Chapter 11
Impact of Economic Development on Regional Structure of Urban Systems in India

Bhawan S. Dahiya

Abstract India is a large country with a very long history of urbanization. The urban systems in India have developed in response to its political economy. Most studies do not consider change at the macro level. The present work studies the growth and evolution of Indian urban systems with an emphasis to include all urban places with more than 20,000 population at national and macroregional levels for a 100-year period and to relate the urban size change with economic development in each macro region. As such this study has the following three objectives: first, it examines the characteristics of urbanization trends as a background to the development of urban systems; second, it measures the rank–size and primacy distribution at national and macroregional levels for a 100-year period, that is, 1901–2001; and third, it evaluates the evolving urban system with economic development. This research has several interesting implications for theory. The present research has contributed to our understanding of the changing structure and behavior of the national and macroregional urban systems in India, through successive time periods during the past century.

Keywords Economic development • Primate city • Urban agglomerations • Urban system • Urbanization • Zipf's rank–size

11.1 Nature of the Problem

The Indian urban system is complex and diverse. It covers a diversified culture and economy, which is reflected in the system itself and particularly in the distribution of its urban places by size. The urban system has developed in response to its political economy. However, a regularity in the distribution of urban places over space as well as in the size and number of urban places can be discernible, and they are indicative of an integrated urban system. However, none of the studies in India except those of Thakur (1980) covers changes at the macro level in the spatial distribution of towns in urban systems for about a 100-year period. Conversely, studies

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by Raza and Habeeb (1976), Habeeb (1981), and Alam (1980) consider longitudinal analysis of urban systems of about a 100-year period. They have analyzed the evolution of the urban system and found distortions in the urban system as a result of the policy adopted during colonial rule to concentrate investments and high-order administrative and political functions in a few large urban centers. Alam (1980) states a condition of hypertrophy, and Raza and Habeeb (1976) contend that this prevents the formation of regional urban systems. Das and Dutt (1993) and Dutt et al. (1994) also cover longitudinal analysis of urban systems of about a 100-year period focusing on rank–size distribution and primate city characteristics in India. Their analysis focuses on historical change in city-size distribution in India at both national and regional levels since 1911, selecting urban areas of only class I cities. India's national urban system has been found to be gradually moving toward Zipf's rank–size distribution, and primate cities have persisted in three macro regions in India. However, if the urban settlement system is disaggregated and examined at the macro level, three distinct rank–size distributions can be identified: (1) primate city distribution, (2) log-normal city-size distribution, and (3) decentralized or polynucleated distribution (Alam 1980). Thus, the belief that urban places are related to each other in some orderly fashion of formation with a system is the basis for the postulation of rank–size rule. This is an investigative hypothesis, a theoretical model or a norm to express a relationship after observed empirical regularity in city size: it provides a discernible pattern in the size distribution of urban places of a region and, hence, it is used as a standard for measuring and explaining the structure and evolution of an urban system. Rank–size distribution is indicative of political unity, economic development, and an integrated urban system, but primate city-size distribution is indicative of political unity, underdevelopment, and imbalance in the distribution of urban places. Thus, a longitudinal study of the growth and evolution of urban systems is imperative, and such studies may lead to better understanding of the structure and behavior of urban systems and ultimately to the formulation of a much-needed dynamic urban place theory.

The present work studies the growth and evolution of Indian urban systems with an emphasis to include all urban places above 20,000 in population at national and macroregional levels for a 100-year period and then to relate the urban size change with economic development in each macro region.

11.2 Objectives of Study

Very few studies of national city size as well as regional-level distribution over a long period of time have included the application of rigorous statistical techniques. Therefore, the objectives of this study are, first, to attempt to examine the characteristics of urbanization trends as a background to the development of urban systems; second, to measure the rank–size and primacy distribution at national and macroregional levels for a 100-year period, that is, 1901–2001; and, last, to relate the evolving urban system with economic development.

11.3 Study Area

India is a large country with a very long history of urbanization. The vast landscape of urban settlements in India provides a laboratory for the study of the complex structure of urban systems. In terms of absolute number of urban settlements and size of urban population, India is possibly the largest urbanized nation in the world today. India's urban population in 2001 was about 285.4 million, and India's recognized urban settlements, numbering 5,161 in 2001, are at various stages of technological and cultural modernization with a remarkable unevenness of development among different regions. The present urban hierarchy, both administrative and economic, and interdependence among cities and towns that have led to the formation of the present Indian urban system is rooted in the British colonial era. The urban system has been found to be highly distorted, dominated by large metropolitan centers such as Mumbai in the west, Kolkata in the east, Delhi in the north, and Chennai in the south. For historical reasons, an urban system has evolved around these four distinct metropolises. The southern region depicts a higher urbanization level with Chennai as the major city, followed by Bangalore, Vishakhapatnam, Coimbatore, Mysore, etc. The western region also has a high level of urbanization, with Mumbai as the major city, followed by Hyderabad, Ahmedabad, Nagpur, and Pune. The eastern region, with Kolkata as its primate city, is quite marked. Kolkata's history of urbanization dates back to the beginning of colonial power when it was selected as the capital for administrative, military, and commercial activities. These activities have proved the initial impetus for its growth, making it the most industrialized metropolis of the country. Delhi has been the dominant city in the northern region since 1951, followed by Kanpur, Jaipur, Lucknow, Ludhiana, Agra, Meerut, Faridabad, Allahabad, and Amritsar. Thus, it is quite evident that the study area includes four macroregional urban systems under which the Indian economic and urban space is structured and has developed over the years. These systems are in the process of becoming integrated and interlinked. The limits of the spatial extent of the four macro regions have not been static over the years because during the past century Delhi's growth has been remarkable, followed by that of Mumbai, Kolkata, and Chennai.

11.4 Review of Literature

Two theories are significant in understanding urban systems: hierarchical and nonhierarchical. The central place theory envisages a hierarchical structure of settlements in a meso-region; this is essentially a normative deduction theory and introduces the idea of a discrete hierarchy of settlements; on the other hand, the primate city and rank–size rule are nonhierarchical theories, both of which are rooted in the empirical inductive approach. The rank–size rule covers the entire settlement system, whereas the primate city concept focuses only on the leading

city. The rank–size rule is essentially an economic rather than a sociological theory of settlement structure (Ramachandran 1989, 203).

