IS THERE AN OPTIMUM CITY SIZE DISTRIBUTION FOR DEVELOPING COUNTRIES?

by

PETER SPENCE GUDGEON

B.A. (Honours), Victoria University of Manchester, 1965

Dip. in Econ. Dev., Victoria University of Manchester, 1967

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF ARTS

in the department

of

Economics and Commerce

SIMON FRASER UNIVERSITY

December, 1968

EXAMINING COMMITTEE APPROVAL

Dr. K. Okuda
Senior Supervisor

Dr. D. Maki
Examining Committee

Dr. N. Robinson
Examining Committee

ABSTRACT

The distribution of city sizes in terms of population in both underdeveloped countries and developed countries, has recently come under close examination by specialists in many academic fields. The advent of general systems theory has proved to be an invaluable analytical approach to the study of city size distributions, in that it incorporates stochastic growth theory, and the concept of entropy. These two aspects of general systems theory have been very useful in explaining some of the empirical regularities observed of city size distributions, especially the log-normal (or rank-size) distribution.

This essay primarily examines the various theories that have been developed to explain the rank-size distribution of cities, and relates these theories to the general systems approach. It is also hypothesized (in a somewhat tentative fashion) that the log-normal city size distribution is an "optimum", equilibrium or "steady-state" distribution toward which city size distributions tend under certain large competitive environmental conditions.

This essay is not intended to be an exhaustive study of the literature, and incorporates only a brief excursion into possible policy considerations of the theoretical and empirical findings on the city size distributions in developing and developed countries.

TABLE OF CONTENTS

LIST OF DIAGRAMS

INTRODUCTION

The existence of different size distributions of cities in both developing and developed countries has long been recognized by students in many disciplines, and has raised some fundamental questions for planning in underdeveloped countries. For example, is there any significance in the fact that some cities have grown faster than other cities? What are the causes of this growth? What are the problems associated with differential growth and size of cities?

Much of the work on urban problems has been done in relation to regional development programming in the United States, and comparatively little research has been undertaken on the fundamental problems of defining an optimum size distribution of cities for developing countries. Is there indeed an optimum? What are the criteria for optimality? Is there an optimum with respect to maximization of economic growth, or is it some broadly defined welfare optimum that is desired? Obviously the optimum size distribution of cities in underdeveloped countries could be defined in terms of economic, social, political, or any other criteria, and the choice of optimum will depend very much on the objective function of the planner and those of society at large.

It is worthwhile at the outset to give some consideration to the general problems of defining our criteria for optimality. One can approach the problem from many different angles; one can define an absolute limit to the size of any one city under different sets of initial conditions and constraints or one could search for an optimum for the whole range of city sizes in any one country.

Any criteria for optimum population size involves, implicitly or explicitly, two elements: first the normative element, which places a positive or negative valuation on a particular situation; and second, a factual element which has the force of a statement of empirical relationships between variation in city size and variation in the situation in question.

One can also attack this problem from (1) the point of view of the theorist of city planning interested in setting general standards for the over-all planning of cities, or (2) determine a list of specific criteria for determining optimum city size, or (3) examine each of the criteria from the standpoint of observable relationship between city size and the variables involved in the criteria.

Consider for example that a criterion of optimum city size is that a city's size should be that which is favorable to the health of its population.

Hence: Let good health = a positive value.
Let ill health = a negative value.

Is there some significant correlation between city size and health? If there were no such correlation, there would obviously be no "most favorable" size, i.e. no optimum.

Clearly then, examining city size from the point of view of the city planning theorist provides only one illustration of a procedure for validating the concept of optimum city size.

Historically the concept of optimum size of cities has underlain planning theory and practice, either in explicit or implicit form.

Among the criteria that have been examined in relation to the optimum city size in both developed and developing countries is:

(1) City size and physical planning of cities with respect to the frequent demand that cities be small enough to enable ready access to the countryside and a resonably moderate journey to work, i.e. transporation problems.

(2) City size and health (mortality rates, incidence of diseases, etc.).

(3) City size and public safety (crime rates, accident rates, fire hazards, etc.).

(4) City size and municipal efficiency (highways, sanitation, public welfare, schools, etc.).

(5) City size and education expenditures.

(6) City size and cost of living.

(7) City size and public recreation (accessibility to parks, zoos, theatres, etc.).

(8) City size and retail facilities.

(9) City size and churches and associations.

(10) City size and family life (degree of homeownership, divorce rates, domestic facilities, etc.).

(11) City size and miscellaneous psychological and social characteristics of urban life (provincialism, friendliness, social contentment, community participation).

It is immediately apparent that one could extend this list indefinately at the risk of increasing the already considerable overlap in the type of relationships, and realizing at the same time that the question of the casual significance of the relationships between city size and these phenomenasis subject to serious problems of statistical interpretation. [1]

A rather bizarre example of planning optimality according to a definite criterion in advanced industrial countries is the idea that cities should be small enough to have a low probability of nuclear destruction. [2]

As a general statement it would be true to say that in the past economists have not paid much attention to optimum city size, and even less attention to optimum city size distributions. More recent research on the relationship of city size to economic policy, especially public investment decisions and growth theory in relation to urbanization and industrialization in underdeveloped countries and developed countries, has helped to eliminate their shortcomings. [3] Yet the study of optimum city size distributions has been meagre to say the least, until the advent of a general systems approach to the study of city size distributions. This approach to the study examines the role, functions, and spatial distribution of cities as a subsystem in a whole integrated system to economic and social development, and has been usefully applied to developed and underdeveloped countries alike. [4]

The multiplicity of different criteria for optimal city size or city size distributions makes it impossible, in my opinion, to arrive at some meaningful overall criterion. It would be impossible to reconcile the different criteria. In view of this a deductive approach to the general problem appears more reasonable. Can one arrive at any conclusions from examination of the many different causes underlying existing city size distributions? Is there a city size distribution that comes closest to an actual or theoretical optimum? Evidence suggests that this may be so, in the form of the log-normal city size distribution.

Consequently much of this essay will be concerned with examination of the log-normal types of city size distribution and their relevance to the problem of an optimum city size distribution. However before this is done one must examine the empirical evidence on existing distributions in developing countries.

I. CITY SIZE DISTRIBUTIONS AND DEVELOPING COUNTRIES

Possibly the most complete and comprehensive empirical study of the city size distributions in developed and developing countries is that by Berry,[5] who analyzed city size distributions and their relationship to levels of economic development in thirty-eight countries. He found that the distributions fall into two major categories, namely the Rank-Size Distribution[6] and the Primate Distribution.[7]

The Rank-Size Distribution was revealed in both developed and underdeveloped countries when the cumulative frequency of cities with a population of greater than twenty thousand people was ranked against the size of city on a log-normal scale. Thirteen of the thirty-eight countries had log-normally distributed sizes.[8] (See Diagram 1a).

The Primate Distribution which was characteristic of fifteen out of thirty-eight countries examined, is observed when a stratum of small towns and cities is dominated by one or more very large cities and there are deficiencies in the number of cities of intermediate size.[9] (See Diagram 1b) Berry's study tended to support the hypothesis that Primate City Distributions are associated with over-urbanization and superimposed colonial economies in underdeveloped countries or with political-administrative controls in indigenous subsistence and peasant economies. Furthermore it has been argued that primate cities have paralytic effects upon the development of smaller urban places and tend to be parasitic in relation to the remainder of the national economy.

Nine out of thirty-eight of the countries examined had distributions intermediate between the log-normal (rank-size) and the primate

