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INDIAN CITY SIZES AND CITY GROWTH

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ABSTRACT

This paper presents a detailed statistical analysis of the relative size of Indian cities. First, it demonstrates from a variety of comparisons that Indian urbanization is less dominated by a few large cities than almost any country in the world.

Estimates of Pareto distributions of city size show that the relative size of large and small Indian cities has changed little during the twentieth century. From 1901 to 1961 there was a slight tendency for the largest cities to grow less rapidly than other cities, while from 1961 to 1981, the situation was reversed.

Estimates for the five major regions of the country also show that there are large regional disparities in relative city size: for example, the eastern and western regions have been dominated by Calcutta and Bombay more than other regions have been dominated by their largest cities. But regional disparities in city size distribution have decreased steadily throughout the twentieth century.

Careful statistical analysis of regional and temporal variations in the Pareto exponents shows that such variations are mainly the result of phenomena that are specific to regions, not of economic and demographic phenomena that have comparable measurements in all regions.

The final section of the paper presents a statistical analysis of determinants of growth of individual cities. Employing growth data for all class cities (those with populations over 100,000) from 1901 to 1971, it was found that cities grown faster when manufacturing employment and national population growth accelerate and when they are large to begin with, but only up to an initial population of less than one million people. Employing a richer data set for the 1961-71 decade, it is shown that cities grow faster the farther they are from the nearest other class one city.

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Table of Contents

Introduction

Previous chapters have analyzed Indian urban growth in international and state contexts. This chapter is concerned with the relative sizes of urban areas and with the growth and industrial structure of urban areas. Both historical and regional comparisons are included. The term "city size distribution" will be used to refer to the subject of this chapter. But it is important to note at the outset that the subjects of the paper are generic urban areas: the set of contiguous urbanized places that makes up an urban complex. In small urban areas, the generic urban area usually coincides with a local government jurisdiction, such as a city. But in large urban areas, the generic urban area often spills over the boundaries of legal cities.

The city size distribution is a subject of intense public and government concern in India. Most concern focuses on the sizes and growth rates of the largest cities. Much popular and scholarly writing accepts as nearly axiomatic that large cities are too large and grow too fast, at least in the absence of constraints imposed by governments. Many five-year plans and other government reports make the same claim. It has been national government policy to constrain the growth and sizes of large, and not-so-large, cities since shortly after independence.

This chapter is concerned with the positive or factual aspects of city sizes and growth. It attempts to build a background of facts and explanation without which normative or policy analysis cannot proceed fruitfully. Policy issues will be discussed in a subsequent report.

Some descriptive measures

Indian census data on city sizes are complete and detailed for census years during the twentieth century. During the early census years of the century, the boundaries of generic urban areas coincided with those of local government jurisdictions except in rare cases. During the post-independence years, many urban areas have grown beyond the bounds of city jurisdictions. By 1981, most class I cities (those over 100,000 population) were considerably smaller than their entire urban areas. The Indian census refers to such places as urban agglomerations, corresponding roughly to what are referred to as metropolitan areas in some countries. Most calculations presented in this chapter are for urban agglomerations whose cores are class I cities. In a few cases city and urban agglomeration are identical. To avoid circumlocution, urban agglomerations that contain a class I city will be referred to as class I cities, but the reference is to the corresponding urban agglomeration in all cases. An example in which city and urban agglomeration are dramatically different is Calcutta. The population of the city of Calcutta was 3.3 million people in 1981, whereas that for Calcutta urban agglomeration was 9.2 million.

India has a rich diversity of city sizes. In 1981, its 156.2 million urban residents lived in 3,245 urban areas. Calcutta, with 9.2 million people was the largest, but 230 had fewer than 5,000 people each. More than 2,000 urban places had fewer than 20,000 people each. 12 urban agglomerations had at least one million people each. Much writing on allegedly excessive city sizes in India emphasizes the increasing percent of the urban population in class I cities. The data, for selected census years from 1901 to 1981, are:

Year	1901	1921	1941	1961	1971	1981
Percent of Urban Population in Class I cities	25.7	29.4	37.9	50.8	56.2	60.4

As with other facets of Indian economic growth, the remarkable characteristic of these data is the smoothness and gradualness of the change.[1]

1. Statistics in this paragraph are from [1].

The percent of the urban population living in these relatively large cities has indeed grown. In 1981, it was 2.4 times its 1901 value, and about twice as large as 50 years earlier. The difficulty with this measure as a guide to thinking about city size distributions is that it is difficult to imagine an economic growth process that would not lead to an increasing share of the urban population in cities of at least some modest size. As a country urbanizes, not only do its large cities grow, although typically less rapidly than the urban population, but also the number of cities in excess of the threshold size increases.

By most easily available measures, India has among the most dispersed city sizes of any country in the world. Its largest urban area, Calcutta, contained 5.9 percent of the urban population in 1981. The only country in the world whose largest metropolitan area had a smaller share of the country's urban population was the Soviet Union, where 4 percent of the urban population resided in Moscow. Low and middle income countries averaged 13 and 29 percent of their urban populations in the largest city in 1980, according to [7]. 80 years earlier, in 1901, Calcutta contained 5.8 percent of India's urban population. The stability of this share is itself remarkable, and indicates virtual equality between Calcutta's and India's urban population growth during the twentieth century.

Broadening the comparison, the following are the 1981 populations and 1961-81 and 1971-81 annual growth rates of India's four largest cities, along with the total and total urban population and their growth rates.

