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Collaboration between Central and State Government and Environmental Quality: Evidences from Indian Cities

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Abstract

Within the context of coordination level between state and central government, we develop an econometric model to estimate the association between income and ambient air pollution, considering the societal preferences jointly influenced by the citizens and the government. We obtain empirical evidence supporting our hypothesis that state level coalition government can effectively improve quality of environment by means of reducing ambient air pollution level. This impact can be increased or decreased based on the societal preferences of the citizens, based on the area of inhabitance and irrespective of the choice of pollutants.

Keywords: Environmental Kuznets Curve; Political collaboration; Air Pollution; Indian cities

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1. Introduction

The association between income and environmental quality in the form Environmental Kuznets Curve (EKC) has been the research interest for the ecological economists for long. Even if we leave aside the contextual evidences of EKC hypothesis, the existing body of literature on this hypothesis has touched upon several significant aspects including need for environmental quality with rise in the level of income, technological efficiency in determining and maintaining environmental quality, and impact of the stage of development process on environmental quality (for a detailed literature survey, see Dinda, 2004). The existing literature on these aspects majorly focuses on the inverted U-shaped form of EKC, and the hypothesis is formed based on this form only, as indicated by Grossman and Krueger (1991). Depending on acceptance or rejection of this inverted U-shape, the association between income and environmental quality can be determined with contextual interventions.

In accordance with the explanation of the turnaround point of EKC hypothesis, once the per capita income level reaches a certain point, environmental degradation starts to diminish because of rising environmental demand and awareness level among the citizens. Even though this argument seems valid prima facie, it focuses presumably on the consequential symptoms rather than the original cause itself. Increase in per capita income may not possibly result in an increase in the level of environmental awareness in an automatic fashion, as it may have been triggered by any third mediating factor, which is not explicitly described in the explanation of EKC hypothesis. One such possible construct may be presence of social sustainability aspect triggered by economic growth. Moreover, considering the democratic political statute of a nation like India, these factors may bring forth other significant aspects when they interact with the political regime of the nation. This has been observed by several researchers. Yearley *et al.* (2003) have used community mapping exercises in urban centers of three cities in UK, and they have found that the participation of native citizens in the environmental policy making can enhance the efficiency of the local government, in a democratic setting. Sneddon *et al.* (2006) has demonstrated the importance of political structures and public participation in determining the shape of politics regarding environmental policies. Cole *et al.* (2005) have analyzed the manufacturing sector of UK during 1990-1998, and they have found that both formal and informal regulatory pressures can effectively demonstrate the air pollution abatement initiatives.

India is a democratic nation with federal structure and the effectiveness of any policy implementation depends largely on the level of coordination within the organs of the federal structure; i.e. between state and central government. There lies the same need of coordination in case of pollution abatement policy implementation as well. In this paper, we propose an econometric model to measure the impact of coordination between central and state government on environmental quality. This model distinctively analyses societal preferences as explanatory variables for determining environmental quality. The interaction of these variables with the center-state coordination has been considered as another set of explanatory variables. We hypothesize that state level center-state coordination can effectively implement pollution abatement policies at city level, which may not be possible if the state government is not in coordination with the central government.

Rest of the paper is organized as follows. Section 2 describes an emission profile of India, section 3 proposes a framework for empirical estimation for Indian cities, section 4 presents data and analysis, and finally, section 5 concludes the paper.

2. Emission profile of India

Due to rapid growth in industrialization, India has experienced a significant growth in the fossil fuel consumption. Adverse effects of this growth have been seen in the growth of ambient air pollution. During the last decade, CO_2 emission has gone up by 72%, SO_2 emission has gone up by 54%, and NO_2 emission has gone up by 42% (Lu et al., 2011; Haq et al., 2015), whereas the particulate matter (PM10) gone up only by 31% and carbon monoxide (CO) by 10% (Masih et al., 2010; Worden et al., 2013). Therefore, keeping in view the importance and growth pattern of the pollutants, we have considered SO_2 and NO_2 emissions for our study.

If we look at the emission affecting tropospheric region, then the NO_2 should be considered as the primary pollutant in this case, as 79% of the tropospheric atmosphere consists of nitrogen (N_2). It is majorly responsible for creation of ground-level ozone, a primary component of smog (Bower et al., 1994; Shi and Harrison, 1997). It is also responsible for creation of various nitrate compounds, which add to the level of respiratory particulate matters in the lower atmosphere (Dockery et al., 1989; Monn et al., 1997; Barnett et al., 2005). Owing to these reasons, rise in the level of NO_2 emission can cause serious damage to ambient atmosphere.

Looking at the emission affecting stratospheric region, SO_2 is considered as one of the two primary pollutants in this case, as the sulphur aerosols formed in this region are majorly caused by SO_2 emission (Friend et al., 1973; Whitby, 1978; Turco et al., 1979; Surratt et al., 2007). Apart from that, SO_2 is soluble in airborne water globules, and thereby, forming sulphurus and sulphuric acid in the form of acid rains (Penkett et al., 1979). Formation of aerosols after reacting with particulate matters can create severe respiratory problems (Brain and Valberg, 1979), and even premature births (Hastwell, 1975). Mainly for these reasons, rise in the level of SO_2 emission can cause serious damage to ambient atmosphere, and the human life.

Central Pollution Control Board of India has already set a number of emission standards, according to which level of SO_2 and NO_2 emissions should not be more than $40\mu g/m^3$ in any industrial or residential cities of India. Bharat Stage emission standards are also in place for controlling the vehicular emissions. Presently, Bharat Stage IV has been implemented only across 14 cities[2] in 2010, and Bharat Stage V is yet to be implemented in 2017. Based on the reports of Central Pollution Control Board, Supreme Court of India has passed a directive in 2001 for controlling ambient air pollution in 16 cities across India. However, in spite of these policies in place, SO_2 and NO_2 emissions across several Indian cities are rising.

3. Empirical framework

The proposed empirical framework is based on a reduced form approach, which does not incorporate the feedback effect from environmental degradation to economic growth. Adapting the framework of Panayotou (1997), we assume that effectiveness of any economic policy depends on collaboration between the ruling parties at state and national level, and therefore, the basic model of EKC turns out to be:

$$E_{it} = C_i + \sum_{j=1}^{3} \alpha_j Y_{jt}^{j} + \sum_{k=1}^{3} \alpha_{k+3} Pop_{kt}^{k} + \alpha_7 CG_{it} + \alpha_8 CG_{it} Y_{it} + \alpha_9 t + \varepsilon_{it} \qquad (1)$$

Where, for city i in year t, E_{it} stands for the level of emission, Y_{it} is the level of income at city level, Pop_{it} is the population, and CG_{it} is the indicator of political collaboration between state and central government. The linear trend variable t is considered as an indicator of technological change over time, α_i are the regression coefficients, ε_{it} is the error term, and C_i is the city level fixed effect. The political collaboration variable CG_{it} has been used both additively and multiplicatively, in order to incorporate the marginal effects on the emission level. This model is the basic point of reference for further analysis. It will be used to analyze the effect of collaborative government on environmental degradation. The direct effects of income and collaborative government have been disjoined by incorporation of CG_{it}, thereby, capturing the movement of environmental degradation in response to policy effectiveness.