DIAGRAM 1a

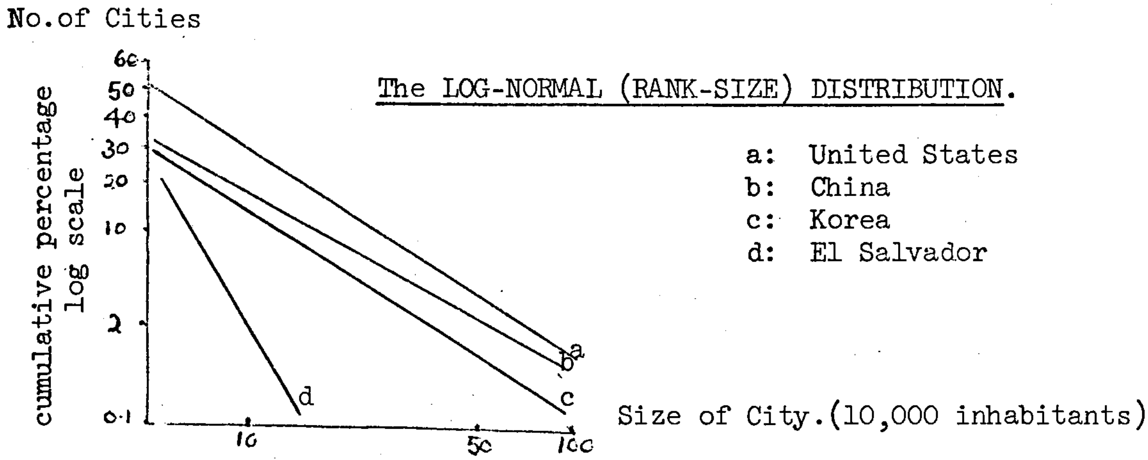


DIAGRAM 1b

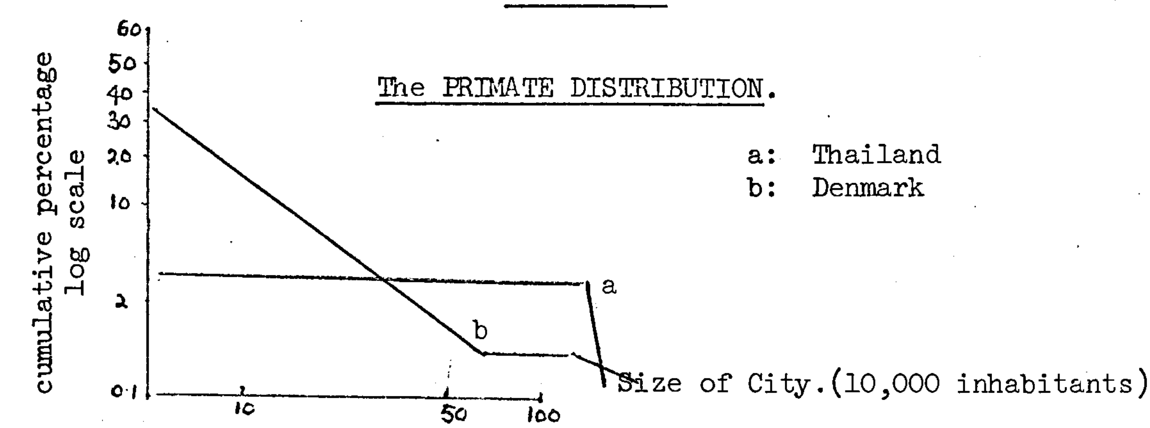
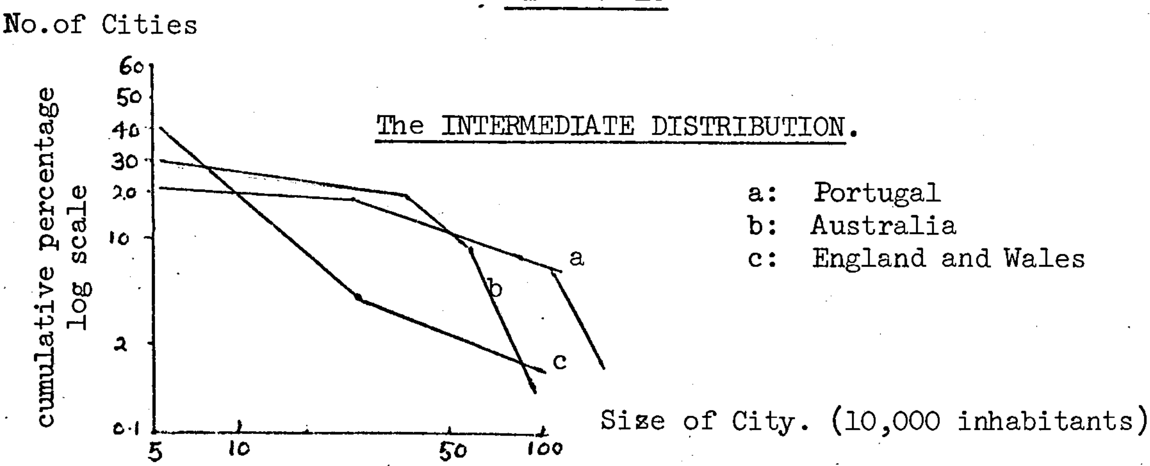


DIAGRAM 1c



distribution.[10] (See Diagram 1c)

A significant conclusion of Berry's study however was that:

> Different city size distributions are in no way related to the relative economic development of countries. Rank-size is not the culmination of a process in which national unity is expressed in a system of cities.[11]

In order to appreciate the significance of Berry's conclusions on the relationship of city size distribution to level of economic development[12] and the relation to the general problem of an optimal city size distribution, one must examine the various theories attempting to explain the empirical regularities manifested in the rank-size (log-normal) distribution.

II. CITY SIZE DISTRIBUTION AND PARETO'S LAW

Among the first economists to recognize certain regularities in the city size relationships was H. W. Singer, [13] who compared the city size distributions for seven countries with the Pareto type of income distribution, and found them both to be of a similar shape.

The Pareto curve is of the form $y = \frac{A}{x^{\alpha}}$ or $y = Ax^{-\alpha}$

where x = income level.
y = number of persons with that level of income or over.

In logarithmic form, $\log y = \log A - \alpha \log x$, and the Pareto curve takes on a linear form that can be conveniently plotted on a double log scale.

Now $-\alpha$ is the elasticity of the function of distribution of incomes, therefore $\alpha = \frac{-d \log y}{d \log x}$ and is constant. Hence α can be interpreted as the elasticity of decrease in the number of persons when passing to a higher income.

By increasing the income x by dx = 1,000, from 10,000 to 11,000, we get a relative decrease in the number of persons by approximately

$$\frac{dy}{y} = \frac{-\alpha}{10{,}000} \cdot 1{,}000 = \frac{-\alpha}{10}$$

Whereas, if dx = 1,000 and x = 11,000

then $\frac{dy}{y} = \frac{-\alpha}{11{,}000} \cdot 1{,}000 = \frac{-\alpha}{11}$ which is less in terms of percentage than the relative decrease obtained at the transition from the income of 10,000 to an income of 11,000. Therefore, the relative decrease (screening) in the number of persons as the income increases is smaller and smaller and diminishes in proportion to the income, therefore $\frac{dy}{y} = \frac{-\alpha dx}{x}$

Hence, the advance to a higher class of incomes is easier for persons who have already reached a higher income than for persons with lower incomes. The reduction in the relative decrease of the number of persons, during transition to higher and higher incomes, in proportion to the income, constitutes the essence of Pareto's Law.[14]

The Pareto formula has been given a probability interpretation by Champernowne.[15] We can regard the Pareto curve in two ways, either as representing the exact number of persons of an income not smaller than x, or in terms of the number of persons with an income smaller than (or not smaller than) its mean value (mathematical expectation). Consequently, according to the Pareto formula, the mathematical expectation of the relative screening decreases in proportion to the income. The mathematical expectation of a person's being transferred to higher classes of income will, therefore, be proportional to the given income. We can consider the city size distribution in a similar manner. For example, the mathematical expectation of a city being transferred to a higher class size of city (through growth of the city in terms of population), is proportional to the given city size. Thus one would expect, on average, the largest cities to grow at a faster absolute rate than the smaller cities through this screening process, and have a lower class mobility than cities of smaller size.

Champernowne has analyzed the development through time of the distribution of incomes between certain income ranges as being a stochastic process, so that the income of any individual in any one year may depend on what it was in the previous year and on a random process. From the regularity that Champernowne had established empirically, Pareto tried to derive a general sociological "law" which he regarded as a "natural law" that held for all times and all societies. It would appear from this "law", that all social reforms intended to remove inequality in the distribution of national income were doomed to failure from the outset, since the law of nature about the distribution of income acted in all conditions and the distribution of income would always take the shape indicated by the formula he established. This conclusion of Pareto may have significant effect on the attempts to redistribute city size distrbutions away from or towards a Pareto-type distribution or to vary the value of α (the slope of the relation under log-normal conditions).[16]

Singer claimed that:

> . . . in the distribution of population among urban agglomerations . . . . (for seven countries) . . . . there appears to be a remarkable statistical regularity, which besides being interesting in itself and affording a complete analogy to Pareto's Law of Income Distribution, yields an exact quantatative measure for the relative roles of the smaller and larger types of human agglomerations, i.e. an index of metropolization.[17]

Neither Singer, Allen, nor Champernowne have drawn any conclusions about the significance of the apparent relationship between the Pareto income distribution and city size distributions, and no doubt for very good reasons.[18] However it could be suggested that Pareto-type distributions are "natural laws of distribution", conforming to an optimum city size distribution under open systems and where there are large and complex competitive forces operating on the city size distribution.

"Optimum" is defined in a very restricted sense, to refer to a distribution towards which any distribution tends under certain complex competitive conditions (i.e. the Pareto distribution). This assumes that social, economic, political, and other forces are minimized when this distribution is attained and it is in essence an equilibrium distribution where forces acting to maintain this equilibrium distribution dominate forces acting to distort this distribution away from equilibrium. A tentative hypothesis might be that: the more a city size distribution conforms to the Pareto distribution, the more it represents an optimum distribution under a large competitive economic system. Thus a measure of non-optimality could be the deviations any one city size distribution has, at every level from the Pareto distribution. These deviations would be very large in the case of the primate distribution, and the question therefore arises of identifying those forces which have caused this deviation from the Pareto distribution.

III. ZIPF AND THE RANK-SIZE RULE

Zipf[19] has probably the best presentation of the empirical findings on rank and size of cities. The rank-size rule states that for a group of cities, usually those exceeding some size in a particular country, the relationship between size and rank of cities is of the form:

$$P_r^{\,q} = \frac{P_1}{r}$$

where P_r = population of a city of rank r
P_1 = population of largest or first-ranking city
q = constant

Zipf's rank-size rule is a special case of the Pareto-type of distribution with $q = 1$ (and where q conforms to α in the Pareto distribution). in logarithms: $\log r = \log P_r - q \log P_r$, so that a plotting of rank against size should give a straight line with a slope of $-q$. Zipf explains the fact that the exponent q equals unity in the rank-size rule, in terms of the equality of the forces of diversification and unification in the economy.[20] Diversification tends to minimize the difficulty of moving raw materials to the places where they are to be processed. Unification tends to minimize the difficulty of moving processed materials to the ultimate consuming populace. Thus if all persons were located at the same point then maximum unification would be achieved. Where both the forces of diversification and unification are at work, a distribution of population is presumed to occur that is at optimum with reference to both forces. Since the force of diversification makes for a larger (n) number of smaller P communities, whereas the force of unification makes for a smaller number of P communities, then an "optimum" city size distribution exists when the distribution follows the rank-size rule and the opposing forces of diversification and unification are equalized.