Credit goes to Zipf (1949) for laying out a strong theoretical logic to the rank–size rule. His rank–size rule emphasizes the regularity in city-size distribution, whereas the primate city concept emphasizes the abnormally large size of the premier city in different regions or nations of the world. In any region or country there are always a few large settlements (cities) and a large number of smaller settlements (towns). In other words, the number of settlements in any region is inversely proportional to the size of the settlements. Zipf explicated the concept within a broad context of a general theory of human behavior and attributed the rank–size regularity to the balancing forces of unification and diversification. The forces of unification result in the emergence of a few large settlements, while the forces of diversification produce a large number of settlements, which are small in size. When plotted from largest to the smallest, the second-ranked city is half the size of the first, the third ranked city is one third the size of the first, the *n*th ranked one is 1/*n*th of the size of the first, and so on, depicting a harmonic progression of cities within the urban hierarchy.

Beckman (1958) pointed out that by the addition of a random element, the discrete steps of the hierarchy could be blurred with a continuous size distribution. Berry (1961) recognized three kinds of city-size distribution: lognormal, primate, and intermediate type. The log-normal distribution appears as a straight line on a logarithmic normal probability graph. A marked gap between the leading city and smaller cities suggests primate type and the intermediate a traditional one. Berry suggests a possible trend of movement of city-size distribution from primate to log normal over time. However, Curry (1964) is the first to attempt a comprehensive formulation of the organizational features of urban systems in terms of cybernetics. Both Berry and Curry argue that rank–size distribution is the result of an entropy maximizing process. Nevertheless, Berry is not always clear and consistent in this respect; he fails to make use of this concept. Curry, on the other hand, is unable to define explicitly how order comes with existence in urban systems (Curry 1964, p. 145). Simon (1955) suggests that log-normal distributions are produced as limiting cases by the stochastic growth process based on the notion of a general systems theory. According to Simon, the rank–size distribution is simply an average condition of a steady state of the system, that is, a condition of entropy. Taking the theoretical log normality postulated by Zipf, an attempt has been made in this research to measure the entropy of the city-size distribution pattern of India at both national and macroregional levels.

Stewart (1958) opined that rank–size rule, although in many cases a reasonable approximation to the actual distribution of towns by size, has no logical basis. It breaks down in many areas at both extremes. The rule is a better description of reality for large heterogeneous areas than for small homogeneous areas.

In the Indian context, there are a few studies that invite attention. Reddy (1969) found feeble urban rank–size regularity in the Krishna and Godavari deltas. In other words, log normality is not in evidence in any outstanding degree. Even in India, it is not present except for the cities of population more than 1 lakh (0.1 million). It

has been asserted by Ahmad (1965) that rank–size relationship holds well in the case of 1-lakh cities in India for 1951 and 1961. Thus, the most important implication of the absence of rank–size relationships at the national level is that we do not have an integrated system of settlements at the national level (Ramachandran 1989, p. 202). In a large and diverse country such as India, this is to be expected. However, the absence of rank–size relationships at the national level is supported by the fact that the urban settlements in many states conform to the rank–size rule and that primacy exists in at least 13 of the 25 states (Ramachandran 1989). Dayal and Thakur (1982) found that in spite of the physical and economic differences in the Bihar plain and Chhotanagpur Plateau, the system characteristics displayed by these two regional urban systems were broadly similar during 1872–1971. The study of rank–size relationship has indicated a trend toward regularity and orderliness in both systems dominated by Patna in the Bihar plain and Jamshedpur-Ranchi in the Chhotanagpur Plateau. The position of primacy has not changed in the Bihar plain, although the position of the largest city in the Chhotanagpur has changed through the years.

Das and Dutt (1993), in their studies on rank–size distribution and primate city characteristics in India, highlighted that India's national urban system is gradually evolving toward Zipf's rank–size distribution. However, primate cities have persisted in three of the four macro regions in India. In other words, over the years, the force of unification is becoming stronger relatve to the force of diversification. Rank–size distribution represents the condition of maximum entropy or randomness, but it has not been proven. The analysis is also made for only class I cities for the period 1911–1990. The population of cities for 1990 were estimated by the Town and Country Planning Organization. Because India is a very large country and has a quasi-federal political structure, which means that much political and economic power lies with the states, it is not expected that primate cities will develop at the national and macroregional levels. Therefore, it is pertinent to ask the question as to what happens to the regional-level primacy as well as rank–size over the years. In other words, four points emerge: (1) national and regional level analysis, (2) inclusion of all urban settlements, (3) entropy analysis of evolving urban system, and (4) explication of politicoeconomic forces affecting the evolving urban system.

11.5 Data Source

The main purpose of the present study has been to delimit a macroregional system boundary, to analyze the change in rank–size and primacy at national and regional levels, and to relate the change with economic development at the macroregional level. To accomplish this task, data have been collected mainly from Census of India publications. The urban size distribution has been studied for the following time periods: 1901, 1911, 1921, 1931, 1941, 1951, 1961, 1971, 1981, 1991, and 2001. Urban areas having populations of at least 20,000 have been taken into account,

which has precluded the collection of field data. The early-published census records have been the primary source of data for the number of urban places for each specific point in time. The census records provide population data of all urban places on a consistent basis at intervals of 10 years. However, there is confusion and ambiguity regarding the definition of urban places. The definition of town has varied since 1872; however, since 1901 the definition has been satisfactory. A standard and rigorous definition of town was ultimately laid down in the census of 1951, and the 1961 and 1971 censuses have adopted urban agglomeration and standard urban area. In this study, each urban agglomeration has been considered as a separate urban place, as has been published by the Census of India (Series I, Part II-A-ii: A Series, Table A-4, 'Towns and Urban Agglomerations').

Data on economic development in the form of Index of Levels of Economic Development—1980 and 1993, and Index of Levels of Development of Infrastructure—2000 have been collected from the 'Profiles of Districts,' 1980, 1983, and 2000, published by Center for Monitoring Indian Economy (CMIE), Mumbai.