[2] National Capital Region, Mumbai, Kolkata, Chennai, Bengaluru, Hyderabad, Ahmedabad, Pune, Surat, Kanpur, Lucknow, Sholapur, Jamshedpur and Agra

To incorporate the social determinants of environmental degradation, Eq. (1) is extended based on societal preferences, which can be exercised involuntarily or via the political system. This condition ensures that in a non-cooperative state level political regime, societal preferences are largely overlooked; whereas, for a collaborative state level political regime, societal preferences are enhanced and complemented by political statute. Therefore, decomposing the model in Eq. (1), the extended EKC model becomes:

$$E_{it} = C_i + \sum_{j=1}^{3} \alpha_j Y_{jt}^{j} + \sum_{k=1}^{3} \alpha_{k+3} Pop_{kt}^{k} + \alpha_7 CG_{it} + \alpha_8 CG_{it} Y_{it} + CG_{it}(\alpha_9 Gen_{it} + \alpha_{10} EC_{it} + \alpha_{11} LR_{it}) + CG_{it} Y_{it}(\alpha_{12} Gen_{it} + \alpha_{13} EC_{it} + \alpha_{14} LR_{it}) + \alpha_{15} t + \varepsilon_{it} \quad (2)$$

Where, Gen_{it} stands for the gender ratio in terms of number of women per thousand men, EC_{it} is the consumption of electricity, and LR_{it} is the literacy rate. Interaction between collaborative government indicator and the societal preferences may affect the nature of EKC curve, which can bring forth marginal effects in this extended reduced form model.

Once these reduced form models are in place to capture the interaction between collaborative government and the societal preferences for determining environmental quality, the influence of collaborative state government on environmental quality is to be analyzed. From Eq. (1), the association can be explained as ($\frac{\partial E_{it}}{\partial CG_{it}} = \alpha_7 + \alpha_8 Y_{it}$) < 0. Now, this phenomenon can be analyzed by the collaborative government variable (CG_{it}) and environmental emission variable (E_{it}), and by analyzing coefficients in Eq. (2), it can be expected that marginal effect of collaborative government on emission is negative ($\frac{\partial E_{it}}{\partial CG_{it}} = \alpha_7 + \alpha_8 Y_{it} + (\alpha_9 Gen_{it} + \alpha_{10} EC_{it} + \alpha_{11} LR_{it}) + Y_{it}(\alpha_{12} Gen_{it} + \alpha_{13} EC_{it} + \alpha_{14} LR_{it}) < 0$).

In order to proceed further with the model, a discussion on the possible effects and explanations of the societal preferences included in the model follows. Three societal preferences have been considered, namely gender ratio, electricity consumption, and literacy rate.

3.1. Gender ratio and environmental emission

Changing role of women in the households and labor force can influence the level of emission in direct and indirect ways. The level of sustainable development prevailing in any nation largely depends on the number of women participating in the labor force (Benería *et al.*, 2015), attending the schools (Taskin, 2009), and being engaged in the decision making process (Rangel *et al.*, 2008). It has been observed that preference over hygienic conditions is more in case of women, as they are found to be more susceptible towards the diseases caused by environmental degradation (Miller, 2008). On the flipside of this argument, according to eco-feminists around the world, females experience more proximity to nature compared to males (Radkau, 2008). Divergence in terms of gendered socialism and the kind of roles to be played by the two sexes from birth, their perspectives towards the world become radically different from each other, and in that course, women largely associate themselves with the natural and social world, whereas men consider themselves as separate and disjoint entities (Coppock *et al.*, 2014).

Empirical studies claim that women are more concerned than men about environmental quality (Lee, 2009; Rocheleau *et al.*, 2013). Following the trail of *Chipko* (tree-hugging) movement, analysis of environment degradation in India perhaps may possibly turn out to be incomplete without the consideration of the influence of women, as they play a significant role in protecting the environmental standards in India (Moore, 2008, 2011). Therefore, it is expected that the gender ratio can play a significant role in determining the turnaround points in the EKCs for Indian cities.

3.2. Energy consumption and environmental emission

Considering the *growth hypothesis* approach, energy consumption in any form leads to economic growth (Akinlo, 2008; Apergis and Payne, 2012) and this phenomenon can be visible in the context of a developing nation. In this context, Aslanidis (2009) talks about three effects working in the background of EKC. Those are scale, composition, and induced technique effects. Out of these three effects, only scale effect talks about the environmental degradation. Energy demand rises with growth of industry and nations transit from biomass to fossil fuel, which results in increased emissions. Pachauri and Jiang (2008) established this association between change in energy consumption pattern and environmental degradation. They conducted this comparative study between Indian and Chinese context during 1999-2000 and found out that a reallocation of energy sources from biomass to fossil fuels leads to lower energy utilization. Poumanyvong and Kaneko (2010) have also established this association in case of 99 countries for 1975-2005. They have also pointed out that reallocation of energy sources from biomass to fossil fuels has increased the emission level. They have attributed increasing emission level majorly to lower energy utilization.

Apart from focusing only on energy consumption, researchers have discussed about various sources of energy and the resultant ambient air pollutions. Nordhaus (1977a) has stated that ignition of fossil fuels brings about emissions of CO_2 into the atmosphere and it stays in the atmosphere for a long while. Owing to the discerning assimilation of emission, the amplified atmospheric accumulation brings about augmented global temperature. This statement has been empirically verified by other researchers as well (e.g., Sinha, 2014; Sinha and Bhattacharya, 2014; Sinha and Mehta, 2014; Shahbaz et al., 2015; Sinha, 2015; Solarin and Lean, 2016). Given the problems regarding the increased industrial heat caused by CO_2 emission, Nordhaus (1977b) has formulated a set of strategies to combat air pollution, like reducing energy consumption, substitution of carbon fuels with non-carbon fuels, rapid afforestation, and diffusion of CO_2 in the ocean. Nordhaus (1991) has studied the greenhouse effect, caused by amassing of CO_2 and other greenhouse gases, in the context of United States. While presenting several strategies regarding reduction of greenhouse effect, he has clearly stated his doubts regarding the possible policy implications. In accordance with Panayotou (1993), during industrial stage of development, environmental degradation takes place due to air pollutants, like SO_2, NO_x, CO, and Suspended Particulate Matter (SPM). Arrow *et al.* (1996) have identified two reason behind this; one, during rapid industrialization stage, furtive users of environmental resources hardly take care about the implications on social welfare. Two, people, who have just started to get the benefits of industrialization in material terms are not in a condition to channelize their disposable income in the direction of environmental well-being.

The researchers have also found out an interesting flaw in EKC hypothesis in terms of inability of EKC to talk about the transfer of pollutants or trade-off between pollutants inside a country or among countries (Rothman; 1998; Tzimas *et al.*, 2007; Sinha and Bhattacharya, 2016, 2017). Rothman (1998) has identified that most of the developed nations try to shift their polluting production base to the poor undeveloped or developing nations; whereas, Tzimas *et al*. (2007) have considered this issue while talking about the trade-off situation between SO_2 and CO_2, and the cause behind acid gases. Holtz-Eakin and Selden (1995) have studied an uneven panel data of 130 countries for the years 1951-1986, and found that the growth in annual emission level will continue at a rate of 1.8% up to 2025. They have also found that the majority of world population is concentrated in the countries, where economic growth and CO_2 emission level are growing rapidly. Deviation in economic growth in those countries does not result in dire transformation in CO_2 emission level. Later on, these studies were conducted on specific countries (Soytas *et al.*, 2007; Zhang and Cheng, 2009). Ozturk (2010) has provided a comprehensive literature survey on these studies.

Considering this rich volume of literature on the link between energy or electricity consumption and economic growth, it is expected that for Indian context as well, electricity consumption may possibly have a positive influence in determining the environmental emission level, thereby influencing the turnaround point of EKC.

3.3. Literacy rate and environmental emission

Without a certain level of education, awareness regarding environmental standards and improvement of environmental quality can hardly arise. Researchers have identified the role of literacy rate in determining the turnaround point of EKC in several contexts (Li *et al.*, 2007; Gürlük, 2009; Mostafa, 2010; Khajuria *et al.*, 2011; Orubu and Omotor, 2011). Presence of educated citizens can ensure a successful public-private partnership to carry out abatement drives and to be the voice of citizens for collective benefit. Michinaka and Miyamoto (2013) have provided the empirical evidence in support of the educated citizens' efforts regarding environmental protection.

Considering the literacy rate, as a proxy for level of education can bring forth significant impacts of the EKC models, and in turn it can influence the turnaround point of those EKCs, and thereby influencing the ambient air pollution levels.