	1981 Population (million)	Annual Growth Rate (percentage)	
		1961-81	1971-81
Calcutta	9.2	2.3	2.7
Bombay	8.2	3.4	3.2
Delhi	5.7	4.4	4.5
Madras	4.3	3.9	3.0
India	658.1	2.2	2.2
India's urban population	156.2	3.5	3.8

During both the 10 and 20 years preceeding 1981, Delhi grew faster than the total urban population and faster than the population of any of the other three largest cities. Otherwise, only Madras grew faster than total urban population during the 1961-81 period, and no other city grew faster than total urban population during 1971-81. Calcutta, the largest of the four cities, had the slowest growth of the four during both periods. Finally, the combined share of the four largest cities in the urban population fell during the 20-year period 1961-1981.

None of the data presented above indicates that India has a growing or unusually large share of its urban population in its largest metropolitan areas. India's largest cities are of course very large, but not by the standards of large cities in other developing countries. Calcutta has about the same population as Seoul, and both are smaller than Sao Paulo and Mexico City. All four are of course smaller than Tokyo and New York. Nevertheless, India has two metropolitan areas that are among the largest dozen or so in the world. Calcutta is certainly the poorest of the world's very large cities.

Pareto distributions of Indian city sizes

The statistics presented in the previous section are interesting and place large Indian cities in historical and international perspective. But they pertain to only a small part of the city size distribution. It is desirable to supplement them with comprehensive measures of city size distributions, which are sensitive to changes in relative sizes of urban areas throughout the distribution.

The best characterization of city size distributions is a statistical frequency distribution that depends on city sizes throughout the distribution. The Pareto distribution has been estimated from data for city sizes in many countries. It is a simple distribution to calculate and understand and has been found to fit city size data well, so it will be used here to analyze Indian data.

The Pareto distribution can be written

$$R = AP_R^{-\beta} \qquad (1)$$

where R = number of urban areas with at least P_R people. A and β are constants to be estimated from the data. Since cities of higher rank (smaller R) have larger populations, both A and β are positive. The larger is β the more nearly equal are cities of various ranks. As β goes to zero, the entire urban population tends to be concentrated in a single city. $\beta = 1$ is a natural dividing line, and that special case of (1) is referred to as the rank size rule, but it has no normative significance. If $\beta < 1$, the distribution is said to be relatively primate, and if $\beta > 1$, it is said to be relatively even.

β is a measure of relative city sizes. Specifically, equal percentage growth of cities of all sizes leaves β unchanged. Rapid relative growth of small cities makes β larger and rapid relative growth of large cities makes β smaller. Putting $R = 1$ in (1), shows that $P_1 = A^{1/\beta}$ is the population of the largest city. If $\beta = 1$, then A equals the population of the largest city, the city of rank two is half the size of the largest city, and the city of rank R is one Rth the population of the largest city.

(1) easily implies the following relationship between the largest and Rth largest urban areas:

$$\frac{P_1}{P_R} = R^{1/\beta} \qquad (2)$$

Table 1 shows P_1/P_R for $R = 2, 5, 10, 20$ and 40, and for selected values of β between 0.7 and 1.3.

Table 1

Selected Values of P_1/P_R for the Pareto Distribution

P_1/P_R	0.7	0.8	0.9	1.0	1.1	1.2	1.3
P_1/P_2	2.69	2.38	2.16	2.00	1.88	1.78	1.71
P_1/P_5	9.99	7.48	5.97	5.00	4.33	3.80	3.45
P_1/P_{10}	26.92	17.78	12.88	10.00	8.13	6.76	5.89
P_1/P_{20}	72.52	42.29	27.81	20.00	15.27	12.02	10.04
P_1/P_{40}	195.41	100.50	60.02	40.00	28.70	21.37	17.12

This range of β values includes most of those that will be reported later.

Table 1 shows why $\beta = 1$ is a natural dividing line for β values. When $\beta = 1$, P_1/P_R equals R . When $\beta > 1$, P_1/P_R is less than R . When $\beta < 1$, P_1/P_R is greater than R . Of course, the farther are β and R from one, the farther is P_1/P_R from R .

In one of the most elaborate studies of city sizes, Rosen and Resnick [5] fitted the Pareto distribution to data for the 50 largest cities in each of 44 countries using 1970 data. In their sample, β ranged from a low of 0.81 for Morocco to a high of 1.96 for Australia, with an average of 1.14. Most of Rosen and Resnick's analysis is based on Pareto distributions estimated from data for legal cities, not metropolitan areas. This biases estimates of β upwards, since large metropolitan areas are larger relative to their legal cities than are small metropolitan areas or urban areas below metropolitan size.

(1) is easy to estimate by least squares if logarithms are taken of both sides. We estimated (1) for a sample of urban populations reported by Mitra [4]. The data consist of male populations of most class I cities for census years, except 1941, from 1901 to 1971. We supplemented the Mitra data by the male populations of all class I cities from the 1981 census [1]. Restriction to male population is a serious issue, to which we return below.[2]

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2. Mitra used male population because of its presumed relationship to industrial structure of cities. We have used the Mitra data because of their easy availability.

The estimates are in Table 2. R^2's are all in excess of .944, and cluster around .99. t-values are all in excess of 28 and most are in excess of 50. Thus, these statistics are not presented. Addition of terms in P^2 and/or P^3 to the right side of the logarithm of (1) did not improve the goodness of fit. We conclude that the Pareto distribution provides an excellent fit to the data and that no other simple distribution would improve the fit. It should be noted that the constant term in the logarithmic regressions is the natural log of A. To double this term is to square A.

