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RELATIONSHIP BETWEEN INFRASTRUCTURE AND POPULATION AGGLOMERATION IN URBAN INDIA: AN EMPIRICAL ASSESSMENT

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Abstract

Deficiency of urban infrastructure facilities is one of the main problems behind the lower rate of urbanization in India. It has also unfavorably affected the realization of the full potential of the urban sector's contribution to national gross domestic product in India. From this perspective, by considering the population in Class I cities (cities with more than 100,000 people), this paper tries to investigate the relevant infrastructure factors that contribute to increase the size of urban populations of large cities in India. Secondly, it assesses the status of class I cities in India as per the availability of different infrastructure facilities and quality of public services. For the entire analysis, the paper uses data pertaining to Census periods 2001 and 2011. The results of the Borda ranking show that bigger cities (e.g., Greater Mumbai, Chennai, Kolkata, Bangalore, and Thiruvananthapuram) have better provision of infrastructure facilities for their urban dwellers than the smaller Class I cities (as per the city population size). On the other hand, ordinary least square regression results show that at the city level, the total number of electricity connections, and the total number of schools, colleges, and universities have a strong positive impact on city population size. Overall estimated results of the regression analysis suggest that improvement of infrastructure facilities may not significantly increase population agglomeration (measured by size, density, and growth rate of city population) in the large cities, but it will substantially improve the potential contribution of the cities to national economic growth in India by improving the ease of living and by facilitating business activities.

Keywords: Infrastructure, Public Services, Agglomeration, Urban India

JEL Classification: R10, H54, 018

Contents

1. INTRODUCTION

The unique feature of India's urbanization is that a major chunk of the urban population is concentrated in class I cities. As of 2011, class I Indian cities (urban centers with populations greater than 100,000) accounted for over 70% of the total urban population, reflecting the "top heavy" pattern of urbanization in India. As per 2011 census data, 31% of India's population living in urban areas contributes to over 63% of India's gross domestic product(GDP).It is expected that India's urban areas will accommodate about 40% of the total population and will contribute around 75% of India's GDP by 2030. In fact, it is anticipated that increasing urbanization in India in the coming decades will play an important role in the structural transformation of the Indian economy and in sustaining the high rate of economic growth (GOI 2011). However, to absorb the higher economic potential, Indian cities and towns need better planning and organization to improve conditions in the years to come. Massive improvement in the physical, institutional, social, and economic infrastructure of the cities is required to fuel development, augment growth, attract investment, and bring about improvement in the quality of life of city dwellers.[1]

Infrastructure-led urban development is one of the main concerns of India's current development policies and programs. Currently, Indian cities and towns lack in quantity and quality of infrastructure and services, and the present availability is much lower than that required by urban households for sustaining urban economic productivity in the future. The Report on Indian Urban Infrastructure and Services (GOI 2011) which deals extensively with this phenomenon has emphasized the importance of delivery of urban public services such as drinking water, sewerage, solid waste management, roads, and street lights for the future sustainable urban development in India. The report also stresses that cities and towns in India must meet the service norms as set out by the Ministry of Urban Development in 2008 to retain/augment the contribution of cities to economic growth. Finally, the report has estimated that Rs 39.2 lakh crore at 2009–2010 prices is required over the 20-year period for this purpose. Of this, the outlay on urban roads accounts for Rs 17.3 lakh crore (or 44%).

Recently, the Government of India has launched several urban development policies and programs to streamline urban infrastructure and service delivery systems, as a part of whichRs98,000 crore (US$ 15,329.26 million) has been allocated to build 100 smart cities in India. The Atal Mission for Rejuvenation and Urban Transformation (AMRUT), has been launched to ensure basic service (such as water supply and sewerage connection, parks, reduction of pollution) delivery to 500 towns and cities in the next 5 years. National Heritage City Development and Augmentation Yojana (HRIDAY) has been launched with a focus on holistic development of the heritage cities in India. Apart from this, Make in India, Swachh Bharat Mission (SBM), Digital India initiative, construction of Museums funded by the Culture Department, and other programs will improve physical and social infrastructure in urban India.

[1] More details about these policies can be found on http://geosmartindia.net/smartcities.html (accessed 12 June 2016)

Table 1: Trends of Patterns of India's Urbanization

	All India Level			Class I Cities		
Census Year	Urban Population (in millions)	Level of Urbanization (%)	No. of Towns	No. of Cities	Volume of Population (in millions)	Share of Country's Total Urban Population
1901	25.85	10.84	1,915	24	6.72	26.00
1911	25.94	10.29	1,864	23	7.13	27.48
1921	28.09	11.18	2,018	29	8.34	29.70
1931	33.46	11.99	2,188	35	10.44	31.20
1941	44.15	13.85	2,392	49	16.88	38.23
1951	62.44	17.29	3,035	76	27.87	44.63
1961	78.94	17.98	2,657	102	40.59	51.42
1971	109.11	19.90	3,081	148	62.45	57.24
1981	159.46	23.34	3,981	218	96.19	60.32
1991	217.55	25.70	4,615	300	141.17	64.89
2001	286.12	27.82	5,161	394	196.48	68.67
2011	377.11	31.16	7,935	468	264.88	70.24

Source: Author's computation by using Census data for various years.

Table 1 presents the trends and pattern of urbanization in India. It can be seen that urban population increased from 25.85 million in 1901 to 377.11 million in 2011. The rate of urbanization also increased steadily—from 10.84% in 1901 to 31.16% in 2011. The number of towns increased from 1,915 to 7,935 during the same period. This is an increase of about 314% in the number of towns. Table 1 also shows that as percentage of urbanization in India is increasing the percentage shares of urban population in class I cities also increasing steadily by increasing its numbers. For instance, while in 1901 the number of class I cities was 24,by 2011 it had increased to 468, which is an increase of about 1,850%.The value of the correlation coefficient between India's total urban population and total urban population living in class I cities is about 98%. Based on this, it can be said that urbanization in India is occurring mainly in and around the class I cities.

Against this backdrop, this paper tries to establish the link between urban infrastructure and urbanization (measured by city population size, city density, and growth rate of city population) in India. It explores the following questions: first, what are the principal infrastructure factors that encourage urban population growth of the large cities in India? Second, what are the positions of the cities as per the availability of different infrastructure factors in India? These two questions will help us to identify the relevant infrastructure factors that encourage population agglomeration and will appraise the present status of the large Indian cities as per the provision of infrastructure facilities. The answers of these two questions will help us to prescribe the best possible policies to overcome the infrastructure challenges for making a vibrant urban India, which will unlock the full economic potential of the large cities in India.

The sample for the study consists of class I cities in India in 2001 and 2011.[2] There are several reasons behind the selection of the Class I cities as units of analysis: first, the main feature of India's urbanization has been the progressive concentration of a huge chunk of population and economic activities in large cities (Kundu 1983). This is

[2] To calculate the Borda ranking of the cities we use two census periods (i.e., 2001 and 2011), but for the regression analysis we use only the latest census data available for 2011.

apparent from the increase in urban population concentration in Class-I cities in recent decades. Secondly, the unavailability of small city-specific data makes it imperative to consider only large cities in India. Thirdly, of the current urban initiatives to promote urbanization in India, such as Smart City Mission in 2015, several policies were mainly designed for the large cities in India.[3] Therefore, the study has chosen Class I cities of India for analysis.

The next section of this paper reviews the main literature, which focuses on urbanization and infrastructure related issues to fill the research gap. Sections 3 and 4 present the methodological approach to empirical estimation and estimated results, respectively. Finally, section 5 highlights the main conclusions and provides policy suggestions.

2. SELECTED REVIEW OF LITERATURE

Generally, infrastructure is defined by relatively permanent and foundational capital investment of a country that facilitates smooth economic activity. It includes administrative, telecommunications, transportation, utilities, education, health care, research and development, and training facilities. In other words, it includes basic buildings, institutions, and facilities or other essential elements that are necessary to sustain and enable economic growth in the economy (Sanchez–Robles 1998; Canning et al. 1994). It plays a key role in our society and constitutes the wheels, if not the engine, of development (Prakash 2005). Infrastructure increases economic productivity, extends degree of specialization (Bougheas et al. 1999; Henderson 1988), lowers production costs (Romer 1987), improves quality of life, alleviates poverty (World Bank 1997), raises international competitiveness, attracts foreign investment, and is helpful in urbanizing the economy (Henderson 2002) as in Pradhan (2007). Barro (1990) explained that infrastructure services reduce technical inefficiencies and financial losses. Goel (2002) argued that an adequate quantity, quality, and reliability of infrastructure are important conditions for overall economic growth. Infrastructure investment generally works through employment multiplier, income multiplier, and investment multiplier. An economy's infrastructure network, broadly speaking, is the very socio-economic climate created by the institutions that serve as conduits of commerce (Pradhan 2007). Thus in the developing countries it is considered as a pace setter and determinant of economic growth and development. It affects economic development through the demand and supply side (Demetriades and Mamuneas 2000). History suggests that the countries that experienced rapid industrialization and urbanization had developed infrastructure first.