4. Data description and estimation results

Once the theoretical underpinning has been discussed, we can go ahead with estimation of the regression based EKC models. The data is for 139 Indian cities[3] for the duration of 2001-2013[4]. We have collected the annual ambient air pollution data for SO_2 and NO_2 from the database of Central Pollution Control Board, and population, literacy rate and gender ratio data from census of India. For capturing the data for collaborative government at state level, we have

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[3] 85 cities belong to industrial areas and 119 cities belong to residential areas. Central Pollution Control Board, India, publishes the segregated emission data for these two areas. Details of these cities are given in Appendix 1E.

[4] During 2001-2013, India has experienced a huge turbulence in the political field, and that too regarding alliance. During this tenure, the ruling parties at Central level changed 3 times, and more turbulence has been observed at the State Level. Due to several policy level decisions, new parties were formed at the State level, and the alliances were made accordingly. Therefore, from political perspective, 2001-2013 has been an interesting tenure for Indian politics.

first identified the ruling parties in the respective states for our study period, from the database of Election Commission of India. Then we have identified their nature of collaboration with the ruling parties at the national level during the study period. If the alliance was found, value of CG_{it} was taken as one, otherwise it has taken as zero. For example, Communist Party of India Marxist (CPIM) was the ruling party of West Bengal till mid-2011, and they used to be one of the supporters of Indian National Congress (INC), which was the ruling party of India from 2004. However, due to lack of congruence regarding Indo-US nuclear deal, Left Front, the main alliance of CPIM, withdrew their support from United Progressive Alliance (UPA), which is the main alliance of INC, in July 8, 2008. For this case, the value of CG_{it} will be 1 from 2004 to 2007, and 0 from 2008 to 2011. Detailed descriptive statistics of these variables are given in Table 1.

Researchers have identified several problems in the econometric techniques used for estimating the EKCs, like, serial dependence, stochastic trends in the time series, and omitted variable bias (Stern, 2004). In this study, we have tried to address some of those problems, like handling multicolinearity, ensuring stationarity of the data, checking the robustness of the estimated models. Multicolinearity is a problem with the model, in which the powered terms of the independent variables are used, and as a result, interactions among those independent variables increase the level of standard errors for their estimated coefficients (see Appendix 1A and 1B). In order to handle this issue, the models have been specified by removing orthogonally transformed independent variables correlating with lower order terms through auxiliary regressions. Once a specification is chosen, the within model has been tested with the original data. Before applying auxiliary regressions, stationarity of the data has been checked by applying LLC (Levin et al., 2002) and IPS (Im et al., 2003) panel unit root tests, and we found all the orthogonally transformed variables to be stationary at level (Appendix 1C). Once the models are estimated, following Barslund et al. (2007), we have checked the robustness of the models by conducting partial regressions for each of the models for full dataset (see Appendix 1D).

Once the diagnostics tests and transformations were applied on the dataset, we found the dataset to be free from the errors, the econometricians indicated in the earlier studies. First, after application of orthogonal transformation and auxiliary regressions, the dataset found to be free from Multicolinearity and serial correlation. After application of the unit root tests, we found the orthogonally transformed variables for each of the cases to be stationary at level, and it indicated that the dataset is free from stochastic trend. Finally, we needed to address the omitted variable bias problem, which is an inherent problem of a reduced form model, like EKC. By application of the robustness checking method applied by Barslund et al. (2007), we have found the estimated models to be robust across the series of partial regressions, and therefore, it can be inferred that the models are free from the omitted variable bias problem. Now, we can proceed with analyzing the dataset.

Table 1: Descriptive statistics of variables

Area	Variable	Units	No. of Obs.	Mean	Std. Dev.	CV.
Industrial	SO_2	in µg / m^3	1105	13.702	8.795	0.642
	NO_2	in µg / m^3	1105	27.854	14.789	0.531
	Y	in Rs. Lacs	1105	9416.416	22320.720	2.370
	Pop		1105	2048788.40	3505110.32	1.711
	CG	Index, 0 (non-collaborative) – 1(collaborative)	1105	0.49	0.50	1.020
	Gen	No. of women per 1000 men	1105	933.884	70.357	0.075
	EC	In GWH	1105	1155.911	2469.734	2.136
	LR	in percentage	1105	77.614	9.243	0.119
Residential	SO_2	in µg / m^3	1547	9.228	6.434	0.697
	NO_2	in µg / m^3	1547	22.744	11.426	0.502
	Y	in Rs. Lacs	1547	7888.848	18705.770	2.371
	Pop		1547	1856043.81	3027841.10	1.631
	CG	Index, 0 (non-collaborative) – 1(collaborative)	1547	0.53	0.50	0.943
	Gen	No. of women per 1000 men	1547	939.868	62.359	0.066
	EC	In GWH	1547	996.222	2139.684	2.148
	LR	in percentage	1547	74.948	9.634	0.129

Firstly, the model represented by Eq. (1) has been estimated and the results are recorded in Table 2. Through this model, an attempt has been made to estimate the EKC for Indian cities using collaboration between state and central government as an indicator of environmental quality, and the explanatory power of nation's political statute for describing her environmental quality has already been discussed by several researchers (see Dryzek, 2013). By looking superficially into the results obtained from this model, it can be seen that the signs of income-environmental quality association are almost similar and positive in all the four cases, which signifies that devoid of any external intervention, it may be hard to improve the level of environmental quality and therefore, inclusion of political regime is necessary in this context.

Table 2: Basic EKC model

	Dependent variable			
	NO_2		SO_2	
	Industrial	Residential	Industrial	Residential
Y	0.428^{a} (0.102)	0.047 (0.085)	0.251^{a} (0.095)	-0.201^{b} (0.086)
Y^2	0.480^{a} (0.072)	0.321^{a} (0.062)	0.153^{b} (0.075)	0.072 (0.067)
Y^3	0.124^{a} (0.040)	0.176^{a} (0.044)	0.058 (0.039)	0.006 (0.044)
Pop	0.160^{a} (0.047)	0.020 (0.040)	0.135^{a} (0.038)	-0.066^{c} (0.037)
Pop^2	0.264^{a} (0.039)	0.196^{a} (0.034)	0.098^{b} (0.042)	0.045 (0.039)
Pop^3	0.170^{a} (0.039)	0.191^{a} (0.036)	0.042 (0.038)	0.003 (0.039)
CG	-0.125^{a} (0.058)	-0.128^{b} (0.052)	0.069 (0.057)	-0.060 (0.052)
CG*Y	0.022^{a} (0.007)	0.018^{a} (0.007)	-0.007 (0.007)	0.010 (0.007)
Year	0.007 (0.006)	0.003 (0.005)	-0.002 (0.007)	-0.012^{c} (0.006)
R^2	0.1146	0.1073	0.1380	0.1161
N	1040	1287	1040	1300
Cross sections	85	119	85	119

a value at 1% significance level

b value at 5% significance level

c value at 10% significance level

None of the five regressions in Table 2 support generally accepted inverted U-shaped form of EKC, even with the intervention of the political regime and the effect of interaction between political regime and income. Therefore, no turnaround points have been established in any of the four cases. Emission for NO_2 and SO_2 in industrial and residential areas show evidence of cubic and inverse associations with elasticity. These results are supported by researchers in ecological economics that only income can never result in enhancement in the environmental quality (Ferrer-i-Carbonell and Gowdy, 2007; Jackson, 2011). While analyzing EKC for developed and developing countries during 1979-1999, Lin and Liscow (2013) have described that interaction between social and political factors have a major role to play in describing the error terms in EKC estimation.

Looking at the marginal effects of political regime on the environmental quality, in all the cases, the marginal effect of center-state coordination on air pollution is negative. This shows that center-state coordination has a positive effect on environmental quality ($\frac{\partial E_{it}}{\partial CG_{it}} < 0$). Looking at the marginal effect of interaction between center-state coordination and income on air pollution, it can be said that collaborative government can possibly ensure green growth, i.e. environmental quality will improve with rise in income in a collaborative government regime at state level ($\frac{1}{\partial CG_{it}}\frac{\partial E_{it}}{\partial Y_{it}} < 0$).