11.6 Methods

The following procedures have been used to analyze data and present them statistically and cartographically:

1. In determining the boundary of Mumbai, Kolkata, Delhi, and Chennai urban systems for 1901, 1911, 1921, 1931, 1941, 1951, 1961, 1971, 1981, 1991, and 2001, a gravity potential model has been applied.
2. The primacy index has been calculated as the ratio between the populations of the premier city and that of the second-ranking city. However, the primacy index of the settlement system has been ascertained by dividing the actual population of the first-ranking city by its expected population (P_1), which has been derived considering the total urban population and the number of urban centers, following the formula suggested by Browning and Gibbs (1961, pp. 441–442) as follows:

$$P_1 = \frac{\sum P}{\sum 1/R}$$

where $\sum P$ is the sum of the population of urban centers and $\sum 1/R$ is the sum of the reciprocal of the ranks.
3. Urban places at the national and macroregional level have been arranged according to population size from the largest to the smallest and ranked as 1, 2, 3, …. n. The logarithmic progression of city-size distribution has been plotted on a graph as log-rank on the x-axis and log-population on the y-axis. The same has been compared with respective regression line and its expected rank–size regularity for the given total urban population and number of urban centers in the system.

The expected population of each urban place has been calculated by dividing the expected population of the premier city (P_1) by its respective rank.

An overall index of deviation between the actual and the expected size has been determined and expressed as a percentage to the total urban population of the region. The amount of population that has to be reshuffled for rank–size regularity has been derived by the following formula (Browning and Gibbs 1961, pp. 441–442):

$$\frac{\sum d/2}{\sum P_e} \times 100$$

where d is the difference between the actual and expected population and P_e is the expected population. The results obtained by the foregoing calculations have been further tested by Spearman rank correlation coefficient (rho, ρ), which measures the correlation between the ranks of the actual population and the ranks of the deviations of the actual population from the expected population and gives further statistical support to the conclusions. It is a measure of the correlation, which requires that both variables be measured at least on the ordinal scale so that objects or individuals can be ranked in two ordered series (Thakur 1976, pp. 18–28). The rho value has been calculated by the following formula (Smith 1975, p. 247):

$$\text{Rho or } r_s = 1 - \frac{6\text{Sd}^2}{n\left(n^2 - 1\right)}$$

where Sd^2 = sum of the squared difference of rank for all the individuals, n = total number of individuals, and r_s = correlation coefficient.

4. Taking the theoretical log-normality postulated by Zipf as given, the entropy of the city-size distribution pattern has been calculated. The entropy measure indicates the degree of deviation of the existing pattern from log normal. The procedure of calculations is as follows (Shannon 1948):

   (i) Let n be the number of urban centers of the existing system. Each urban center i consists of a fraction of the total urban population of the system, which is denoted as y_i ($y_i > 0$ and $i = 1, 2, \ldots, n$). It is obvious that

   $$\sum_{i=1}^{n} Y_i = 1 \tag{11.1}$$

   (ii) As the distribution of the city size is an outcome of a simple probabilistic process, entropy, H_R, of the system can be calculated such that

   $$H_R = -\sum_{i=1}^{n} y_i \log_2 y_i \tag{11.2}$$

where y_i is the probability of a given number of people occurring in an urban center i ($i = 1, 2, \ldots, n$), expressed as a fraction of the total urban population. H_R is simply the entropy of the urban population shares of the system. When the shares of all the urban centers within the system are equal, i.e., when $y_i = 1/n$, ($i = 1, 2, \ldots n$), a complete homogeneity is reached and $H_R = H_{max} = \log_n n$.

When all the y_i are zero, except one, which is unity, a minimum entropy occurs, $H_R = H_{min} = 0$, as there is only one urban center within the system. These are the two extreme theoretical states of the equilibrium of the city-size distribution system.

(iii) According to the theoretical rank–size rule, the urban population shares are in the form of a sequence of ratios, such as

$$P_R : P_R / 2 : P_R / 3 : \ldots\ldots : P_R / n$$

where P_R is the population of the largest urban center and n is the number of the total urban centers. The entropy of this theoretical system, HL, has also been calculated by means of Eq. 11.2 provided, for comparison purpose, the total number of urban centers and the total urban population are correspondent to the existing pattern and the shares within the theoretical system follow the foregoing sequence of ratios. In this theoretical system, the probability density function of each size class of urban centers is the same, and it represents an average state of equilibrium, i.e. state of log normality. Obviously $H_{min} < H_L < H_{max}$ and $H_L/H_{max} = \text{Cos } 45° = 0.7071$.

(iv) A ratio of the entropy measures of the existing pattern to the theoretical log-normal pattern has been calculated such that

$$R_R = H_R / H_L$$

when the two measures are alike, $R_R = 1$, the existing system is of a lognormal distribution. If $R_R < 1$, the greater is the tendency toward primate distribution. On the other hand, if $R_R > 1$, the greater is the tendency toward a distribution in which the medium-size urban centers dominate.

(v) To compare the R_R ratios over time, the trend of movement of the city-size distribution pattern of the systems has been traced.

5. The decadal and the interregional differences in the levels of economic development have been analyzed through cartographic techniques, frequency distribution of districts according to the levels of economic development, coefficient of variation, and chi-square value at 1 % significance level.
6. The impact of economic development on regional structure of urban settlement systems has been highlighted with the help of comparison among the parameters of primacy, rank-size distribution on the one hand and the coefficient of variation and average levels of economic development at national and macroregional levels on the other.

11.7 Findings

The major findings of the study can be summarized under the following headings.

11.7.1 Trends and Patterns of Urbanization in the Twentieth Century

The past century, particularly the post-Independence period, registered a tremendous growth of urbanization in terms of percentage of urban population to the total population, density of urban population per square kilometers, and number of towns as well as size of towns. However, the urban systems of the four macro regions have revealed significantly different trends and patterns in this regard. It has been observed that through the successive time periods the Delhi region has expanded toward Kolkata as well as Mumbai, and Mumbai is encroaching the Kolkata and Chennai regions, whereas Kolkata has annexed a small part of northeastern Andhra Pradesh, which was earlier in the Chennai region (Fig. 11.1).

