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SIZE DISTRIBUTION PATERN OF CITIES AND TOWNS IN KERALA (1951-2001 CENSUS): AN EMPIRICAL ANALYSIS

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ABSTRACT

The process of urban growth is closely related to the size distribution of cities. The distribution of urban population takes place among settlements of differing sizes along a continuum from small towns to giant cities. The mono–centric urban structure becomes monocentered and dominates the rest of the urban system. The study of urban growth by size class of towns will help us to understand the changes of urban development in a region. To describe the size distribution of cities, we use Zipf's law, which states that the size distributions of cities follow a simple Pareto distribution with shape parameter equal to 1. In this paper we have performed a test for Zipf's law census data for Kerala's city and town sizes distribution for the period 1951 – 2001. The analysis of data reveals that class I and Class II towns dominates the urban system in Kerala in terms of their share in urban population. An indepth study of the City Size Distribution demonstrated that the value of Pareto coefficient is approximately equal to1 for the full data and for the different sample threshold population.

Keywords: Zipf's law, Pareto Exponent distribution, City size distribution, Rank – Size Rule.

1. INTRODUCTION

The distribution of urban population takes place among settlements of differing sizes along a continuum from small towns to giant cities with population of tens of millions. Cities grow initially benefitting from the increasing agglomeration economy, but after a certain stage due to congestion and crowding diseconomies set in resulting the urban sprawl into the adjoining area. The mono-centric urban structure becomes multi-entered and dominates the rest of the urban system.

In the evolving urban structure, the small and intermediate towns are expected to grow slowly compared to large cities in the early phases of urbanization. In the latter phases, the smaller towns are expected to grow as a result of congestion and crowding in the large and intermediate towns. This cycle of urbanization postulated by Geyer and Kontually (1993) in terms of primate city, intermediate city and small city phase keeps on repeating not necessarily with same group of towns. The study of urban growth by size class of towns will help us to understand the changes of urban development in a region. 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) established Gibart's law as a statistical explanation for Zipf's law, thereby opening new avenues for theoretical and empirical research on the rank-size rule and 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 works of Gabaix, Giessen and Suedekum (2009) studied the Zipf's law for cities in the regions and the country. This important aspect is the basis and motivation for our study of City Size Distribution in Kerala, a State in India for the period 1951 -2001.

The structure of this paper is as follows. In section 2 a detailed account of urban scenario in Kerala is presented. Section 3 deals with the theoretical aspects of City Size Distribution Models and a select review of the research carried out for the last 50 years. In section 4 we have presented the data structure on City Size Distribution and results of basic Zipf regression. Summary and Conclusions of the study are presented in section 5.

2. Kerala

2.0 Kerala and its demographic profile

Kerala is one of the 29 states of India and covers an area of 38,863 square kilometres. It is the twenty-first largest state in India by area and 12th most populous state. Kerala lies in between the high Western Ghats on the east and the Arabian sea on the west, the width of the state varies from 35 kilometres to 120 kilometres. According to the geographical features the state can be divided into hills, valleys, midland plains and coastal belt.

Kerala is the 9th largest contributor to Indian's GDP. Kerala has a high human development index 0.814 which is significantly higher than the national average of 0.575.

A demographic profile on Kerala based on 2001 census is given in Table 1

Table 1: A Demographic profile of Kerala and India based on 2001 Census is given below

	Kerala (in millions)	India(in millions)
Total Population	31.84	1028.73
Decadal Population Growth	9.43	21.54
Population density(per.sq.km)	819	324
Sex ratio	1058	933
Literacy	90.86	64.84
Percentage of Urban to total Population	25.97	27.78

[Source: Census of India 2001]

2.1 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.

2.2 Basic Statistics of Urban Population in Kerala

The basic Statistics of urban and rural population according to 2001 census is given in Table 2.

Table2: **Population of Kerala by sex and residence: 2001**

Kerala	Male	Female	Total Population	Sex ratio
Urban	40,17,332	42,49,593	82,66,925	1058
Rural	1,14,51,282	121,23,167	2,35,74,449	1059
Total	1,54,68,614	1,63,72,760	3,18,41,374	1058

The total number of urban dwellers in Kerala as per the population total of Census on India 2001 is 82, 66,925. Males number 40,17,332 while Females total 42,49,593. The total number of urban dwellers in the country is 28,53,54,954 consisting of 15,01,35,894 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 25.97% in Kerala. Kerala stands 12th in terms of its urban population.