Table 3: Extended EKC model

	Dependent variable			
	NO_2		SO_2	
	Industrial	Residential	Industrial	Residential
Y	0.516[a] (0.102)	0.064 (0.084)	0.272[a] (0.101)	-0.144 (0.091)
Y^2	0.395[a] (0.079)	0.305[a] (0.065)	0.176[b] (0.079)	0.078 (0.069)
Y^3	0.145[a] (0.040)	0.108[b] (0.044)	0.072[c] (0.040)	-0.008 (0.045)
Pop	0.161[a] (0.048)	0.030 (0.040)	0.101[b] (0.048)	-0.089[b] (0.043)
Pop^2	0.198[a] (0.044)	0.176[a] (0.037)	0.114[a] (0.043)	0.042 (0.040)
Pop^3	0.182[a] (0.040)	0.127[a] (0.036)	0.059 (0.039)	-0.009 (0.039)
CG	0.041[a] (0.013)	0.010[c] (0.006)	0.003 (0.006)	0.008 (0.007)
CG*Y	0.012[c] (0.006)	0.015[b] (0.007)	-0.010 (0.006)	0.010 (0.007)
EC*CG	0.010 (0.007)	0.014 (0.008)	-0.002 (0.007)	0.019[b] (0.009)
Gen*CG	-0.024[a] (0.009)	-0.020[b] (0.010)	-0.011 (0.009)	-0.005 (0.011)
LR*CG	0.025[b] (0.010)	0.005 (0.014)	0.029[a] (0.010)	0.003 (0.015)
EC*CG*Y	-0.004 (0.006)	0.000 (0.006)	-0.009 (0.006)	-0.013[b] (0.006)
Gen*CG*Y	-0.007 (0.009)	0.006 (0.007)	-0.011 (0.009)	0.014[c] (0.008)
LR*CG*Y	-0.002 (0.010)	-0.042[a] (0.010)	0.027[a] (0.010)	-0.018 (0.011)
Year	0.005 (0.006)	0.005 (0.005)	-0.006 (0.006)	-0.005 (0.005)
R^2	0.1526	0.1272	0.1511	0.1430
N	1040	1287	1040	1300
Cross sections	85	119	85	119

a value at 1% significance level
b value at 5% significance level
c value at 10% significance level

Looking at the marginal effects of political regime on the environmental quality, in all the cases, the marginal effect of center-state coordination on air pollution is negative. This shows that center-state coordination has a positive effect on environmental quality ($\frac{\partial E_{it}}{\partial CG_{it}} < 0$). Looking at the marginal effect of interaction between center-state coordination and income on air pollution, it can be said that collaborative government can possibly ensure green growth, i.e. environmental quality will improve with rise in income in a collaborative government regime at state level ($\frac{1}{\partial CG_{it}}\frac{\partial E_{it}}{\partial Y_{it}} < 0$).

Table 4: Elasticity of variables at sample mean

	Dependent variable			
	NO_2		SO_2	
	Industrial	Residential	Industrial	Residential
Y	0.910	2.385	2.989	-0.114
Pop	5.699	2.373	1.624	0.940
CG	-0.533	-1.428	-0.074	-0.437
Gen	-0.038	-0.010	-0.039	0.052
EC	0.001	0.007	-0.035	0.009
LR	-0.008	-0.161	0.116	-0.067

Table 5: Elasticity of dependent variables with respect to center-state coordination

		Dependent variable							
		NO_2				SO_2			
		Industrial		Residential		Industrial		Residential	
		Y		Y		Y		Y	
		H	L	H	L	H	L	H	L
Gen	H	-0.514	-0.372	0.007	-0.047	-0.707	-0.450	0.062	0.025
	L	-0.499	-0.362	0.010	-0.045	-0.688	-0.439	0.063	0.025
EC	H	-0.098	-0.028	0.255	0.200	-0.569	-0.344	-0.830	-0.450
	L	0.015	0.023	0.202	0.148	-0.217	-0.131	-0.430	-0.234
LR	H	0.141	0.129	-1.639	-1.015	1.376	0.869	-0.760	-0.460
	L	0.140	0.126	-1.535	-0.951	1.310	0.828	-0.716	-0.433

Elasticity is defined as ($\Delta Ei / Ei$) / ($\Delta CGi / CGi$), with income and preference shifters at 15th percentile (L) and 85th percentile (H)

Once the basic model has been estimated and the significant impact of coalition government on environmental quality has been observed, the extended EKC model in Eq. (2) can be estimated. The estimation results are recorded in Table 3. Further, point elasticities have been estimated for both the pollutants considering industrial and residential areas. Elasticity values have been recorded in Table 4 and 5 and demonstrated through Figure 1 to 4. In Table 4, all the elasticity values have been estimated at the sample means. In Table 5, all the elasticity values are relative in nature, and are estimated at the high (85th percentile) and low (15th percentile) levels of the independent variables.

As per the results reported in Table 3, it can be seen that income-environmental quality association does not change in any of the cases. The evidence of inverted U-shaped EKC is missing except the case of SO_2 emission in residential areas, where the turnaround point is within the range of sample. The correspondence of the obtained results demonstrates the legitimacy of decomposition and the explanatory powers of social preferences in determining environmental quality are thereby reinstated. Relative elasticities reported in Table 5 are reasonably stable and marginal effect of the interaction between center-state coordination and income of air pollution is negative and for center-state coordination is positive in all the cases, just like the previous case.

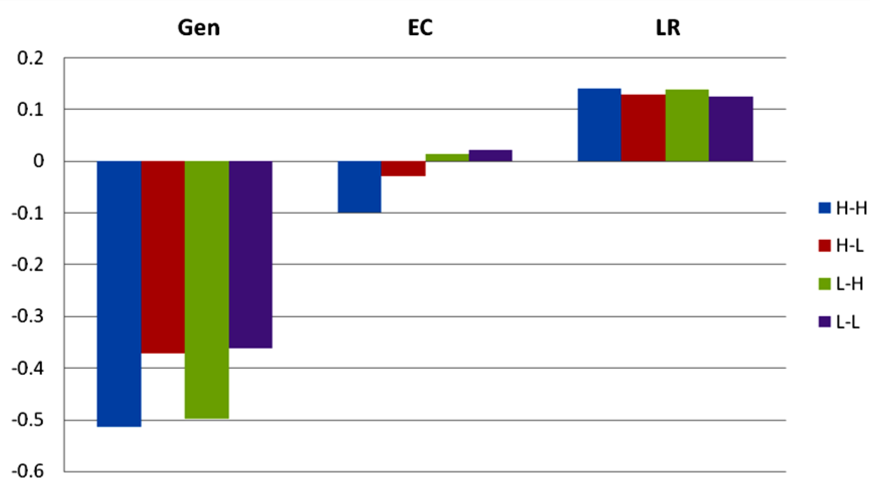

Figure 1: Elasticity of NO_2 with respect to CG (for industrial areas)

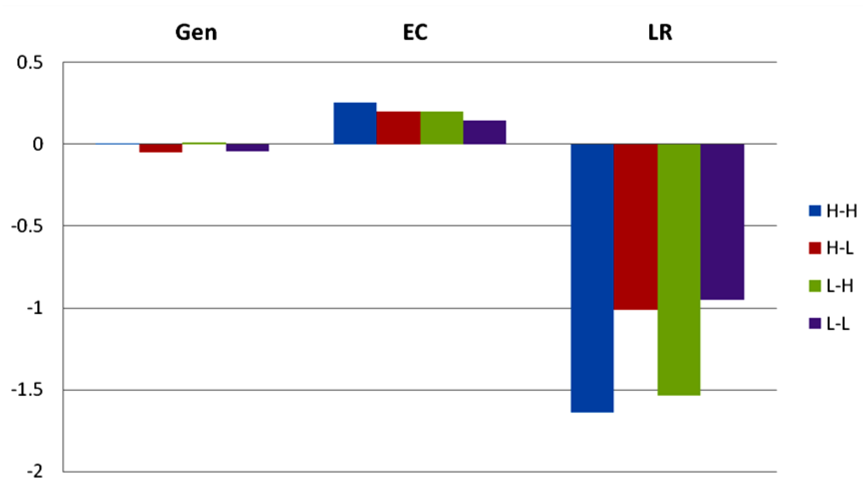

Figure 2: Elasticity of NO_2 with respect to CG (for residential areas)