However:

> . . . it is certainly not clear what are the logical links between the scheme proposed by Zipf to explain rank-size regularity and observed rank-size regularity.[21]

Isard, writing in 1956, also has considerable scepticism about the rank-size rule:

> . . . how much validity and universality should be attributed to this rank-size rule is, at this stage, a matter of individual opinion and judgement.[22]

A number of other authors have also questioned the validity of the rank-size rule. Stewart argues that:

> The so-called rank-size rule . . . is an empirical finding not a logical structure. Nevertheless, its partial verification suggests an underlying logical basis.[23]

Furthermore Stewart decided that large heterogeneous areas fit the model better than small relatively homogeneous areas, and that the rank-size rule "breaks down in many areas at both extremes—the largest and smallest towns" and that well-structured areas of urban dominance tend to have an S-shaped rather than a linear logarithmic distribution of towns by size.[24]

It cannot be denied, however, that to a limited extent there is some basis for the formulation of hypotheses and additional exploration on the nature of the relationship between the rank-size rule and an optimum city size distribution. In terms of the forces of unification and diversification it could be argued that in those developing countries in which there is a predominance of small towns, there is also a predominance of the forces of diversification over those of unification.

IV. CHRISTALLER AND THE SIZE CLASSES OF CITIES

A well known alternative interpretation to that of Zipf, both regarding the size of cities and the processes cauing size regularities, is that of Walter Christaller. [25] The schemes of Zipf and Christaller are similar in many respects. Both utilize notions of the domain of cities (domain of goods) for the performance of various economic activities and the rules of behavior leading to the spatial system of central places and associated arrangements of city sizes (diversification and unification) are quite similar.

However for comparative purposes Christaller only presented a formal theory of city sizes and their distribution for his k=3 network of cities in homogeneous space. [26] In the k=3 network, let the hierarchy of centres be taken as ranks $r = 1, 2, 3 \ldots .$ and the population of largest city (primate city) = K, second largest ranking cities = K/3, etc. A rank-size distribution in the manner of Zipf is formed if the exponent:

$$q = \frac{\log (K/r)}{\log (K/3^{r-1})}$$

thus where $= 2$

$$q = \frac{\log (K/2)}{\log (K/3^{2-1})}$$

and if $q \log P = \log (K/r)$

$$\text{then } \log P = \log (K/2) \cdot \frac{\log (K/3)}{\log (K/2)}$$

and $P = K/3$ as required by Christaller's theory. [27]

Christaller, in fact, treated his formulation of the basis of a hierarchical system of cities as an analytical problem of determining a rational or "optimum" spatial orientation of cities. In Christaller's case we should be very cautious about interpreting his system of spacing and size distribution of cities as in any sense optimal, [28] although it is essentially a deductive theory from general assumptions, since it is a relationship between rank and size of the city's tributary areas and not its population. [29]

V. THE CITY-SIZE DISTRIBUTION AS A STOCHASTIC PROCESS

The general shape of the observed city-size distribution has led many recent students to consider the distribution as generated by stocahstic growth processes. An early attempt to formulate such an approach was by Champernowne,[30] with regards to the Pareto income distrbution, and by Stouffer in relation to migration patterns,[31] who derived a Yule-type distribution for mobility and distance of migration.[32]

Simon[33] has argued that the distribution of city-sizes was one of a family of distributions which have the following general characteristics in common:

(a) They are J-shaped, or at least highly skewed, with very long tails which can be approximated closely by a function of the the form:

$$f(i) = ({}^{a}/i^{k})b_{i}, \text{ where a, b, and k are constants,}$$

and the convergence factor b is so close to 1 that it often may be disregarded. Thus, for example, the number of cities that have a population i is approximately $a/_{i}k$.

(b) The exponent k is of the form $1 < k < 2$.

(c) The function describes the distribution, not merely in the tail, but also for small value of i.

These three properties just identified, define the class of functions which Simon terms the Yule Distribution.

Stated in these terms, the distribution for city sizes is evolved under roughly the following notions. Consider a total population k distributed in cities, with a city considered to be an aggregate of population larger than some threshold size. The probability that the $(k + 1)$st person being found in cities of size i is assumed to be proportional to $i\,f(i,k)$. It is also assumed there is a constant probability that the (k=1)st person will be in cities not previously of threshold size when the total population was k. Thus a model for expected city size distributions can be calculated as follows from a set of equations derived from Simon's original model:[34]

Let (i) $\alpha = {}^{n}K/k$

(ii) $f(1) = {}^{n}K/2 - \alpha$

(iii) $f(i)/f(i-1) = (1-\alpha)(i-1)/1 + (1-\alpha)i$

where K is the total urban population in the ^{n}K cities of greater than threshold size.
where n is the number of cities equal to or greater than threshold size of population k.
and f(i) = number of cities of population i.

From equations (i) and (ii) and the successive application of equation (iii), the expected distribution of city sizes can be constructed.

Since the situation will scarcely, if ever be found in which $\alpha > \varepsilon$ (where ε is an extremely small number), we may write this system in the more simplified form:

(ii)* $f(1) = n_{K/2}$

(iii)* $f(i)/f(i-1) = (i-1)/(1+i)$

then from (ii)* and by successive application of (iii)*, the expected distribution of city sizes may be constructed.

The distribution of f(i), the number of cities of size i, may be readily converted into the rank-size distribution, where μ_i is the number of cities of size equal to or greater than size i, by the use of the following transformation:

$$\mu_i = n_k - f(i_j)$$

where μ_i is the number of centres of population equal to or greater than size i.
n_K is as before.
and $f(i_j)$ is the total number of centres of population less than i.

Another stochastic theory of city size distribution is that of Thomas. [35] Thomas notes that Jefferson's formulation of the qualitative "law of the primate city" evidences recognition that the unequal population sizes of cities presents problems "worthy of investigation". [36] Jefferson's notion that a country's leading city is always disproportionately large and exceptionally expressive of national capacity and feeling implies that functional changes in the nature of the city accompanies changes in population size. However because of the qualitative nature of the "Law", it is not possible to ascertain what is meant by "disproportionately large". This term, when attached to a particular observation, indicates that the magnitude of the observation exceeds some <u>expected value</u>, but no precise expected value is provided by Jefferson. In Christaller's scheme of cities the largest city in an area was not "disproportionately large", but merely "as large as it should be."

Thomas' purpose was therefore to develop a model of city distributions which was consistent with the observed facts and could possibly provide an "expected" city size distribution, and that this "ideal" city size distribution was based on the log-normal distribution or variations of it. This log-normal distribution (or "steady state" distribution) will occur under certain basic assumptions. These are fourfold:

<u>MODEL 1</u>

(i) No city has a locational advantage in relation to physical and cultural characteristics of the area, thus the population of cities differs only by chance.

(ii) A large number of independent forces determine the population size or changes in the population size of cities.

(iii) The change in population size of a city in relation to its initial size is very small during any one period.

(iv) Growth of city size is proportional to city size. [37]

The development of a log-normal frequency distribution of city size occurs as follows:

let X_o = population size at initial time period (t_o)

X_1 = population size at end of time period (t_1)

hence growth of city from $t_1 - t_o = X_1 - X_o$ (1.1)

but relative growth $G = X_1 - X_o / X_o$ (1.2)

thus $X_1 - X_o = G_1 X_o$ (1.3)

and $X_1 = G_1 X_o + X_o = X_o(G_1 + 1)$ (1.4)

n.b. Magnitude of G_1 is independent of X_o (Assumption (iv)).

Therefore over n time intervals

$$\sum_{K=1}^{n} G = \left(\frac{X_k - X_{k-1}}{X_{k-1}}\right) \quad (1.5)$$

However because of Assumptions (ii) and (iii)

$$\sum_{K=1}^{n} \left(\frac{X_k - X_{k-1}}{X_{k-1}}\right) \simeq \int_{X_o}^{X_n} dx/X = \log_e X \Big[_{X_o}^{X_n} = \log_e N - \log_e X_o \quad (1.6)$$

Therefore substituting in (1.5) gives

$$\sum_{K=1}^{n} G = \log_e X_n - \log_e X_o \quad (1.7)$$

$$\text{or } \log_e X_n = \log_e X_o + G_1 \div G_2 + \ldots . G_{n-1} + G_n \quad (1.8)$$

Thus if $G_1, G_2 \ldots G_n$ are stochastically independent, then $\sum_{K=1}^{n} G$ leads to a normal distribution as $n \rightarrow \infty$

Hence, $\log_e X_n$ is normally distributed,

and X_n is log-normally distributed.

MODEL 2 The development of a log-normal frequency distribution of city size.

(i) Physical and cultural variables which affect city size are unevenly distributed over the area. Thus certain cities will have more favourable locations than others. The effect of differences in quality of location is to differentiate city population sizes, that is, even at the outset, population size cannot be treated as a normally distributed "error" term.

(ii) to (iv) as before.