The remarkable characteristic of the data in Table 2 is the smoothness and gradualness of changes in the estimates. β estimates show a gradually rising trend, with a peak in 1961 and slight decreases during the succeeding twenty years. Thus, during the first 60 years of the century, relatively small class one cities grew slightly faster than relatively large class one cities. During the last 20 years relatively large cities have grown very slightly faster than somewhat smaller cities. Thus, the estimates imply that Indian city sizes became somewhat more nearly even from 1901 to 1961 and slightly less so from 1961 to 1981.[3]

Table 3 gives a rough idea of the magnitudes involved in the changes reported in India's city size distribution in Table 2. All the β estimates in Table 2 are between 1.0 and 1.2 Thus, those two columns in Table 1 bracket the P_1/P_R values implied by the estimated distributions.

3. t-statistics for the post-independence β's in Table 2 are between 60 and 90. They imply that the β estimates are significantly different from each other.

Table 2

Pareto Distributions of Indian Cities
1901-1981

Year	Ln A	β	Number of Observations
1901	13.96	1.02	49
1911	14.02	1.02	44
1921	14.36	1.04	53
1931	15.62	1.13	62
1951	15.73	1.07	75
1961	17.31	1.17	99
1971	17.17	1.13	99
1981	17.30	1.10	216

Source: Estimated from Column 4, Appendix Tables I-VII, of [4]. 1981 estimates are from data in column 5, Provisional Table 4 of [1].

Table 3

Actual and Calculated Relative City Sizes

Year	P_1/P_2 Actual	P_1/P_2 Calculated	P_1/P_{10} Actual	P_1/P_{10} Calculated
1961	1.22	1.81	7.31	7.16
1981	1.11	1.88	7.57	8.11

Source: Actual, [1] and [4]; calculated, from Table 2 and (2).

Table 3 compares actual and calculated values of P_1/P_2 and P_1/P_{10} for 1961 and 1981 to provide insight into how much more primate the Indian city size distribution has become during the 20-year period. Since β fell from 1961 to 1981, the calculated P_1/P_2 and P_1/P_{10} increased modestly. In fact, P_1/P_{10} did increase slightly, but P_1/P_2 fell. Bombay and Calcutta held ranks one and two in 1961, but their ranks reversed in 1981 (male population). Poona was the 10th largest city in 1971 and Nagpur was 10th largest in 1981. Bombay and Calcutta switched ranks several times during the 20th century, but throughout the century their male populations have been much closer to each other than would be predicted by a Pareto distribution estimated from any significantly large set of Indian cities.

It can be seen from Table 3 that the change in β from 1961 to 1981 results in only slight changes in calculated values of P_1/P_2 and P_1/P_{10}. Both the actual and calculated values of relative sizes of India's large cities have changed little during the 20-year period.

The conclusion from these estimations is that the trend during the 20th century has been toward a more nearly even city size distribution in India, with a slight reversal since 1961. It is probable that not much significance should be attached to the modest increase in the relative sizes of the largest cities that is estimated to have occurred since 1961. But the estimates in Table 1 do not indicate any success of national government programs to disperse population from large cities. Nor do they suggest that the relatively large sizes of the largest Indian cities are a legacy of colonialism. The trend was toward equality in city sizes during the colonial period, whereas it has been erratically toward growth of the largest cities since independence.

Regional City Size Distributions

India is a large country with many urban areas throughout the country. That makes it possible to study regional changes and differences in the city size distribution. There is no theory about the appropriate geographical unit in which to fit a Pareto distribution to city size data. Intuition suggests that the more economically integrated a geographical area is the better the Pareto distribution should fit the city size data. Even if the intuition is correct, there is no way to know how integrated a geographical area should be in order to make estimation of a Pareto distribution plausible. In fact, scholars have fitted Pareto distributions to regional city size data in the U.S. and elsewhere with results nearly as good those obtained at national levels. States are inappropriate units of analysis for city size distributions. Not only are there too few urban areas in many states, but also a few urban areas, notably Delhi and Chandigarh, are not in states.

Many Indian demographic, economic and other studies divide India into five regions. Definitions of regions differ somewhat among studies. We have adopted the regional classifications used by Mitra [4] and other authors.

North

Chandigarh
Delhi
Haryana
Himachal Pradesh
Jammu & Kashmir
Punjab
Rajasthan

East

Assam
Arunachal Pradesh
Bihar
Meghalaya
Mizoram
Manipur
Tripura
Nagaland
Orissa
Sikkim
West Bengal

South

Andhra Pradesh
Karnataka
Kerala
Laccadive & Minicoy Is.
Pondicherry
Tamil Nadu

West

Gujarat
Goa
Maharashtra
Nagar Haveli

Central

Madhya Pradesh
Uttar Pradesh

Using Mitra's [4] data for male populations, we are able to calculate Pareto distributions for each of the five regions for each of the census years for which the national estimates were reported in Table 2, with the exception of the Eastern region for 1901, 1911 and 1921. At least two city populations are needed to estimate the two parameters of the Pareto distribution, and until 1931 there was only one city, Calcutta, in the Eastern region


INDIA
JAMMU
AND
KASHMIR
HIMACHAL
PRADESH
PUNJAB
HARYANA
PAKISTAN
Delhi
NEPAL
UTTAR
PRADESH
RAJASTHAN
BHUTAN
ARUNACHAL
ASSAM
MEGHALAYA
NAGALAND
MANIPUR
MIZORAM
BIHAR
BANGLA
DESH
WEST
BENGAL
Calcutta
BURMA
GUJARAT
MADHYA PRADESH
ORISSA
DIU DAMAN
MAHARASHTRA
Bombay
BAY
OF
BENGAL
ARABIAN
SEA
ANDHRA
PRADESH
GOA
KARNATAKA
Madras
PONDICHERRY
TAMIL
NADU
KERALA
ANDAMAN AND NICOBAR ISLANDS
(INDIA)
LACCADIVE, AMINDIVI
AND MINICOY ISLANDS
(INDIA)
CEYLON

that was large enough to be included in Mitra's data. By 1931, 5 cities in the Eastern region were included.