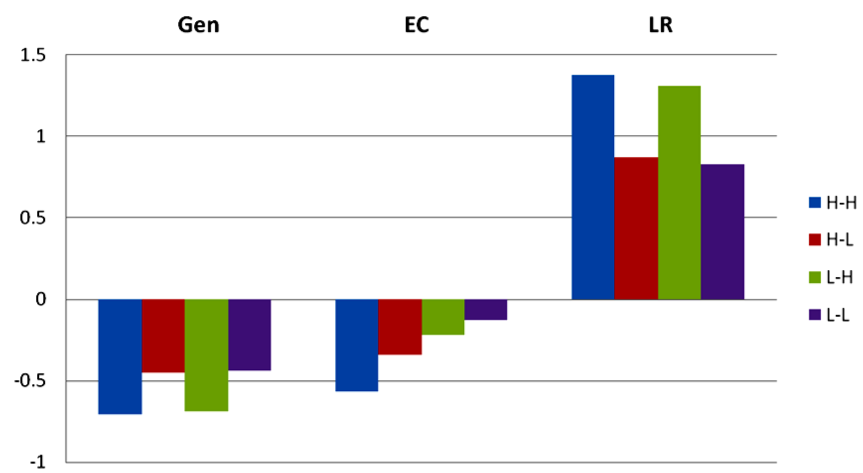

Figure 3: Elasticity of SO_2 with respect to CG (for industrial areas)

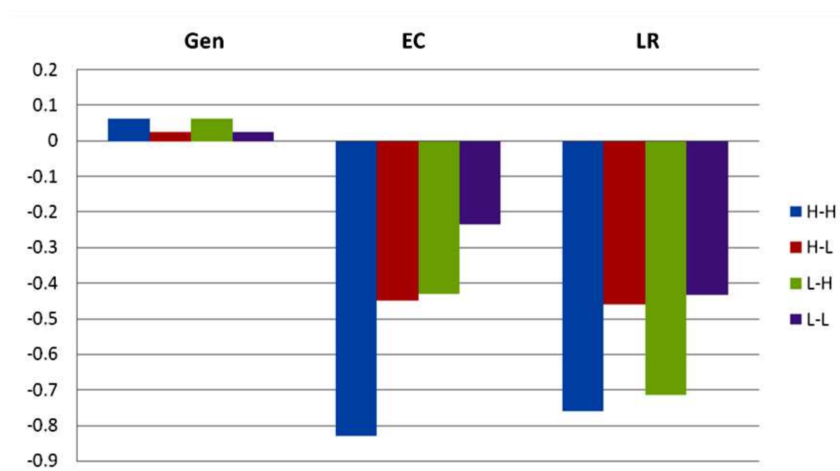

Figure 4: Elasticity of SO_2 with respect to CG (for residential areas)

Now we can analyze the marginal effects of the social preferences on environmental quality. Let us start the discussion with the first social preference parameter, i.e. gender ratio. It has inverse association with air pollution in three out of four cases at the sample mean. When it has been interacted with the political collaboration parameter, the coefficients are negative in all the cases, showing the efficacy of an abatement policy with high percentage of female population in a city. However, while interacting with income level, the associations are negative only for industrial areas. This may mean more women joining the workforce can improve the environmental condition of the industrial areas. However, as indicated by Andersen *et al.* (2008) and Veuthey and Gerber (2010), gender ratio can turn out to be unresponsive towards environmental quality determinations, which can hardly be controlled by government intervention. Therefore, in the residential areas, the marginal effect of gender ratio, interacted by level of income has positive association with air pollution, though the point elasticities in this case are much lower than the previous case.

Next, we analyze consumption of electricity. It has direct association with air pollution in three out of four cases at the sample mean, which is similar in case of interaction with center-state coordination. However, while interacting with income level, the associations have changed radically. Apart from the NO_2 emission in residential areas, in all the three cases the associations are negative and it seems that the pattern of energy consumption can be largely influenced by the political statute of the state in terms of collaboration with the center. Devoid of political intervention, along with rise in income from industrial growth, change in the pattern of energy consumption may not seem to be possible. Considering residential areas, NO_2 emission can be caused by vehicular transportation (Yusuf and Resosudarmo, 2009), usage of kerosene heaters (Coria, 2009), usage of grills and cooking facilities (MacKerron and Mourato, 2009), consumption of tobacco (Kattan *et al.*, 2007), inadequate sanitation facilities (Artés *et al.*, 2009) etc, which is hard to control by government intervention only. Therefore, in this case only, the association has been found to be positive.

Next, we see the final social preference parameter, i.e. literacy rate. It has inverse association with air pollution in three out of four cases at the sample mean. Only interaction with center-state coordination may not prove out to be successful in this case, as attainment of education is directly associated with income level (Kamanga *et al.*, 2009; Welsch, 2009). Therefore, interaction with level of income is significant in this case. However, relative point elasticities suggest that the negative effect of this interaction on air pollution level is visible only in case of residential areas. For industrial areas, this association is positive and comparable to that of the values in residential areas in absolute terms. By analyzing the structure of cities pertaining to industrial areas, it can be seen that due to rapid industrialization, several slum areas were formed around the industrial belts. Slum-dwellers' daily existence called for direct and derived demand of fossil fuel consumption and this lifestyle pattern resulted in increased emission in the industrial regions of India. Inhabitants of these areas are majorly marginal labors, who have a very low level of disposable income and educational attainment may be a luxury for them (Newman *et al*., 2008).

5. Conclusions

This paper studies environmental quality as a consequence of coordination between the central and state governments, which is important for a federally structured nation. Taking the other relevant explanatory variables into account, this paper proposes two models: basic with societal variables and extended with role of political regime included. The paper first analyzes the association between income and ambient air pollution for 139 Indian cities during 2001-2013. It is found that an inverted U-shaped EKC is not necessary as the political regime of a state is capable of determining environmental quality of a city. Effectiveness of center-state coordination is found to be relevant, when societal preference parameters were interacted through it. Combined results of both the models suggest that presence of center-state coordination and the interaction of societal preferences with political regime can improve environmental quality.

There are few limitations of this study. In this study, we have gathered the annual average pollution data for the cities. In order to bring forth more effectiveness, spatial distribution of the emission data could have been used, and for mapping the air pollution, interpolation methods like, inverse distance weighting (IDW) or kriging might be used. This might provide a better measure of the air pollution measures. Bringing forth caveats regarding the non-randomized distribution of gender ratio and literacy rate across the cities can enrich the study by controlling the selection bias problem, which has not been addressed in this study. Lastly, considering household level aggregate survey data can bring forth more insights regarding the turnaround points of the EKC. These are some shortcomings of the study, which can be used for further research in this area.

Apart from the aforementioned points, further research in this area can be taken up by considering the city level municipal government regimes and actual policies. Analysis of the feedback effect from environmental pollution to income level considering additional explanatory variables can bring forth more significant insights regarding impact political dimensions on environmental quality, considering the case of Indian political statute.