Assuming that the initial size distribution will be log-normal in form; what sort of distribution will arise if a new set of forces (or old ones strengthened) act on the distribution?

let X_o = initial population size at t_o,

X_1 = population size at t_1

Y_o = transformation of X_o into natural logarithms, therefore

$Y_o = \log_e X_o$

n.b. Y_o is normally distributed (See Model 1)

Therefore absolute change in Y_o in period $= Y_1 - Y_o$ (2.1)

relative change in Y_o in period $= B_1 = Y_1 - Y_o/Y_o$ (2.2)

Therefore for t_n we have $n\sum_{k=1}^{n} B = \sum_{j=1}^{n} \left(\frac{Y_k - Y_{k-1}}{Y_{k-1}}\right)$ (2.3)

As before $\log_e Y_n = \log_e Y_o + B_1 + B_2 + \ldots + B_{n-1} + B_n$ (2.4)

n.b. Since $\log_e Y_n$ is normally distributed, and $Y_n = \log_e X_n$ the logarithms of the logarithms of X_n are normally distributed.

Therefore transforming to anti-logarithms, we may say that the frequency distribution of city population size assumes a very skew log-lognormal form. The Law of Proportionate Effect is also altered:

Since $B_1 = Y_1 - Y_o/Y_o$ (2.5)

Then $Y_1 = B_1Y_o + Y_o$ (2.6)

i.e. $\log_e X_1 = B_1\log_e X_o + \log_e X_o$ (2.7)

which gives $X_1 = X_oBX_o = X_o(B + 1)$ (2.8)

Thus within a stochastic framework, we can state that the log-lognormal distribution occurs when growth at any step of the process is a random power of the previous population size.

Thomas tested the size distribution of eighty-nine cities for Iowa in 1900 and found that the distribution approximated the log-lognormal distribution, rather than the log-normal.[38] Kalecki, has shown however, that over a long time the skewedness of successive frequency distributions increases.[39] Thomas has developed a separate model to incorporate this tendency. Madden,[40] in a study of the growth of U.S. cities over a 160 year period from 1790 to 1950 has demonstrated the stability of the rank-size (log-normal) distribution over time, despite the fact that individual cities moved about over fairly wide ranges within the rankage. The changes in rank by size of the different large cities of the nation presumably reflect the changing roles played by cities in the population system; that is, they reflect the changing shares of the total urban economic activity obtained by these cities at various decades. Similarly, it was shown that the percentage growth of cities (in terms of a mean growth for different size groups), is unrelated to the position of the city in the general distribution, confirming a previous formulation by Vining,[41] which is very similar to that derived by Thomas.

The empirical evidence from both developed and developing countries seems to suggest that the log-normal distribution or variations of it for city sizes is fairly common. It has been demonstrated that the log-normal distribution and the log-lognormal distribution (classes of Yule distributions) arise, under certain conditions, out of stochastic growth processes over time. These distributions are "steady state" or "statistical equilibrium", or "natural law" distributions. The log-normal distribution appears to arise out of stochastic growth processes in an open system and where the probability of growth of an individual city is simply proportional to the city size. The log-lognormal distribution arises out of stochastic growth processes in a closed system, and growth is a random power of size of city. [42]

IV. CITY SIZE DISTRIBUTIONS AND POLICY CONSIDERATIONS

The questions now arise, of which distribution best describes the city-size distribution in developing countries, and what are the causes behind the variations between the city size distribution? What, for example would be the effect on national economic growth of attempts to change a city size distribution from a log-normal to a non log-normal distribution? This has considerable relevance for centralization or decentralization policies—is a decentralization policy under certain conditions going to lead to considerable changes in the whole of the distribution such that it is no longer in a state of statistical equilibrium or in a steady state?

Assuming that the log-normal distribution is an optimum distribution in a situation where there are a large number of random and competitive forces operating in the socio-economic and political systems, is there likely to be a most efficient allocation of city sizes when the distribution conforms to the log-normal distribution? If the answer is in the affirmative, can one also assume that economic growth (and growth in the average size of cities) is maximized with this type of distribution?

Policies for decentralizing economic activities have been criticized on the basis that economic growth is maximized when it is concentrated in certain favourable large urban areas, i.e. the growth pole theory. [43] The argument is that by vertical and horizontal linkage effects and a spillover of growth from one region or city to another, the whole system will grow at a faster rate than under any other conditions. Critics of decentralization policies have consistently argued this point for many years. Furthermore in terms of the attempts to impose maximum limits to the size of the largest city, it is interesting to conjecture about the possible effects such a policy would have under different initial conditions, on the whole distribution of cities.

Randomness is postulated as a convenient technique for investigating the overall properties of the settlement field. [44] Such a formulation is neutral as to rationality whether socially or economically oriented: every decision may be optimal from a particular point of view and yet the resulting actions as a whole may appear as random. Lack of information, social ties and so on will change an economizing optimizing problem but not the randomness formulation.

Since it is not possible to identify and measure all the forces that control the city size distribution, the observation that city size distributions tend towards the log-normal under competitive forces may provide a clue to the formulation of policy decisions under certain circumstances. A town planner, for example, tries to reconcile a whole series of opposing forces, to achieve some form of social optimum city size and distribution of cities, and often finds it impossible to arrive at some unique solution. Yet empirical evidence shows that under certain conditions, that of a large competitive system, city size distributions tend towards the log-normal or log-lognormal. It could be argued therefore that any distribution that does not conform to the log-normal distribution is non-optimal at that point in time. Thus primate city distributions, which have arisen out of peculiar historical, geographical, sociological, political, or economic forces are non-optimal. This hypothesis would suggest that a policy of either heavily investing in intermediate size cities or of reducing the primacy of the largest city will encourage a move toward an optimum. (See Diagram 2) A policy of restricting the absolute growth of the largest city in a country, could have some undesirable affects on the overall rate of growth of all other cities, especially if the existing distribution of cities is the log-normal. In this case, there would be a growth of intermediate size cities and further deviation from the log-normal distribution. (See Diagram 3)

Interesting analogies to the problem of policy considerations with respect to city size distributions have arisen in the case of the size distribution of firms. Simon and Bonini, [45] have noted that the size distribution of firms (whether within a single industry or a whole country), is almost always highly skewed, and that its upper tail resembles the Pareto (or log-normal) distribution. Attempts at economic explanation of the observed facts about concentration of industry have always assumed that the basic causal mechanism was the slope of the long-run average cost curve; but there was little discussion of why this mechanism should produce, even occasionally, the particular highly skewed distributions that are observed. The static cost curve analysis yields no explanation as to why the observed distributions approximate the Pareto distribution, it only shows a critical minimum size of firm in an industry. Simon and Bonini argued that plant cost curves are generally J-shaped, and below some critical size unit costs rise rapidly, above the critical size costs vary only slightly with size of firm:

We can say then, that, the characteristic cost curve for the

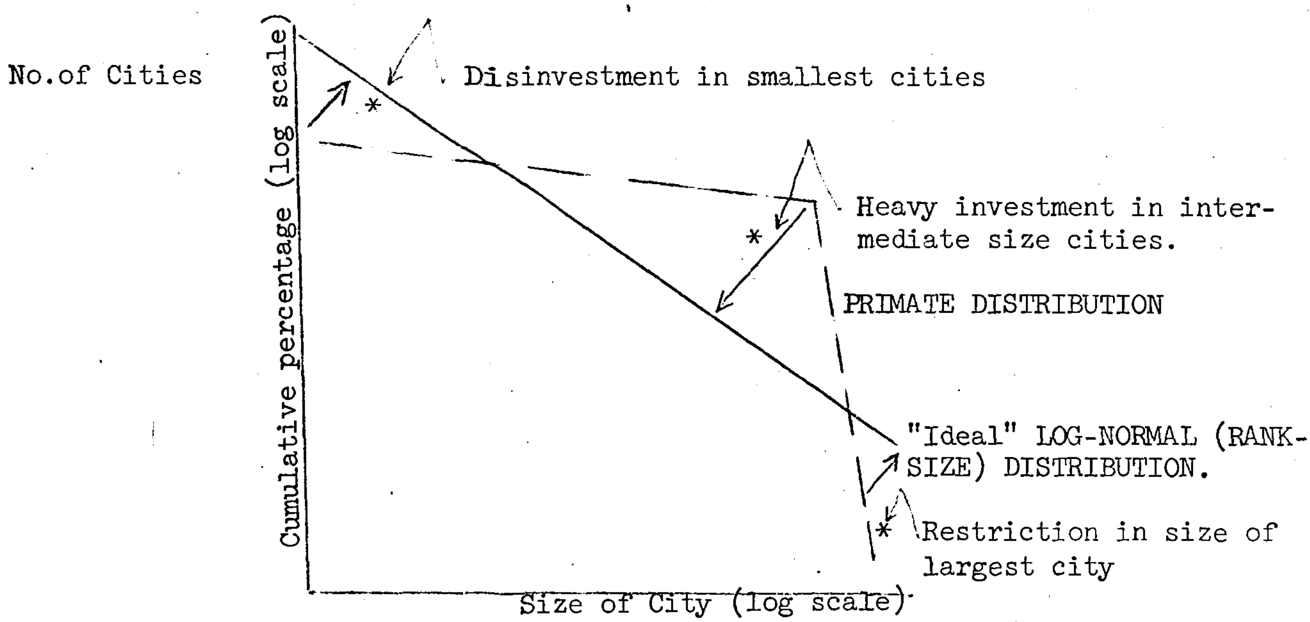


DIAGRAM 2: POSSIBLE EFFECTS of a REDISTRIBUTION POLICY.

