Do negative externalities have any impact on population agglomerations? Evidence from Urban India

Tripathi, Sabyasachi and Kaur, Shupinder

Department of Economics (School of Business), Lovely Professional University

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Sabyasachi Tripathi*
Shupinder Kaur**

Abstract

India's current haphazard unplanned urbanization has brought in its wake myriad problems like increase in number of vehicles, energy consumption, air pollution, noise pollution, violence, traffic congestion, traffic injuries and fatalities etc. In this perspective, the present paper tries to analyze and evaluate the trends and patterns of the different forms of urban negative externalities. It also measures the impact of negative externalities on city population agglomeration in India. In the absence of reliable city level data, the paper focuses only on 42 class I (population one lakh or more) cities in India and bases the analysis on four types of urban negative externalities i.e., number of registered motor vehicles, air pollution, road accidents, and crimes. The trends and patterns analysis suggests that urban India is currently witnessing a higher increase in the number and density of registered vehicles, air pollution, road accidents and also crimes. The OLS regression results show that negative externalities such as city wise air pollutions, number of registered motor vehicles (measured by tractors and trucks density), and city-wise number of crimes have a negative effect on city population agglomerations. However, number of accidents, car density and total number of buses show a positive effect on city population agglomerations. Finally, this paper seeks to highlight the role of eco friendly public transport systems funded by the government in curbing urban negative externalities in India.

Key Words: Urbanization, negative externalities, economic growth, India.

JEL Classifications: R11, R12, R40

*Assistant Professor, Department of Economics (School of Business), Lovely Professional University, Phagwara, Punjab 144411, Email: sabya.tripathi@gmail.com.
**M.phil. Scholar, Department of Economics (School of Business), Lovely Professional University, Phagwara, Punjab 144411.Email: shavujassu89@gmail.com.

I Introduction

Globally, the pace of urbanization has been faster than ever before in recent years. Fifty-four per cent of the global population lived in urban areas in 2014 as against 30 per cent in 1950, and it estimated to reach 66 percent by 2050 (United Nations, 2014). In India, in 1951 only 62.4 million i.e. 17.3 per cent population was living in urban areas; it increased to 31.2 per cent, i.e. 377.71 million by 2011. As per 2011 census, the top five urbanized Indian cities are Mumbai (12.44 million), Delhi (11.03 million), Bangalore (8.44 million), Chennai (7.08 million) and Hyderabad (6.73 million).

Data presented in Table 1 indicates that India has been experiencing a steep increase in both total size of urban population as also percentage of urban population. However, a major chunk of urban population in India is concentrated in class I cities. The percentage of urban population rose from 17% to 31% in the period 1951 to 2011. After independence, the highest urban exponential growth rate reached 3.79% in the decade 1971-1981. During 2001-2011, urban growth rate declined to 2.76% but the level of urbanization leaped from 27.7% in 2011 to 31% in 2011. Census 2011 puts the number of such class I cities/towns as 468. The corresponding number in Census 2001 was 394. The classification of cities on the basis of population-size has resulted as a top- heavy composition of urbanization, i.e. a sharp increase in the number of Class I cities in the country. Most importantly, 264.9 million urban populations lived in class I cities/ towns in 2011 and constitute about 70% of the total urban population in the country. Being hubs for economic growth, the contribution of cities to India's gross domestic product has always been quite sizeable. In this perspective, it can be said that Class I cities play a pivotal role in accelerating economic growth and development. Modernization of cities is one of the main factors behind the increase in the number of cities and the population therein. It happens largely through rural to urban migration spurred by the attraction of urban opportunities like availability of better schools colleges and medical facilities, better transportation and primarily employment opportunities.

Table: 1 Trend of Urbanization in India 1951-2011

Census Year	Urban population (in millions)	Percentage of urban population	Annual exponential urban growth rate (%)	No. of class I cities	Percentage of population in class I cities
1951	62.4	17.3	-	76	44.6
1961	78.9	18.0	3.47	102	51.4
1971	109.1	19.9	2.34	148	57.2
1981	159.5	23.3	3.79	218	60.3
1991	217.5	25.7	3.09	300	65.2
2001	286.1	27.9	2.75	393	68.6
2011	377.1	31.2	2.76	468	70

Source: Authors' using data from Census of India for various years

Urbanization plays a pivotal role in economic growth; urbanization and economic growth have always had a high positive correlation, which means higher degree of urbanization invariably leads to higher per capita income. Urbanization is also linked with industrialization and growth of commercial and service sectors. Evidently, it has promoted higher economic growth in India as well. As can be seen from Table 2, in 1951 urban population was about 17.3% of the total, but its contribution to national income was about 29%. In 2001, the urban population accounted for about 30% of the total, but its contribution to national income was a colossal 60%. The Mid-Term Appraisal of the Eleventh Five Year Plan shows puts the urban share of GDP at about 63 per cent for 2009-10, and this share is projected to increase to 75 percent by 2030. A study by Indian Institute for Human Settlement (IIHS), "Urban India 2011: Evidence" (IIHS, 2012) estimated that India's top 100 largest (as per the population size) cities produced about 43% of the GDP, with 16 % of the population and just 0.24% of the land area.

Table: 2 Urban Concentrations to National Income

Year	% of urban to total population	Estimate contribution to national income (%)
1951	17.3	29
1981	23.3	47
1991	25.7	55
2001	30.5	60

Source: Government of India (GOI).

At present, India has six cities in the 'fastest growth' category and their contribution to national income is also high compared to other cities. These cities play a leading role in the growth of the country's economy as well as demographic change. Delhi is the largest city in India and in 2015, Delhi's contribution to GDP growth was 8.5%; Delhi's contribution to population growth was 3.5% in the period 2000-2015, both of which were larger than the contribution of other Indian cities. Kolkata's contribution to GDP growth was 6.8% in the period 2000-2015 and to population growth 1.7%. Hyderabad's contribution to population growth in the period 2000-2015 was 2.15% and contribution to GDP 7.2%. Chennai's contribution to population growth during the above years was 1.59% and its contribution to 7.8%. Bengaluru's contribution to population growth in the period 2000-2015 was contribution to GDP 7.6%. Mumbai's contribution to population growth in the period 2000-2015 was 2.3% and contribution to GDP 7.6%. Overall, India's top 6 cities have contributed the largest to the growth of GDP and population in the period 2000-2015.[1]

[1] The data is collected from the following website: http://www.insidermonkey.com/blog/6-fastest-growing-cities-in-india-in-2015-376759/5/

The above discussion clearly indicates that urbanization has a positive link with economic growth. Most importantly, large cities have been generating larger percentage of GDP than other small town & cities, due to economic effects of agglomeration. On the other hand, large cities in India have also encountered several negative externalities, e.g., increase in number of private vehicles, increasing energy consumption, air pollution, noise pollution, violence, traffic congestion, traffic injuries and fatalities etc.

Negative externalities are the cause of increase in concentration of population and high per capita income. High per capita income generates affordability as well as need for personal private vehicles, which in turn results in higher energy consumption and also environmental decay. Cities' growth largely depends upon the benefits from agglomeration economy, but after reaching a certain stage cities' growth stagnates due to negative externalities. In fact, such deleterious externalities can be traced to policy failures and absence of regulatory mechanisms.