Appendix 1A: Correlations among variables (for NO_2 emissions)

	Y	Y^2	Y^3	*Pop*	Pop^2	Pop^3	*CG*	*Y*CG*	*EC*CG*	*Gen*CG*	*LR*CG*	*EC*CG*Y*	*Gen*CG*Y*	*LR*CG*LY*	NO_2
For Industrial area															
Y	1.000														
Y^2	0.987	1.000													
Y^3	0.956	0.990	1.000												
Pop	0.965	0.947	0.911	1.000											
Pop^2	0.965	0.959	0.933	0.997	1.000										
Pop^3	0.959	0.964	0.948	0.987	0.997	1.000									
CG	0.146	0.156	0.164	0.075	0.081	0.086	1.000								
*Y*CG*	0.369	0.384	0.390	0.295	0.302	0.307	0.948	1.000							
*EC*CG*	0.427	0.442	0.448	0.358	0.364	0.369	0.909	0.991	1.000						
*Gen*CG*	0.144	0.154	0.160	0.072	0.078	0.083	1.000	0.947	0.907	1.000					
*LR*CG*	0.156	0.167	0.174	0.082	0.088	0.094	0.999	0.952	0.913	0.999	1.000				
*EC*CG*Y*	0.533	0.562	0.578	0.463	0.476	0.486	0.809	0.950	0.975	0.807	0.816	1.000			
*Gen*CG*Y*	0.366	0.381	0.386	0.292	0.299	0.303	0.949	1.000	0.991	0.948	0.953	0.948	1.000		
*LR*CG*LY*	0.376	0.392	0.399	0.300	0.308	0.313	0.943	0.999	0.991	0.943	0.949	0.952	0.999	1.000	
NO_2	0.132	0.164	0.189	0.125	0.147	0.168	0.004	0.034	0.050	-0.002	0.002	0.078	0.027	0.031	1.000
For Residential area															
Y	1.000														
Y^2	0.990	1.000													
Y^3	0.964	0.992	1.000												
Pop	0.951	0.930	0.896	1.000											
Pop^2	0.954	0.943	0.918	0.997	1.000										
Pop^3	0.951	0.950	0.934	0.988	0.997	1.000									
CG	0.213	0.224	0.229	0.128	0.132	0.136	1.000								
*Y*CG*	0.424	0.438	0.443	0.329	0.336	0.340	0.955	1.000							
*EC*CG*	0.478	0.493	0.497	0.385	0.392	0.396	0.922	0.993	1.000						
*Gen*CG*	0.213	0.223	0.227	0.126	0.131	0.134	1.000	0.955	0.921	1.000					
*LR*CG*	0.216	0.227	0.232	0.128	0.133	0.137	0.999	0.955	0.921	0.999	1.000				
*EC*CG*Y*	0.584	0.609	0.621	0.487	0.499	0.508	0.830	0.955	0.978	0.829	0.830	1.000			
*Gen*CG*Y*	0.423	0.437	0.441	0.327	0.334	0.338	0.955	1.000	0.993	0.955	0.956	0.954	1.000		
*LR*CG*LY*	0.426	0.440	0.445	0.329	0.336	0.341	0.953	0.999	0.991	0.953	0.955	0.954	0.999	1.000	
NO_2	0.129	0.138	0.146	0.146	0.158	0.169	-0.082	-0.056	-0.048	-0.086	-0.076	-0.021	-0.060	-0.050	1.000

Appendix 1B: Correlations among variables (for SO_2 emissions)

	Y	*Y*^{2}	*Y*^{3}	*Pop*	*Pop*^{2}	*Pop*^{3}	*CG*	*Y*CG*	*EC*CG*	*Gen*CG*	*LR*CG*	*EC*CG*Y*	*Gen*CG*Y*	*LR*CG*LY*	SO_2
For Industrial area															
Y	1.000														
Y^2	0.987	1.000													
Y^3	0.956	0.990	1.000												
Pop	0.965	0.947	0.911	1.000											
Pop^2	0.965	0.959	0.933	0.997	1.000										
Pop^3	0.959	0.964	0.948	0.987	0.997	1.000									
CG	0.146	0.156	0.164	0.075	0.081	0.086	1.000								
*Y*CG*	0.369	0.384	0.390	0.295	0.302	0.307	0.948	1.000							
*EC*CG*	0.427	0.442	0.448	0.358	0.364	0.369	0.909	0.991	1.000						
*Gen*CG*	0.144	0.154	0.160	0.072	0.078	0.083	1.000	0.947	0.907	1.000					
*LR*CG*	0.156	0.167	0.174	0.082	0.088	0.094	0.999	0.952	0.913	0.999	1.000				
*EC*CG*Y*	0.533	0.562	0.578	0.463	0.476	0.486	0.809	0.950	0.975	0.807	0.816	1.000			
*Gen*CG*Y*	0.366	0.381	0.386	0.292	0.299	0.303	0.949	1.000	0.991	0.948	0.953	0.948	1.000		
*LR*CG*LY*	0.376	0.392	0.399	0.300	0.308	0.313	0.943	0.999	0.991	0.943	0.949	0.952	0.999	1.000	
SO_2	-0.124	-0.095	-0.068	-0.130	-0.114	-0.098	0.018	-0.023	-0.022	0.014	0.015	-0.036	-0.027	-0.026	1.000
For Residential area															
Y	1.000														
Y^2	0.989	1.000													
Y^3	0.962	0.991	1.000												
Pop	0.953	0.932	0.897	1.000											
Pop^2	0.956	0.945	0.919	0.997	1.000										
Pop^3	0.952	0.952	0.935	0.988	0.997	1.000									
CG	0.197	0.211	0.218	0.114	0.119	0.124	1.000								
*Y*CG*	0.419	0.436	0.442	0.327	0.334	0.339	0.951	1.000							
*EC*CG*	0.477	0.494	0.499	0.386	0.394	0.398	0.916	0.993	1.000						
*Gen*CG*	0.196	0.210	0.217	0.113	0.118	0.122	1.000	0.951	0.915	1.000					
*LR*CG*	0.201	0.215	0.223	0.116	0.122	0.126	0.999	0.952	0.916	0.999	1.000				
*EC*CG*Y*	0.583	0.610	0.623	0.489	0.502	0.511	0.821	0.954	0.978	0.820	0.822	1.000			
*Gen*CG*Y*	0.419	0.435	0.440	0.326	0.333	0.337	0.952	1.000	0.992	0.952	0.952	0.953	1.000		
*LR*CG*LY*	0.422	0.439	0.445	0.328	0.336	0.341	0.949	0.999	0.991	0.949	0.952	0.953	0.999	1.000	
SO_2	-0.013	-0.009	-0.004	-0.034	-0.030	-0.025	-0.014	-0.027	-0.023	-0.017	-0.011	-0.035	-0.030	-0.024	1.000

