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RESEARCH ARTICLE

THE SIZE DISTRIBUTION OF CITIES AND TOWNS IN ANDHRA PRADESH (1951-2001)

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ABSTRACT

Urbanization is an index of transformation from traditional rural economies to modern industrial one. It is a progressive concentration of population in cities/towns. To describe the size distribution of cities, we use Zipf's law, which states that the size distribution of cities follows a simple Pareto distribution with shape parameter equal to 1. In this paper we have performed a test for Zipf's law in respect for Andhra Pradesh city and town sizes distribution for the period 1951-2001. The analysis of data reveals that class I cities dominate Andhra Pradesh urban scene in terms of their share in urban population. We have performed sensitivity analysis and observed the resulting impact on the Pareto coefficient. An indepth study of the City Size Distribution demonstrates that the value of the Pareto coefficient increases when the threshold population increases for 2001 census data.

INTRODUCTION

Urbanization is an index of transformation from traditional rural economies to modern industrial one. It is a long term process. It is progressive concentration of population in urban unit. Davis (1962) explained urbanization as a process of switch from spread out pattern of human settlements to one of concentration in urban centers. The onset of modern and universal process of urbanization is relatively a recent phenomenon and is closely related with industrial revolution and associated economic development. A majority of the developing countries started experiencing urbanization only since the middle of 20th century. In a formerly rural economy country like India, because of need to decrease the number of persons dependent on agriculture and to improve productivity in rural areas, urbanization is viewed as a prerequisite of growth. The urban population in India has grown from 25.7 million in 1901 to 286.1 million in 2001. After independence in 1947, the rate growth of urban population increased from 2.64 percent in 1951 to 3.88 percent in 1981 and thereafter declined to 2.77 in 2001: but the share of urban population to the total population of the country constantly increased from 10.9 percent in 1901 to 15.92 percent in 1951 and thereafter to 27.78 percent in 2001.

Jain (1971), Ashish Bose (1980), Rakesh Mohan and Chandrasekhar Pant (1982), Kundu (1983), Ramachandran (1989) and Sivaramakrishnan *et al.* (2005) have made substantial contributions for the study of urbanization in India. Gabaix (1999) have shown that if a country is composed of several regions and if Gibart's law holds in each region, then Zipf's law will be satisfied for all regional and also for the National City Size Distribution. Based on this pioneering work by Gabaix (1999), Giessen and Sudekum (2009) have stated that Zipf's law also holds good for regional city size distribution. This important aspect has motivated us to study the City Size Distribution in region/state in India Viz. Andhra Pradesh and this is the novel conceptual contribution of this paper. The structure of the paper is as follows. A detailed account of urban scenario of Andhra Pradesh is presented in section 2. Section 3 contains the theoretical aspects of City Size Distribution models and a select review of the related works. In section 4 we have presented the data structure on City Size Distribution and models fitted for the full data and sample threshold data. Summary and conclusions of the study are given section 5.

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Andhra Pradesh

Andhra Pradesh and its demographic profile

Andhra Pradesh is one of the 29 states of India and covers an area of 2,75,000 square Kilometers (106,204 sq.miles). It is the fifth largest state in India both in area and population and ranks tenth in terms of its urban population. The density of the population is 275 per square kilometers. Andhra Pradesh is bounded on the north by Orissa and Chattisgarh, on the west Maharashtra and Karnataka, on the South by Tamil Nadu and in the east by Bay of Bengal with a coastal line of 974 kilometers. Andhra Pradesh is the third largest contributor to India's GDP. It has a Human Development Index of 0.572 which is lower than the national average 0.572.

A demographic profile of Andhra Pradesh and India based on 2001 census is given below:

Table 1: Demographic profile of Andhra Pradesh and India (2001 Census)

	Andhra Pradesh (in millions)	India (in millions)
Total Population	76.21	1028.73
Decadal Population Growth	14.59	21.54
Population Density (per sq. km.)	277	324
Sex ratio	978	933
Literacy	60.47	64.84
Percentage of urban to total population	27.04	27.78

Definition of Urban area

The definition of an urban unit in the Census of India 2001 is as follows:

1. All places with a Municipal Corporation, Municipality, Cantonment Board or Notified Town Area Committee, etc.
2. All other places that satisfied the following criteria:
   (a) A minimum population of 5000,
   (b) At least 75% of the male working population should be engaged in non-agricultural pursuits and
   (c) A density of population of at least 400 per sq. km. (1000 per sq. mile).