In India, the number of urban-specific private vehicles like scooter, motorcycle, etc. increased from 24.7% in 2001 to 35.2% in 2011. Further, the number of vehicles like car, jeep and van increased from 5.6% in 2001 to 9.7% in 2011. Increase in vehicle population leads to deterioration of environmental quality. Major greenhouse gases like Carbon Monoxide (CO), Sulfur dioxide (SO_2), Carbon dioxide (CO_2) and Nitrogen dioxide (NO_2) generate air pollution. India now ranks fifth in GHG emission after China, European Union, United States and Russian. Road accidents are caused by improper interaction between vehicles and roadway features. With the phenomenal increase road length (road network) the number of road accidents has also increased, i.e. from 4.89 lakh in 2014 to 5.01 lakh in 2015. Violence is also a part of negative externalities which is also the main cause for the increase seen in the growth of population and also poverty. Overall, in India, the total number of cognizable offences registered under provisions of India Panel Code (IPC) increased from 31.2 % in 2003 to 39.2% in 2013.

In the context of city-wise negative externalities, as can be seen from Table, 3 Delhi has the highest total number of registered vehicles (88.21lakh) followed by Bengaluru (55.60lakh), Chennai (4934), Ahmedabad (3420) and Mumbai (2571). The table also shows that Delhi occupies the top rank for the total number of reported cognizable offences. On the other hand, Mumbai occupies the top rank for the total number of road accidents. It can also be seen from the table that a huge amount of PM_{10} (221) is present in Delhi which is attributed to exhaust emissions of diesel vehicles. Mumbai has relatively less number of (25.71lakh) motor vehicles as compared to Chennai (49.34 lakh) but has more amount of PM_{10} (90) in the air. Ahmedabad also has a high amount of PM_{10} (86) as compared to Chennai (56).

Table 3: Trends of Negative Externalities in Large Cities in 2015

Class I Cities	Registered motors (In thousands)	Cognizable crime (in numbers)	Road accidents (in numbers)	SO_2	NO_2	PM_{10}
				in micrograms		
Delhi	8851	173977	8085	5	59	221
Bengaluru	5560	35576	4834	5	20	131
Chennai	4934	13422	7328	13	20	56
Ahmedabad	3420	15964	1837	13	20	86
Mumbai	2571	42940	23468	3	23	90

Note: 1. PM_{10}: Particular Matter

2. A Cognizable crime is one in which, a police officer can arrest the offender without warrant, and is generally a crime of serious nature.

Source: Authors' compilation using data from various sources.

In this perspective, the present paper sets out the following objectives: first, it measures the negative externalities which occur due to urbanization; second it analyzes the recent trends and patterns of negative externalities in India; third it also estimates the effect of negative externalities on urban population agglomeration; and finally, it puts forth appropriate policies to promote urbanization with the realization of lower negative externalities for achieving higher and sustainable urban economic growth in India. The basic objective of these empirical exercises is to promote planned urbanization with a view to realize the highest potential effect of urbanization on economic growth in India. The results of this analysis will hopefully help to promote a planned urbanization in India, which is Indian cities are currently lacking. Due to the paucity of city-wise data for several variables, this study considers 42 Class I cities of India. The study roughly covers the 10 year period 2005 - 2015.

II Review of literature

Several international empirical studies have established the relationship between CO_2 emission and urbanization by considering the experience of both developed and developing countries. Martínez-Zarzoso and Maruotti (2011) examined the relationship between urbanization and CO_2 emission from 1975 to 2003 in different countries. This study concluded that population growth has a greater impact on CO_2 emission. The negative relationship between urbanization and CO_2 emission is also highlighted in the study. It is also pointed out in the study that in most high income countries, once urbanization reached a certain level, emissions contributed negatively to growth, but low- middles incomes countries have positive elasticity in the matter of emissions. Sharif and Raza (2016) analyzed bi- directional relationship between CO_2 emissions and urbanization by using time series data for Pakistan for the time period 1972 to 2013. The findings of the study show that energy consumption, GDP, urbanization and population are the main sources of enhanced CO_2 emissions.

Sodhri and Garinwe (2016) examined the correlation between energy consumption, urbanization and CO_2 emissions in Jakarta's megacity for the period 2001-2014. By applying Granger causality test and co- integration test to evaluate the attributes of energy consumption and CO_2 emissions in different sector of urbanization, the study concluded that there is a positive relationship between high per capita income and vehicles ownership. The study also indicated that higher CO_2 emissions are due to the increase in the number of motorcycle, private vehicles and poor public transportation. Shabaz et al. (2016) examined the effect of urbanization on CO_2 emissions in case of Malaysia for the period 1970-2011. The study found strong links between energy consumption and urbanization in Malaysia cities. The analysis found that economic growth, energy consumption and urbanization have positive relationship with CO_2 emissions. The correlation between urbanization and CO_2 emissions can be plotted as a U-shaped curve. It signifies that in the initial stages of urbanization CO_2 emissions decline but after a certain stage of urbanization CO_2 emissions start increasing. Cole and Neumayer (2004) in their study examined the impact of demographic factors on air pollution. Using cross-country and time series data, the study concludes that the demographics factors like household's size, age structure, urbanization, income, population size etc. have a statistically significant relationship with CO_2 emission, whereas SO_2 has a statistically significant relationship with energy production and population.

In the Indian case, a large body of literature on urban economic growth and agglomeration (e.g., Tripathi and Mahey, forthcoming, Tripathi, 2013, 2015) establish the link between urbanization and economic growth. Tripathi and Mahey (forthcoming) investigates the relevant determinant of urbanization growth in Punjab for the period 1961 to 2011. The study finds the existence of a positive relationship between urbanization and economic growth in Punjab. Tripathi (2013, 2015) highlighted the positive link between urbanization and economic growth in India. The study argues that there is non-linear link between spatial concentration of economic activity and economic growth in India. The study also validates the Williamson hypothesis that GDP growth of agglomeration economy can rise only up to certain level.

In the context of cost and benefits of urbanization, Sridhar (2016) argued that urbanization has a symbiotic relationship between rural and urban segments. Urbanization and economic growth positively impacts rural to urban migration and reciprocally, rural areas benefit by the remittances made by rural migrants to their homes. On the flip side, urban areas become congested due to migration to cities/urban spaces in search of jobs. Another negative impact of rural- urban migration is unsettling of the ratio gap in state population, and also the community cost arising from altered rural- urban population ratio.