Table 4 presents estimates of the regional Pareto distributions, and repeats the national estimates for comparison. Once again R^2's and t-statistics are large. The smallest R^2 is .792 and most are above .900. The smallest t-statistic is 4.5 and most are above 20. Thus, they are not presented in the table.

Four of the regions have been dominated by one of India's four largest cities throughout the century: the East by Calcutta, the West by Bombay, the North by Delhi and the South by Madras. Kanpur is the largest city in the Central region, with a 1981 population of 1.7 million (0.9 million males). In 1981, Kanpur was India's eighth largest urban area.

The regional differences in the Pareto exponents are much larger than the temporal differences. In 1931, 1951 and 1961, the Eastern region was the most primate of the five regions, showing the extreme domination of that region by Calcutta until 1971. The domination was even greater before 1931. Until 1971, the Western region was the second most primate region, showing Bombay's domination of that region. The Southern region is dominated by Madras, but in most census years its Pareto exponent has been only somewhat smaller than the national exponent. The Northern region has been increasingly dominated by Delhi during the twentieth century, showing the growing importance of the national government. The Central region is the least primate of the five regions, with a remarkably even city size distribution.

Table 4

Pareto Distributions by Indian Regions
1901-1981

YEAR		ENTIRE COUNTRY	NORTH	SOUTH	EAST	WEST	CENTRAL
	Ln A	13.96	11.50	11.87	[illegible]	8.06	15.24
1901	β	1.02	0.950	0.962	NA	0.607	1.22
	N*	49	8	14	1	8	18
	Ln A	14.02	10.92	10.94	NA	7.77	15.95
1911	β	1.02	0.897	0.851		0.589	1.284
	N*	44	8	12	1	6	17
	Ln A	14.36	10.35	12.42		8.66	15.97
1921	β	1.04	0.835	0.975	NA	0.643	1.283
	N*	53	8	15	1	9	20
	Ln A	15.62	9.99	13.95	6.61	8.15	18.48
1931	β	1.13	0.784	1.085	0.491	0.607	1.483
	N*	62	8	22	5	7	20
	Ln A	15.73	11.14	13.74	7.36	9.36	18.19
1951	β	1.07	0.831	1.004	0.542	0.657	1.382
	N*	75	11	24	8	1	22
	Ln A	17.31	11.51	15.50	11.05	11.67	17.81
1961	β	1.17	0.837	1.127	0.792	0.813	1.319
	N*	99	12	28	15	19	25
	Ln A	17.17	11.19	14.68	11.636	12.14	17.71
1971	β	1.13	0.785	1.030	0.827	0.827	1.282
	N*	99	12	28	15	19	25
	Ln A	17.30	13.09	15.88	13.82	12.98	16.12
1981	β	1.10	0.907	1.082	0.955	0.862	1.122
	N*	216	30	66	37	39	44

* Number of Observations

Source: Calculated from data in [1] and [4].

Although the regional disparities in Pareto exponents are large, they have become smaller as time has passed. In most years until 1961, the largest regional Pareto exponent was about twice the size of the smallest. In 1931, the largest was more than three times the smallest. By 1981, the largest was only 1.3 times the smallest. There are no analytical studies that indicate what forces might produce reductions in regional disparities among Pareto exponents. It is tempting to conjecture that it results from increasing integration of the Indian economy. Suppose, for example, that particular economic activities are most productive in cities of particular sizes. Then, the more mobile are inputs among cities, the more similar will be the distribution of city sizes among regions. Some such phenomenon must be behind the increasingly similar regional Pareto distributions.

It will be recalled that the Pareto distributions reported have been estimated from male populations of selected class I cities. If, as has been concluded, city sizes fit the Pareto distributions closely, estimation from samples of cities is adequate provided sample sizes are large enough. Nevertheless, one would like to know whether enlarging the sample to include smaller urban areas affects the estimates.

Much more important is the exclusion of females from the estimates. If the sex ratio were the same in all urban areas, then exclusion of females would affect the estimate of A but not that of the exponent β in the Pareto distribution. However, there were only 935 females per 1000 men in all of India in 1981. Almost no class I city had as many females as males, and a few had fewer than 750 females per 1000 males. It is possible that the sex ratio varies systematically by city size or region.

To test these possibilities, we reestimated the Pareto exponents for 1981, since the data were easily available. Table 5 shows three estimates of the Pareto distribution each for the country as a whole and for the five regions: the first is repeated from the 1981 row in Table 4, for comparison; the second is based on the total population of all class I cities; and the third is based on total populations of all class I and class II cities (those with 50,000 to 100,000 people). Inclusion of class II cities more than doubles the national and most regional samples. Again, it is unnecessary to report R^2's and t-values. The smallest R^2 in Table 5 is .9129 and most are above .95. The smallest t-value is 18.9, and most are above 25.

The Pareto exponents for total population of all class I cities are extremely close to those for the male population. Certainly, the differences are not significant. Interestingly, all the regional exponents extimated for total population exceed corresponding estimates for the male population. This indicates that the female-to-male ratio is slightly higher in small cities I cities than in large class I cities. Presumably, the reason is that males are somewhat more likely to migrate by themselves to large than to small cities.