Let us discuss the linkage between infrastructure and urbanization in the economy. A classic paper by Tiebout (1956) entitled "A Pure Theory of Local Expenditures" highlighted the factors that influence the choice of a municipality by consumer-voters. The paper argued that the availability and quality of public facilities and services such as schools, municipal golf courses, beaches, parks, police protection, roads, and parking facilities enter into the decision-making process for choosing a municipality. Finally, the paper predicted that consumer-voters would move to a community/municipality/city, which exactly satisfies their preferences. This paper provides a basis for our analysis. Haurin's (1980) model estimated the impact of a favorable climate on city population. The paper found that a relative increase in the climatic differential would induce people to move toward the improved area. Using his

[3] More details about these policies can be found on tjnnurm.nic.in/ and smartcities.gov.in/ (accessed 12 June 2016).

model, Haurin also finds that in equilibrium, average wage rates will vary among regions and compensate for differences in endowments of location-specific attributes. He shows that compensation can also occur through differences in the price of housing, and this result is dependent on the parameters of the model and the manner in which the site-specific factor (climate) affects production and consumption. In summary, the paper found that urban areas better endowed with location-specific attributes attract more population and grow more when compared with areas with less favorable climate.

Asoka et al.(2013) tried to estimate the perspective impacts of population growth on infrastructure and service provision in the Eastleigh neighborhood of Nairobi, Kenya. The paper revealed that 90% of the basic infrastructure and services were negatively impacted by population growth in Eastleigh neighborhood. Over 65% of the neighborhood's population was not satisfied with the availability of two water services within the neighborhood, while 58% of the city residents did not have access to a clean water supply at all.

Shetty (2012) dwells on the importance of infrastructure sector and also the need for Private–Public Partnerships in infrastructure development. The paper highlights the need for greater infrastructure investment and the requisite expertise to manage such investment for building a sustainable future for the country. Planning and building urban infrastructure for the benefit of the society, economy, and environment require both horizontal and vertical integration. India Infrastructure Report 2011 (IDFC 2011) highlights the poor state of affairs in the urban water sector of the country. Inadequate access, poor quality, and poor reliability are the major problems with urban water supply. As estimated by Nair (2012), about 21% of the urban population lives in squatter settlements where access to basic services is extremely poor; about 30% to 50% households do not have sewerage connections and less than 30% of total waste water is treated. Toutain and Gopiprasad (2006) highlight the inadequate urban service provisioning—mainly in terms of drinking water, sanitation, energy, transport, solid waste management, environmental degradation, pollution, etc. Their paper also provides a framework and a set of regulations for urban development by examining the link between urban development and infrastructure provision and ingrates urban infrastructure with various initiatives including those of the private sector. Most importantly, the findings by Urban Infrastructure in India (FICCI 2011) uphold the fact that the present levels of urban infrastructure are grossly inadequate to meet the demand of the existing urban population. Considering the need to provide infrastructure to meet the requirements of urban centers in India, there is a gaping shortfall in the funds available for improving and maintaining basic urban infrastructure.

Most importantly, Pradhan (2007) investigated the impact of infrastructure on urbanization in India. The paper used a composite infrastructure development index which is based on three sub indices, i.e., physical infrastructure development index (transport facility [road and railways], gross irrigated area, per capita consumption of electricity and telecommunication), social infrastructure development index (literacy rate, infant mortality rate, and residential houses), and financial infrastructure development index (credit deposit ratio of nationalized banks, share of state tax revenue in NSDP, and post offices). Finally, the paper, using multivariate principal component analysis (PCA), confirmed that infrastructure has a significant positive impact on urbanization in India.

A brief review of the literature suggests that quantitative analysis of the role of infrastructure in urban population agglomeration is very inadequate in the context of urban India. The present paper tries to fill this research gap by using appropriate techniques and by employing the best possible data available from the Census of India. Most importantly, this paper has attempted to justify Tiebout's (1956) model in an Indian context. It investigates the relevant infrastructure factors that contribute to population concentration in the large cities in India. Since India's urbanization is still lower than that of other developing counties such as the People's Republic of China (PRC), it is important to know which factors contribute to urbanization in India. The basic motive is that if we can increase urbanization through infrastructure development we can achieve higher economic growth as urban agglomerations in India has a strong positive effect on economic growth (Tripathi 2013). The present study is an improvement on the earlier studies in many respects: Firstly, while Pradhan (2007) attempted to measure the effect of infrastructure on urbanization at the all India level or state level, our paper has attempted it at city level using the latest census data from 2011. Secondly, we also use the Borda Rule technique to compare the city level availability of infrastructure facilities, which is completely new in the Indian context.

3. METHODOLOGY

3.1 Use of the Borda Rule to Rank Cities based the Availability of Infrastructure and Provision of Basic Public Services

To compare the city-level availability of infrastructure and basic facilities we employ Borda Rule. The novelty of using this rule is the following: Dasgupta (1993, 2001) used this approach in the context of international comparisons of wellbeing and to see the gender inequality among India states. Therefore we find that this methodology will be perfect to compare the availability of city-level infrastructure facilities as well. In fact, Dasgupta and Weale (1992) used this approach to measure the quality of life in different countries. They have argued that the Borda Rule is simple, hence its strengths and weaknesses transparent and therefore it provides an immediate justification to use it. Following these arguments we use the Borda Rule to compare availability of infrastructure facilities in different Indian cities. It is obvious that the quality of life and wellbeing of city dwellers depend on the availability of urban infrastructure facilities such as health, education, roads, etc.

The Borda Rule offers a method of rank-order scoring. The process involves giving each alternative (i.e., city)a point for its rank in each criterion of ranking, then add each alternative score for obtaining its aggregate score, and finally rank alternatives on the basis of their aggregate scores.[4] Table 2 provides the definitions of the variables that are employed to compute the Borda Rule and for the ranking of cities as per the availability of infrastructural facilities.[5]

[4] See Dasgupta and Weale (1992) for an excellent explanation of the Borda Rule. Noorbakhsh (1998) also used the Borda index to examine the components and structure of the Human Development Index of the United Nations Development Programme (UNDP). The strengths and limitations of the Borda Rule have been investigated by Goodman and Markowitz (1952) and Fine and Fine (1974). The Borda score focuses only on ordinal information. Of Arrow's (1963) classic axioms, the Borda Rule violates the one concerning the independence of irrelevant alternatives.

[5] The study defines variables in such a way that they reflect the availability of infrastructure and public service delivery in a city as much as possible.

Table 2: Detailed Definition of Variables used to Compute Borda Ranking

	Measurement of the Variables	
	2001	2011
Variable	Ranking as per the Ascending Order	
Y_1	The amount of rainfall of a city	
Y_2	The difference between maximum and minimum temperature of city	
Y_3	The road distance to State Head Quarters (HQ) from a city	
Y_4	The road distance to district HQ from a city	
Y_5	The road distance to nearest sub-division from a city	
Y_6	The road distance to nearest city with population of 1 Lakh and more from city	
Y_7	The road distance to nearest the Railway Station from a city	
Y_8	The total road distance to Tahsil from a city	The total road distance to nearest city with population of 5 Lakh and more from a city
	Ranking as per the Descending Order	
Y_9	The total amount of road length in a city	
Y_{10}	The total number of latrines in a city	
Y_{11}	Total water supply capacity in city	
Y_{12}	The total number of electricity connection in a city	
Y_{13}	The total number of hospitals in a city	
Y_{14}	The total number of schools in a city	
Y_{15}	The total number of colleges in a city	
Y_{16}	The total number of universities in a city	
Y_{17}	The total number of people with shorthand skills in a city	
Y_{18}	The total number of working women's hostel in a city	
Y_{19}	The total number of recreational facilities in a city	
Y_{20}	The total number of banks in a city	
Y_{21}	The total number of credit societies in a city	
Y_{22}	The total amount of receipt of a city	The total number of old age home of a city
Y_{23}	The total amount of government expenditure in a city	The total number of orphanage homes in a city

Source: Author's compilation.

3.2 Determinants of Infrastructure and Public Services of Large Cities

To estimate the determinants of populations of urban agglomerations (UA) by considering the infrastructure and public services factors of large cities, the econometric model used here assumes the following regression equation:

$$UA = \alpha_0 + \sum_{i=1}^{23} \alpha_i X_i + e \quad (1)$$

Where e represents the error term and α_0 is a constant. We use an ordinary least square (OLS) model for the estimation of the regression model.