The density of urban population per square kilometer has increased from 5.4 in 1901 to 93.4 in 2001 (excluding Jammu & Kashmir and Assam). Among the four macro regions, the Chennai region maintained the highest density of urban population throughout the past century, while the Kolkata region remained at the bottom line. From 1901 to 1951 and again in 2001, the Delhi region moved above the national average, whereas the Mumbai region has registered higher than national average since 1961. At the end of the past century, that is, in 2001, the Mumbai region has exceeded the Delhi region by a slender margin (Table 11.1).

When compared on the basis of density of towns and urban agglomerations per 1,000 km^2, it is found that India has reached the benchmark of at least one (1.2) per 1,000 km^2 in 1991 as against only 0.24 in 1901. In 2001, all the four regions attained this benchmark. In 1901, Delhi had the highest density of towns (0.46) followed by Chennai (0.24), Mumbai (0.21), and Kolkata (0.14). in 1961, Chennai surpassed Delhi and in 2001 Chennai recorded 2.5 towns per 1,000 km^2, followed by Delhi (1.6), Kolkata (1.11), and Mumbai (1.07). Consequently, the average area of dominance per town has decreased. It is found that in 2001 the average area of dominance in India, Chennai, Delhi, Kolkata, and Mumbai was 15.04, 11.32, 14.14, 16.93, and 17.24, respectively; the corresponding figures in 1901 were 36.53, 36.36, 26.30, 47.13, and 38.46 (Table 11.2).

Thus, it can be concluded that all the macro regions have grown in terms of both number and size of towns. Chennai has grown relatively more in terms of number of towns whereas Mumbai has grown more in terms of size of towns, particularly large cities. This statement is further corroborated by the figures of average size of towns. In 1901, the average size of towns and agglomerations were 31,831, 31,793, 19,992, 15,997, and 22,843 in the regions of Chennai, Kolkata, Mumbai, Delhi and India, respectively; by 2001, the corresponding figures have increased to 58,492, 60,088, 89,571, 59,392, and 66,394.

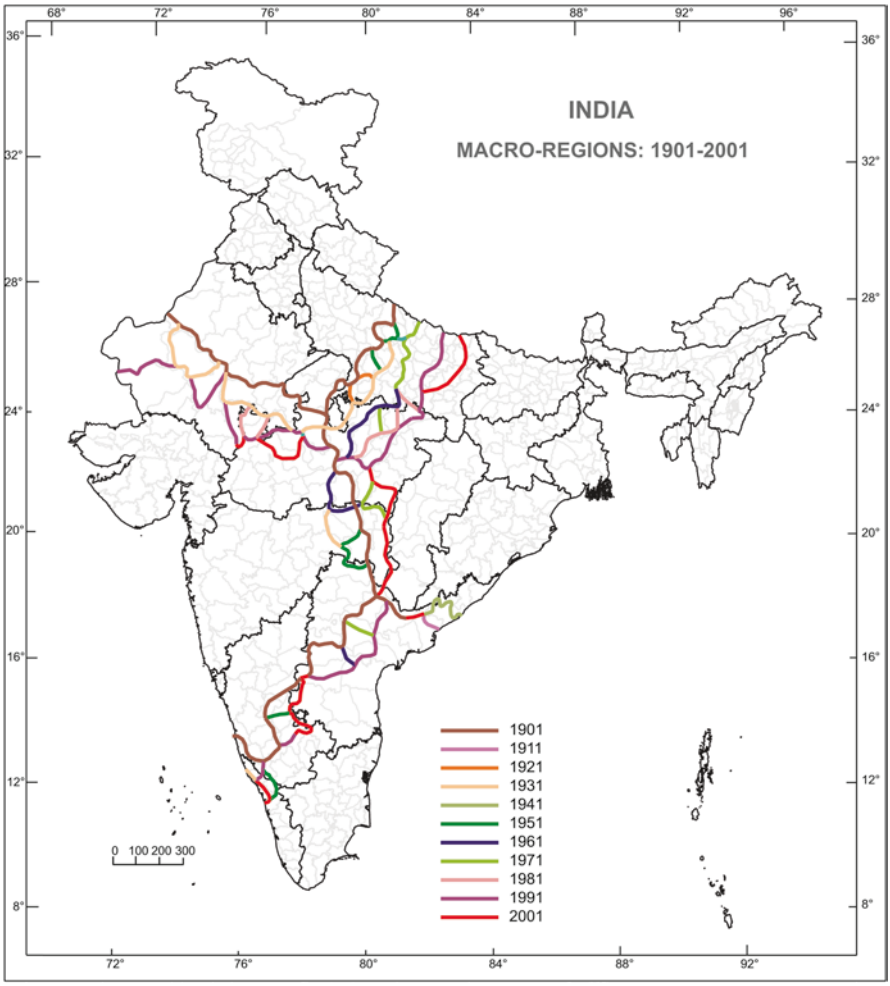

Fig. 11.1 India: macro regions 1901–2001

Table 11.1 Changes in areas of macro-urban systems: 1901, 1951, and 2001

	Area (in '000' km^2)			Changes in area (in '000' km^2)		
Region	1901	1951	2001	1901–1951	1951–2001	1901–2001
Mumbai	967	935	918	−32	−17	−49
Kolkata	1,105	1,042	931	−63	−111	−174
Delhi	766	896	1,071	+130	+175	+305
Chennai	457	422	375	−35	−47	−82

Source: Computed by the author

Table 11.2 Density of urban population, density of towns/1,000 km^2, average area of dominance, and average size of towns (1901, 2001)

Region	Year	Density of urban population/km^2	Density of towns/1,000 km^2	Average area of dominance (in '00' km^2)	Average size (population) of towns
Mumbai	1901	4.3	0.21	46.5	19,992
	2001	95.9	1.07	9.3	89,571
Kolkata	1901	4.6	0.14	69.8	31,793
	2001	66.7	1.11	9.0	60,088
Delhi	1901	7.4	0.46	21.7	15,997
	2001	94.5	1.59	6.3	59,392
Chennai	1901	7.7	0.24	41.6	31,831
	2001	145.3	2.48	4.0	58,492
India	1901	5.4	0.24	41.9	22,843
	2001	93.4	1.41	7.1	66,394

Source: Computed by the author

11.7.2 Structure of National Urban System of India

An attempt has been made to analyze the temporal changes in the structure of the urban settlement system of India from 1901 to 2001 on the basis of empirical constructs of Jefferson's 'primate city urban system' and Zipf's 'rank–size urban system' (Figs. 11.2, 11.3).