There are several studies in India which highlight the relationship between different negative externalities and urbanization. Pucher et al. (2007) in their study analyzed a comparative overview Indian and Chinese experience, focusing on four major problems faced by the two countries due to increased motorization, air pollution, and mobility problems of the poor, road accidents and roadway congestion. These problems are generally exacerbated by unorganized urbanization, rapid growth of population and unbridled motorization. To mitigate these negative externalities, it must be accompanied by strict policies for the improvement of environment such as improvement in public transport, rise in taxes, restriction of motor vehicles in congested areas, etc. Reddy and Balachandra (2012) found that motorized mobility has a positive correlation with air pollution, increasing number of vehicle and urbanization in India. The paper also suggested some policies for the improvement in overall transport system, like use of cycles, walking and also improving in public transport to make the city livable. Singh (2012) reviewed the trends of motorized growth in India considering the time period of 1951-2009. The study found that metropolitan cities are suffering from problems such as noise pollution, air pollution, road congestion and high level of accidents and consequent worsening the people's quality of life. Rao et al. (2016) study at the magnitude of urban air pollution particularly through motorization and its impact on environment in the metropolitan city of Hyderabad considering the time period 2005-2015. The study finds the growth of vehicular population as a matter of concern for environmental protection. The increasing demographic pressure is another reason for the increase in transportation demand. The study concludes that there is a paramount need for strict regulatory policies by the government to improve air quality and ensure future sustainability. Sridhar (2010) analyzed and estimated the relationship between urbanization and climate change. It also highlighted the fact that climate change has an inverse effect on ecology as also on city life. Solanki et al. (2016) concluded that increase in vehicular population tends to increase heterogeneous traffic conditions. The study underlines the earlier findings that urban areas contribute overwhelmingly to the country's GDP. Urbanization positively impacts per capita income which in turn leads to increase in vehicle population. Rapid increase in vehicle population has a linier relationship increased congestion and delays in travel time. Mohan's (2004) study on Bangalore stated that road accidents is a causes of traffic crashes, increasing number of registered motor vehicles mixed traffic, speed of vehicles, highway passing through semi urban area etc.

III Measurement of different forms of negative externalities of urbanization in India

Urbanization is a complex process and has numerous dimensions. There exists negative and positive externality across all economic activities undertaken in the urban area. Positive externalities of urbanization are generally measured through the estimation of urbanization and economic development which is measured in terms of evident economic growth by various studies (Tripathi, 2013, 2015). However, it is difficult to measure the negative externalities of urbanization as it has many facets and also because the available data is very scanty. Table 4 presents the measurement of different urban negative externalities in India. The study mainly considers 4 types of urban negative externalities i.e., number of registered motor vehicles, degree of air pollution, number of road accidents, and crimes. It is obvious that these four factors represent the negative externalities of urbanization. Registered motor vehicles considered herein include two wheelers, cars, jeeps, tractors, Omni buses, trucks, taxis, buses, passenger auto, and light motor vehicles. The levels of SO_2, NO_2, and PM_{10} are considered to measure urban air pollution in India. The total number of accidents and cognizable crimes is also factored in, to measure the negative externalities of urbanization in India.

Table 4: Measurement of different urban negative externalities in India

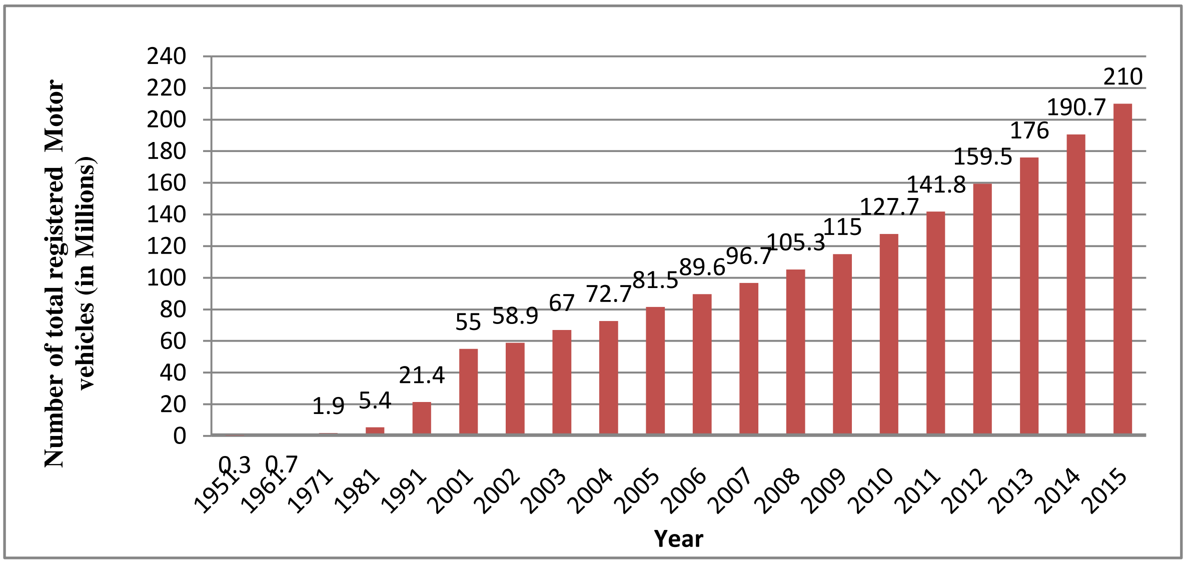
Variable	Sub-variable	Variable Measurements	Data Source	Year
Total number of registered motor vehicles	Two wheelers, cars, jeeps, tractors, Omni buses, trucks, taxis, buses, passenger auto, light motor vehicles	1. Vehicle density is measured by dividing the total number of registered vehicles in a particular city by the total population residing in that city. 2. Percentage share of sub-vehicles is measured by dividing the total number of registered sub-vehicles by the total number of registered vehicles in a particular city. 3. Growth rate is measured by taking the average annual growth rate	Road transport year book	2005 to 2015
Air pollution (in microgram per cubic meter unit)	Sulphur dioxide (SO_2), Nitrogen dioxide (NO_2) , and Particular Matter (PM_{10}) emissions	Carbon Intensity or per capita emissions is measured by dividing the total annual SO_2, NO_2, PM_{10} emissions by the total population residing in a particular city.	Indiastat.com and Central Pollution Control Board (CPCB)	2008 to 2015
Total number of road accidents	Total Number of accidents	Accidents per 1000 population: Total number of accidents occurred in a city is divided by total population of that city, and multiplying the product by 1000.	Ministry of road transport & highways transport research wing.	2008 to 2014
Total number of crimes	Cognizable crimes under the Indian Penal Code	Cognizable crimes per 1000 population: Total number of crimes occurred in a city is divided by the total population of that city. Then the ratio is multiplied by 1000.	Crimes Records Bureau (CRB)	2008 to 2015

Source: Authors' compilation

V Trends and Patterns of negative externalities of urbanization in major class I cities of India.

This section examines the recent trends and patterns of negative externalizes in urban India by focusing on large cities. The compound annual growth rate (CAGR) of total registered vehicles in India was 9.8% in the period of 2005 to 2015. As graphically shown in Figure 1, the number of total registered vehicles increased to 210 million in 2015 from 0.3 million in 1951.