Table 3: Details of the Control Variables used in Equation 1

Abbreviation of Control Variables	Explanation	Expected Sign
X_1	City-level rainfall	–
X_2	City-level difference between maximum and minimum temperature	–
X_3	State HQ road distance from a city	–
X_4	District HQ road distance from a city	–
X_5	Sub-division road distance from a city	–
X_6	Nearest city with population of 1 lakh and more road distance from a city	–
X_7	Nearest city with population of 5 lakh and more from a city	–
X_8	Railway station road distance from a city	–
X_9	City-level total road length	+
X_{10}	City-level total no. of latrines	+
X_{11}	City-level total water supply capacity	+
X_{12}	City wise total no. of electricity connection	+
X_{13}	City-level total no. of hospital	+
X_{14}	City-level total no. of schools	+
X_{15}	City-level total no. of colleges	+
X_{16}	City-level total no. of university	+
X_{17}	City-level total no. of orphanage home	+
X_{18}	City-level total no. of shorthand	+
X_{19}	City-level total number of working women's hostel	+
X_{20}	City-level total number of old age home	+
X_{21}	City-level total number of recreational facilities	+
X_{22}	City-level total number of banks	+
X_{23}	City-level total number of credit society	+

Source: Author.

Following Tripathi (2013), we consider the following three variables to measure urban agglomerations: (1) city population size, (ii) city population growth rate, and (iii) density of city population. To measures infrastructure and quality of basic services we use several variables based on available Census data. Table 3 provides the information of the independent variables used in regression equation 1. The explanatory variables are mainly organized into three major categories, i.e., environmental conditions, spatial interaction, and availability of basic infrastructure facilities. Environmental effect of a city is considered because it may increase in-migration by providing favorable climatic conditions, which actually increases the population concentration in a city (Haurin 1980; Sridhar 2010). This regression model considers city-level rainfall and temperature differences (i.e., maximum – minimum) as the proxy variable to measure the effect of environment on population concentration on towns/cities in India. The assumption here is that higher rainfall and higher temperature differences may affect badly on the city's climatic condition and may reduce population concentration in the cities/towns. On the other hand, the effect of spatial interaction is considered on the assumption that higher distance to a large city may reduce the market potential which accordingly reduces the population of a city (Krugman 1991; Tripathi 2013). To measure spatial interaction, road distance to nearest State headquarters(HQ), District HQ Sub-division, city with Population of 1 Lakh and more, city with population of 5 Lakh and more, railway station from a city are considered. Ades and Glaeser (1995) explained that higher distance to a large/capital city from a city decreases political

power as it discourages government to transfer higher amount of resources to a distant city, which reduces population concentrations of that city. Therefore negative impact is expected from these variables on the role of concentration of city population.

Finally, infrastructure variables are considered for the analysis. Infrastructure has a positive role on the level of urbanization. For instance, Pradhan (2007) confirmed the significant role of infrastructure in determining the level of urbanization. The paper considers data on city/town level infrastructure variables as available from the latest Census data in 2011, such as basic infrastructure facilities (i.e., city wise total road length, latrines, water supply, electricity connection, and hospital), educational infrastructure (city-level total number of schools, colleges, universities, and shorthand institutes), financial infrastructures (i.e., city-level total number of banks and credit society) and other important infrastructure facilities (i.e., city-level total number of working women's hostel, old-age home, recreational facilities, and orphanage home) for analysis on the assumption that all these variables indeed have a positive effect on urbanization in India. Among the different infrastructure variables we consider total number of shorthand institution as learning shorthand is also a special type of skill, which increases chance of getting job and higher salary. Therefore, we include this variable in the infrastructure facilities as it provides skill as other educational institutes. In addition to that working women hostel, old-age home, recreational facilities and orphanage home have been considered as these infrastructure facilities attracts more people to a city. For example, working women hostel helps women workers to continue their work with safety and lower living cost in a new urban location which increase the urbanization rate. A complete list of variables and their measurements are given in Appendix Table 1.

4. EMPIRICAL RESULTS

4.1 Discussion of Results Computed using Borda Ranking

In this section we summarize the results obtained from the Borda Ranking for comparing city-level infrastructure facilities. Table 4 provides the classification of cities based on the calculated ranks as per the Borda Rules. The large cities are arranged as per their Borda ranks. To compute Borda ranks of the large cities, summative ranks of the cities based on 23 variables are arranged in ascending order. This indicates that the lowest value of the summative ranks is given highest rank, i.e., score 1, and the highest value of the summative ranks is given the lowest rank, i.e., score 447 (or 507). Table 4 lists the names of the 20 top cities and 20 inferior cities as per the provision of infrastructure facilities. The table also presents the names of the states where the cities are located. The ranking ranges from the best (score of 1–Greater Mumbai in 2001 and Bruhat Bengaluru Mahanagara Palike in 2011) to the worst (score 447–KirariSuleman Nagar located in Delhi State in 2001, and score 507–Dabgram located in the state of West Bengal in 2011). This indicates that the city dwellers in Greater Mumbai and Bruhat Bengaluru Mahanagara Palike (or Kirari Suleman Nagar and Dabgram) are enjoying the best (or worst) infrastructure facility and provision of public services.

The results show that the five best performing cities are Chennai, Kolkata, Bangalore, Thiruvananthapuram, and Ahmedabad as of 2001.The five highest-ranking cities are Chennai, Greater Mumbai, Greater Hyderabad Municipal Corporation (GHMC), Thiruvananthapuram, and Mysore as of 2011. In contrast, the five lowest performing/ranking cities are Dallo Pura, Deoli, Mango, Sultan PurMajra, and Bhalswa Jahangir Puras of 2001. The five lowest ranking cities are Mandoli,Navi Mumbai Panvel Raigarh (NMPR), Mustafabad, Bhiwadi, and Khoraas of 2011. The results also show that out of 20 best ranking cities 9 (or 10) cities in 2001 (or 2011) are the state capitals. This indicates that state capitals have better infrastructure facilities and provision of quality of public services than non-capital cities. Most importantly, results show that the highest ranked cities are located in the states of Maharashtra, Gujarat, Madhya Pradesh, Andhra Pradesh, and Karnataka. The worst performing cities are located in the states/UT of Delhi, Uttar Pradesh, Jharkhand, and West Bengal.

Table 4: Rank of the Class I Cities based on Accessibility of Infrastructure Facilities in India

Rank	City	State/Union Territory	Rank	City	State/Union Territory
		2011			
1	BBMP*	Karnataka	489	Karawal Nagar	Delhi NCT
2	Chennai*	Tamil Nadu	490	Shikohabad	Uttar Pradesh
3	Greater Mumbai*	Maharashtra	491		
4	GHMC*	Andhra Pradesh	492	Santipur	West Bengal
5	Thiruvanan–thapuram*	Kerala	493	Baraut	Uttar Pradesh
6	Mysore	Karnataka	494	Kirarisuleman Nagar	Delhi NCT
7	Guwahati*	Assam	495	Deoli	Delhi NCT
8	Indore	Madhya pradesh	496	Chandausi	Uttar Pradesh
9	Warangal	Andhra Pradesh	497	Burari	Delhi NCT
10	Lucknow*	Uttar Pradesh	498	Akbarpur	Uttar Pradesh
11	Ahmadabad	Gujarat	499	Sultan PurMajra	Delhi NCT
12	Pune	Maharashtra	500	Puruliya	West Bengal
13	Dehradun	Uttarakhand	501	GokalPur	Delhi NCT
14	Mangalore	Karnataka	502	Greater Noida	Uttar Pradesh
15	Chandigarh*	Chandigarh	503	Mandoli	Delhi
16	Bhopal*	Madhya Pradesh	504	NMPR	Maharashtra
17	Vadodara	Gujarat	505	Mustafabad	Delhi NCT
18	Hubli–Dharwad	Karnataka	506	Bhiwadi	Rajasthan
19	GVMC	Andhra Pradesh	507	Khora	Uttar Pradesh
20	Delhi Municipal corporation (Urban)*	Delhi	508	Dabgram	West Bengal

continued on next page

Table 4 *continued*

Rank	City	State/Union Territory	Rank	City	State/Union Territory
		2011			
1	BBMP*	Karnataka	489	Karawal Nagar	Delhi NCT
2	Chennai*	Tamil Nadu	490	Shikohabad	Uttar Pradesh
3	Greater Mumbai*	Maharashtra	491		
4	GHMC*	Andhra Pradesh	492	Santipur	West Bengal
5	Thiruvanan–thapuram*	Kerala	493	Baraut	Uttar Pradesh
6	Mysore	Karnataka	494	Kirarisuleman Nagar	Delhi NCT
7	Guwahati*	Assam	495	Deoli	Delhi NCT
8	Indore	Madhya pradesh	496	Chandausi	Uttar Pradesh
9	Warangal	Andhra Pradesh	497	Burari	Delhi NCT
10	Lucknow*	Uttar Pradesh	498	Akbarpur	Uttar Pradesh
11	Ahmadabad	Gujarat	499	Sultan PurMajra	Delhi NCT
12	Pune	Maharashtra	500	Puruliya	West Bengal
13	Dehradun	Uttarakhand	501	GokalPur	Delhi NCT
14	Mangalore	Karnataka	502	Greater Noida	Uttar Pradesh
15	Chandigarh*	Chandigarh	503	Mandoli	Delhi
16	Bhopal*	Madhya Pradesh	504	NMPR	Maharashtra
17	Vadodara	Gujarat	505	Mustafabad	Delhi NCT
18	Hubli–Dharwad	Karnataka	506	Bhiwadi	Rajasthan
19	GVMC	Andhra Pradesh	507	Khora	Uttar Pradesh
20	Delhi Municipal corporation (Urban)*	Delhi	508	Dabgram	West Bengal