It has been found, on the basis of the most dominant city, that the past century has been shared by two premier cities. During the first half (1901–1951) of the century, Kolkata U.A. enjoyed the premier position, while in the second half Mumbai U.A. occupied this position. The national primacy index has fluctuated during successive time periods. A higher index of primacy of 1.80, 2.07, and 1.24 has been recorded in 1901, 1941, and 2001, respectively, whereas the intervening periods have a low primacy index with a minimum of 1.02 in 1981. Thus, during the last century, no single city can be designated as the primate city of the national urban system of India. The absence of a primate city may be explained by the large size of the country, its colonial heritage, and weaknesses in the forces of nationalism in the country. Several cities have functioned as the nerve centers of national administration, economic, and cultural activities at different time periods. Hence, the Indian urban system, at least during the past century, has experienced the dominance of some large cities, particularly Mumbai, Kolkata, Delhi, and Chennai.

A cursory view of the rank–size distribution of urban settlements on log-log graphs for successive time series reveals that the lower part of the distribution more closely fits a straight line than does the upper part, which represents the largest cities, most of which were to be bigger in size to fall in the truncated log-normal line. Further, the increasing length and upward shifts of the exponential line during successive periods explain that over the years our national urban system has grown in terms of number as well as the size of towns. Second, it is found that the regression

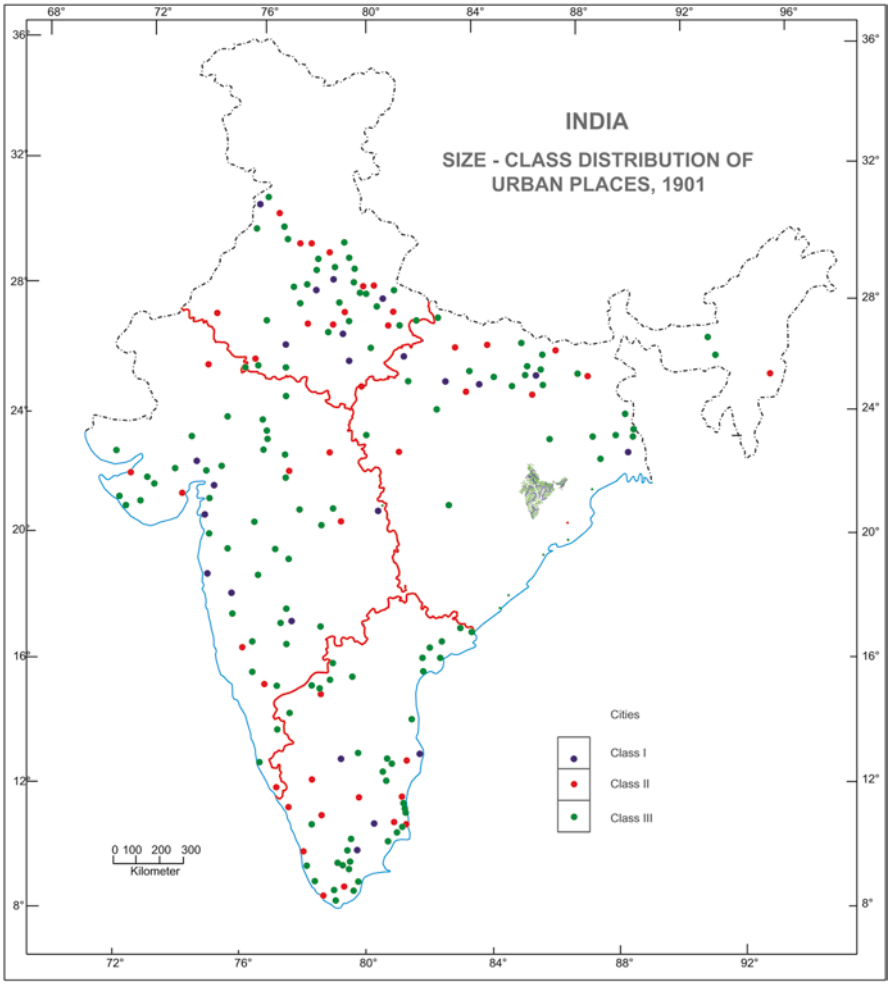

Fig. 11.2 India: size-class distribution of urban places, 1901

of size on rank is highly reliable as in all time periods the theoretical relationship between the rank and the population, as hypothesized by Zipf, explains more than 99 % of the variance. Third, the coefficient of regression of size on rank has been less than unity but it has increased from 0.7585 in 1901 to 0.9568 in 2001, which suggests that throughout the past century the forces of diversification have been dominant over the forces of unification in determining the size and number of cities in the national urban system, but their dominance has continuously decreased. As the regression coefficient in perfect condition of the 'rank–size rule' is 1.00, hence the coefficient (0.9568) shows that both forces are in a state of close balance and the national urban system of India has attained a near-perfect regularity of the rank–size