3. City Size Distribution Models

3.0 Urban growth and Statistical models City Size Distribution

Urbanization has been in recent years a key area of debate among economists and development analysts. The urban area plays a key role in the regional economy as the spatial link when most economic activities take place. A standard method to test whether the distribution of cities is consistent with various theories of urbanization is to check if the power law holds. The power law of the distribution of cities is a property that applies to many distributions with fat tails. The income distribution is another social economic example of a fat (right) tail distribution. At the end of 19th century's for the first time Pareto applied this power law for the study of income distributions.

3.1 Zipf's Law

The new school (2010, paragraph 10) states:

(Pareto) argued that in all countries and time the distribution of wealth follows a regular logarithmic pattern that can be captured by the formula.

$\log N = \log A + m \log x$ ..... (1)

when N is the number of income earners who receives income higher than x, and A and m are constants. The law was subsequently applied to the distribution of Germen cities by Auerbach (1913) and he has denoted the variables of the power law equation as follows: N is population size of the city with rank x, with the largest city ranked 1, the second largest city ranked 2, and so on; A and m are parameters: the former is the intercept that equals the expected value of the logarithmic of the largest city and latter is the slope which equals the power law parameter. The power law parameter m is a negative number of which the absolute value is known as $\propto$ in the city size distribution literature. Zipf (1949) emphasised the special case in which $\propto = 1$; consequently, this particular case is known as Zipf's (or the Rank-Size Rule)

The estimate of $\propto$ indicates the degree of city size distributions skewness. If Zipf's law does not hold there are two possibilities:

(i) If $\propto$ > **1**, the city size distribution is more uneven and the biggest city is larger than Zipf's law predicts;

(ii) If $\propto$ < 1, the city size distribution is more even and the biggest city is smaller than Zipf's law expects.

3.2 A select review of city size distribution models

Simon (1955) used a model of city growth and formation to produce a City Size distribution. A number of extensive surveys exist. Carrol (1984) covers earlier work in some detail; Chessire (1999) provides a survey of most recent work.

One of the first attempts to measure empirical validity of zipf's law in an international comparison is the influential paper by Rosen and Resnik (1980). Their result is that 32 out of 44 countries have Pareto exponents greater than unity and the mean exponent to be 1.136, which is to some extent bigger than the Pareto exponents that is implied by the Rank Size rule ($\propto$ = 1). This indicates that population of these countries are more evenly distributed than expected according to Zipf's law. In addition they provide evidence for cities not being distributed according to a power law, finding significant non-linear terms and put forward the argument that the rank-size rule is only an approximation to the description of city size distributions.

Parr (1985) has applied Pareto law of income distribution for the analysis of city structures. He has computed Pareto coefficient as a measure of interurban concentration and shown how this coefficient varies through time within a nation. On the basis of evidence from 12 nations, he has stated that over a time a nation tends to display a U- shaped pattern in the degree of interurban concentration and explored the various bases for the temporal pattern of concentration within a nation.

Another strand of work, associated primarily with Alperovich (1985) and also with Kamecke (1990), is the investigation, of whether, or not, urban system really conforms to the rank size rule. Alperovich pointed out that it is not only a question of whether the distribution of city sizes conforming to Pareto distribution but also whether is satisfies rank size rule viz., $\propto$ = 1. If the rank size rule is applied precisely, it implies that the constant A is equal to the population of the largest city. Alperovich (1988, 1989) derived a series of tests for the conformity of rank size rule and explored the issue of the sensitivity of rank size rule tests to sample size.

Cameron (1990) has raised somewhat technical question in the methodology adopted by Rosen and Resnick (1980) to estimate the value of $\propto$ based on a number of independent variables- such as income levels, industrial value added as a proportion of GDP, railway mileage and overall population density. She has finally concluded that variation in City Size distribution across countries reflect not just national factors but also the characteristics of the individuals cities that constitute particular urban system.

Guerin – Pace (1995) studied the variability of rank-size parameters for the data on French cities and demonstrated the sensitivity of the Pareto's exponent to the variations of city sample size. He had also shown that the non-paretion behaviour of city size Distribution which appears in some censuses can be linked to the particular growth process of middle sized cities. The size distribution of cities is Pareto distributed, is scale free. Gabaix (1999) established this relationship formally. He showed that if city growth is scale independent (the mean and variance of city growth rates do not depend on city size: Gibart's law) and the growth process has a reflective barrier at some level arbitrarily close to 1 viz., Zipf's law.

Eaton and Eckstein (1997), Fan (1999) Dobkins and Ioannides (2001), Black and Henderson (2003) and Gabaix and Ionnides (2004), Nitsch (2005), and Soo (2005, 2007) have made substantial contributions for the study of City Size Distribution models. Bosker etal (2008) used empirical evidence on the evolution West German City Size Distribution.