Note: 1: * represents State capital city; BBMP = Bruhat Bengaluru Mahanagara Palike; GHMC = Greater Hyderabad Municipal Corporation; GVMC = Greater Visakhapatnam Municipal Corporation; KSN = Kirari Suleman Nagar; NMPR = Navi Mumbai Panvel Raigarh.

2: Though Table 1 presents 394 (or 468) Class I cities in 2001 (or 2011) by using Census data, but for the analysis we have considered 447 (or 508) Class I cities in 2001 (or 2011) using data from Town Directory, which is part of a Census publication exclusively on cities and towns in India. Town directory provides data for more cities/towns than Census of India. For example, Census of India considers National Capital Territory (NCT) of Delhi (i.e., Delhi UA (Urban Agglomeration) as a one UA, whereas, Town directory provides data for 113cities/towns (namely, Dallo Pura, Delhi Cantonment, etc.) by diving Delhi UA. We consider Town Directory data as it represents true picture of the different parts of NCT of Delhi than at aggregate level. However, all UAs, which are considered for the analysis are having population more than one lakh (i.e, with more than 100,000 populations or Class I cities).

Source: Author.

The table also shows that 10 cities—Ahmedabad, Bangalore, Bhopal, Chennai, Greater Mumbai, Hyderabad, Indore, Pune, Thiruvananthapuram, and Vadodara—were the best 20 ranking cities (as per the availability of best infrastructure facilities and provision of infrastructure facilities) both in 2001 and 2011.On the other hand, Aurangabad, Bhubaneswar, Guntur, Jabalpur, Jaipur, Kolkata, Kozhikode, Nagpur, Raipur, and Surat were listed under the 20 best ranking cities in 2001 but lost their position in 2011. In contrast, Chandigarh, Dehradun, Delhi Municipal Corporation (Urban), Guwahati, Greater Visakhapatnam Municipal Corporation(GVMC), Hubli–Dharwad, Lucknow, Mangalore, Mysore, and Warangal cities were not listed under the 20 best ranking cities in 2001 but gained ranks in 2011. This indicates that these cities have been providing the best infrastructure facilities in recent years.

Table 5: Rank Correlation Coefficient (Spearman)

	Rank Based on Borda Rule			Rank Based on Borda Rule	
Variable	**2001**	**2011**	**Variable**	**2001**	**2011**
Y_1	0.054	0.2773***	Y_{13}	0.645***	0.67***
Y_2	0.167***	0.1939***	Y_{14}	0.755***	0.761***
Y_3	–0.155***	–0.0263	Y_{15}	0.427***	0.583***
Y_4	0.499***	0.4931***	Y_{16}	0.608***	0.661***
Y_5	0.468***	0.4307***	Y_{17}	0.597***	0.71***
Y_6	–0.083*	0.1368***	Y_{18}	0.729***	0.762***
Y_7	0.312***	0.3116***	Y_{19}	0.818***	0.802***
Y_8	0.667***	0.6880***	Y_{20}	0.579***	0.576***
Y_9	0.552***	0.7228***	Y_{21}	0.393***	0.641***
Y_{10}	0.541***	0.4988***	Y_{22}	0.606***	0.044
Y_{11}	0.757***	0.7983***	Y_{23}	0.607***	0.706***
Y_{12}	0.583***	0.5275***			

Note: *** (or *) indicates statistical significance at 1% (or10%) level.

Variable definitions are given in table 2.

Source: Author.

The rank correlation coefficient was computed to measure the relationship between the individual ranks of large agglomerations as per the 23 variables and rank of agglomerations based on the Borda Rules. Table 5 presents the computed Spearman's correlation coefficients. It shows that the correlation coefficients are positive and statistically significant(except regarding ranking of cities as per the road distance to State Headquarters (HQ) from a city in 2011 and the total number of old-age homes in a city). The results specify that the rank of cities as per the different variables (such as, ranking of cities as per the difference between maximum and minimum temperature of the city, the road distance to district HQ from a city, the road distance to the nearest sub-division from a city, the road distance to nearest the Railway Station from a city, etc.) is closer to the rank of cities based on the Borda ranking.

This clearly shows that if a city achieves a higher rank based on the individual variables, it also achieves a higher rank based on the Borda Rules. Most importantly, Appendix Figure 1 indicates a 69% negative correlation between the log of city population and the value of total Borda score. This implies that bigger cities (defined by higher city population) have higher infrastructure and quality of public service facilities than smaller cities. However, there is a reverse relationship between city population density and the value of the total Borda score (r^2 is 0.19) in Appendix Figure 2. A similar relationship (as r^2 is 0.04) is also observed between city the population growth rate and the value of total Borda score in Appendix Figure 3.This indicates that the cities with higher levels of density and higher population growth rates have lower infrastructure facilities (i.e., a higher value of the Borda score).

4.2 Estimated Regression Results: Determinants Population of Class I Cities

4.2.1 Data

We now move on to investigate the determinants of large city populations by considering different infrastructure facilities by employing an OLS model. Appendix I summarizes the definitions and descriptive statistics of data used in equation 1. Table 6 presents the descriptive statistics of the variables. The high values of coefficient of variance (CV) for city-level total number of working women's hostel, railway station road distance from a city, city-level water supply capacity, sub-division road distance from a city, and total number of credit society indicate a greater variability relative to the mean in these variables. In contrast, road distance to the nearest city with population of 5 lakh and more, road distance to state HQ, city-level average rainfall, and city-level difference between maximum and minimum temperature, etc., show a lower spread of data in these variables.

Table 6: Description of Data used in the Regression Equation

Variable	Mean	Standard Deviation	Minimum	Maximum	Coefficients of Variation
Total city population (TCP) in Lakh	4.3	9.9	1	110	230.2
City population growth rate (CPGR) from 2001 to 2011	24	28	–60	340	116.7
City density (CD)	8,478	7,015	679	67,594	82.7
City rain fall in millimeter (CR)	977	542	11	3508	55.5
Difference between maximum and minimum temperature (MNT)	30	10	0	49	33.3
State HQ road distance (in kms.) (SHQ)	251	189	0	998	75.3
District HQ road distance (in kms.) (DHQ)	13	24	0	120	184.6
Sub-division road distance (in kms.) (SDR)	1	5	0	45	500.0
Road distance to nearest city with population of 0.1 million and more (in kms.) (CP1)	36	69	0	1,190	191.7
Road distance to nearest city with population of 5 lakh and more (in kms.) (CP5)	106	105	0	1,190	99.1
Road distance to nearest railway station road distance (in kms)(RSD)	6	61	0	1,190	1,016.7
Total road length (in kms.) (TRL)	490	16,96	2	29,939	346.1
Total no. of latrines (TL)	73,284	183,752	14	2,063,946	250.7
Total water supply capacity (in lakh kilo-liters) (TWSC)	0.7	4.7	0.0	86.3	671.4
Total no. of electricity connection (TEC) in lakh	1.2	2.8	0.0	27.0	233.3
Total no. of hospitals (TH)	90	311	2	5014	345.6
Total no. of schools (TS)	339	723	9	8397	213.3
Total no. of colleges (TC)	25	45	1	532	180.0
Total no. of universities (TU)	1	2	0	18	200.0
Total no. of orphanage homes (TOH)	2	5	0	66	250.0
Total no. of short hands (TNS)	44	95	0	1,007	215.9
Total no. of working women's hostels (TWH)	21	346	0	7,005	1,647.6
Total no. of old age homes (TOGH)	1	3	0	32	300.0
Total no. of recreational facilities (TRF)	41	76	0	630	185.4
Total no. of banks (TB)	69	219	2	2247	317.4
Total no. of credit societies(TCS)	92	394	0	5193	428.3

Source: Calculated by Author by using 508 observations.