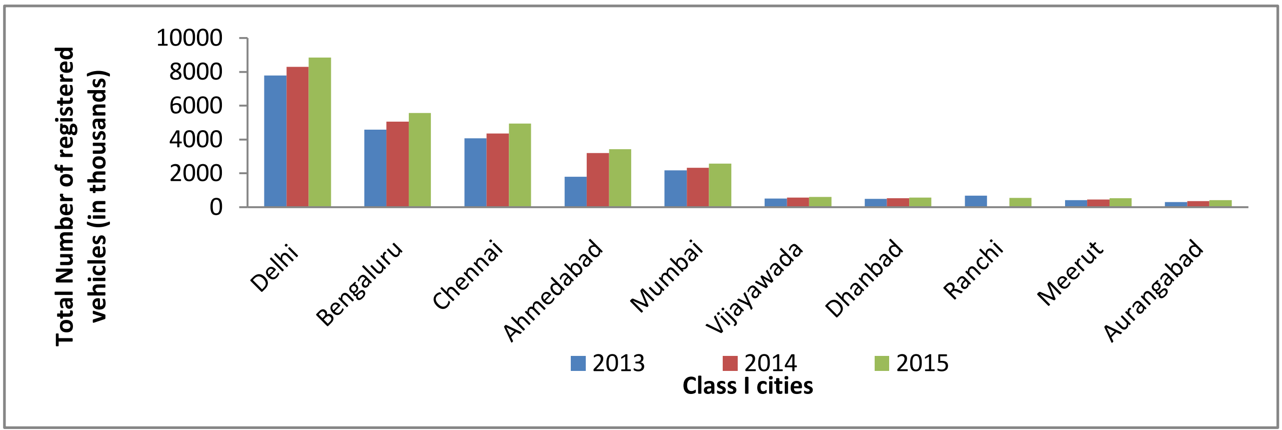
Figure 1: Total Registered vehicles in India (in Millions)



Source: Authors' using data from Transport Year Book, Government of India (GoI)

Figure 2 shows the growth trends of total number of registered motor vehicles in top 5 and bottom 5 (as per the population size in 2011) Class I cities (out of 42 cities) in India for the period 2013 to 2015. In this period, Delhi had the highest number of registered vehicles (77.85 lakh) followed by Bengaluru (45.91 lakh), Chennai (40.72 lakh), Mumbai (21.87 lakh), Ahmedabad (17.96 lakh). Most importantly, these top five cities accounted for 34.8% of the total number of registered vehicles in urban India in 2013. Among the lowest 5 class I cities, Aurangabad had the lowest number of registered motor vehicles (3.10 Lakh) in 2013. In 2015 also, Delhi topped the list with the highest number of registered vehicles (88.51 lakh), followed by Bengaluru (55.60 lakh), Chennai (49.34 lakh), Ahmedabad (34.20 lakh), Mumbai (25.71 lakh). These top five cities accounted for an increase of 38.2% in the total number of registered vehicles in 2015 than it was 34.8 % in 2013.

Figure 2: Total registered motor vehicles in Class I cities in India



Source: Same as Figure 1

Table 5 captures the annual growth rate in the number of registered vehicles in selected class I cities. The table shows the increase/ decrease in growth rate during the period from 2012-13 to 2014-15. In 2012-2013, the highest growth rate in the number of registered vehicles was registered in Bengaluru (10.47%) followed by Aurangabad (10.32%), Mumbai (7.79%), Chennai (8.10%), Dhanbad (6.06%), Delhi (5.92%). However, Ahmedabad, Vijayawada, Meerut had negative growth in the number of registered vehicles in the same period. In 2013-14 Aurangabad witnessed the highest growth rate (16.77%) in the number of vehicles from the previous period, while Bangalore achieved stable growth rate of vehicle population. In the same period, Ahmedabad, Vijayawada and Meerut witnessed increase in growth rate of vehicles. In 2014-15, the highest growth rate was maintained by Aurangabad (17.68%) followed by Meerut, Mumbai, Bangalore etc.

Table 5: Annual growth rate (%) of total registered vehicles of selected Class I cities of India

Selected Class I cities	2012-13	2013-14	2014-15
Delhi	5.92	6.53	6.73
Bengaluru	10.47	10.00	10.10
Chennai	8.10	6.93	13.32
Ahmedabad	-39.77	7.99	7.54
Mumbai	7.79	6.68	10.20
Vijayawada	-6.51	9.86	7.39
Dhanbad	6.06	6.33	8.06
Meerut	-1.90	11.41	14.38
Aurangabad	10.32	16.77	17.68

Source: Same as Figure 1.

Table 6: Trends of vehicle density in selected class I cities in India

Class I cities	2005	2010	2011	2012	2013	2014	2015
Delhi	424	683	655	666	706	752	802
Bengaluru	519	679	373	492	544	598	658
Chennai	499	725	488	531	574	614	696
Ahmedabad	464	NA	NA	302	322	573	613
Mumbai	108	148	150	163	176	188	207
Vijayawada	NA	614	316	374	350	385	413
Dhanbad	NA	29	35	398	422	449	485
Meerut	NA	372	323	321	315	351	401
Aurangabad	NA	NA	216	240	265	309	364

Source: Same as Figure 1

Table 6 captures the increase in density of vehicles in selected class I cities in India. It can be clearly seen from the table that Delhi's vehicles density increased from 424 in 2005 to 802 in 2015, which is the highest growth rate among the selected 42 class I Indian cities. Interestingly, the increasing trend in vehicle density was evident during the period in all the selected cities without exception. Among the class I cities Delhi, Bengaluru, Chennai, Ahmedabad, and Mumbai had higher vehicle density than other cities like Vijayawada Dhanbad, Meerut, and Aurangabad. This proves that urban dwellers in major metro regions depend more on vehicles for their daily use compared to other metros.

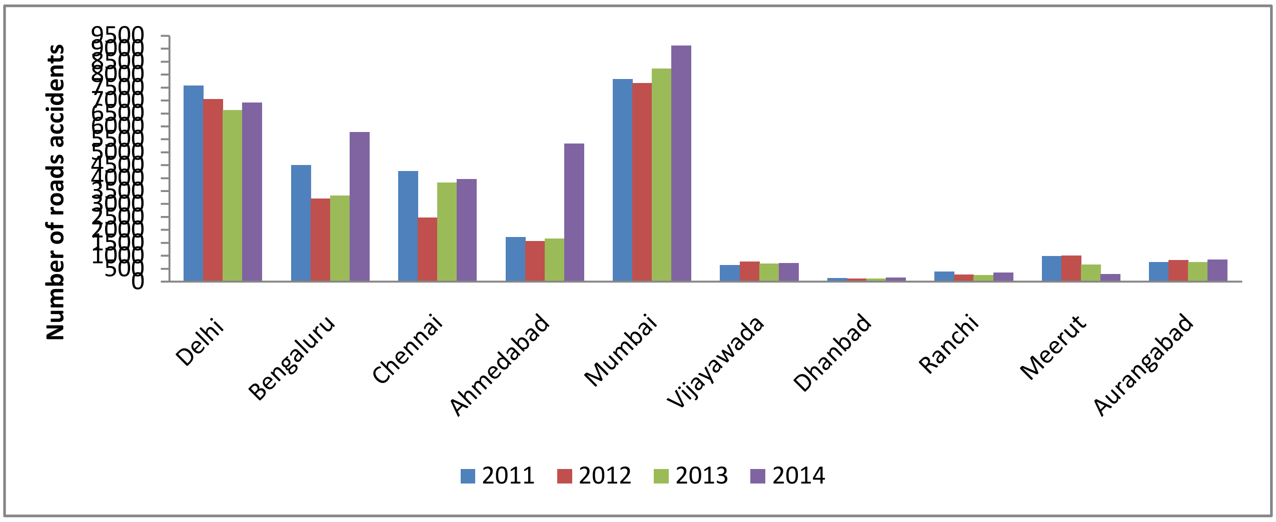
Table 7: Emission from urban transport vehicles in selected Class I cities in India