All places, which have been notified under law and have local bodies like municipal corporations, municipalities, municipal committees, municipal boards, municipal town committees, cantonment boards, notified areas, notified area committees, town committees, town areas, town boards, town municipalities, sanitary boards etc., irrespective of their demographic characteristics have been included in the category of towns.

Basic statistics of urban population in Andhra Pradesh

The following table contains the basic statistics of urban and rural population according to 2001 census.

Table 2: Population of Andhra Pradesh by sex and residence: 2001

Andhra Pradesh	Male	Female	Total population	Sex ratio
Urban	1,05,90,209	1,02,18,731	2,08,08,940	965
Rural	2,79,37,204	2,74,63,863	5,54,01,067	983
Total	3,85,27,413	3,76,82,594	7,62,10,007	978

The total number of urban dwellers in Andhra Pradesh as per the Population total of the Census of India 2001 is 7,62,10,007. Males number 3,85,27,413 while females total 3,76,82,594. The total number of urban dwellers in the country is 285,354,954 consisting of 150,135,894 males and 135,219,060 females. The percentage of urban population to total population in the country works out to 27.78% as against the ratio of 27.08% in Andhra Pradesh. Andhra Pradesh ranks fifth in terms of its urban population 2001.

City Size distribution models

Urban growth and statistical models of City Size Distribution: Urban growth is an economic phenomenon which is closely linked with the process of urbanization. The size distribution of cities is the result of pattern of urbanization, which result in city creation. The studies of urban growth by size class of towns with helps to understand the stages of urban development. In the evolution of urban systems, there exists two dynamics: a slow one which acts at the macro-level and characterize the evolution of city size distribution; and a more rapid one which acts at the micro level of the individual city, this being the dynamic of the variation of city population over short term intervals. For modeling the evolution of an urban settlement over a long period of time, it is necessary to understand clearly how the two dynamics interacts in an urban system.

Zipf's Law

Auerbach (1913) and Singer (1936) demonstrated that the city size distribution could be represented as a Pareto distribution

$$y=Ax^{-\alpha} \quad (3.1.1)$$

or

$$\log y=\log A-\alpha \log x \quad (3.1.2)$$

where x is the population of a city; y is the rank of cities if cities are ordered from largest to smallest; A and α are constants. In addition, Zipf (1949) proposed that the distribution of city size takes a special form of the Pareto distribution, with shape parameter α = 1, and A corresponding to the size of the largest city. This is known as Zipf's law.

A select review of city size distribution models

Simon (1955) used a model of city growth and formation to produce a City Size Distribution. Carroll (1984) studied in detail the various aspects of National City size Distributions. Empirically the Pareto law has been proved a very accurate description of City Size distributions in many different countries and at different times within a country (Rosen and Resnick, 1980: Mills and Hamilton, 1994; Fujita et al.,(1999). Fan (1988) studied the size, growth and distribution of Chinese cities. Gabaix (1999) has shown that city growth is scale independent and the growth process has reflective barrier at some level arbitrarily close to 1 viz, Zipf's law. The remarkable contributions by Eaton and Eckstein (1997) on France and Japan, Dobkins and Ioannides (2001) on USA, with later work by Black and Henderson (2003) and Ioannides and Overman (2003) on USA establish some basic facts about urban system and their development in France, Japan and USA over the last century or so. Gabaix and Ioannides (2004) have reviewed the empirical evidence on the upper tail of city size distribution and discussed the theories that have been advanced to explain the approximate constancy of the distribution across very different economic and social systems, emphasizing both bare-bone statistical theories and more developed economic theories. Cordoba (2004) studied the necessary and sufficient condition to produce a Pareto distribution of city sizes within a class of standard urban models. Soo (2005) assessed the empirical validity of Zipf's law, using new data on 73 countries. He used two different estimation method viz., standard OLS and Hill estimator. Using OLS he found that, for majority of countries (53 out of 73), Zipf's law is rejected. Nitsch (2005) performed a meta-analysis of previous empirical findings on Zipf's law, and found that, on average, the empirical studies resulted with a Pareto exponent which is greater than one.