Inclusion of class II cities in the sample makes the exponent larger nationally and in all regions except the Central. Thus, Pareto distributions estimated from cities in classes I and II give less evidence of population concentration in the largest cities than do those estimated from class I cities. The differences in estimated Pareto exponents from inclusion of females and class II cities are not large. The estimates in Table 5 suggest that the preceeding analysis, based on estimates from the male population in class I cities, is not far from the mark.

Table 5

Alternative Estimates of Pareto Distributions
1981

REGION		Ln A	β	N
ENTIRE	1)	17.30	1.10	216
COUNTRY	2)	18.12	1.109	216
	3)	18.27	1.121	486
NORTH	1)	13.09	0.907	30
	2)	13.74	0.915	30
	3)	14.44	0.968	56
SOUTH	1)	15.88	1.082	66
	2)	16.65	1.086	66
	3)	17.00	1.113	151
EAST	1)	13.82	0.955	37
	2)	14.56	0.969	37
	3)	16.28	1.102	85
WEST	1)	12.98	0.862	39
	2)	13.64	0.871	39
	3)	14.35	0.926	84
CENTRAL	1)	16.12	1.122	44
	2)	16.91	1.130	44
	3)	16.73	1.116	110

LINE 1) Male population of class I cities
LINE 2) Total population of class I cities
LINE 3) Total population of class I & class II cities.

Source: Calculated from [1] and [4].

Determinants of city size distributions

We have seen that there are large differences in Pareto exponents among regions and moderate differences through time, with a tendency toward regional convergence in recent decades. What explains these regional differences and temporal changes?

Economic analysis is of little help on this matter. Several empirical studies, notably those of Henderson [2] and Rosen and Resnick [5], have shed some light on the subject. Both these studies regressed measures of country city size distributions on country characteristics, cross-sectional regressions employing data from developed and developing countries.

Both studies find that countries with large populations, or large urban populations, have relatively even city sizes. Whereas one large city may serve the specialized production needs of a small country, several large cities are needed for this purpose in a large country. India is a large country, and it is not surprising that it contains several large cities. Likewise, it is not accidental that India's four largest cities are near the four extremes of the country. Rosen and Resnick also found that countries with large per capita GNP had relatively even city size distributions. High income presumably means that demands are great enough to support the production of a relatively large number of large and intermediate size cities. Henderson found that countries with federal systems of government had much more nearly even city size distributions than countries with unitary governments. His explanation is that states or provinces have constitutional authority in federal countries and can bid for funds for infrastructure and government services for many cities, whereas such funds are likely to go to the national capital in a unitary system. India is of course a federal country and that variable does not differ among regions. These studies differ from each other as to specification of the dependent variable and as to choice of independent variables. Several independent variables either are not available or do not vary among regions or through time within India.

It would not be fruitful to undertake statistical analysis of the 8 national estimates of the Pareto exponents in Table 2. The sample is too small and relevant variables change too slowly. Thus, a combination of cross-sectional and time series analysis is necessary, using all the estimates in Table 4, to enlarge the sample and to introduce variability.

Income is the key variable that other scholars have found to be important but that is missing from Indian data. No income measure is available for Indian cities. Income measures are available by state, but only for the post-independence period. Both studies referred to above found high income to be a significant correlate of a relatively even distribution of city sizes.

Total population is the second variable found in earlier studies to be consistently correlated with the city size distribution. The city size distribution becomes more nearly equal as population increases. Not surprisingly, the effect has been found to be nonlinear. As population becomes large, the effect of additional population on the city size distribution diminishes. Regional population can be compiled from Indian census data for the entire 80-year period covered by this study. After some experimentation, it was found that the square root of population provided the best results.

Henderson found that a high ratio of manufacturing to service workers was correlated with a relatively even distribution of city sizes. His interpretation is that a large resource-based sector relative to the mobile or footloose service sector permits several large cities to develop. The regressions reported below include the percent of the labor force in manufacturing. Less good results were obtained using Henderson's variable.

The discussion in the previous section suggests that some remaining regional variation in Pareto exponents may not be explained by measurable regional variables. If so, inclusion of regional dummies is appropriate.

The resulting regressions, with and without the regional dummies, based on the regional β estimates in Table 4 are:

$$\beta_{it} = + 1.055 + \underset{(2.3835)}{.6984} P_{it}^{1/2} + \underset{(1.591)}{.0115} I_{it}$$

$$- \underset{(9.385)}{.4468} N - \underset{(6.227)}{.2996} S - \underset{(12.324)}{.6762} E - \underset{(10.064)}{.7439} W \tag{3}$$

$$R^2 = .91$$

and

$$\beta_{it} = 1.200 + \underset{(1.156)}{.9138} P_{it}^{1/2} - \underset{(2.440)}{.0260} I_{it} \tag{4}$$

$$R^2 = .18$$

where

β_{it} = Pareto exponent for ith region and t th year (treated as positive numbers),
i = N, S, E, W, C;
t = 0 in 1901, 1 in 1911, etc.

P_{it} = population of i th region and t th year,

I_{it} = percent of workers in manufacturing in the ith region and t th year,

N = Northern region

S = Southern region

E = Eastern region

W = Western region

C = Central region

N, S, E, and W take the value one when i refers to that region and zero otherwise. Only four dummies are needed; when i is the central region, its locational impact is included in the constant term. The four dummy variables simply permit the constant term, but not the slope coefficients, to vary by region. t-values are in parentheses below coefficients to which they refer.