Class I Cities	**SO_2 /Capita /Year**		**NO_2 /Capita /Year**		**PM_{10} /Capita /Year**	
	2011	2015	2011	2015	2011	2015
Delhi	0.54	0.45	5.53	5.35	20.12	20.03
Bengaluru	1.66	0.59	3.32	2.37	10.78	15.51
Chennai	1.27	1.83	3.39	2.82	12.98	7.90
Ahmedabad	2.51	2.33	4.48	3.59	14.88	15.42
Mumbai	0.40	0.24	2.65	1.85	9.32	7.23
Vijayawada	4.06	3.39	7.45	23.02	60.94	72.45
Dhanbad	13.77	10.33	30.99	31.85	178.21	144.63
Ranchi	16.77	NA	32.61	NA	153.71	NA
Meerut	3.82	NA	34.38	NA	93.96	NA
Aurangabad	6.83	10.24	26.47	34.15	70.86	70.01

Source: Authors' calculation using data from CPCB, GoI

Urban air pollution emanating from urban transport vehicles is measured in this study in terms of per capita emissions of SO_2, NO_2, and $PM_{10.}$ Table 7 shows the amount of emissions from transport vehicles in selected class I cities/ urban regions in India. Emission here refers to the noxious gases spewed by internal combustion engines of transport vehicles. SO2, NO2, and PM_{10} level is measured in per capita terms and reveals the pollution levels in different class one cities. The table makes it clear that metro cities like Delhi, Bengaluru, Chennai, Ahmedabad, and Mumbai have better air quality and are less polluted as compared to cities which are less populated and have smaller number of motor vehicles, like Vijayawada, Dhanbad, Ranchi, Meerut, Aurangabad etc. Delhi and Mumbai have improved their performance in 2015 compared to 2011 as the level of SO_2, NO_2 and PM_{10} have decreased from their previous level. The improved air quality might be due to the rapidly developing eco friendly urban transport in these cities/ urban regions. However, in the same period of time, Dhanbad city registered the highest amount of PM_{10} (144.63per/ capita) in 2015 followed by Aurangabad PM_{10} (70.01 per/ capita) among the selected class I cities. This indicates that as smaller class I cities grow and their population increase, their dependency on private motor vehicles also increases significantly.

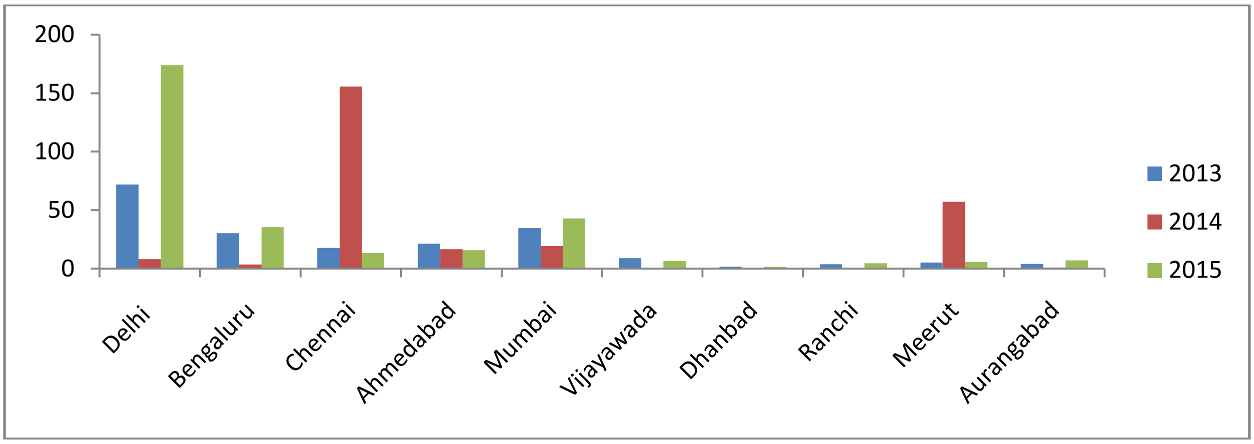
Figure 3: Trends of total number of road accidents in Selected class I cities



Source: Authors' using data from CRB, GoI.

Figure 3 provides a comparison of the total number of road accidents occurred across selected class I cities in India for the years 2011 to 2014. The figure indicates that there is a marked increase in the number of road accidents occurred in metros/urban regions in India. Increase in the number of motor vehicles over the years has been found to be the major cause of road accidents. There was an increasing trend in occurrence of road accidents in Mumbai city in the years 2011-2015. The cities of Bengaluru and Ahmedabad also witnessed an increasing trend in occurrence of road accidents during the above years. The number of registered vehicles in a city has a direct relationship with increase in the number of road accidents. The cities that have fewer number of registered motor vehicles and smaller population have registered fewer number of road accidents.

Figure 4: Trends of Cognizable crimes in selected class I cities (in Thousands)



Source: Authors' using data from CRB, GoI

Finally, the paper analyzes the trends in total number of crimes in selected class I cities in India. Urbanization and population concentration have a direct association with incidence of crime, as evidenced by the experience of major metros in India. As illustrated in Figure 5, in the years 2013 to 2015, Delhi registered the highest ever number of crimes followed by Chennai which also witnessed a sharp increase in crime rate. However, cities like Vijayawada, Dhanbad, Ranchi, and Aurangabad (except Meerut) have reported less number of crimes in these years presumably because of low population concentration and lesser urbanization rate.

V Impact of negative externalities on urban agglomerations in India

The following paragraphs are devoted to measuring the impact of the negative externalities on population agglomeration in selected class I cities in India. To empirically investigate the impact of negative externalities on urban population agglomeration in India, the following OLS regression model is used.

$$UA = \alpha_0 + \sum_{i=1}^{11} \alpha_i X_i + \epsilon \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where UA stands for population of urban agglomerations. The X_is are independent variables i.e. city wise accidents per 1000 population, number of crimes per 1000 population, city wise indices of air population (measured by per capita SO_2 emissions, per capita NO_2 emissions, per capita PM_{10} emissions) and city wise number of registered motor vehicles (measured in terms of two wheelers density, car density, tractors density, trucks density, number of buses, and auto density).

Appendix table A1 provides a list of all the cities included in the study. Table 8 explains the means, standard deviations, minimum, maximum, and coefficient of variation (CV) values for the variables used for the regression analysis. Most importantly, the CV aims to describe the dispersion of the variables in a way that does not depend on the variable's measurement unit. The higher values of CV for number of crimes per 1000 population, railway station, tractors density, per capita SO_2 emissions, and city populations indicate a greater dispersion in these variables. On the other hand, accidents per 1000 population, two wheelers density, and car density show a lower dispersion in these variables. Table 9 presents the raw correlation coefficients. The result indicates that per capita SO_2, NO_2, PM_{10} are negatively correlated with city population. The correlation coefficients are also statistically significant. On the other hand, it is positively correlated with car density and total number of busses. The correlation coefficients are statistically significant at 5 % level.