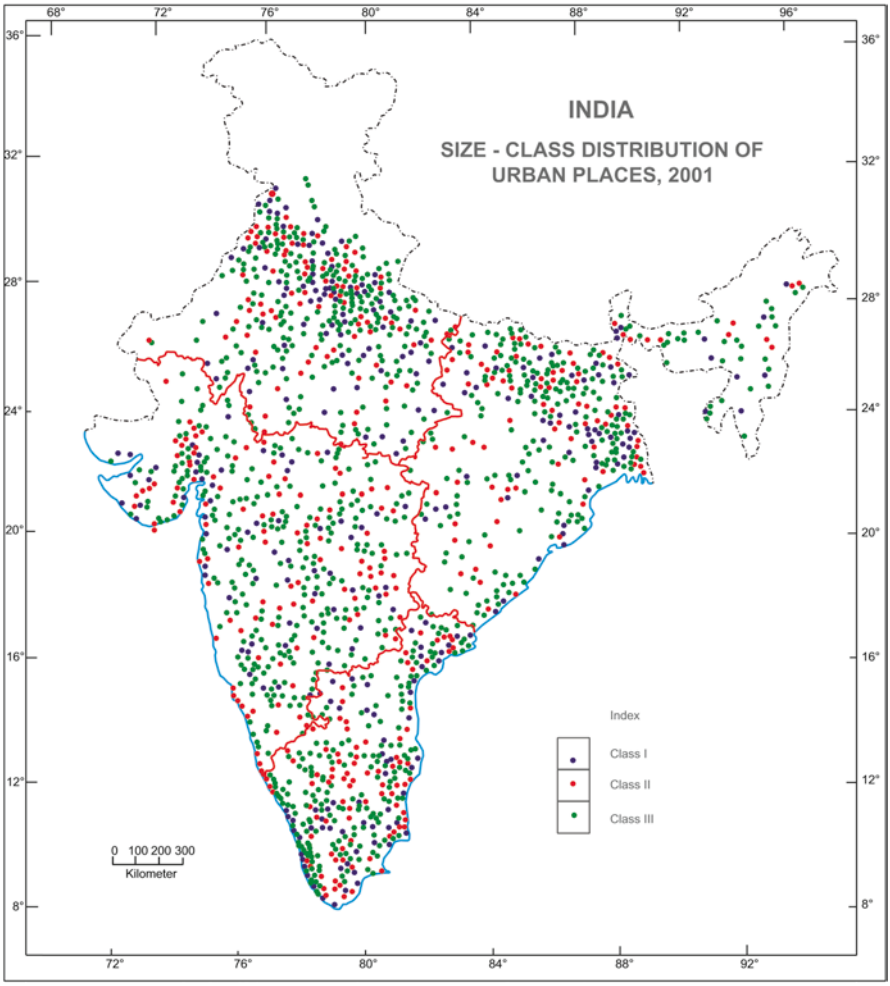

Fig. 11.3 India: size-class distribution of urban places, 2001

rule. In other words, the increasing slope of the best-fit lines toward unity through successive time periods indicates that the average rate of change in the population of settlements in accordance with their ranks has increased to attain regularity of rank–size rule and ultimately, in 2001, it has almost accorded with the rule. This trend has been confirmed by the decreasing percentage of population to be reshuffled for rank–size regularity (Fig. 11.4, Table 11.3).

Fourth, the value of the Spearman rank correlation coefficient (rho: the correlation coefficient between ranks of actual and ranks of deviation of actual from the expected population) has increased to such an extent (0.990 in 2001) that at the end of the century there has been a near-perfect correlation between ranks and the

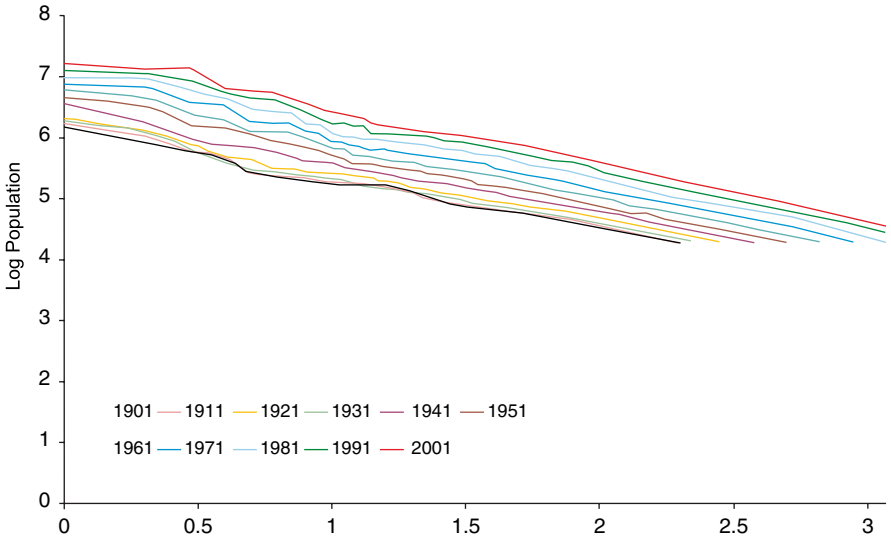

Fig. 11.4 India: rank–size distribution 1901–2001

Table 11.3 Factors of rank–size distribution of urban system in India (1901–2001)

Census year	Regression coefficient of size on rank	Population to be reshuffled (in %)	Rho (correlation coefficient between ranks of actual and ranks of deviation of actual from expected population)	Entropy changes H_R/H_L (R_r)
1901	–0.7585 log *r*	16.34	0.519	1.2294
1911	–0.7695 log *r*	13.54	0.327	1.1017
1921	–0.7728 log *r*	13.91	0.439	1.1022
1931	–0.7861 log *r*	15.16	0.664	1.1168
1941	–0.8267 log *r*	12.21	0.815	1.0936
1951	–0.8537 log *r*	9.87	0.735	1.0800
1961	–0.8619 log *r*	10.40	0.903	1.0831
1971	–0.8817 log *r*	10.50	0.929	1.0827
1981	–0.9123 log *r*	10.50	0.977	1.0848
1991	–0.9301 log *r*	10.47	0.992	1.0859
2001	–0.9568 log *r*	10.46	0.993	1.0804

Source: Computed by the author

amount of deviation from perfect rank–size regularity. Further investigations revealed that most of the top-ranking cities had divergence below the expected line whereas most of the remaining large cities had divergence above the expected line. Thus, a large number of settlements, mostly lower-ranking ones, have almost reached their expected size for rank–size regularity. Last, the entropy changes in rank–size distribution also give statistical support that the Indian urban system is growing as well as moving toward rank–size regularity.