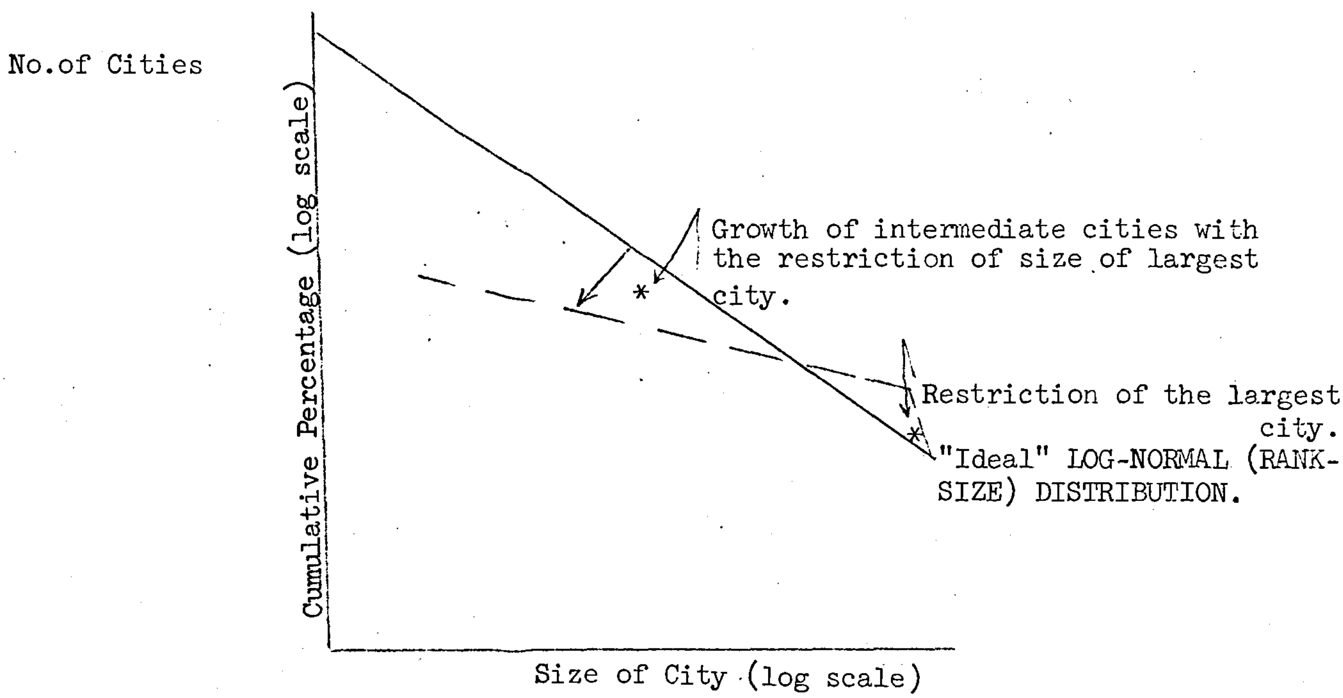


DIAGRAM 3: POSSIBLE EFFECTS of RESTRICTING the SIZE of the LARGEST CITY.

firm shows virtually constant returns to scale for sizes above some critical minimum. Under these circumstances the static analysis may predict the minimum size of firm in an industry but it will not predict the size distribution of firms. [46]

Simon and Bonini attempt to explain the size distribution of firms on the basis of a stochastic model. They postulate (from an assumption) that the distribution of percentage changes in size of the firms (over a year) in a given class size is the same for all class sizes. [47]

THE MODEL

Assume there is a minimum size, S_m, of firm in an industry. Above this minimum size, unit costs are constant. Individual firms in the industry will grow (or shrink) at varying rates depending on such factors as (a) profits, (b) dividends policy, (c) new investment, (d) mergers.

These factors in turn, may depend upon the efficiency of the individual firm, exclusive access to particular factors of production, consumer brand preference, the growth and decline of a particular industry, products in which it specializes, and numerous other conditions. [48]

The operation of all these forces will generate a probability distribution for the changes in size of firms of a given size.

Thus the first basic assumption (the Law of Proportionate Effect) is that this probability distribution is the same for all size class of firms that are well above S_m.

The second basic assumption distribution is that new firms are being "born" in the smallest size class at a relatively constant rate.

It has been shown that under these assumptions the Yule Distribution will be the steady-state distribution of the process.

Let $f(s)ds$ be the probability density of firms by sizes. Then the Yule Distribution is given by $f(s) = KB(s, p + 1)$.

Where $B(s, p + 1)$ is a Beta function of s and $(p + 1)$.

K is a normalizing constant,

p is a parameter.

It is easy to show that as $S \rightarrow \infty$, $f(s) \rightarrow M_s^{-(p + 1)}$, which is the Pareto Distribution.

Thus in considering any observed distribution of firm sizes above the critical minimum size, any substantial deviation of the results from those predicted from the stochastic model is a reflection of some departure from the Law of Proportionate Effect or from one of the assumptions of the model. Having observed such a departure, we can then try to provide for it some reasonable economic interpretation. Such a deviation may be a measure of concentration, as Aitchison and Brown argue. [50] The parameter (p) can also be used to account for the distribution of firm sizes, hence in this particular model, the concentration in an industry is not independently determined, but is a function of the rate of new entry. (Where $p = 1$ the rate of entry of new firms into the system = 0.) [51]

If firm sizes are determined by a stochastic process, then the appropriate way to think about public policy in this area is to consider the means by which the stochastic process can be altered, and the consequences of employing these means. As a very simple example, if the rate of entry into the industry can be increased, this will automatically reduce the level of concentration, as measured by the usual indices. Similarly, if, through tax policies or other means, a situation of sharply increasing costs is created in an industry, this situation should cause a departure from the Yule Distribution, in the direction of lower concentration. Furthermore the same equilibrium distribution may be produced with various degrees of mixing, i.e. reordering of the rank of firms in an industry, according to the dictates of desirable public policy goals (i.e. mobility of firms versus concentration of firms).

Simon and Bonini also suggest that when the environment is changing at a rate that is large compared with the adaptive speeds of the organisms:

> . . . we can never expect to observe the system in the neighbourhood of equilibrium, and we must invoke some substitute for the static equilibrium if we wish to predict behaviour. [52]

The problems of arriving at an optimum city size distribution may be considered from the same point of view as that adopted by Simon and Bonini. Much of the existing literature on cities, only considers the optimum size of cities, and there is little reference to the optimum size distribution of cities.

In considering, for example, the economic case for and against a policy of encouraging the growth of large or small centres, or to see whether there is any economic "virtue" in a policy of decentralization, the approach suggested by Simon and Bonini may be useful. A decentralization plan has been followed in Australia, for example, since at least World War II. On purely economic grounds it appears on first sight that it is an unjustifiable policy, in terms of efficient resource allocation, but on broader socio-economic grounds it may be the reverse. According to Berry's study [53] Australia has a city size distribution that is intermediate between the log-normal and the primate. This is confirmed by Neutze[54] who remarks on:

> . . . the absence of medium size high concentration of population in the state capitals and a dearth of medium sized centres.

The absence of medium sized regional centres may have been a major factor causing new growth in recent years to crowd into the state capitals of Australia. Thus the appropriate policy might be to promote some of these centres and provide a wider choice for firms that find location in small centres unprofitable. [55]

The argument for a decentralization policy is usually stated in terms of net social costs and benefits of redistribution of industry, people, employment, investment, etc., taking into account externalities and the relation of the policy to overall growth. Among the external effects of private (and public) location decisions are those of traffic congestion and public expenditure on road building, etc., in relation to city size. [56] The general conclusion is that the external costs of traffic growth will be greater in large rather than in small centres. The same analysis can be applied to parking facilities, fares in public transport, length of journey to work, and cost of public services, etc., in terms of external diseconomies of growth. Account must also be taken of economies of scale in public services, government administration, the differences in cost of private goods and services in terms of variation of prices with city size. Intervention in the market allocation mechanism with respect to cities is only justified if the pecuniary and non-pecuniary external economies and diseconomies are so large that they cannot be ignored and if the government intervention produces a more socially optimum distribution, which it may well not do under conditions of imperfect foresight. [57]

One possible external effect of growth of cities stems from scale economies or diseconomies in the provision of public services. If public services are more expensive in large cities, growth brings external diseconomies. Conversely, if costs fall with growth there are external economies. If we can measure the effect of size of centre on these costs we can show the direction and the magnitude of the external effects and also the way they affect the relative attractiveness of large and small centres. If we plot cost against size and get a U-shaped average cost curve then the external effects will be causing unduly large cities. They will be doing so as long as costs rise more rapidly or fall more slowly as population grows. The major problems, especially in developing countries, are not only the lack of data, but also differences in quality of services which may affect costs. [58] K.S. Lomax, [59] in an early study of British towns, found that costs were lowest, in terms of expenditure per head in centres of from 50,000 to 100,000 people, however no account was taken of quality differences in services. Other studies (especially in the U.S.) have found very little relationship between population of municipality and costs of local government service, with the exception of water, sewage, and education. [60]

Isard, [61] for example, has discussed the emergence of the spatial pattern of cities of different sizes in terms of economies and diseconomies of scale arising from activities positively associated with size of city (agglomeration and deglomeration economies). Urbanization economies arise out of:

> . . . a higher level of use of the general apparata of an urban structure (such as transportation facilities, gas and water mains, and the like) and from a finer articulation of economic activities.

(daily, seasonally, and inter-industrially). Urbanization diseconomies are engendered by rises in the cost of living and money wages, in the costs of local materials produced under conditions of diminishing returns, in time-cost and other costs of transportation, and in land value and rents. Cities also attract or repel units of production in accordance with the urbanization (for the most part, external) economies or diseconomies relevant to each unit of production.