Appendix 1C: Results of unit root tests on orthogonally transformed variables

	Variables	*LLC*		*IPS*	
		Without Trend	*With Trend*	*Without Trend*	*With Trend*
Industrial area	*Y*	-16.2965[a]	-6.8163[a]	-37.5030[a]	-26.8551[a]
	Y^2	-5.5158[a]	-11.6618[a]	-32.7814[a]	-26.6830[a]
	Y^3	-9.1848[a]	-8.9591[a]	-54.3925[a]	-29.4724[a]
	Pop	-14.3427[a]	-7.3552[a]	-26.8843[a]	-23.1144[a]
	Pop^2	-12.4674[a]	-13.6498[a]	-37.2434[a]	-27.2680[a]
	Pop^3	-15.4992[a]	-9.9858[a]	-46.6287[a]	-36.4835[a]
	CG	-10.4185[a]	-11.4940[a]	-5.5967[a]	-5.8406[a]
	*Y*CG*	-8.4117[a]	-11.6301[a]	-3.9367[a]	-5.3428[a]
	*EC*CG*	-13.6024[a]	-13.7469[a]	-3.1207[a]	-6.5853[a]
	*Gen*CG*	-9.5367[a]	-12.5693[a]	-4.1638[a]	-6.4060[a]
	*LR*CG*	-8.5379[a]	-12.5208[a]	-5.0757[a]	-7.2171[a]
	*EC*CG*Y*	-8.8982[a]	-11.9333[a]	-5.9461[a]	-6.1616[a]
	*Gen*CG*Y*	-5.6859[a]	-8.5212[a]	-1.4848[c]	-5.3255[a]
	*LR*CG*LY*	-6.1649[a]	-9.5937[a]	-1.9757[b]	-5.1033[a]
	SO_2	-8.0513[a]	-12.6177[a]	-5.8129[a]	-9.6686[a]
	NO_2	-9.4581[a]	-12.1006[a]	-6.7817[a]	-10.4469[a]
		Without Trend	*With Trend*	*Without Trend*	*With Trend*
Residential area	*Y*	-8.0993[a]	-17.6492[a]	-42.3210[a]	-30.0741[a]
	Y^2	-7.5079[a]	-13.9121[a]	-52.2443[a]	-45.8173[a]
	Y^3	-8.9135[a]	-13.5671[a]	-45.8662[a]	-29.2544[a]
	Pop	-16.5065[a]	-9.3415[a]	-43.8224[a]	-32.1782[a]
	Pop^2	-11.6594[a]	-12.7653[a]	-47.2210[a]	-42.8784[a]
	Pop^3	-13.3132[a]	-13.1806[a]	-36.3002[a]	-30.3592[a]
	CG	-11.2140[a]	-11.8815[a]	-6.3687[a]	-6.1872[a]
	*Y*CG*	-5.8658[a]	-14.2516[a]	-3.3751[a]	-3.2930[a]
	*EC*CG*	-20.9726[a]	-17.0788[a]	-6.4829[a]	-6.4880[a]
	*Gen*CG*	-10.1852[a]	-14.5125[a]	-4.5423[a]	-7.3767[a]
	*LR*CG*	-5.5467[a]	-12.1731[a]	-2.7735[a]	-7.8812[a]
	*EC*CG*Y*	-10.9359[a]	-12.1758[a]	-5.9138[a]	-6.6077[a]
	*Gen*CG*Y*	-5.1000[a]	-11.3623[a]	-2.5335[a]	-7.4817[a]
	*LR*CG*LY*	-7.0167[a]	-11.5350[a]	-2.6795[a]	-5.5166[a]
	SO_2	-12.0099[a]	-15.8957[a]	-6.4437[a]	-10.4660[a]
	NO_2	-9.9455[a]	-15.0488[a]	-4.0390[a]	-5.2182[a]

a Value at 1% significance level

b Value at 5% significance level

c Value at 10% significance level

For IPS test, W-t-bar values are reported
For LLC test, Adjusted t-statistics are reported

Appendix 1D: Robustness check for the estimated models

		For NO_2 Emissions							*For SO_2 Emissions*						
		Control Variables			*Testing Variables*				*Control Variables*			*Testing Variables*			
		Y	Y^2	Y^3	*Pop*	Pop^2	Pop^3	*CG*	*Y*	Y^2	Y^3	*Pop*	Pop^2	Pop^3	*CG*
Industrial area	Regression 1	0.1793	-0.0011	0.0013	.	.	.	.	-0.6824	0.0573	-0.0013	.	.	.	.
	Regression 2	0.2047	-0.0021	0.0014	0.0321	.	.	.	-0.6691	0.0578	-0.0013	-0.0167	.	.	.
	Regression 3	0.1931	-0.0063	0.0015	0.0025	0.0025	.	.	-0.6814	0.0576	-0.0013	-0.0002	-0.0002	.	.
	Regression 4	0.9371	-0.0997	0.0031	0.9393	0.0758	.	.	-0.2684	0.0235	-0.0007	-0.7086	-0.0266	.	.
	Regression 5	0.1638	-0.0106	0.0016	0.0002	.	0.0002	.	-0.6812	0.0566	-0.0013	-0.0000	.	0.0000	.
	Regression 6	0.7978	-0.0767	0.0020	1.0140	.	0.0020	.	-0.3129	0.0312	-0.0011	-0.3885	.	0.0007	.
	Regression 7	0.6335	-0.0508	0.0008	.	0.0820	0.0042	.	-0.3724	0.0410	-0.0016	.	-0.0317	0.0016	.
	Regression 8	0.2275	-0.0085	0.0019	0.2373	0.2583	0.0087	.	-0.6287	0.0785	-0.0033	-1.4122	-0.1431	0.0044	.
	Regression 9	0.1733	-0.0022	0.0014	.	.	.	-0.0421	-0.6870	0.0581	-0.0013	.	.	.	0.0325
	Regression 10	0.1914	-0.0027	0.0014	0.0220	.	.	-0.0372	-0.6800	0.0583	-0.0013	-0.0084	.	.	0.0306
	Regression 11	0.1873	-0.0064	0.0015	0.0022	0.0022	.	-0.0294	-0.6880	0.0577	-0.0013	-0.0002	-0.0002	.	0.0334
	Regression 12	0.9461	-0.1000	0.0032	0.9434	0.0757	.	-0.0330	-0.2772	0.0238	-0.0007	-0.7046	-0.0268	.	0.0321
	Regression 13	0.1616	-0.0105	0.0016	0.0002	.	0.0002	-0.0224	-0.6848	0.0565	-0.0013	-0.0000	.	0.0000	0.0361
	Regression 14	0.8059	-0.0770	0.0020	1.0193	.	0.0020	-0.0313	-0.3214	0.0315	-0.0011	-0.3829	.	0.0007	0.0327
	Regression 15	0.6396	-0.0509	0.0008	.	0.0823	0.0042	-0.0299	-0.3793	0.0411	-0.0016	.	-0.0314	0.0016	0.0333
	Regression 16	0.2520	-0.0057	0.0018	0.1325	0.2503	0.0085	-0.0264	-0.6618	0.0824	-0.0035	-1.5544	-0.1539	0.0047	0.0358
		For NO_2 Emissions							*For SO_2 Emissions*						
Residential area	Regression 1	0.7696	-0.1107	0.0052	.	.	.	.	0.7683	-0.1109	0.0050	.	.	.	.
	Regression 2	0.5433	-0.0955	0.0047	0.1021	.	.	.	0.9787	-0.1228	0.0054	-0.1140	.	.	.
	Regression 3	0.5790	-0.1000	0.0048	0.0048	0.0048	.	.	0.8869	-0.1157	0.0052	-0.0037	-0.0037	.	.
	Regression 4	2.1311	-0.2404	0.0082	0.0997	0.0834	.	.	1.7124	-0.1870	0.0067	-1.2715	-0.0440	.	.
	Regression 5	0.6181	-0.1033	0.0048	0.0003	.	0.0003	.	0.8315	-0.1127	0.0052	-0.0002	.	0.0002	.
	Regression 6	1.9273	-0.2105	0.0068	1.0544	.	0.0022	.	1.6575	-0.1756	0.0061	-0.7638	.	0.0012	.
	Regression 7	1.7090	-0.1794	0.0054	.	0.0831	0.0043	.	1.5495	-0.1568	0.0051	.	-0.0637	0.0030	.
	Regression 8	1.3110	-0.1254	0.0031	0.7503	0.2183	0.0078	.	0.2081	-0.0293	0.0031	-0.5231	-0.5702	0.0159	.
	Regression 9	0.7311	-0.1061	0.0051	.	.	.	-0.1251	0.7608	-0.1100	0.0050	.	.	.	-0.0186
	Regression 10	0.5692	-0.0954	0.0047	0.0753	.	.	-0.1086	0.9810	-0.1218	0.0054	-0.1251	.	.	-0.0455
	Regression 11	0.5864	-0.0984	0.0048	0.0038	0.0038	.	-0.1020	0.8829	-0.1142	0.0052	-0.0041	-0.0041	.	-0.0431
	Regression 12	2.0960	-0.2352	0.0081	0.0437	0.0805	.	-0.0871	1.6949	-0.1845	0.0067	-1.2494	-0.0428	.	-0.0333
	Regression 13	0.6136	-0.1009	0.0047	0.0002	.	0.0002	-0.0957	0.8237	-0.1111	0.0052	-0.0002	.	0.0002	-0.0396
	Regression 14	1.8994	-0.2064	0.0067	1.0352	.	0.0021	-0.0861	1.6431	-0.1736	0.0061	-0.7563	.	0.0012	-0.0319
	Regression 15	1.6847	-0.1759	0.0054	.	0.0815	0.0042	-0.0855	1.5368	-0.1551	0.0051	.	-0.0631	0.0029	-0.0311
	Regression 16	1.3103	-0.1251	0.0032	0.6474	0.2088	0.0075	-0.0849	0.2011	-0.0302	0.0031	-0.4991	-0.5678	0.0158	-0.0293

Note: Robustness of the models for full dataset is ensured, as the coefficient signs of core variables remain unchanged.