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 U shaped pattern and this is support of the conclusion arrived by Parr (1985).

Urzua (2010) studied the limitation in testing for Zipf's law. Gonzalez- Val (2011) estimated the local Zipf coefficient using the data for the entire 20th century of the complete distribution of cities without only size restrictions in the U.S. Matlaba et al (2011) has studied the Evolution of the Urban System in Brazil.

4. Data structure on City Size Distribution

4.0 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.

4.1 Urban Size Class under Indian Census

Census of India classifies urban centres into six classes. Urban centre with population of more than one Lakhs is called a city and less than one Lakhs 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

4.2 City Size Distribution in Kerala (1951-2001)

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

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	4	3	10	21	6	1	**45**
1961	4	4	22	17	4	1	**52**
1971	5	8	32	11	3	1	**60**
1981	6	8	55	14	4	1	**88**
1991	9	17	69	34	10	1	**140**
2001	10	24	72	37	15	1	**159**

[Source: Census of India Volumes- Kerala]

4.2.1 Basic Results on City Size Distribution

The process of urbanization in Kerala is quite different from other southern states. Class III cities have been growing up systematically through all the 6 decades. It is also observed that in the case of Class IV and Class V towns there is oscillatory movement during 1951 – 2001. We have examined the movement of towns across the censuses and also the emergence of new towns. The important observation is that class I and class II cities dominates the urban system in Kerala in terms of their share (more than 50%) in the urban population.

4.3 Results of Basic Zipf regression

4.3.0 Slope estimates for the full data set

Zipf's regression estimates are computed for the census period 1951-2001 and the results are presented in Table 4(a)

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

Census Year	Model fitted	R^2
1951	Log y = 11.967 – 0.9182 log x (0.376) (0.038)	0.9322
1961	Log y = 12.460 – 0.9354 log x (0.374) (0.037)	0.9281
1971	Log y = 13.207 – 0.9774 log x (0.349) (0.034)	0.9354
1981	Log y = 14.606 –1.0728 log x (0.401) (0.039)	0.8995
1991	Log y = 14.047 – 1.0471 log x (0.261) (0.025)	0.9255
2001	Log y = 14.641 – 1.0259 log x (0.233) (0.023)	0.9296

For the full data set, the slope estimates increases upto 1981 and then decreases. This clearly shows that the distribution of urban population was more even upto 1981 and then it has become more uneven ofter 1981. This indicates that biggest city is larger than the Zipf's law prediction. The estimates of the slope values are statistically significant at 5% significance level.

4.3.1 Sensitivity of the slope estimates to sample thresholds

The sensitivity analysis has been carried out with the following threshold populations. Threshold levels were determined based on the dimension of the Kerala urban system and urban definition of India census.

(i) A threshold level of population 5000 and above

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

The results based on the above threshold population levels are given in Tables 4(b) and 4(c)

Table 4(b): Threshold Population 5,000 and above (1951 -2001)

Census Year	Model fitted	R^2
1951	Log y = 11.946 – 0.916 log x (0.379) (0.038)	0.932
1961	Log y = 13.099 – 0.9963 log x (0.299) (0.029)	0.9592
1971	Log y = 13.592 – 1.0133 log x (0.317) (0.031)	0.9505
1981	Log y = 14.777 – 1.089 log x (0.401) (0.039)	0.9030
1991	Log y = 14.754 – 1.050 log x (0.262) (0.025)	0.9260
2001	Log y = 16.080 – 1.159 log x (0.186) (0.018)	0.9680

Table 4(c): Threshold Population 10,000 and above (1951 -2001)

Census Year	Model fitted	R^2
1951	Log y = 11.875 – 0.9110 log x (0.403) (0.040)	0.934
1961	Log y = 13.342 – 1.0190 log x (0.293) (0.029)	0.966
1971	Log y = 13.768 – 1.0300 log x (0.314) (0.030)	0.956
1981	Log y = 15.581 – 1.1640 log x (0.370) (0.035)	0.930
1991	Log y = 15.841 – 1.1511 log x (0.229) (0.022)	0.9557
2001	Log y = 16.629 – 1.2080 log x (0.182) (0.017)	0.975

5. SUMMARY AND CONCLUSION

The average value of the Pareto coefficient is 0.9961 for full data, 1.0308 for the threshold population 5,000 and above and 0.9619 for the thrshold population 10,000 and above. The value R^2 for the study period ranges between 0.8995 and 0.9354. The value of the Pareto coefficient has not shown any pattern and this requires further examination. As a final research, we can compare urban growth Kerala with other states India for a deeper understanding of the form of Regional City Size Distribution.

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