Table 8: Description of data used in the regression equation

Variables	Obs.	Mean	Std. Dev.	Min	Max	C.V.
City population (CP)	42	2662982	2746128	601574	1.24E+07	103.12
Number of crimes per 1000 population (NCP)	42	5.01	8.46	1.28	57.61	168.82
Per capita SO_2 emissions (SO_2)	42	7.18	9.43	0.4	57.02	131.29
Per capita NO_2 emissions (NO_2)	42	17.18	13.48	2.65	76.03	78.47
Per capita PM_{10} emissions (PM_{10})	42	87.43	77.08	9.32	306.9	88.16
Two wheelers density (TWD)	39	277.08	167.79	7.55	639.06	60.56
Car density (CD)	39	51.18	45.17	4.59	191.77	88.25
Tractor density (TD)	38	7.55	10.41	0.05	44.83	137.90
Truck and lorry density (TRD)	42	8.16	7.93	0.65	35.96	97.07
Total number of buses (TNB)	34	8133.35	10968	386	45757	134.86
Accidents per 1000 population (AP)	42	0.47	0.228	0.06	1.18	48.51
Auto density (AD)	42	8.56	7.54	2.11	34.15	88.11

Source: Authors' calculation

Table 9: Correlation coefficient of the regression variables

	CP	NCP	SO_2	NO_2	PM_{10}	TWD	CD	TD	TRD	TNB	AP	AD
CP	1											
NCP	-0.14	1.00										
SO_2	-0.32*	-0.05	1.00									
NO_2	-0.47*	0.06	0.82*	1.00								
PM_{10}	-0.49*	0.00	0.56*	0.71*	1.00							
TWD	0.02	0.15	-0.35*	-0.24	-0.08	1.00						
CD	0.39*	0.51*	-0.29	-0.23	-0.35*	0.42*	1.00					
TD	-0.26	-0.06	-0.09	0.20	0.23	0.28	-0.10	1.00				
TRD	-0.08	0.06	-0.08	0.03	0.15	0.49*	0.12	0.36*	1.00			
TNB	0.78*	-0.03	-0.31	-0.44*	-0.44*	0.19	0.55*	-0.25	0.17	1.00		
AP	0.13	0.28	0.06	0.15	-0.12	0.30	0.39*	0.22	0.25	0.19	1.00	
AD	0.14	0.48*	-0.02	0.01	-0.11	0.28	0.55*	-0.07	0.38*	0.30	0.33*	1.00

Note: See Table 8 for variable definitions. The correlation coefficients are based on 33 observations. * Indicates statistically significant at 5 % level.
Source: Authors'

Table 10 presents the estimated regression results from Equation (1). Regressions 1–3 report OLS results, with robust standard errors (to control for heteroskedasticity) taking care of the multicollinearity problem.[2] The population size of urban agglomeration stands as a dependent variable in the regression models 1-3. The significant values of F statistics for Regressions 1–3 indicate that the overall model is statistically significant. The test of normality, i.e., that the residuals are normally distributed, is confirmed by kernel density estimates, which are presented in Appendix Figures A1, A2, A3. A non-graphical test is also done by considering the Shapiro–Wilk test for normality. The statistically insignificant Z values do not reject the null hypothesis that the distribution of the residuals is normal at least at 5 % level of significance.. The higher values of R^2 indicate that Regressions 1–3 can explain a good percentage of total variation in the dependent variable. The study has also calculated the adjusted R^2, as it adjusts for the number of explanatory terms in a model, i.e., it incorporates the model's degrees of freedom. The multicollinearity problem does not seem to be troublesome, as the mean VIF values do not exceed 10 for Regressions 1–3.

Regression model 1 shows that city-wise accident per 1000 population has a statistically significant (at 10% level) positive impact on the population size of the urban agglomerations. The result comes as a surprise and indicates that a 10 % increase in accidents per 1000 population increases urban population agglomerations by 8.7 percent. Number of crimes per 1000 population has a negative effect on the size of urban agglomerations. The results show that a 10 % increase in the numbers of crimes reduces urban agglomerations by 0.18 %. The result is statistically significant at 1 % level. On the other hand, among the numbers of motor vehicles, city-wise tractors and trucks density has a negative effect while city-wise total number of buses has a positive effect on city population agglomeration. The results contradict with each other. However, none of the variables are considered to measure the air pollutions show any statistically significant effect on population agglomerations. In addition to two wheelers density, car density, and auto density do not have any statistically significant effect on the dependent variable.

Regression 2 shows that city-wise per capita NO_2 emissions and per capita PM_{10} emissions have a statistically significant negative effect on the size of city population. In particular, a 10 percent increase in per capita NO_2 emissions (or per capita PM_{10} emissions) reduces the size of urban population agglomerations by 0.24 (or 0.02) percent. Car density has a statistically significant effect on size of city populations. However, per capita emission of SO_2 and two wheelers density do not

[2] To test the Homoskedasticity of the residuals, the Breusch–Pagan/Cook-Weisberg test is performed. The estimated significant value of the chi2 rejects the null hypothesis that thevariance is constant. Therefore, to correct for heteroskedasticity the robust standard errors are used.

show any statistically significant effect on the dependent variable as in regression 1. Finally, regression 3 shows that per capita SO_2 emission has a negative effect on city populations. The result is statistically significant at 1 % level. The coefficient value -0.025 indicates that a 10 % increase in city-wise SO_2 per capita reduces size of population agglomerations by 0.25 %.

Table 10: Measurement of impact negative externalities on urban agglomeration

Independent variables	Log of Population in 2011		
	1	2	3
Intercept	14.68***	14.84***	14.59***
	(0.367)	(0.337)	(0.355)
Accidents per 1000 population	0.873*		0.727**
	(0.44)		(0.339)
Number of crimes per 1000 population	-0.018***	-0.039***	-0.027***
	(0.004)	(0.012)	(0.003)
Air pollution			
Per capita SO_2 emissions	-0.015	0.011	-0.025***
	(0.011)	(0.012)	(0.008)
Per capita NO_2 emissions	-0.011	-0.024**	
	(0.008)	(0.0113)	
Per capita PM_{10} emissions	0.0002	-0.002*	
	(0.001)	(0.001)	
Number of registered motor vehicles			
Two wheelers density	-0.0005	-0.463	-0.067
	(0.0007)	(0.845)	(0.075)
Car density	-0.004	0.008*	
	(0.002)	(0.005)	
Tractors density	-0.013**		-0.015***
	(0.006)		(0.004)
Trucks and lorries density	-0.017*		-0.013*
	(0.009)		(0.007)
Total number of buses	0.049***		0.044***
	(0.008)		(0.006)
Auto density	-0.003		-0.004
	(0.008)		(0.006)
F stat	36.75***	15.48***	69.8***
Mean VIF	2.78	2.47	1.48
R square	0.87	0.56	0.84
Adjusted R square	0.81	0.47	0.79
Shapiro–Wilk test for normality (Prob>z)	0.116	0.066	0.098
No. of observations	33	39	33

Source: Estimated by using Equation (1). Figures in parentheses represent robust standard errors.
***, ** and * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

VI Conclusion

The present paper tries to measure the negative externalities of urbanization in India. It also analyzes the trends and patterns of urban negative externalities in India from the period of 2005-2015. Finally, it measure the effects of negative externalities on population agglomerations in selected 42 Class I cities in India.