In considering the optimum spatial distribution and hierarchy of different cities within a given technological and resource environment, such urban economies and diseconomies are important. It is tempting to define an overall index of economy or function of economy by summing a series of net economies for different city sizes to arrive at an optimal size of city. Isard rejects this procedure on the grounds that there are too many "logical objections". [62] Also:

> . . . standardization of cities is subject to serious criticism. There are no standard cities, each is unique.

There is also a problem of weighting the importance of individual net economies curves. Another objection, perhaps the most serious of all, stems from the neglect of inter-dependence among the sets of net economies curves:

> The above considerations are sufficient in themselves to invalidate the use, even in an approximate fashion, of a simple total curve or index of economies and diseconomies in the

functioning of cities of various sizes. [63]

It appears that we are thrown back to considering the approach advocated by Simon and Bonini (for firm size distributions) for the city size distribution also. Since we have so many competitive social, economic, political, and other forces operating on the city size distribution and it is difficult to isolate what may be the critical factors determining the city sizes and their distribution, it would be more sound to analyze the problem of optimum city size distribution within the context of the total national environment. In order to facilitate our understanding of the integrated nature of the whole city size distribution it would be convenient and illuminating to consider the distribution as a subsystem in a larger system of the functioning of society.

VII. CITY SIZE DISTRIBUTIONS AND GENERAL SYSTEMS THEORY

The stability of the rank-size formulation over time [64] and between nations [65] has been explained by various authors [66] in terms of steady state stochastic growth processes. The tendency for living systems to maintain steady states of many variables which keep all subsystems in order of balance both with one another and with their environment is the essence of general systems theory. These steady-states are described in terms of entropy, in accordance with the second Law of Thermodynamics, in which maximum entropy is a state of randomly distributed energy and essentially a normal or average state of equilibrium. That the rank-size distribution is a random state is borne out by Simon and as such it is a proper subject of systems theory. Thus city size distributions may be treated in terms of average conditions of maximum entropy and in the more general context of the development of systems theory. [67]

A broad review of the unifying nature of general systems theory in relation to what has been discussed so far is in order at this juncture. A system is a set of objects (for example, central places), attributes of the objects (population, establishments, business types, traffic generated), inter-relationships among the objects (mid-point locations for lower level centres, uniform spacing at any given level), and among the attributes (the central place hierarchy).

Systems may be closed, i.e. entirely self-contained,or open, in the sense that they exchange energy (materials, messages, and ideas) with a surrounding environment. Closed systems have a given energy supply available to do work. As work is performed the energy is dissipated and will eventually become randomly distributed throughout the system. Using the terminology of the second Law of Thermodynamics, the system will then have reached a condition of maximum entropy. In terms of central place theory, a central place system, if it were closed and had run down to a state of maximum entropy then population and other attributes of centres would be completely unrelated to level of centres in the hierarchy. In fact any trace of hierarchy would vanish.

With relative constancy in energy inputs and approximate balance of inputs and outputs, open systems settle into an organized equilibrium between the tendency to move toward maximum entropy and the need for organization to perform work. Such an organized equilibrium is called a steady-state. A central-place system is open. The central place hierarchy is a form of organization that performs the work involved as efficiently as possible, and the rank size regularity is a manifestation of a steady-state equilibrium. A steady-state balances (1) the need for organization into a hierarchy to perform the work efficiently, and (2) randomization due to chance local differences. Any decrease in energy inputs increases the entropy in an open system, and causes adjustments changing the form of the steady-state. By the same token, increasing energy inputs cause form adjustments leading to further organization (or negative entropy). Open systems also contain feedback mechanisms that affect growth even under conditions of constant energy inputs. Positive feedback would tend to decrease the randomizing effects of local variability, and negative feedback to increase them, thus respectively increasing either organization or entropy.

One conclusion of the general systems theorists is worthy of note: The steady state in an open system is one that obeys principles of equifinality. Whatever the initial size of the central places, the same city steady-state will be achieved provided the energy flows are the same. The steady-state results solely from energy flows, independent of the initial size conditions. Thus a rank-size relationship will result solely from the balance of local variability and the organizational needs for a hierarchy under a given set of demand and supply conditions. This is also a characteristic of the competitive model used to derive a central-place system. Barry has attempted to integrate many of the elements of systems of central places into the general systems approach, thus incorporating central-place theory.[68] Berry states that cities and sets of cities are systems susceptible to the same kinds of generalizations, constructs, and models, as in general systems theory since city systems incorporate the two complementary ideas of entropy and information. Entropy is achieved in the steady-state of a stochastic process and is, as has been stated before, at its maximum if this process is unconstrained (the rank-size rule).[69]

Consider the case where the aim is to divide N people among two settlements, each having an equal chance of attracting a given population. Let the number of settlements having a population of i persons be Z_i, and $\sum_{i=0}^{N} Z_i = 1$. The number of ways in which people can be distributed among the settlements, neglecting the spatial aspect and considering only the frequency distribution is $p = \frac{Z!/N}{\prod_{i=0} Z_i!}$ $(0 \leq i \leq N)$

When the system is large its entropy is:

$$H = \log P = Z\log Z - \quad Z_i \log Z_i$$

Where H = entropy.

H is maximized when $Z_i = ({}^{Z}/_{N})^{e^{-i/n}}$

Where $n = {}^{N}/_{Z}$, the mean population per settlement.

This exponential distribution can be written as a cumulative distribution function:

$$Z_i \; \dot{T} = T \; 1 - e^{-i/n}$$

Where T = size of largest city.

Under these circumstances, entropy is maximized when $H_{max} = Z\log({}_eN)$, i.e. the most probable state of the system is that which gives maximum entropy, or when the sum of logarithms is a maximum. This corresponds to a situation in which, given the size of the largest city, the probability that the (u + 1)st city has a population P(u + 1) is equal to q.

Where $P = \dfrac{P(u+1)}{P(u)}$ with P(u) = the population of the largest city.

The ratio q is a constant.

In this sense $H_{max} = Z\log({}_eN)$ becomes similar to the rank-size rule:

$$P_1 = 1(P_r)^q$$

It also follows that a system of cities obeying the rank-size rule is in a state of equilibrium in which entropy has been maximized. It is for this reason that Berry and Garrison [70] and Curry [71] argue that systems which deviate from the rank-size rule are more worthy of attention than are systems which follow. It is in this sense that the primate city distribution has such interest in relation to developing countries. Are they also a distribution in disequilibrium in terms of the entropy concept?

Maruyama states that equilibriating theory (cybernetics) may have a contradiction in the form of a disequilibriating system. Many instances can be cited in which feedback does not lead to self-corrections towards some pre-set equilibrium (morphostasis), [72, 73] in the form of the steady-state distribution. Rather, progressively greater contrasts appear as for example, between Myrdal's Rich Lands and Poor Lands, [74] or with progressively greater centralization of functions in fewer large cities, or when "the growth of a city increases the internal structuredness of the city itself." [75]

Maruyama's thesis is relevant to the problem of the fantastic growth of primate cities in many underdeveloped countries. Could these primate cities be examples of a deviation amplifying mutual causal process, which will take certain underdeveloped countries further away from the hypothetical optimum equilibrium city size distribution. That this is a serious possibility should not be discounted.

> In an economically underdeveloped society, on the other hand under the laissez-faire policy and free play of market forces, the few privileged people accumulate more power and wealth while the living standards of the poor tends to fall. [76]

Berry argues that this deviation (and therefore structure) amplifying trend in a system is a tendency towards maximum information and reordering, and away from maximum entropy. Thus the two forces are essentially in opposition. [77]

A glance at the data for the U.S. shows it to be more ordered than India, and less than Australia, for example.[78]

The evidence presented by Berry on city size distributions and economic development, suggests that although city size distributions are essentially uncorrelated to levels of development, they are correlated with other factors of a country's development, such as size of the country, age of urbanization, etc. The log-normal distribution is hypothesized as representing a steady-state condition of maximum entropy, whereas a primate distribution may indicate a simpler, patterned structure. Progression from the primate to the log-normal stage is reached when the urban society is old and complex and has been influenced by large numbers of forces in many ways such that the patterning effects of any of these forces are lost. Evidence to support this hypothesis was found in the fact that the advanced countries with primate distributions were very small, which limited possible complexities entering into the urban scene, and the lesser developed countries with log-normal distributions were generally very large and with long histories of urbanization which increased the possibility of the urban pattern being affected by many forces.

However it is difficult to be certain that those countries which do display a log-normal distribution have in fact an equilibrium city size distribution in the sense that there is no pressure to move away from this equilibrium distribution. In order to examine whether there is a socio-economic and political optimum in a country with a log-normal distribution, the city size distribution of India will be examined.

VIII. INDIAN CITY SIZE DISTRIBUTION

The rate of urban population growth in India in the last few decades has been phenomenal. From 1941 to 1951 the growth was from 13.5% to 17.3% of the total population, representing an urban growth of 34.8%. The growth of urban places in and by itself would be of less concern if it did not produce at the same time a number of social problems which are new and demand constructive solutions. Unemployment in Indian cities is high, especially among educated persons, and this creates social and political problems. The growth of cities is due in large part to rural-urban migration, the conditions and causes of which are still little understood. Moreover, housing, water supply, and sanitary services are sorely lacking in Indian cities, and the rapid growth of population creates increasing pressures to supply even minimum facilities of this kind. This makes necessary some action in the direction of urban planning in order to better balance short run and long run needs. Much of the present growth of cities takes place by the building of shanty towns, which are being built on any piece of land that happens to be available. Indian cities, and especially the smaller towns, suffer from a plethora of slums. Thus it appears that even though it has a log-normal distribution, Indian cities are not without their problems.