The R^2 in (3) is remarkably large, whereas that in (4) is similar to the values obtained by Rosen and Resnick in their cross-country regression. Henderson, using a different dependent variable, obtained an R^2 of .69. The much larger R^2 is (3) than in (4) means that much of the regional variation in β is not correlated with regional variation in P and I. The regional dummies permit unbiased estimates of coefficients of P and I to be obtained, and yield a large R^2, but leave the regional variation in β unexplained.

Both regressions imply, as others have found, that larger populations lead to relatively even city size distributions. The positive coefficient of I in (3) implies, as Henderson found, that a large manufacturing employment share leads to an even city size distribution. The negative coefficient of I in (4) casts doubts on the specification in (4).

The regional dummy coefficients confirm what was observed in the previous sections. All four regional dummies have negative coefficients, implying that the central region has the most nearly even city size distribution, even aside from effects of P and I. Then, regional effects cause increasingly unequal city sizes as one moves from S to N to E to W.

The gradual convergence of regional city size distributions noted in the previous section raises the question of the extent to which convergence of the β's results from convergence in P and I values among regions. That question can be answered by reestimating (3) with regional dummies that are functions of time. In that specification, two variables, N and Nt, represent the northern region. As before, N is one when β refers to the northern region and zero otherwise. t refers to the census year. Similar changes are made in dummies for other regions. For example, if the coefficient of N were negative and that for Nt were positive, it would mean that the northern regional effect started, in 1901, negative, but became positive as time passed.

The new regression is

$$\beta_{it} = 1.287 - \underset{(.245)}{.281P_{it}^{1/2}} + \underset{(.207)}{.0020I_{it}}$$

$$- \underset{(4.060)}{.404N} - \underset{(5.273)}{.364S} - \underset{(7.354)}{1.110E} - \underset{(6.122)}{.748W}$$

$$- \underset{(.336)}{.0099Nt} + \underset{(.998)}{.0288St} + \underset{(2.875)}{.0954Et} + \underset{(1.298)}{.040Wt}$$

$$+ \underset{(.628)}{.0135Ct} \qquad R^2 = .950 \qquad (5)$$

In this formulation, the coefficients of the population and manufacturing employment share terms are both insignificant and that of the population term has the wrong sign. The four regional dummies again all have negative coefficients and are highly significant. Except for Et , coefficients of the products of regional dummies and time are insignificant. All but Nt have positive signs.

(5) confirms the findings from Table 4. In the early years of the century, when t was small, all four other regions had smaller β's than the central region. β's for all regions except the northern have tended to increase through time. The time trend in the eastern regional dummy is much larger than the others. R^2 is somewhat larger than in (3).

The conclusion from these regressions must be that the increasingly similar regional city size distributions have been the result of specifically regional influences, not the result of regional population and manufacturing shifts.

Growth of Individual Urban Areas

Previous sections have dealt with national and regional city size distributions and their determinants. That analysis is based on the assumption that city sizes in a nation or region form a system whose component cities move in relationship to each other. The stability of the city size distribution in India and other countries, over long periods of time and despite economic, population and urban growth, makes compelling the notion that city sizes can be understood only in relationship to each other.

Yet relative city sizes do change. Cities change positions in the distribution and the distribution itself changes. The city size distribution is a statistical summary of a complex set of phenomena affecting the growth of one, several or all the cities in a country or region. It seems worthwhile to step down from the level of national or regional aggregation and provide some analysis at the level of individual cities. The basic purpose of the analysis in this section is to shed light on the detemrinants of growth of individual cities.

The basic idea of the analysis in this section is that cities grow to the extent that their ability to provide employment grows. The basic theoretical notion on the matter is known as economic base theory. It rests on the assumption that most manufacturing production in a city is for export outside the city. If so, manufacturing employment in a city depends on demands elsewhere for products best manufactured in the city. On this view, other production in the city, such as services, is to satisfy the demands of the city's residents. Economic base theory leads to the notion that manufacturing employment is an important determinant of the total population of a city, but that causation in the opposite direction is unimportant.

Economic base theory is at best an approximation. An unknown, but probably substantial, part of manufacturing production in Indian cities is consumed in the city itself. Probably, the proportion of manufactured goods consumed in the city in which they are produced is greater the larger the city. In addition, some services produced in cities are exported outside the city in which they are produced. Bombay provides financial services for much of India, Delhi provides national government services for all of India, and many urban areas provide educational, agricultural and other services for surrounding rural residents. Thus, the strength of the correlation between manufacturing employment and city size is to some extent a test of economic base theory. The data are available for censuses starting in 1901.

There are, however, several other variables likely to influence growth of individual cities. First, the finding earlier in this report that regional dummy variables were important in understanding regional variations in city size distributions suggests that regional dummies might also be important in understanding growth of individual cities. Second, many people in India and elsewhere believe that large cities grow fast merely because they are large. If so, the initial population of the city will be correlated with the city's growth rate. Third, a city might grow faster the higher the income in the state in which the city is located. Fourth a city might grow faster the farther it is from other large cities.

In principle, the dependent variable might be either a city's population or its growth rate. Both because of dimensionality considerations and in order to avoid introducing heteroschedastic error terms, which may cause poor coefficient estimates, we employed the growth rate of the urban area as dependent variable. The sample is the percentage growth from one census year to the next of the class I cities employed in Mitra's [4] study and used earlier to estimate the Pareto distributions. A city was included for any decade for which Mitra presented population data at both ends of the decade. All growth rates available for any part of the period from 1901 to 1971 were included. 1971-1981 growth rates could not be included because 1981 manufacturing employment data are not yet available. More data are available for more recent decades.