Appendix 1E: Profile of the cities considered for the study

Northern zone cities

Cities	*Category*	*Area (in km²)*	*Average Income (in Rs. Lacs)*
Agra	R & I	4028.00	2757.73
Allahabad	R	70.50	1969.87
Amritsar	R & I	2683.00	5120.72
Anpara	I	179.00	33.09
Bathinda	I	210.00	1199.01
Chandigarh	I	114.00	11545.39
Delhi	R & I	1484.00	141540.54
Dera Baba Nanak	R	74.00	30.75
Dera Bassi	I	157.00	104.14
Faridabad	R & I	2151.00	6891.56
Firozabad	R & I	2362.00	933.02
Gajraula	R & I	3.00	85.20
Ghaziabad	I	133.30	3255.79
Gobindgarh	R & I	110.00	342.37
Hisar	R	215.00	1550.41
Jalandhar	R & I	3401.00	3742.07
Jhansi	R	5028.00	883.88
Kanpur	R & I	403.70	4860.48
Khanna	R & I	28.00	546.07
Khurja	R & I	142.00	218.19
Lucknow	R & I	2528.00	4575.94
Ludhiana	R & I	310.00	7041.89
Meerut	R	141.90	2275.02
Naya Nangal	R	79.00	216.13
Noida	R & I	203.00	898.82
Patiala	R & I	339.90	1849.33
Varanasi	R	1550.00	2311.78
Yamunanagar	I	255.00	1697.51

Eastern zone cities

Cities	*Category*	*Area (in km²)*	*Average Income (in Rs. Lacs)*
Angul	R & I	6232.00	101.51
Asansol	I	127.30	3483.23
Balasore	R	3076.00	413.54
Berhampur	R	86.82	825.29
Bhubaneshwar	R	135.00	1972.63
Cuttack	R	398.00	1545.48
Dhanbad	R	2052.00	2579.06

Southern zone cities

Cities	*Category*	*Area (in km²)*	*Average Income (in Rs. Lacs)*
Alappuzha	R & I	46.18	1183.72
Bangalore	R & I	741.00	27833.29
Belgaum	I	94.00	2104.68
Chennai	R & I	426.00	35175.94
Chittoor	I	95.97	16345.00
Coimbatore	R & I	246.80	8484.66
Gulbarga	R	64.00	1849.82
Guntur	R	230.00	29531.17
Hassan	R	6814.00	584.94
Hubli-Dharwad	R & I	404.00	3257.90
Hyderabad	R & I	217.00	23908.91
Kakinada	R	31.51	2380.17
Khammam	R	94.37	16931.76
Kochi	R & I	732.00	8865.43
Kollam	R & I	73.03	4193.20
Kottayam	R & I	2208.00	1418.18
Kozhikode	R & I	128.00	7912.58
Kurnool	R	65.91	24195.29
Madurai	R & I	243.00	6074.51
Malappuram	I	33.61	5852.29
Mangalore	I	184.45	2175.75
Mysore	I	132.00	3390.89
Nalgonda	R	105.00	21183.45
Nellore	R	48.39	17839.74
Palakkad	I	1363.00	1240.79
Patancheru	R	122.00	18160.77
Pathanamthitta	R	23.50	176.15
Salem	R	124.00	3800.27
Thoothukudi	R & I	50.66	1586.06
Thrissur	R	101.40	6607.24
Trivandrum	R & I	214.90	6772.38
Vijayawada	R & I	61.88	7465.44
Visakhapatnam	R & I	540.00	25727.63
Warangal	R	407.80	21277.51

Western zone cities

Cities	*Category*	*Area (in km²)*	*Average Income (in Rs. Lacs)*
Ahmedabad	R & I	464.00	28261.90

Durgapur (WB)	R & I	154.00	1622.43	Alwar	R & I	150.00	802.27
Haldia	I	162.00	560.93	Amravati	R & I	122.00	3261.53
Howrah	R & I	1467.00	13675.52	Anklesvar	R & I	213.00	638.82
Jamshedpur	I	209.00	2828.23	Aurangabad (MS)	R	139.00	5828.57
Jharia	I	280.00	209.68	Chandrapur	R & I	77.00	1641.59
Kolkata	R & I	185.00	40475.25	Greater Mumbai	I	4355.00	65021.10
Patna	R	3202.00	2063.98	Jaipur	R & I	111.80	7115.57
Ranchi	R	175.00	2324.72	Jamnagar	R	53.30	2849.73
Rayagada	R & I	7073.00	162.13	Jodhpur	R & I	78.60	2653.26
Rourkela	R	340.00	1283.99	Kolhapur	R	66.82	2875.63
Sambalpur	R	6702.70	613.82	Kota	R & I	318.00	2291.08
Sindri	I	65.00	196.50	Lote	R & I	144.00	277.01
Talcher	I	2025.00	94.34	Mahad	R & I	175.00	140.17
Central zone cities				Mumbai	R & I	603.00	93969.58
Cities	*Category*	*Area (in km^2)*	*Average Income (in Rs. Lacs)*	Nagpur	R & I	217.60	12603.27
Bhilai Nagar	R & I	45.20	2574.87	Nashik	R & I	360.00	7604.93
Bhopal	R & I	285.90	3695.98	Navi Mumbai	R & I	344.00	855.59
Dewas	R & I	535.00	572.51	Pune	R & I	700.00	24672.11
Gwalior	R	780.00	2191.14	Rajkot	R & I	170.00	6200.10
Indore	R & I	530.00	4139.85	Roha	R & I	120.00	107.19
Jabalpur	R	367.00	2563.17	Sangli	R & I	118.20	2608.01
Khajuraho	R	175.00	48.21	Solapur	R & I	148.90	4895.32
Korba	R	316.00	881.79	Surat	R & I	326.50	19780.00
Nagda	R & I	120.00	208.66	Tarapur	I	627.00	36.78
Raipur	R & I	226.00	2493.15	Thane	R & I	147.00	53789.04
Sagar	R	6375.00	740.34	Udaipur	R & I	37.00	1130.71
Satna	R & I	200.00	561.41	Vadodara	R & I	235.00	8368.20
Singrauli	R	2200.00	441.38	Vapi	R & I	425.89	665.21
Ujjain	R & I	152.00	1031.14				
North-Eastern zone cities							
Cities	*Category*	*Area (in km^2)*	*Average Income (in Rs. Lacs)*	*Cities*	*Category*	*Area (in km^2)*	*Average Income (in Rs. Lacs)*
Bongaigaon	R	6.00	1462.12	Nagaon	R	128.00	5572.44
Daranga	R	78.00	1831.42	Nalbari	R	160.00	1558.21
Dibrugarh	R	66.14	2670.31	North Lakhimpur Town	R	15.00	2077.97
Golaghat	R	3502.00	2149.91	Sibsagar	R	2667.70	2340.84
Guwahati	R	215.00	1904.49	Silchar	R	15.75	341.35
Hailakandi	R	1327.00	1302.50	Tezpur	R	40.00	139.26
Margherita	R	162.00	54.36	Tinsukia	R	3791.00	2658.54

Note: “R” signifies Residential; “I” signifies Industrial; “R & I” signifies Residential and Industrial

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