In as much as these urban centres (especially those over 100,000) form a system, and in that capacity, affect the urban and economic structure of India, it is of interest to analyze the properties of the urban centres comprising the system. Along what dimensions of variation can Indian cities be arranged? What are the major similarities and differences that characterize these relatively large urban agglomerations?

Harris and Ullman, [79] summarized the classical principles of urbanization by recognizing three different types of cities:

1. Cities as central places performing comprehensive services for a surrounding area.

2. Cities as transport foci and break of bulk points.

3. Specialized function cities performing one service such as mining, maufacturing, or recreation for large areas.

More recently Redfield and Singer [80] introduced another classification of cities. Discussing the cultural role of cities, they recognized two types of cities:

1. Cities of orthogenetic transformation. These are of the rural order . . . . of culture carried forward.

2. Cities of heterogenetic transformation. These are cities of the technical order, where local cultures are disintegrated and new integrations of society are developed . . . .

In addition, these authors recognized two patterns of urbanization, primary and secondary. In the primary phase a precivilized folk society is transformed by urbanization into a peasant society with correlated urban centres. This process takes place almost entirely within the framework of a core culture that develops in an indigenous civilization. Secondary urbanization follows primary urbanization when a folk society, precivilized, peasant, or partly urbanized, is further urbanized by contact with peoples of widely different cultures from that of its own members.

Hoselitz,[81] recognizes yet another set of cities on the basis of their role in the economic development of an area. According to him a city is generative if its continued existence and growth is one of the factors accountable for the economic development of the area in which it is located. It is parasitic if it exerts an opposite impact. Further in an attempt to tie together his ideas with those of Redfield and Singer, he observes that although orthogenetic cities tend to limit if not impede cultural change, this does not mean that orthogenetic cities are necessarily parasitic with regard to economic growth.

Further, the process of primary urbanization, though leading to a reinforcement of existing cultural patterns, may be generative of economic growth. In the same way cities in certain stages of secondary urbanization may exert an unfavorable effect upon economic growth of the wider geographical unit of which they form a part. An example is that of colonial cities. In a similar vein, Berry points out that the process of secondary urbanization exerts itself when an integrated system of cities develops, usually under the influence of forces external to the local culture.

> Heterogenetic cities result . . . in complex nodal systems of economic organization characterized by rapid social change.[82]

How relevant are these notions to an understanding of Indian cities? Do Indian cities fall into one of the four possible classes as mentioned by Hoselitz in his discussion of generative and parasitic cities?[83] In the opinion of many students of Indian urbanization, Indian cities, like their counterparts in the Western world, are centres of heterogenetic transformations and are generative of economic growth. Also, the prevelent processes of urban growth in India display a pattern which is considered as secondary urbanization.

This of course is not intended to imply that there are no differences between the pattern of Indian urbanization, what ever it may be, and the urban patterns that exist in the Western world. During the past decade a number of studies have appeared which deal specifically with urbanization in the non-Western world. [84] The authors of these works suggest that urbanization in Asia may involve quite different patterns of development and inter-relationships with economic development than those observed in the West. Some of the major differences indicated by them are:

1. Urban development in many countries of Asia is largely an outgrowth of colonialism.
2. There is an increasing role of central planning and governmental interventionism in Asian economic development.
3. There are great differences in basic outlook and value systems between Asia and the West. [85]

Although Indian urbanization shares most of the characteristics common to other developing nations, it nevertheless has some distinctive features. To begin with, India has a long urban tradition which goes back more than a thousand years. Unlike many countries of the non-Western world, India has a well-developed urban hierarchy so far as city size distribution is concerned. There is ample evidence to the effect that rural-urban migration is the most important factor contributing to urbanization in India and this migration is directed not only towards the very large cities but also to hundreds of medium-sized and smaller cities in almost all regions. Furthermore it has been argued that urbanization is neither a necessary nor a sufficient condition for economic growth. For these reasons and many others a policy of decentralization has been advocated in India. The conflict between centralization and alternative forms of decentralization is at the moment a very real issue in India.[86] One aspect of this is the posing of the problem as a choice between two different patterns of economic development, one village based and the other urban based. The balance between industrial growth and urban development, the postulates of equality between rural and urban standards of living, and the costs and benefits of regional dispersal of industries, are the elements that make decentralization a real but still undecided issue.

Due to rapid population growth which has led to pressure on the urban centres and stagnation of the rural economy, rapid urbanization has tended to precede rather than follow industrialization, leading to a wide "development gap". It appears in two different forms, in the form of "over urbanization" i.e. urbanization exceeding the range of economic development, and in that of a marked deficiency of urban facilities and services.[87] It is for these reasons that Indian planning policies have tended to concentrate on decentralization and foster the growth of medium sized towns.[88] J.P. Lewis, in a study of the overall economic problems of Indian development argues that there is not:

> . . . as usual discussions sometimes seem to suggest, any lack of medium sized centres lying between villages, on the one hand, and the larger cities on the other. Instead, throughout the city size distribution there presently are bases upon which further concentrations of activities of population could be built.[89]

India, it appears, although it does have a log-normal distribution, suffers from many serious social and economic urban problems. Planning policies have been directed towards reducing the size of the largest cities, and fostering the growth of the medium sized towns. If the hypothesis is correct, that the log-normal distribution is an optimum city size distribution, then this policy would only lead to a non-optimal distribution of city size. Lewis' observation on the city size distribution in India would tend to support this hypothesis. It is impossible to arrive at any definite conclusions on the validity of a decentralization policy in relation to the log-normal distribution without further analysis, so at the present time the question of whether or not the existing distribution is an optimum is still open. It could be argued that the present distribution minimizes the socio-economic forces acting on it to change despite the fact that these forces appear to be very large. Any other distribution may conceivably increase the serious social and economic problems in the urban centres. This conclusion is also unverifiable at the present moment, but it is interesting to keep in mind.

IX. CONCLUSION

There is considerable theoretical support in the literature for the hypothesis that the log-normal (or rank-size) distribution is an "optimum", steady-state or statistical equilibrium distribution, under certain conditions (cf. the Pareto distribution). The existence of the log-normal distribution for city sizes in both underdeveloped and developed countries, appears to be the result of the interaction of numerous competitive forces over a long period of time. In India, for example, the log-normal distribution has evolved during a long history of urbanization. The primate distribution, which shows the greatest deviation from the log-normal, results from the dominance of a small number of very large forces to produce this distribution. Primate cities suffer from problems similar to the largest cities in the log-normal distribution, but to a much greater extent.

The rejection of an approach based on net urban economies to analyze the optimum city size, is reasonable when taken in the context of a systems approach to city size distributions. General systems theory, incorporating stochastic growth theory, appears to be a meaningful way of examining the problem of an optimum city size distribution, since it focuses attention away from single optimizing criteria, and more toward the whole of the distribution. It is evident that there are many problems in testing the hypothesis that the log-normal distribution is an optimum. In the case of India, with a log-normal city size distribution, many social and economic problems face its cities, which appear to be almost insoluble.

Considerable work must be undertaken before it can be firmly established that any one type of distribution is an optimum under a wide variety of conditions, although it appears that a theoretical framework has evolved which may be a useful analytical approach to the general problem of optimum city size distribution.

REFERENCES

[1]See E. Howard, Garden Cities of Tomorrow (London: Faber and Faber Ltd., 1946).
F.J. Osborn, Transport, Town Development and Territorial Planning of Industry No. 20 (London: The New Fabian Research Bureau, Victor Gollancz, Ltd., 1934), p. 20.
Lewis Mumford, The Culture of Cities (New York: Harcourt Brace, 1938), p. 488.

[2]Tracy B. Augur, "The Dispersal of Cities as a Defense Measure", Bulletin of the Atomic Scientists, Vol. IV, May, 1948, pp. 131 - 134.

[3]Walter Isard, Location and Space Economy (New York: John Wiley and Sons, Inc., 1956), esp. pp. 182 - 188.

[4]Forrest Pitts, Urban Systems and Economic Development (Eugene, Oregon: University of Oregon, School of Business Administration, 1962).

[5]B.J.L. Berry, "City Size Distributions and Economic Development", Economic Development and Cultural Change, Vol. 9, 1961, pp. 537 - 588. Reprinted in J. Friedmann and William Alonso, Regional Development and Planning (Cambridge, Mass.: The M.I.T. Press, 1964). Berry's work was based on data presented in N. Ginsburg, Atlas of Economic Development (Chicago: 1961).

[6]See George K. Zipf, Human Behavior and the Principle of Least Effort (Cambridge: Addison-Wesley Press, 1949).

[7]Mark Jefferson, "The Law of the Primate City", The Geographical Review, XXXIX, 1939.

[8]Italy, Finland, Belgium, U.S.A., Poland, West Germany, Switzerland, India, Korea, China, Brazil, El Salvador, Union of South Africa.

[9]Greece, Austria, Spain, Denmark, Netherlands, Sweden, Portugal, Uruguay, Peru, Guatemala, Mexico, Dominican Republic, Thailand, Japan, Ceylon.

[10]Parkistan, Malaya, Nicaragua, Ecuador, Yugoslavia, Norway, England and Wales, Australia, Canada, New Zealand.

[11]Berry, op. cit., p. 585.

[12]The other major findings of Berry's study were:

On the log-normal distribution.
"It is noticeable that countries with long urban traditions such as India and China, and highly developed countries such as the United

States and Germany have very similar distributions."