11.7.3 Regional Structure of Urban Systems

Throughout the century, Kolkata, Mumbai, Delhi, and Chennai have been the largest cities in their respective regions. Among the four macro regions, Kolkata has maintained its highest degree of regional primacy with its climax at 12.63 in 1951, which was 5.89 in 1901 and 7.74 in 2001. When primacy is defined with index as more than three, then Chennai has never been a primate city, except in 1911, when its second-ranking city (Hyderabad) was annexed in the Mumbai gravity region. Mumbai has experienced oscillations in its regional primacy index. In 1901, 1921, and 1961–1981, Mumbai's regional primacy index has more than three. On the other hand, Delhi's primacy has increased successively and reached from 1.14 in 1901 to 4.75 in 2001.

Regional rank–size distribution revealed that the urban systems of Mumbai, Delhi, and Chennai have moved toward rank–size regularity through successive time periods; Kolkata, which was close to rank–size regularity in 1901, depicts a 'U-shaped' trend with highest departure in 1951. Thus, by 2001, all regional urban systems have come closer to regularity. In this regard, Mumbai is a classic example with coefficient of regression of size on rank as 0.997, followed by Delhi (0.974), Chennai (0.954), and Kolkata (0.952).

Thus, considering primacy and rank–size distributions, it has been found that at the end of the century, the Chennai region has shifted to 'binary pattern' with Bangalore as its second-ranking city is in close competition in hierarchy distribution. On the other hand, Kolkata maintained a 'primate pattern' with climax in 1951. Delhi has moved toward 'primate pattern' but is still lagging behind Kolkata in primacy and leading in rank–size regularity. Mumbai has come closest to the 'theoretical rank–size pattern' (Tables 11.4, 11.5, 11.6).

Table 11.4 Coefficient of regression of size on rank: 1901–2001

Year	Mumbai	Kolkata	Delhi	Chennai
1901	0.7616	0.9517	0.7240	0.7875
1911	0.8648	0.9491	0.7123	0.7249
1921	0.8488	0.9479	0.7428	0.7409
1931	0.8587	0.8997	0.7967	0.7658
1941	0.9026	0.8861	0.8626	0.7994
1951	0.9311	0.8632	0.9061	0.8333
1961	0.9263	0.8648	0.8994	0.8673
1971	0.9326	0.8747	0.9193	0.8844
1981	0.9569	0.9094	0.9336	0.9196
1991	0.9677	0.9048	0.9607	0.9456
2001	0.9966	0.9521	0.9738	0.9526

Source: Calculated by the author

Table 11.5 Spearman rank correlation coefficient between ranks of actual population and ranks of deviations of actual population from the expected population: 1901–2001

Year	Mumbai	Kolkata	Delhi	Chennai	India
1901	0.0146	0.8152	0.6273	0.6845	0.519
1911	0.4063	0.9403	0.6442	0.6268	0.327
1921	0.3827	0.9659	0.7783	0.4722	0.439
1931	0.2404	0.7968	0.7765	0.5080	0.664
1941	0.4696	0.9841	0.7342	0.6786	0.815
1951	0.4383	0.9650	0.4936	0.4505	0.735
1961	0.3677	0.5413	0.2790	0.3777	0.903
1971	0.5167	0.2228	0.4464	0.4069	0.929
1981	0.6038	0.7326	0.5984	0.5711	0.977
1991	0.9362	0.7060	0.8062	0.7083	0.992
1991	0.95432	0.97861	1.03137	1.02809	1.0859

Source: Calculated by the author

Table 11.6 Entropy changes in regional city-size distribution (H_R/H_L)

Year	Mumbai	Kolkata	Delhi	Chennai	India
1901	1.04036	0.91604	1.14431	1.05197	1.2294
1911	0.97668	0.87689	1.14537	1.08370	1.1017
1921	0.98606	0.85928	1.13803	1.08900	1.1022
1931	1.00553	0.87574	1.12540	1.09571	1.1168
1941	0.99502	0.82637	1.09985	1.09779	1.0936
1951	0.96307	0.82441	1.06548	1.07184	1.0800
1961	0.96620	0.88309	1.04766	1.05996	1.0831
1971	0.95762	0.91858	1.03442	1.04739	1.0827
1981	0.95795	0.93653	1.03677	1.03990	1.0848
1991	0.95432	0.97861	1.03137	1.02809	1.0859
2001	0.94559	0.98620	1.02137	1.01887	1.0804

Source: Computed by the author

11.7.4 Levels of Economic Development

India has registered an average annual growth rate of 5.80 % in gross domestic product (GDP) at factor cost from 1980 to 2000. The per capita income has increased from Rs. 5,352 in 1980 to Rs. 10,561 in 2000, that is, it doubled within this period. In other words, India has made a significant growth in the fields of agriculture, mining, manufacturing, and service sectors during these two decades, which has led to tremendous economic development in the country. Simultaneously, substantial decrease in the coefficient of variation in economic development revealed that India has decreased regional imbalances in economic development during the last two decades of the century.

Each macro region has made substantial economic development, and the distribution of districts according to the level of economic development in each region has become more and more normal from the positively skewed one. However, interregional differences in the distribution of districts according to their level of economic development are still significant, even at the 99 % confidence level, as the calculated value of 'chi-square' in each year was much greater than the tabulated value. However, the calculated value of chi squared has decreased over the years. Thus, the interregional differences have decreased substantially but are still significant at the 0.01 % significance level. During this period, Chennai remained the most developed region, whereas Kolkata retained its lowest position. In 1980, Mumbai had the second position but in 1993 Delhi pushed it to the third position.

The regional coefficient of variation (a better device for comparison between different sets of data) in economic development revealed some interesting facts. (1) The variability in the distribution of economic development has decreased tremendously in each region as well as at national level. (2) In 1980, the variability in economic development was maximum in the Kolkata region followed by Delhi, Mumbai, and Chennai. In 1993, it was highest in Mumbai followed by Kolkata, Delhi, and Chennai. In 2000, the variability in infrastructural development was maximum in Delhi region, followed by Chennai, Mumbai, and Kolkata in that order. (3) The variability in the distribution of economic development in India has decreased by more that 50 % within these two decades. The most drastic decrease was registered in Kolkata region followed by Mumbai, Delhi, and Chennai.