Table 7 presents the correlation coefficients of the variables. The computed values of the correlation coefficients (r^2) explain that the size of city population is positively linked with the total number of toilets (i.e., r^2 is 0.92), the total number of electricity connections (i.e., r^2 is 0.94), the total number of schools (i.e., r^2 is 0.90), and the total number of banks (i.e., r^2 is .87). In contrast, a city's total population size is negatively correlated with state HQ road distance from a city (i.e., r^2 is –0.14), road distance to district HQ from a city (i.e., r^2 is –0.12), road distance to nearest city with population of 0.1 million and more from a city (i.e., r^2 is –0.03), and nearest city with population of 1 lakh and more from a city (i.e., r^2 is 0.12). Higher values of r^2 show some problem of multicollinearity. Therefore, to avoid this problem the study has chosen right specification of the model, which considers dropping of the high collinear regression variables.

Table 7: Correlation Coefficients of Determinants of Population of Agglomerations in India

	TCP	CPGR	CD	CR	MNT	SHQ	DHQ	SDR	CP1	CP5	RSD	TRL	TL
TCP	1.00												
CPGR	0.04	1.00											
CD	0.09	–0.03	1.00										
CR	0.05	–0.04	–0.09	1.00									
MNT	0.04	0.12	0.01	–0.15	1.00								
SHQ	–0.14	–0.08	–0.15	0.05	0.02	1.00							
DHQ	–0.12	0.05	–0.08	–0.07	–0.10	0.05	1.00						
SDR	0.00	0.14	0.17	–0.07	0.01	–0.08	0.21	1.00					
CP1	–0.03	0.03	–0.10	0.05	0.13	0.06	–0.08	–0.09	1.00				
CP5	–0.12	0.03	–0.22	0.11	0.02	0.21	–0.05	–0.20	0.54	1.00			
RSD	–0.03	–0.02	–0.01	0.17	–0.10	–0.06	–0.02	0.00	0.77	0.50	1.00		
TRL	0.75	0.01	0.06	–0.02	0.04	–0.09	–0.09	0.03	–0.02	–0.08	–0.02	1.00	
TL	0.92	0.08	0.08	0.04	–0.01	–0.12	–0.11	–0.01	–0.05	–0.12	–0.03	0.77	1.00
TWSC	0.10	0.03	–0.02	0.00	0.02	–0.11	–0.06	–0.03	–0.04	–0.04	0.00	0.06	0.11
TEC	0.94	0.06	0.08	0.05	0.02	–0.12	–0.13	–0.03	–0.04	–0.13	–0.02	0.72	0.94
TH	0.38	–0.06	0.01	0.04	0.02	–0.10	–0.09	0.00	–0.04	–0.04	–0.02	0.40	0.33
TS	0.90	0.03	0.06	0.00	0.07	–0.10	–0.13	–0.03	0.01	–0.06	–0.02	0.73	0.85
TC	0.76	0.03	–0.02	0.00	0.08	–0.04	–0.16	–0.08	0.02	–0.03	–0.03	0.67	0.77
TU	0.56	0.04	0.00	0.02	0.02	–0.12	–0.17	–0.10	0.01	0.00	–0.02	0.27	0.59
TOH	0.66	0.04	0.00	0.10	–0.10	–0.04	–0.09	–0.06	–0.03	–0.06	0.00	0.70	0.72
TNS	0.47	0.04	–0.03	0.08	–0.03	–0.05	–0.12	–0.11	0.00	–0.03	–0.01	0.27	0.51
TWH	0.40	0.12	0.01	–0.01	0.00	–0.06	–0.03	–0.02	–0.02	–0.04	–0.01	0.33	0.52
TOGH	0.56	0.03	0.00	0.10	–0.12	–0.09	–0.05	–0.06	–0.07	–0.12	–0.02	0.54	0.63
TRF	0.61	0.01	0.01	0.09	–0.08	–0.01	–0.10	–0.07	0.03	–0.05	0.01	0.41	0.63
TB	0.87	0.01	0.07	0.10	–0.01	–0.15	–0.12	–0.03	–0.05	–0.11	–0.03	0.66	0.83
TCS	0.30	0.00	0.02	–0.01	0.04	0.10	–0.09	–0.06	0.03	–0.01	–0.01	0.23	0.29

	TWSC	TEC	TH	TS	TC	TU	TOH	TNS	TWH	TOGH	TRF	TB	TCS
TCP													
CPGR													
CD													
CR													
MNT													
SHQ													
DHQ													
SDR													
CP1													
CP5													
RSD													
TRL													
TL													

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Table 7 *continued*

	TWSC	TEC	TH	TS	TC	TU	TOH	TNS	TWH	TOGH	TRF	TB	TCS
TWSC	1.00												
TEC	0.10	1.00											
TH	0.12	0.35	1.00										
TS	0.09	0.87	0.33	1.00									
TC	0.10	0.75	0.34	0.83	1.00								
TU	0.09	0.61	0.22	0.61	0.57	1.00							
TOH	0.05	0.67	0.33	0.66	0.65	0.46	1.00						
TNS	0.08	0.49	0.11	0.50	0.53	0.49	0.43	1.00					
TWH	0.08	0.46	0.03	0.53	0.52	0.38	0.39	0.48	1.00				
TOGH	0.04	0.57	0.29	0.49	0.52	0.38	0.70	0.26	0.15	1.00			
TRF	0.07	0.60	0.22	0.55	0.55	0.53	0.59	0.58	0.25	0.50	1.00		
TB	0.09	0.85	0.30	0.80	0.65	0.51	0.55	0.38	0.38	0.49	0.49	1.00	
TCS	0.01	0.32	0.10	0.32	0.38	0.25	0.37	0.36	0.02	0.10	0.40	0.29	1.00

Note: See Table 3 for variable definitions. The correlation coefficients are based on 508 observations.
Source: Author.

4.2.2 Results of Estimation: Determinants of Population of Large Urban Agglomerations

Finally, this section presents the estimated results for finding the determinants of population of large agglomerations in India. Table 8 presents the regressions results of equation 1. Regression models 1–3 consider city population size as the dependent variable. Regressions 4–5 consider city population density and Regression 6 considers population growth as the dependent variable. Regressions 1, 4, and 6 show the estimates of the full regression model by considering all the variables. Regressions 2, 3, and 5employ results of parsimonious models excluding explanatory variables that do not show statistical significance or match with the expected sign conditions of the regression parameters. The results of regressions 1–6 in the study provide the best fit models in terms of predicted signs, significance level of the variables, and goodness of fit of the regressions, according to the variables available. To get rid of heteroskedasticity and multi-collinearity problems we use robust standard errors and variance inflation factor (VIF).The overall models for Regression 1–6 are statistically significant as we have found significant values of F statistics. Regressions 1–5 explain a better percentage of total variation in the dependent variable as $R^2$and R^2adjusted values are high. Finally, lower VIF values (i.e., less than 10) do not give rise to the multicollinearity problem.

We now explain the regression results based on impact of different independent variables on the dependent variables. Regressions 4 and 5 show that city-level average rainfall has a negatively significant effect (at 5% level) on city population density. A 10% rise in average rainfall reduces city population density by 13%. The result runs against the expected sign. Nonetheless, average rainfall does not have any statistically significant effect on size of population and growth rate of city population. Difference between maximum and minimum temperatures has a positive (as predicted) and statistically significant effect on city population size and growth rate of city population. But it does not show any significant effect on density of city population. Distance to state headquarters (HQ) from a city has a statistically significant and negative (as predicted) effect on the city population size/density/growth rate. In particular, a 1% increase in distance to state HQ from a city decreases city population (or city population density or city population growth rate) by 99% (or 3.69% or 0.02%), as in regression model 1 (or 5 or 6). This result supports our expected hypothesis.