State income data (real net domestic product per capita) were available for a significant number of states only for the 1961-1971 census decade. And the distance variable was calculated only for that decade. Thus, two regressions are presented. For the 1901-1971 period, a large sample of city growth rates can be regressed on the city's initial population, its growth rate of manufacturing employment, and the regional dummies. For the 1961-1971 decade, a smaller sample of city growth rates can be regressed on the above variables, income in the state in which the city is located, and the distance variable.

The regressions are

$$G_{it} = \underset{}{4.052} + \underset{(7.500)}{.105}\, G_{Mit} + \underset{(7.669)}{.905}\, G_t + \underset{(.542)}{.560}\, P_{i,t-1}$$

$$- \underset{(.679)}{.036}\, P^2_{i,\ t-1} + \underset{(.747)}{2.955}\, N + \underset{(.903)}{2.454}\, S$$

$$- \underset{(.534)}{2.244}\, E + \underset{(2.677)}{8.972}\, W \qquad R^2 = .355 \tag{6}$$

and

$$G_{i71} = 20.251 + \underset{(6.450)}{.287}\, G_{Mi71} + \underset{(.896)}{1.329}\, P_{i61} - \underset{(1.125)}{.0745}\, P^2_{i61}$$

$$- \underset{(1.529)}{10.294}\, N - \underset{(.055)}{.283}\, S + \underset{(.182)}{.947}\, E + \underset{(.684)}{4.733}\, W$$

$$+ \underset{(.639)}{.0217}\, NDP_{i61} - \underset{(1.904)}{.000813}\, P_{ic61}/d_{ic} \tag{7}$$

$$R^2 = .416$$

where G_{it} is the percent growth of city i's population between census years t-1 and t , G_{Mit} is percent growth of city i's manufacturing (both factory and household) employment during the same decade, G_t is percent growth of national population between t-1 and t , $P_{i,t-1}$ is city i's population in census year t-1 , N, S, E and W are the regional dummies (central included in the constant term), NDP_{i61} is 1961 real per capita net domestic production in the state in which city i is located, P_{ic61} is the 1961 populations of the closest class I city to city i , and d_{ic} is airline distance from city i to the closest class I city. t-statistics are in parentheses beneath coefficients to which they apply.

G_{Mit} and G have highly significant coefficients of the expected signs in (6), and G_{Mi} has in (7). G could not be included in (7) since it does not vary among the observations from which they apply.

G_{Mit} and G have highly significant coefficients of the expected signs in (6), and G_{Mi} has in (7). G could not be included in (7) since it does not vary among the observations from which (7) is estimated. Rapid growth of its manufacturing employment and of national population induce fast growth in a city's population. The coefficient of G in (6) is nearly one, meaning that, other things equal, cities grow almost as fast as the national population growth rate. Some writers contend that fast national population growth causes an even faster urban population growth. The opposite is true of the large sample of class I cities on which (6) is based, since (6) says that national population growth leads to somewhat smaller proportionate growth of cities.[4] The coefficient of G_M is highly significant, but small, in both (6) and (7). If city population were proportionate to its manufacturing employment, as economic base theory predicts, the coefficient of G_M would be one. The estimated coefficients of .105 and .287 in (6) and (7) imply elasticities of a city's population with respect to its manufacturing employment of about 0.1 and 0.3, contrary to the indication of economic base theory.

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4. Substitution of regional or national urban population for G in (6) led to slightly less satisfactory estimates.

In both (6) and (7), it was found that inclusion of terms in P and P^2 provided more satisfactory results than alternative functional forms. In both regressions, the coefficient of P is positive and that of P^2 is negative, indicating that a large initial population stimulates growth at low initial population levels, but that the effect disappears at high initial population levels. Both equations indicate that the effect of large initial population on population growth turns negative at modest initial population levels: about 780,000 in (6) and 890,000 in (7).[5] This implies that a large initial population discourages further city growth starting at initial populations somewhat below one million. This evidence is in opposition to the view that large cities grow rapidly because they are large. Unfortunately, significance levels are not great for P and P^2 coefficients in (6) and (7).

In both regressions, the Western region is the most favorable to the city growth. But none of the regional dummies except for the coefficient of W in (6) is highly significant.

The coefficient of the state income variable in (7) has a positive sign, as should be expected. It indicates that cites grow faster in high than in low income states. The reason is undoubtedly that used to explain the correlation between urbanization and income by country in an earlier chapter. High income promotes urbanization and whatever promotes urbanization causes rapid city growth. It should also be mentioned that regressions not reported show that cities grow rapidly if they are in states with high agricultural wage rates.

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5. P is in units of 100,000 in (6) and (7).

Undoubtedly, city and agricultural incomes interact in causing rapid city growth. But regressions containing agricultural wages were not quite as satisfactory as (7).

The coefficient of the distance variable in (7) also has the expected sign. Other things equal, cities grow faster the farther they are from the nearest class I city. Experimentation with alternative forms suggested, as a gravity model would indicate, that the effect of distance from the nearest class I city on a city's growth depends on the population of the nearest city. Other things equal, a large nearby city deters growth more than a small nearby city. The effect is quite significant. Other nearby cities than the nearest class I city may also affect the growth of a city, but we have not been able to study such effects.