11.7.5 Impact of Economic Development on Regional Structure of Urban Systems

It has been found that the level of economic development and its coefficient of variation have a close bearing on the pattern of rank–size distribution of settlements in a country or region. A close scrutiny of association between these two sets of data revealed the following. First, decreasing coefficient of variation within economic development over the years leads the city-size distribution toward rank–size regularity; this explains the movement of India and its each regional urban system toward rank–size regularity during the last 20 years of the century. Second, in a fairly well developed region, economic progress with decreasing coefficient of variation to a moderate level, rank–size distribution tends to attain a binary pattern, as in the region of Chennai. Third, substantial increase but still at a low level of economic development with significant decrease to a low level in variation shifts the primate-city pattern toward rank–size regularity, but primacy still is found to be high, as in the case of the Kolkata region. Fourth, a moderate level of eco-development accompanied by a sharp decrease in variation moves the city-size distribution toward a theoretical rank–size regularity, as in the Mumbai region. Fifth, and last, fair growth in economic development with decreasing variation but still at a moderately high level shifts the urban system toward rank–size regularity as well as increases the primacy of the premier city, as can be seen in the region of Delhi (Tables 11.7, 11.8, 11.9).

Table 11.7 Primacy index, level of economic development, and intraregional variation in economic development

	Primacy index			Level of economic development			Variation in economic development		
Region	1981	1991	2001	1981	1991	2001	1981	1991	2001
Mumbai	3.61	2.90	2.96	119.5	98.3	94.8	87.4	77.2	23.78
Kolkata	10.01	10.02	7.74	75.8	60.2	90.7	147.1	72.0	19.1
Delhi	3.50	4.15	4.75	102.9	100.2	115.4	119.8	71.8	61.5
Chennai	1.47	1.31	1.13	126.6	116.9	132.2	66.9	51.5	42.7
India	1.02	1.14	1.24	100.0	100.0	100.0	114.6	94.6	51.1

Source: Computed by the author

Table 11.8 Coefficient of regression of size on rank and variation in economic development

	Coefficient of regression of size on rank			Level of economic development			Variation in economic development		
Region	1981	1991	2001	1981	1991	2001	1981	1991	2001
Mumbai	0.957	0.968	0.997	119.5	98.3	94.8	87.4	77.2	23.7
Kolkata	0.909	0.905	0.952	75.8	60.2	90.7	147.1	72.0	19.1
Delhi	0.934	0.961	0.974	102.9	100.2	115.4	119.8	71.8	61.5
Chennai	0.920	0.946	0.953	126.6	116.9	132.2	66.9	51.5	42.7
India	0.912	0.930	0.957	100.0	100.0	100.0	114.6	94.6	51.1

Source: Computed by the author

Table 11.9 Entropy of city-size distribution and intraregional variation in economic development

	Entropy ratios			Level of economic development			Variation in economic development		
Region	1981	1991	2001	1981	1991	2001	1981	1991	2001
Mumbai	0.958	0.954	0.946	119.5	98.3	94.8	87.4	77.2	23.7
Kolkata	0.936	0.979	0.986	75.8	60.3	90.8	147.1	72.0	19.1
Delhi	1.037	1.031	1.021	102.9	100.2	115.4	119.8	71.8	61.5
Chennai	1.040	1.028	1.019	126.6	116.9	132.2	66.9	51.5	42.7
India	1.085	1.085	1.080	100.0	100.0	100.0	114.6	94.6	51.1

Source: Computed by the author

11.8 Conclusions

The present research has contributed to our understanding of the changing structure and behavior of the national and macroregional urban systems in India through successive time periods during the past century. It was observed that the forces of diversification dominated the forces of unification at the aggregate national level as well as macroregional levels, but their dominance has decreased over the time periods, particularly during the post-Independence period. The national and all four macroregional urban systems were found shifting toward regularity in their rank–size

distribution. By 2001, these forces were almost accorded a balance, and rank–size distributions in all the respective urban systems were observed very close to Zipf's curve, particularly in the Mumbai macro-urban system, followed by the macroregional urban systems of Delhi, Chennai, and Kolkata. Second, India has never had a primate city at national level, at least during the past century, nor is expected to do so in the near future, mainly because of its large area, which needs at least one premier city in each macro region to serve the population properly. Hence, it was found that all the four macro regions have at least one premier city. Kolkata has been a classical example of regional primacy, although decreasing since Independence. Delhi's regional primacy has increased throughout the century. The Mumbai region has had oscillations in its primacy index, and since 1981 it is third in terms of regional primacy, whereas Chennai cannot be designated as a primate city, at least since Independence, as its index of primacy is less than two, because of the rapid growth of the second-ranking city, Bengaluru. Thus, the Chennai region has moved toward bimodal city-size distribution, whereas in the macro regions of Kolkata, Delhi, and Mumbai, primacy exists at the top, and the other urban places in these systems have come closer to rank–size regularity. Third, it was observed that level of urbanization is directly related to the level of economic development, but it is the variation in economic development that affects city-size distribution. Generally, high variation gives rise to primacy and low variation gives rise to rank–size regularity. In short, all hypotheses under this research have been proved.

This research has several interesting implications for theory. First, the evidence from India, particularly, from different macroregional systems, is consistent with theory that the level of primacy in an urban system first rises and later, when regional imbalance decreases at a higher level of economic development, falls, and the city-size distribution shifts toward rank–size regularity. Second, at a middle stage, there can be primacy at the top rank, although with trial fits into Zipf's curve, that is, rank–size regularity.

11.8.1 Future Research

Future research needs to be carried on in the following direction. Attention should be paid to the study of dynamics of growth in a macroregional urban systems, especially the eastern region, dominated by Kolkata in a system framework. The region should be delimited on the basis of flows to quantitatively determine the system boundary of Kolkata and its subsystems, such as Patna, Ranchi, Bhubaneswar, Guwahati, and Siliguri, that is, how the subsystems nest within a larger macrosystem of Kolkata in a core–periphery interacting space economy. Research is needed to focus on the changing system boundary of Kolkata covering both colonial and postcolonial settlement. The sphere of influence of Kolkata is shrinking, which needs to be proved and confirmed, as well as how Kolkata has served the needs of society in the surrounding region over the years.

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