Table 8: Determinants of Large City Population Agglomeration
(measured by size, density, and growth rate of city populations)

	Size of City Population in 2011		
	(1)	(2)	(3)
City rainfall	22.9	26.824	
	(18.06)	(28.46)	
Difference between maximum and minimum temperature	1,704.85**	2,779.27***	
	(746.54)	(903.81)	
State HQ road distance	–99.63**	–93.05*	
	(43.21)	(48.35)	
District HQ road distance	415.14*		
	(211.46)		
Sub-division road distance	3,441.63**		
	(1,444.32)		
Road distance to nearest city with population of 1 lakh and more	151.425		–524.32*
	(156.54)		(305.08)
Road distance to nearest city with population of 5 lakh and more	–106.528	–190.66**	
	(89.84)	(93.7)	
Railway station road distance	–128.671		357.15
	(188.83)		(353.52)
Total road length	–21.043		288.71***
	(49.11)		(44.83)
Total number of latrines	1.87***	2.22***	
	(0.597)	(0.767)	
Total water supply capacity	0.002		0.043
	(0.011)		(0.048)
Total number of electricity connection	1.052***		
	(0.44)		
Total number of hospital	81.737		
	(75.38)		
Total number of schools	478.43***	468.67***	
	(179.29)	(132.16)	
Total number of colleges	903.29		4,935.83***
	(1223.7)		(1,269.97)
Total number of university	–38,605.530		14,0436.8***
	(30,279.16)		(38,036.01)
Total number of orphanage home	5,729.014		–8,624.16
	(6,150.13)		(13,218.66)
Total number of shorthand	125.11		915.62*
	(173.84)		(505.75)
Total number of working women's hostel	–491.68***		
	113.66		
Total number of old age home	–22,150.68*		27,382.41
	(11,622.15)		(14,039.54)
Total number of recreational facilities	590.241	580.16	
	(475.24)	(457.18)	
Total number of banks	606.764	988.48*	
	(442.94)	(528.51)	
Total number of credit society	–156.53**		45.25
	(77.65)		(97.19)
Intercept	–59,378.88	–32,280.07	57,232.04***
	(35,992.23)	(35,384.85)	(20,558.39)
R^2	0.9439	0.9162	0.7398
Adjusted R^2	0.9439	0.9149	0.7345
F statistics	13,964.7***	51.78***	184.02***
Mean VIF	3.6	2.44	2.24
No. of observations	508	508	508

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Table 8 *continued*

	Density of City Population in 2011		City Population Growth Rate from 2001 to 2011
	(4)	(5)	(6)
City rainfall	–1.36**	–1.307**	0.001
	(0.537)	(0.536)	(0.003)
Difference between maximum and minimum temperature	22.71		0.302**
	(28.03)		(0.118)
State HQ road distance	–3.45	–3.69*	–0.016**
	(2.17)	(2.08)	(0.007)
District HQ road distance	–47.49***	–44.78***	0.046
	(13.17)	(12.51)	(0.052)
Sub-division road distance	190.94*	208.47**	0.85*
	(98.06)	(97.66)	(0.464)
Road distance to nearest city with population of 1 lakh and more	–24.3***		0.053
	(6.66)		(0.027)
Road distance to nearest city with population of 5 lakh and more	–16.63***	–19.26***	0.033
	(3.82)	(3.99)	(0.02)
Railway station road distance	38.08***	17.91***	–0.083***
	(8.05)	(4.51)	(0.031)
Total road length	–0.057		–0.003***
	(0.37)		(0.001)
Total number of latrines	0.01	0.012***	0.001
	(0.006)	(0.003)	(0.001)
Total water supply capacity	–0.001***	–0.001***	0.001
	(0.000)	(0.000)	(0.001)
Total number of electricity connection	0.001		0.001
	(0.004)		(0.001)
Total number of hospital	–0.27		–0.005
	(0.545)		(0.004)
Total number of schools	2.15**		–0.005
	(0.957)		(0.004)
Total number of colleges	–41.94***	–32.91***	–0.029
	(12.81)	(9.95)	(0.058)
Total number of university	–162.12		–0.544
	(331.79)		(1.101)
Total number of orphanage home	–118.9		0.351
	(109.86)		(0.497)
Total number of shorthand	–6.61**	–6.09**	–0.002
	(3.15)	(3.08)	(0.013)
Total number of working women's hostel	0.128		0.010**
	(0.771)		(0.004)
Total number of old age home	–73.69		0.469
	(171.15)		(1.093)
Total number of recreational facilities	1.29	–1.23	–0.020
	(4.89)	(4.82)	(0.018)
Total number of banks	–3.04		–0.013
	(2.69)		(0.009)
Total number of credit society	1.73**	1.27**	0.003*
	(0.67)	(0.502)	(0.003)
Intercept	13,555.5	13,896.47***	9.917
	(1,438.06)	(1,341.85)	(5.094)
R^2	0.135	0.1212	0.098
Adjusted R^2	0.094	0.098	0.055
F statistics	6.17***	5.4***	40.17***
Mean VIF	3.6	1.69	3.60
No. of observations	508	508	508

HQ = headquarters.

Note: Figures in parentheses are robust standard errors. *** (or ** or *) indicate statistical significance at the 1% (or 5% or 10%) level, respectively.

Source: The results are estimated by using Equation 1.

Distance to district HQ from a city negatively and significantly affects the density of city population, although it significantly and positively affects the size of city population. These results oppose each other and run against the expected sign conditions. Surprisingly, it has no statistically significant effect on the growth rate of city populations. Road distance to sub-division from a city has a positive and significant effect on city population size, city population density, and city population growth rate. The results run against the expected sign. The road distance to the nearest city with population of 1 lakh and more and the nearest city with population of 5 lakh and more has an unfavorable and significant effect (as predicted) on city population size and density of city population. The results indicate that proximity to large cities tends to increase the size of city population and city population density, which implies the existence of market and scale economies. The finding supports the results of previous research (Krugman 1991; Sridhar 2010; Tripathi 2013). Nonetheless, these variables have no statistically significant effect on growth rate of city population. Road distance to nearest railway station from a city has a negative (as predicted) and statistically significant effect on the city population growth rate. A 100% increase in road distance to the nearest railway station from a city tends to decrease the city population growth rate by 8.3%. It has a positive and significant effect on city population density but no impact on city population size. Total road length has a positive (or negative) impact on city population size (or city population growth rate).The results contradict each other. Surprisingly, total road length has no statistically significant impact on city population density. Most importantly, city-level total number of latrines has a positive impact on city size population and city population density. The coefficient 2.22 (or 0.012) in regression model 2 (or 5) implies that a 10% increase in the total number of latrines increases city population (or density) by 22% (or 0.12%). Total supply of water has a negative statistically significant (at 1% level) effect on city population density. It runs against the expected sign of the coefficient. However, it does not have any effect on city size population. The total number of electricity connections has a positive and statistically significant effect (as predicted) on city size/population; a 10%% increase in the total number of electricity connection increases city size/population by about 11%. However, it has no impact on city population density. The total number of schools also has a positive and significant effect on size and density of city population.

The total numbers of colleges has a positive (or negative) statistically significant effect on city size population (or density of city population). The results contradict each other. The total number of universities has a positive and significant effect on the size of the city population. But it does not have any effect on population of city density. Total numbers of shorthand have a positive (or negative) statistically significant effect on city size/population (or density of city population). The results contradict each other. The total numbers of working women hostels have a negative (or positive) statistically significant effect on city size/population (growth rate of city population). The results contradict each other. But it has no impact on city population density. The total numbers of old-age homes also have a statistically significant effect on city size population. Surprisingly, it has no impact on city population density. Most importantly, the total number of banks has a statistically significant (at 10%) positive (as predicted) effect on city size population. It has no impact on city population density. Finally, although the total number of credit societies has a negative and significant effect on the size of the city population, it has a statistically significant effect on the density and growth rate of the city population. This result is in line with the expected hypothesis. The estimated results show that the total number of hospitals and the total number of orphanage homes has no significant effect on the size, density, and growth rate of the city population. In contrast, the total number of toilets, total water supply capacity, total number of schools, total number of colleges, total number of universities, total number

of people with shorthand skills, total number of old age homes, and total number of banks have no statistically significant effect on the city population growth rate.

5. MAJOR CONCLUSIONS AND POLICY IMPLICATIONS

The present study investigates the following two important topics: First, using the Borda Rules the conditions of the Class I cities in India in 2001 and 2011in terms of their provision of infrastructure facilities and quality of public services are established. Secondly, using the OLS method, it explores the relevant economic determinants of city population agglomerations based on availability of infrastructure facilities and basic public services. Finally, it proposes the best policy options to facilitate infrastructure-led urban development in India.

The analysis shows that the urban population has increased steadily over the recent decades, which is evidenced by an increase in the share of the urban population and an increase in the numbers of towns and cities in India. The growing share of the urban population is mainly concentrated in and around Class I cities in India. In 2011, Class I cities accommodated about 70% of the total urban population, which implies a "Top Heavy" model of India's urbanization pattern.

The computed Borda rankings show that Greater Mumbai, Chennai, Kolkata, Bangalore, Thiruvananthapuram, Greater Mumbai, Ahmedabad, GHMC, Thiruvananthapuram, and Mysore in 2001 had better availability of infrastructure facilities for their urban dwellers. The results show that bigger cities (defined as such by higher levels of population) enjoy higher infrastructure and quality of public service facilities than smaller cities. However, a reverse relationship is seen between city population density (or city population growth rate) and availability of infrastructure facilities in the cities.