The trends and pattern analysis suggest that the class I cities accommodate about 70% of urban population in India. At all India level total number of registered vehicles increased by 55 million in 2001 to 210 million in 2015. Among the class I cities, Delhi had the highest number of registered vehicles (8851 thousands) in 2015 and Aurangabad had the lowest number of registered vehicles (426 thousands). But the Annual growth rate of registered vehicles was the highest in Aurangabad i.e., 17.68% as compared to Delhi i.e., 6.73% in 2014-15. The growth-trend in vehicle density was highest in Delhi i.e., 802 in 2015 but the lowest vehicle density was registered in Mumbai i.e., 207 during the above period. Higher concentration of population and increase in vehicle population in a specific area generate different forms of noxious emissions like: SO_2, NO_2, and PM_{10}. Largest amounts of such emissions are presently seen in Dhanbad, followed by Vijayawada, Aurangabad etc. The highest number of road accidents was reported in Mumbai (i.e., 9000) during the above years, followed by Delhi, Bengaluru, Ahmedabad etc. Incidence of cognizable crimes is also a one of the negative externalities of urbanization as is the experience of cities like Delhi, Chennai, Meerut, etc.

The OLS regression results show that negative externalities such as city wise air pollution (measured by per capita emissions of SO_2, NO_2, and PM_{10}), number of registered motor vehicles (measured by tractors and trucks density), and city-wise number of crimes per 1000 population have a negative effect on city population agglomerations. On the other hand, accidents per 1000 population, car density and total number of buses have a positive effect on city population agglomerations.

Finally, the study suggests the following policy options for the promotion of urbanization in India by minimizing negative externalities. First, promoting fuel switching vehicles: recently, China jointly with European companies has designed a car which is capable of meeting to revised emissions standards. Another suggestion is that the government should acquire the technology to produce such type of cars in order to control pollution in Indian cities. This apart, there is also a need to provide significant subsidies to adopt electric vehicles in place of gasoline vehicles. Electric vehicles can play a significant role in the years to come in accomplishing the desired levels of environmental protection. Second, scrapping of highly polluting vehicles: Indian class I cities need to adopt this policy to mandate that motor vehicles like cars, jeeps, trucks, etc. and such other vehicles that emit high levels of pollution should be scrapped outright or disallowed to be used. Third, investment in transport sector: there is a need make appropriate investments in the transport infrastructure of the class I cities. Such investments are direly needed if the country is to reduce the traffic jam and accidents and ultimately overcome the negative externalities of urbanization and reaping its positive externalities. Finally, there is a need to promote more eco friendly public transport systems such as bus rapid transit (BRT) system not only to reduce emissions but also reduce traffic jam and accidents. It is finally hoped by giving due consideration to the policies suggested herein, Indian cities will be turn a new leaf in history and morph into engines of economic growth.

Table A1. Name of the Class I cities used in the regression analysis

Agra, Ahmedabad, Allahabad, Amritsar, Aurangabad, Bangalore, Bhopal, Chandigarh, Chennai, Coimbatore, Delhi, Dhanbad, Ghaziabad, Gwalior, Hyderabad, Indore, Jabalpur, Jaipur, Jamshedpur, Jodhpur, Kanpur, Kochi, Kolkata, Kota, Lucknow, Madurai, Meerut, Mumbai, Nagpur, Nashik, Patna, Pune, Raipur, Rajkot, Ranchi, Srinagar, Surat, Tiruchirappalli, Vadodara, Varanasi, Vijayawada, Visakhapatnam.

Source: Authors' compilation.

Figure A1. Appendix Figure 1 for Regression 1.

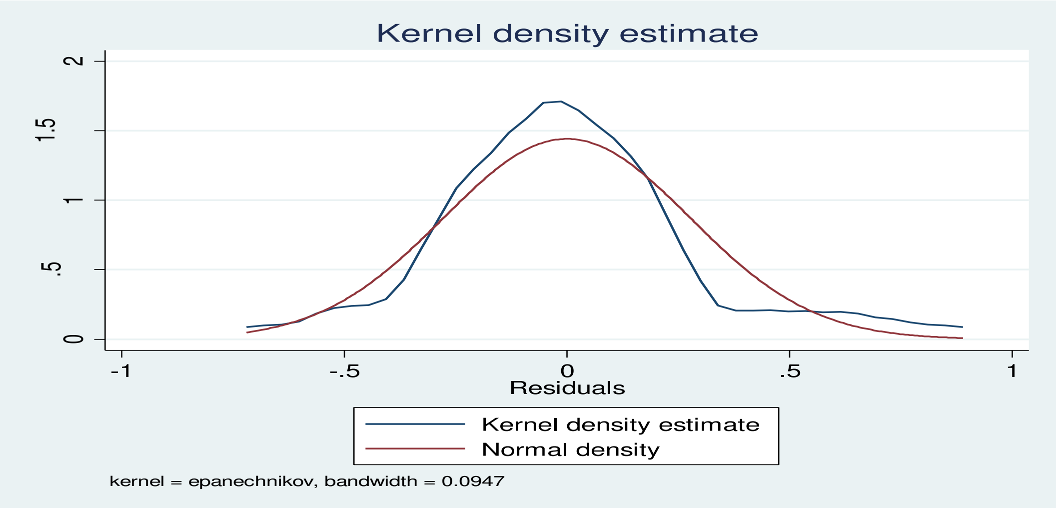


Figure A2. Appendix Figure 2 for Regression 2.