Table 3. Size Distribution of Cities and Towns (1951-2001)

Census Year	> 1,00,000	50,000-1,00,000	20,000-50,000	10,000-20,000	5,000-10,000	< 5,000	Total
1951	5	11	34	54	19	3	126
1961	10	9	50	45	14	0	128
1971	13	18	63	37	10	1	142
1981	22	33	67	24	10	1	157
1991	36	42	68	22	6	0	174
2001	47	52	56	33	21	2	211

Soo (2007) performed a test of Zipf's law using data for Malaysian cities from five population censuses (1957, 1970, 1980, 1991 and 2000) and concluded that Zipf's law is rejected for the periods except 1957, in favour of a City Size Distribution that is more unequal than would be predicated better, are more favorable to Zipf's law. Bosker *et al.* (2008) used empirical evidence on the evolution and structure of the west- German City Size Distribution to assess the relevance of the three different theories of urban growth. Subbarayan (2009) has made some initial attempts to study the size distribution of cities in an Indian State and concluded that the value of Pareto coefficient showed a U shaped pattern and this is support of the conclusion arrived by Parr (1985) . Urzua (2010) has noted a common fitfall in testing for Zipf's law. Gongalez-Val (2011) has applied the methodology proposed by Ioannides and Overman (2003) to estimate a local Zipf coefficient using data for the entire twentieth century of the complete distribution of cities without any size restrictions in the U.S. Matlaba et al.(2011) have studied the evolution of size distribution of urban system in Brazil between 1907 and 2008.

Data structure on city size distribution

Data on City Size Distribution

India has very rich source of information for urban studies. The census volumes, both at the National and the state and district levels, provide a mine of information for rural and urban places for a period of 60 years. It is also main source of information for temporal studies focusing in the recent past. The census also provides data on intra – city spatial units. The census periods used are: 1951, 1961, 1971, 1981, 1991 and 2001.

Urban size class under Indian census

Census of India classifies urban centres into six classes. Urban centre with population of more than one lakh is called a city and less than one lakh is called a town. Cities accommodating population between one to five million are called metropolitan cities and more than five million are mega cities. Majority of metropolitan and mega cities are urban agglomerations. An urban agglomeration may consist of any one of the following three combinations:

(i) A town and its adjoining urban outgrowths,
(ii) Two or more contiguous towns with or without their outgrowths and
(iii) A city and one or more adjoining towns with their outgrowths together forming a contiguous spread.

Examples of urban outgrowth are railway colonies, university campus, port-area, military cantonment located within the revenue limits of a village or villages contiguous to the town or city. Urban population by size classification is based on the following:

Class	**-**	**Population**
I	-	Greater than 1,00,000
II	-	50,000 – 1,00,000
III	-	20,000 – 50,000
IV	-	10,000 – 20,000
V	-	5,000 – 10,000
VI	-	Less than 5000

City Size Distribution in Andhra Pradesh (1951-2001)

The number of cities / towns for each census year under six classes given in the following Table 3.

Basic Results on City Size Distribution

The process of urbanization in Andhra Pradesh is primarily large-city oriented. It is important to note that class I cities have been growing up systematically through all the five decades. We have examined the movement of towns across the census periods and alsothe emergence of new towns. The important observation is that the Class I cities dominated the urban scene in Andhra Pradesh in terms of their share in the urban population. In 1951, the share of class I cities was19.59% whereas class V and VI towns had 4.36% of the urban population. The share of class I towns has increased from 1961 onwards. The increase was maintained in the following decade's upto 2001. In the case of class IV and class V towns, we find that there is a downward movement from 1951 onwards and up to 1991. It is also observed that in the case of class III towns there is oscillatory movement of the population between 1951-2001.The massive increase in the share of I class cities has often been attributed to faster growth of the large cities, without taking into consideration the increase in the number of these cities. Indeed, the basic reason for the increasing dominance of these cities is the graduation of lower-order towns into class I category. In 1951 for example, there were only 5 towns in class I category. This figure went upto 47 in 2001. This can be attributed to the natural growth of population and migration of people to urban centres.

Results of Basic Zipf regression

Slope Estimate for full data set

The computation of Zipf regression has been performed for the census periods 1951-2001 using Rank-Size rule. The Zipf regression results are presented in the following table.

(i) During the period 1951-2001 the value of the slope estimate is greater than one and it clearly indicates that there was uneven distribution of the urban population.