OLS regression results suggest that the difference between maximum and minimum temperatures has a negative effect on size and growth rate of city population. State HQ road distance from a city has a negative effect on size, density, and growth rates of city populations. The distance to the railway station from a city has a positive effect on urban agglomeration as measured by city population density. The total number of latrines has a favorable effect on size and density of city population. Most importantly, the total number of electricity connections, and the total number of schools, colleges, and universities has a positive effect on city size/population.

In the context of water supply, the Report on Indian Urban Infrastructure and Services (GOI 2011) found that 64% of the urban population in India is covered by individual connections and stand posts. The corresponding figure for the PRC is 91%, for South Africa 86%, and for Brazil 80%. The duration of water supply in Indian cities ranges from 1 hour to 6 hours compared with 24 hours in Brazil and the PRC and 22 hours in Viet Nam. Out of the 5161 cities/towns in India, 4,861 do not have even a partial sewerage network and 18% of urban households do not have access to any form of latrine facility and defecate in the open. Public transport accounts for only 22% of urban transport in India compared with 49% in the Philippines and 40% in South Africa and Brazil.[6] The question then arises as to why these facilities are very sparse in urban India. Inadequate investment in urban infrastructure is one of the main reasons behind

[6] The data is originally from the Report on Indian Urban Infrastructure and Services (2011) while the discussion is mainly based on information available from http://financingcities.ifmr.co.in/blog/2013/01/31/summary-of-report-on-indian-urban-infrastructure-and-services-2011-part-i/ (accessed 12 June 2016).

the poor quality of infrastructure and public provision of service delivery in urban India. Other, equally important, reasons are poor maintenance of assets, fragmented institutional set up, and capacity constraints. Very importantly, Mohanty et al. (2007) showed that for 35 municipal corporations, there was, on average, under-spending of 76% on capital investments necessary to meet minimum standards of services.

Finally, we suggest that infrastructure facilities and public service provision are essential for increasing population agglomerations, which will lead to higher economic growth in India. We also support the current policies and program, which are considered by the present government of India to facilitate infrastructure and lead urban development in India. There has been a recent slowdown in the growth rate of population in million-plus cities (53 cities in 2011) in India. For example, Greater Mumbai UA, which had seen 30.47% population growth from 1991–2001, has recorded 12.05% during 2001–2011. Similarly, population growth in Delhi UA (from 52.24% to 26.69% in 2001–2011) and Kolkata UA (from 19.60% to 6.87% in 2001–2011) have also slowed down considerably. This is also evidenced by the regression analysis as many infrastructure variables show a negative effect of population agglomerations. Therefore, the paper suggests that improvement in infrastructure facilities may not significantly increase population agglomeration (measured by size, density and growth rate of city population) in the large cities, but it will substantially improve the potential contribution of the cities to India's economic growth by improving ease of living and ease of doing business.

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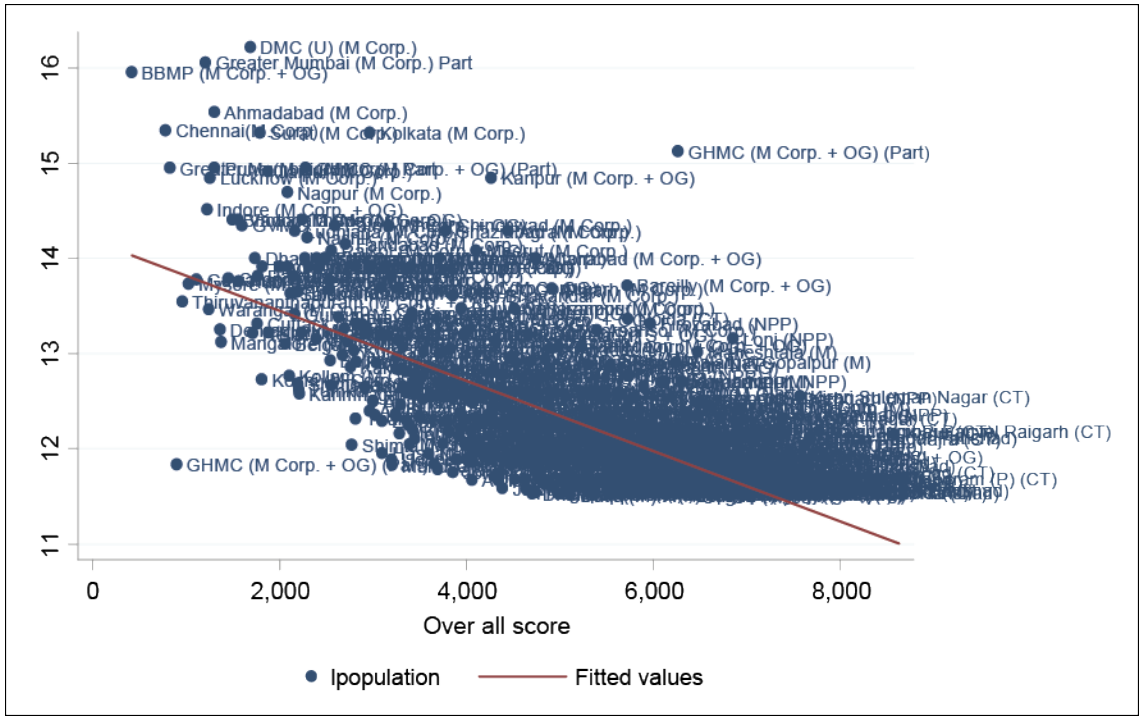
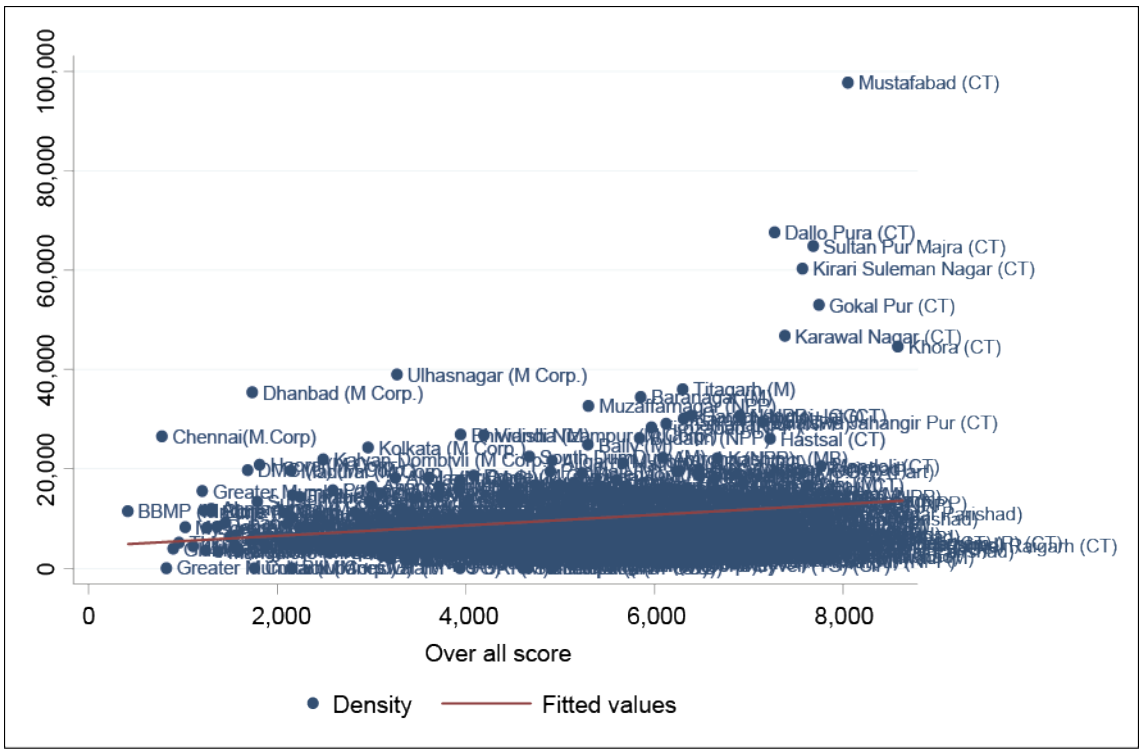
APPENDIX