(6) and (7) provide other insights into determinants of individual city growth. As with such studies in other countries, a considerable amount of the variance in city growth rates is left unexplained by available economic or demographic variables. In addition, in (6) and (7) a considerable amount of the explanatory power comes from the regional dummies, despite their uneven significance levels. The regressions leave unspecified the content of the regional influences: resource availability, state or national government policies, or other influences.

(6) and (7) suggest that as industrialization proceeds and spreads to a large set of cities, many cities will grow to sbustantial size. The regressions provide no support for the belief that large cities grow faster than small ones or that growth is fostered by size. The regressions provide evidence that manufacturing employment stimulates city population growth, but much less than is indicated by economic base theory.

Industrial Characteristics of Individual Cities

We conclude this report with some further analysis of industrial distribution by city size. Many Indian scholars and government officials are concerned about what they fear is an excessive concentration of manufacturing employment in large cities. The policy issue will be discussed in another paper. Here we provide some factual background.

Table 6 shows the percentage of all manufacturing employment located in the one, 5 and 10 cities with the most manufacturing employment in census years from 1901 to 1971. The cities with the largest manufacturing employment are not the same as the cities with the largest populations. For example, Bombay had the largest manufacturing employment, but not the largest population, in all census years in the table.

All three columns show an almost uniformly upward trend until 1951, and a strongly downward trend during the succeeding two decades. The trends are remarkably uniform in the three columns, with the sole exception of the 1931 drop in column 1. The 1951 shares are all 3.76 - 3.92 times the corresponding 1901 shares, and 1.72 - 1.91 times the 1971 shares. Thus the trend of increasing and then decreasing shares has been approximately uniform among the 10 cities with the most manufacturing employment, although the cities occupying particular ranks have changed.

Beyond doubt, part of the phenomenon represented by the figures in Table 1 is the urbanization of manufacturing that was discussed in the previous chapter. But that does not explain the falling shares after 1951, since manufacturing urbanized rapidly after 1951. Another remarkable fact about the data in Table 6

Table 6

Percent of Indian Manufacturing Employment in Cities with Large Manufacturing Employment

Year	Largest City	Largest 5 Cities	Largest 10 Cities
1901	.92	2.29	2.98
1911	1.25	2.33	3.08
1921	1.62	2.89	3.75
1931	1.38	3.05	4.19
1951	3.61	8.87	11.20
1961	3.31	7.73	9.71
1971	2.10	4.65	5.93

Source: [4] and [3].

is the smallness of the shares. For example, Table 6 shows that in 1971 Bombay had only 2.10 percent of manufacturing employment, whereas it had 5.58 percent of urban and 1.13 percent of total population.

The most important question about the trends in Table 6 is the extent to which they reflect government programs to disperse manufacturing from large cities. Undoubtedly, market forces were at work to some extent. Manufacturing would naturally disperse from its traditional centers as other cities grow in size and improve in infrastructure. In addition, improvements in inter-city transportation permit manufacturing to disperse from consuming centers. Finally, as has been pointed out, Sekhar [5] concluded that government dispersal programs have had little effect on manufacturing location by city size. Nevertheless, the strength of the dispersal of manufacturing from its traditional centers and its coincidence with government programs to foster it suggest that some of the post-independence dispersal recorded in Table 6 might have been influenced by government.

Some additional light can be shed on this issue by one additional regression. (8) shows the regression of percentage of the male population that is employed in manufacturing (PPM) on total population (P) and on time (t). The data are all the cities studied by Mitra [4] for census years from 1901 to 1971.

$$PPM_{it} = 13.844 + \underset{(4.5093)}{4.1390}\, P_{it} - \underset{(0.9899)}{0.1176}\, t \qquad (8)$$

$$R^2 = .041$$

As should be expected, the coefficient of population is positive and highly significant. Perhaps surprisingly, the coefficient of time is negative. Most surprisingly, R^2 is only .041. Thus, averaged over the long time and the many class I cities covered by the Mitra data, only 4 percent of the variance of the percent of the male population employed in manufacturing is explained by total population and time. Thus, total population is only a minor influence on manufacturing's share in total male population.

The final data to be presented in this report are in Table 7. It shows correlation coefficients between percent of male population in manufacturing and total male population for the cities in Mitra's study. Despite the declining share of all manufacturing employment in the 10 largest cities since 1951, shown in Table 6, the correlation between city size and manufacturing share shows no tendency to become smaller in the most recent data in Table 7.

The conclusion of this section is that there is hardly any relationship between city size and manufacturing's share of total employment. In no census year in the 20th century has male population explained more than 7.5 percent of the variance in manufacturing's share in male employment in India's class I cities. Furthermore, there is no evidence of a time trend in this relationship. Manufacturing location must be explained by other variables than city population, presumably variables concerned with efficiency of locations.

Conclusions

India has a rich and dispersed distribution of city sizes. The distribution has persisted with only gradual changes during the 20th century. The city size distribution varies greatly among India's 5 large regions. The regional distributions have become more similar to each other and to the national distribution during the 20th century. Only a small part of the convergence of the regional distributions is explained by regional population growth and by industrialization.

Table 7

Correlations Between Percent of Male Population in Manufacturing and Total Male Population, by Year

Year	Correlation
1901	.1617
1911	.1861
1921	.2736
1931	.0624
1951	.2683
1961	.2180
1971	.2693
All years	.1975

Source: Calculated from data in [4].

Growth rates of individual cities are affected by industrialization and by income levels in states in which cities are located. The regional effect on individual city growth is slight.

There has been rapid dispersal of manufacturing employment from the largest manufacturing centers during the period since independence. Yet the correlation between city population and the share of its labor force in manufacturing has not decreased since independence.

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