(ii) It is interesting to note that during the period 1981-2001 the slope estimate is less than one and it clearly indicates that there was even distribution of urban population.

(iii) It is also observed that for the full data set the slope estimates are decreasing over time leading to even distribution of urban population. The estimates of the slope estimates are all statistically significant at 5% significance level.

Table 4(a): Full data (1951-2001)

Census Year	Model fitted	R^2
1951	logy = 15.432 - 1.179 log x (0.305) (0.031)	0.921
1961	logy = 15.458 - 1.151 log x (0.259) (0.026)	0.941
1971	logy = 14.833 - 1.054 log x (0.204) (0.020)	0.953
1981	logy = 13.847 - 0.926 log x (0.213) (0.020)	0.932
1991	logy = 14.313 - 0.937 log x (0.247) (0.023)	0.908
2001	logy = 12.639 - 0.773 log x (0.222) (0.021)	0.870

Sensitivity of the slope estimates to sample thresholds

In order to examine the sensitivity of slope estimates to the choice of sample threshold we defined several sample cut-offs, chosen taking into account the dimension of the Andhra Pradesh urban city system and current cut-offs for urban definition of Indian Census. We have performed sensitivity analysis with the following threshold population:

(i) A threshold level of population 5000 and above.
(ii) A threshold level of population 10,000 and above.

The result obtained based on the above threshold population level are given below:

Table 4(b): Threshold population 5000 and above (1951-2001)

Census Year	Model	R^2
1951	logy = 16.120 - 1.246 log x (0.269) (0.027)	0.946
1961	logy = 15.458 - 1.151 log x (0.259) (0.026)	0.941
1971	logy = 15.005 - 1.070 log x (0.192) (0.019)	0.960
1981	logy = 13.996 - 0.939 log x (0.206) (0.019)	0.938
1991	logy = 14.313 - 0.937 log x (0.247) (0.023)	0.908
2001	logy = 12.852 - 0.792 log x (0.219) (0.020)	0.880

Table 4(c): Threshold population 10000 and above (1951-2001)

Census Year	Model	R^2
1951	logy = 17.812 - 1.409 log x (0.211) (0.021)	0.978
1961	logy = 16.882 -1.286 log x (0.197) (0.019)	0.976
1971	logy = 15.870 - 1.149 log x (0.138) (0.016)	0.983
1981	logy = 14.895 - 1.020 log x (0.169) (0.020)	0.967
1991	logy = 15.191 - 1.015 log x (0.213) (0.020)	0.942
2001	logy = 14.406 - 0.928 log x (0.206) (0.019)	0.930

The average value of the Pareto coefficient is 1.003 for full data, 1.023 for the threshold population 5000 and above and 1.135 for the threshold population 10,000 and above. Moreover the value of R^2 for the period of study ranges between 0.8700 and 0.9530.

Sensitivity of the slope estimates to sample thresholds for 2001 Census Data

It is frequently suggested in the literature that Zipf's law holds only for the upper tail of the urban system: that is, for the largest cities rather than for the entire urban system. Zipf's law in general does not hold for the entire Andhra Pradesh urban system. We perform a sensitivity analysis by successively reducing the number of cities/towns in the sample and observed the resulting impact on the value of the slope estimate.

Table 5: Sensitivity Analysis

2001	SIZE	α	R^2
Full Data	211	0.773	0.870
5000 above	209	0.792	0.880
10000 above	188	0.928	0.930
20000 above	155	1.100	0.976
30000 above	139	1.154	0.985
50000 above	99	1.198	0.983
75000 above	61	1.246	0.975
100000 above	47	1.271	0.968

It is interesting to note that the value of the slope coefficient increases when the threshold population increases for 2001 census data.

Summary and Conclusions

In this paper we have discussed the Zipf's law for Andhra Pradesh cities/ towns. The average value of slope estimate is 1.003 for full data. For threshold population 5000 and above and for threshold population 10,000 and above the slope estimates are 1.023 and 1.135 respectively. We have investigated the time evolution of the rank-size distribution for the population of cities to show how the Pareto exponent changes with time. We also find that the Pareto law fits Andhra Pradesh cities/towns data well. As a final remark, we can compare Andhra Pradesh experience of urban growth with that of other states in India for a deeper understanding of the form of regional City Size distribution.

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