments for ln(NSDP) include lagged values of ln NSDP by one year and two years.