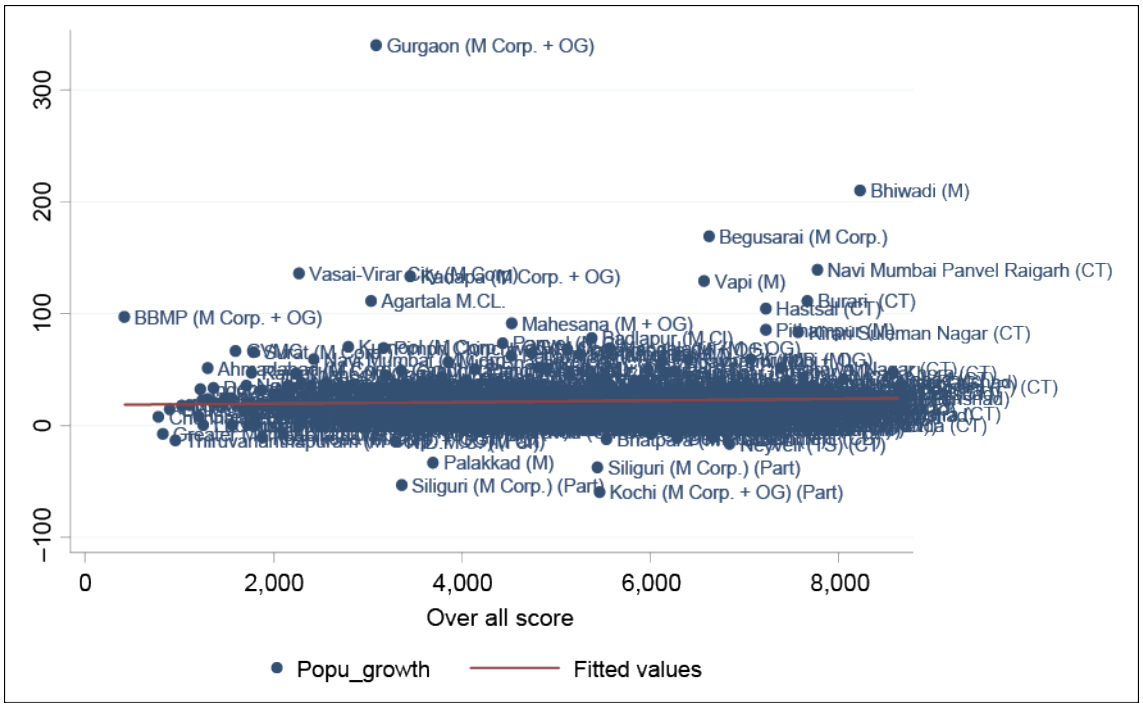
Appendix Figure 1: Relationship between Log of City Population and Value of Borda Score in 2011



Appendix Figure 2: Relationship between City Population Density and Value of Borda Score in 2011



Appendix Figure 3: Relationship between City Population Growth Rate and Value of Borda Score in 2011



Appendix Table 1: Variable Definitions used in Calculation of Borda Ranking and Regression Analysis

Srl. No.	Name of the Variable	Variable Definition	
		2001	2011
1	Rainfall (in Millimeters)	Average Rainfall	
2	Temperature (in Centigrade)	Difference between Average Maximum temperature and Average Minimum temperature	
3	State Head Quarters	The State HQ Road Distance from a city	
4	District Head Quarters	The district HQ Road Distance from a city	
5	Sub-Division Head Quarters	The Sub-Division Head Quarters Road Distance from a city	The Sub-division/Taluk/Tahsil/Police Station/ Development Block/Island HQ Road Distance (in kilometers) Road Distance from a city
6	Tahsil/Taluk/Mandal/ PS/Development Block/Island Head Quarter	The Tahsil/Taluk/Mandal/PS/ Development Block/Island Head Quarter Road Distance from a city	NA separately
7	Nearest City (Having 1 Lakh and Above population)	Road distance to Nearest City with 1 Lakh and more population (in kilometers)	
8	Railway Station distance	Railway Station Road Distance (in kms)	
9	Total Receipt	City-level total Receipt through taxes Etc. + Loan + Advance + Government Grant + Revenue derived from Municipal properties and power apart from taxation + Other sources	NA

continued on next page

Appendix Table 1 *continued*

Srl. No.	Name of the Variable	Variable Definition	
		2001	2011
10	Total Expenditure	City-level total expenditure through general Administration+ Public Safety +Public Health and Convenience + Public Works + Public Institutions +Others (Specify)	NA
11	Total Road	City-level total Kachcha Road length (in km.) + Pucca Road length (in km.)	
12	Number of Latrines (umbers)	City-level total number Water Borne + Service + Others latrines	City wise total number Pit + Flush/Pour + Service + Others latrines
13	Total water supply	City-level total Protected Water supply (Capacity in Kilo-liters).	
14	Electrification (Number of Connections)	City-level Total number of connection by Domestic + Industrial + Commercial + Road Lighting (Points) + Others	City–wise Total number of Electricity–Domestic Connection + Electricity–Industrial Connection + Electricity–Commercial Connection +Electricity–Road Lighting Connection + Electricity–Others Connection
15	Medical facilities (Numbers)	City-level Total Number of Hospital + Number of Dispensary + Number of Health Centre + Number of Family Welfare Centre + Number of TB Clinics + Number of Nursing Home + Number of Other Medical Institutions	City-level total number of Hospital Allopathic + Hospital Alternative Medicine + Dispensary/Health Centre + Family Welfare Centre (Numbers) + Maternity and Child Welfare Centre + Maternity Home + T.B. Hospital/ Clinic + Nursing Home
16	Number of colleges (Numbers)	City wise Number of Arts College + Number of science Collage + Number of Commerce College + Number of Arts & science Collage + Number of Arts & Commerce College + Number of Arts, Science & Commerce College + Number of Law College + Number of any Other College of Degree Level or Above + Number of Medical College + Number of Engineering College + Number of polytechnics	City-level total number of Govt. Degree College-Art + Private Degree College-Art Only + Govt. Degree College-Science Only + Private Degree College-Science Only + Govt. Degree College-Commerce Only + Private Degree College-Commerce Only + Govt. Degree College-Art and Science Only + Private Degree College-Art and Science Only + Govt. Degree College-Art and Commerce Only + Private Degree College-Art and Commerce Only + Govt. Degree College-Art, Science and Commerce + Private Degree College-Art, Science and Commerce + Govt. Degree College-Law + Govt. Degree College-Others + Private Degree College-Others + Govt.-Medical College + Private-Medical College +Govt.-Engineering College + Private-Engineering College +Govt.-Management Institute + Private-Management Institute + Govt.-Polytechnic + Private-Polytechnic
17	Total university (Numbers)	City-level total number of universities	City wise total number of Govt. Degree College-University +Private Degree College-University
18	Total number of shorthand	City-level total number of Recognized shorthand, Typewriting & Vocational training Institutions	City-level total number of private-Shorthand + Govt.-Typewriting + Private-Typewriting +Govt.-Shorthand and Typewriting + Private-Shorthand and Typewriting + Govt.-MS Office + Govt.-Desk Top Publishing + Private-Desk Top Publishing + Govt.-vocational + Private-Vocational(Others) + Govt.-Non Formal Education + Private-Non Formal Education + Govt.-Special School for Disabled + Govt. + Private-Others

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Appendix Table 1 *continued*

Srl. No.	Name of the Variable	Variable Definition	
		2001	2011
19	Number of schools (Numbers)	City-level total number of higher Secondary/Intermediate etc. + secondary/Matriculation + Middle/Junior secondary + Primary + Number of Adult Literacy Centers	City-level total Govt. Primary + Private Primary + Govt. Middle + Private Middle + Govt. Secondary + Private Secondary + Govt. Senior Secondary + Private Senior Secondary School
20	Working Women's Hostels (Numbers)	City wise total Number of women's Hostels	City wise total number of Govt.-Working Women's Hostel + Private-Working Women's Hostel
21	Number of Recreational and Cultural facilities (Numbers)	City-level number of Recreational and Cultural facilities + Stadium +Cinema + Auditorium/Drama/Community Halls + Public Libraries + Reading Rooms	City-level total number of Govt.-Stadium + Private-Stadium + Govt.-Cinema Theatre + Private-Cinema Theatre + Govt.-Auditorium/Community Hall + Private-Auditorium/Community Hall + Govt.-Public Library + Private-Public Library + Govt.-Public Reading Room + Private-Public Reading Room
22	Banks (Numbers)	City wise total number of Banks	City wise total number of nationalized Bank + Private Commercial Bank +Co-operative Bank
23	Credit Society (Numbers)	City wise total Agricultural Credit Societies + Non-Agricultural Credit Societies	
24	Orphanage Home (Numbers)	NA	City wise total number of Govt.-Orphanage Home + Private-Orphanage Home
25	Old Age Home (Numbers)	NA	City wise total number of Govt.-Old Age Home + Private-Old Age Home (Numbers)
26	Nearest City with Population of 5 Lakh and more Road Distance (in Kilometers)	NA	Nearest City with Population of 5 Lakh and more Road Distance (in kilometers)

NA = not available.

Note: Data are sourced from Town directory, various period of Census of India, GoI.

Source: Author's compilation.