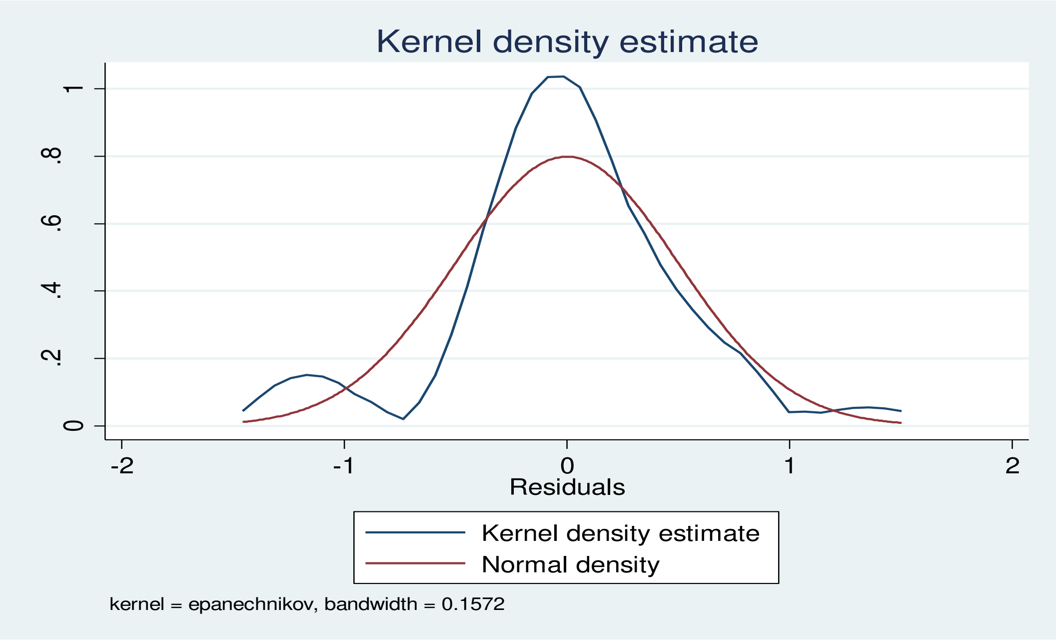
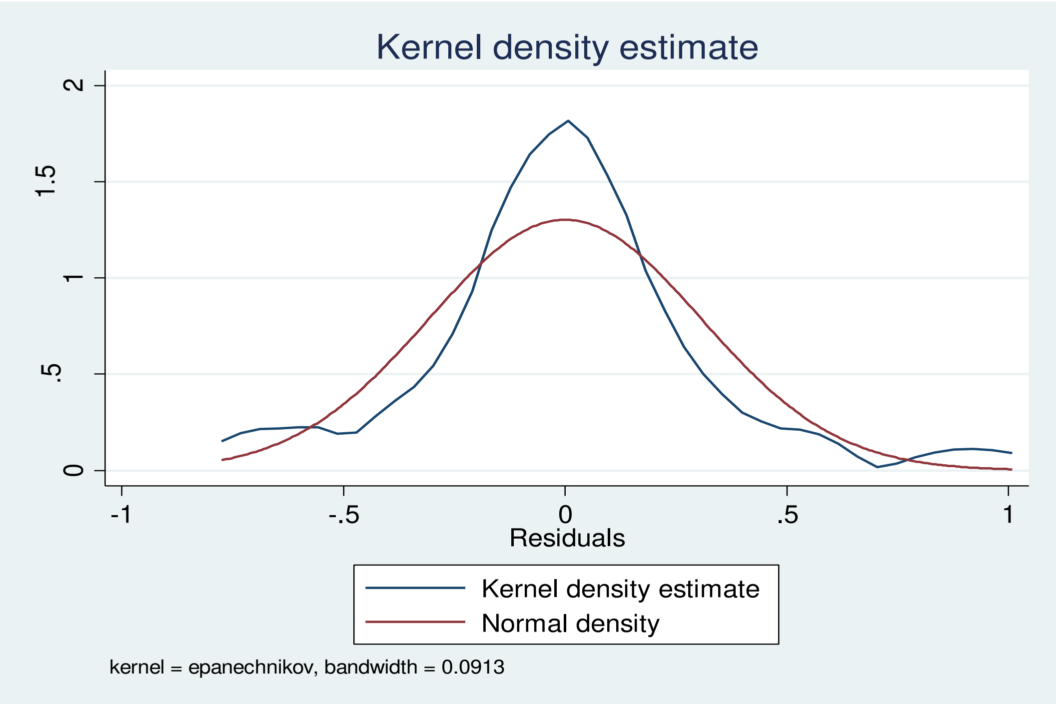


Figure A3. Appendix Figure 3 for Regression 3.



References

Cole, M. A., & Neumayer, E. (2004). Examining the impact of demographic factors on air pollution. *Population and Environment*, *26*(1), 5-21.

Indian Institute for Human Settlements (2012): *Urban India 2011: Evidence*, Bangalore, India, accessed on 5 June 2013 from iihs.co.in/wp-content/uploads/2013/12/IUC-Book.pdf.

Martínez-Zarzoso, I., &Maruotti, A. (2011). The impact of urbanization on CO 2 emissions: evidence from developing countries. *Ecological Economics*,*70* (7), 1344-1353.

Mohan, D., (2004). The road ahead: Traffic injuries and fatalities in India. Transportation research and injury prevention programme. Indian Institute of Technology, Delhi. Available at: http://tripp.iitd.ernet.in/publications/paper/safety/road_ahead.pdf.

Pucher, J., Peng, Z.R., Mittal, N., Zhu, Y., & Korattyswaroopam, N. 2007. Urban transport trends and policies in China and India: impacts of rapid economic growth. *Transport Reviews*, 27(4), 379-410.

Rao, B.V., Ramjee, E.,& Reddy, V.V., (2016). Analysis of increase in vehicle population and its effect on air pollution in Hyderabad: India. *India Journal of Applied Research*, 6 (5), 401-405.

Reddy, B.S., and Balachandra, P. (2012).Dynamics of urban mobility: A comparative analysis of megacities of India. *Transport Policy*, 21, 152- 164.

Sharif, A., & Raza, S. A. (2016). Dynamic relationship between urbanization, energy consumption and environmental degradation in Pakistan: Evidence from structure break testing. *Journal of Management Sciences*, *3*(1), 1-21.

Shahbaz, M., Loganathan, N., Muzaffar, A. T., Ahmed, K., & Jabran, M. A. (2016). How urbanization affects CO_2 emissions in Malaysia? The application of STIRPAT model. *Renewable and Sustainable Energy Reviews*, *57*, 83-93.

Singh, S.K. (2012). Urban transport in India: issues, challenges, and the way forward. European Transport/ TrasportiEuropie (2012). Issue,52 (5), 1-26.

Solanki, M.J., Umrigar, F.S., Zallu, L.B., and Amin, A.A. (2016). Travel Time & Congestion .Analysis under Heterogeneous traffic condition of C.B.D. Area Case Study of Surat-Rajmarg(Chowk Bazar to Delhi Gate). International Journal of Current Engineering and Technology, 6 (4), 1224- 1234.

Sodri, A., & Garniwa, I. (2016). The effect of urbanization on road energy consumption and co_2 emissions in emerging megacity of Jakarta, Indonesia. *Procedia-Social and Behavioral Sciences*, *227*, 728-737.

Sridhar, K.S. (2010). Carbon Emissions, Climate change, and Impacts in India Cities. Indian Infrastructure Report, in India Infrastructure Report2010: Infrastructure Development in a Sustainable Low Carbon Economy: Road Ahead for India, (eds., 3iNetwork),pp.345-354,Oxford University Press: New Delhi, 2010.

Sridhar, K.S. (2016) Costs and benefits of urbanization: The Indian case", ADBI Working Paper series, No. 607, Tokyo. Available at: https://www.adb.org/sities/default/files/publication/204406/adbi-wp607.pdf.

Tripathi, S. (2013). Do large agglomerations lead to economic growth? Evidence from urban India. Review of Urban & Regional Development Studies, *25* (3), 176-200.

Tripathi, S. (2015), Large agglomerations and economic growth in urban India: An application of panel data model, *Urban India* 35: 1, 45- 62.

Trpathi.S., and Mahey, K.(forthcoming). Urbanization and economic growth in Punjab (India): An empirical analysis. Urban Research & Practice, 1-24.

United Nations (2014): *World Urbanization Prospects: The 2014 Revision, Highlights*, New York, United Nations, Population Database, Population Division, Department of Economic and Social Affairs, accessed on 15 June 2014 from http://esa.un.org/unpd/wup/Highlights/WUP2014-Highlights.pdf.