On the primate distribution.
"All fifteen of the countries with primate city distribution were small and they range from underdeveloped Thailand through countries with dual and peasant economies to Denmark and the Netherlands with highly specialized agricultural economies."
Primacy was considered the simplest city size distribution and affected by only a few simple but dominant forces. The rank size distribution however arises out of a complexity of competing economic, social, and political forces over a long period of time.
"There is no relationship between type of city size distribution and the degree to which a country is urbanized. Countries which have until recently been politically and/or economically dependent upon some outside country tend to have primate cities which are the national capitals, cultural and economic centres, often the chief port, and the focus of national consciousness and feeling."
The model in effect proposes a major hypothesis, that is, increased entropy is accompanied by a closer approximation of a city size distribution to log-normality. This leads to further sub-hypotheses namely that (1) the smaller the country is and (2) the shorter is the history of urban life in that country and (3) the lower and hence simpler is the level of economic and political development in the country, the fewer will be the forces acting on that country's cities.
Hence as the level of economic development increases, the level of complexity of city distribution increases. This led Berry to consider the relationship between relative levels of economic development and city size distributions.
Forty-five indices of economic development, based on transportation, energy, agricultural yields, communications, G.N.P., trade, demographic and other data, were reduced to four basic patterns of economic development, based on (i) technological, (ii) demographic, (iii) trading, and (iv) size of country characteristics. (i) and (ii) were further reduced to a scale of economic-demographic development, which was related to the types of city size distribution. Furthermore it was found that "different city size distributions are in no way related to the relative economic development of countries". Hence primacy is not related to level of urbanization of a country, since level of urbanization and level of economic development are highly correlated. There is no ready explanation in the level of economic development, for variations in city size distributions on a scale from simple structure (primary) to entropy (log-normality)., op. cit., p. 572 et seq.

[13]H.W. Singer, "The 'Courbe des Populations': a Parallel to Pareto's Law", Economic Journal, Vol. 46, 1936, pp. 254 - 263.

[14]This screening process is also known as the "Law of Proportionate Effect".

[15]See D.G. Champernowne, "A Model of Income Distribution", Economic Journal, Vol. 63, pp. 318 et seq.

[16]Champernowne mentions the " . . . impossibility of drawing any simple conclusions about the effect on Pareto's α of various redistributive policies . . . .", Ibid., p. 319.

[17]Singer, op. cit., p. 260.
See also G.R. Allen, "The 'Courbe des Populations'. A Further Analysis", Bulletin of the Oxford Institute of Statistics, Vol. 18, 1954, pp. 179 - 189.

[18]Allen fitted the Pareto formula to 44 countries and finds:
"The main conclusions are therefore that the Pareto law can be used with much success to summarize the relationship between size of towns and number of towns above a specified size (2,000)", Ibid., p. 184.

[19]Zipf, op. cit., p. 264.

[20]Zipf, Ibid., p. 376.

[21]B.J.L. Berry and W.L. Garrison, "Alternate Explanations of Urban Rank-Size Relationships", Annals of the Association of American Geographers, Vol. 47, 1958, pp. 83 - 91.

[22]Isard, op. cit., p. 57.

[23]C.T. Stewart, "The Size and Spacing of Cities", The Geographical Review, Vol. 48, 1958, pp. 222-242.

[24]See also Kenneth E. Rosing, "A Rejection of the Zipf Model (Rank-Size Rule) in Relation to City Size", The Professional Geographer, Vol. 18, No. 2, 1966, pp. 75 - 82.

[25]W. Christaller, Die Zentralen Orte in Suddeutschland (Jena: Gustav Fischer, 1933, translated in 1954 at the Bureau of Population and Urban Research, University of Virginia, by C. Baskin.).

[26]Christaller's $k = 3$ network was the optimum pattern of hexagonal networks organized according to a marketing principle. For the transport principle the optimum network was $k = 4$, for the administrative principle $k = 7$.

[27]Berry and Garrison, op. cit., p. 86.

[28]See Rutledge Vining, "A Description of Certain Spatial Aspects of an Economic System", Economic Development and Cultural Change,

Vol. 3, 1955, pp. 147 - 195. Vining argues that "The analytical problem is not that of determining an 'optimum' or 'economical' spatial orientation of cities. Rather it is that of analyzing a process implicit in a sequence of individual actions performed within a specified system of constraints. The characteristics of this process are among the relevent features to be considered."

29 The considerable degree of empirical correspondence to the rank-size rule for population may suggest the proposition that the populations of cities tend to be directly related to their maximum hinterlands.

30 Champernowne, op. cit., p. 318.

31 S.A. Stouffer, "Intervening Opportunities: A Theory Relating Mobility and Distance", American Sociological Review, Vol. 5, 1940, pp. 845 - 868.

32 The Yule Distribution is a general term for the log-normal types of distribution, and includes the log-lognormal distribution.

33 See also H.A. Simon, "On a Class of Skew Distribution Functions", Biometrika, Vol. 42, 1955, pp. 425 - 440. Also reprinted as Chapter 9 in Models of Man (New York: John Wiley and Sons, Inc., 1957).

34 The notation used is that of Berry and Garrison, op. cit., pp. 88 - 89.

35 E.N. Thomas, "Additional Comments on Population-Size Relationships for Sets of Cities", in Quantitative Geography, W.L. Garrison and D.F. Marble (eds.) (Evanston, Ill.: Northwestern University Studies in Geography #3, 1967).

36 Ibid., p. 167.

37 This is the "Law of Proportionate Effect", mentioned earlier (see p. 10), i.e. "A variate subject to a process of change is said to obey the Law of Proportionate Effect if the change in the variate at any step of the process is a random proportion of the previous value of the variate." See J. Aitchison and J.A.C. Brown, The Log-Normal Distribution (Cambridge: The University Press, 1967), p. 22.

38 Thomas, op. cit., p. 179.

39 M. Kalecki, "On the Gibrat Distribution", Econometrica, Vol. 13, 1945, pp. 161 - 170.

40 C.H. Madden, "On Some Indications of Stability in the Growth of Cities in the U.S.", Economic Development and Cultural Change, Vol. 4, 1956, pp. 236 - 253.

[41] R. Vining, "Regional Variation in Cyclical Fluctuation Viewed as a Frequency Distribution", Econometrica, July 1945, Vol. 4, pp. 187 - 188.

[42] The log-normal distribution is also shown to hold for the population density pattern of cities. See B.J.L. Berry, "The Internal Structure of the City" in Urban Prospects and Problems, Law and Contemporary Problems, Vol. XXX, 1965 (School of Law, Duke University, North Carolina), pp. 111 - 119.
See also H.H. Winsborough, "City Growth and City Structure", Journal of Regional Sciences, Vol. 4, 1963, who argued that measures of concentration of the city's population and of congestion of cities can be derived from the log-normal distribution as applied to city sizes and to urban population densities.

[43] Albert O. Hirschman, The Strategy of Economic Development (New Haven and London: Yale University Press, 1958).

[44] See L. Curry, "Explorations in Settlement Theory: The Random Spatial Economy, Part 1", Annals of the Association of American Geographers, Vol. 54, 1964, pp. 138 - 146.

[45] H.A. Simon and C.P. Bonini, "The Size Distribution of Business Firms", American Economic Review, Vol. 48, 1958, pp. 607 - 617.

[46] Ibid., p. 608.

[47] This assumption is justified on the basis that since there exists constant returns to scale above a critical minimum size of firm, it is "natural to expect the firms in each class size to have the same chance on the average of increasing or decreasing in size in proportion to their present size." This is the Law of Proportionate Effect as mentioned before. Ibid., p. 609.

[48] Ibid., p. 610.

[49] See Simon, op. cit., pp. 427 - 430.

[50] Aitchison and Brown, op. cit., pp. 111 - 116.

[51] It is also apparent that p is a measure of the degree of competitiveness in the system, as $p \rightarrow 2$, the competitiveness also increases. Analogies with city size distributions are immediately apparent.

[52] Simon and Bonini, op. cit., p. 616.

[53] Berry, op. cit., p. 575.

[54] G.M. Neutze, Economic Policy and the Size of Cities (Canberra: The Australian National University, 1965).

[55] Ibid., pp. 37 - 38.

[56] T. Scitovsky, "Two Concepts of External Economies", Journal of Political Economy, Vol. 63, 1955, pp. 446 - 449.

[57] J.A. Stockfish, "External Economies, Investment and Foresight", Journal of Political Economy, Vol. 62, 1954, pp. 143 - 151.

[58] W.Z. Hirsch, "Measuring Factors Affecting Expenditure Levels of Local Government Services", Metropolitan St. Louis Survey, St. Louis, 1957.

[59] K.S. Lomax, "The Relationship Between Expenditure Per Head and Size of Population of County Boroughs in England and Wales", Journal of Royal Statistical Society, Vol. 106, 1943, pp. 51 - 59.

[60] There have been many studies of the relationship of expenditures to city sizes especially in the U.S. Among the more important are: W.Z. Hirsch, "Expenditure Implications of Metropolitan Growth and Consolidation", The Review of Economics and Statistics, Vol. 41, 1959, pp. 232 - 241. H.E. Brazer, City Expenditure in the U.S., (New York: National Bureau of Economic Research, 1959). J. Margolis (ed.) The Public Economy of Urban Communities (Baltimore: Resources for the Future Inc., John Hopkins Press, 1965).

[61] Isard, op. cit., pp. 57 - 58.

[62] Ibid., p. 186.

[63] Ibid., p. 188.

[64] Madden, op. cit., pp. 247 - 249.

[65] Berry, op. cit., p. 582.

[66] For example, Simon, op. cit., pp. 427 - 428 and Champernowne, op. cit., p. 319.

[67] R. Vining, "A Description of Certain Spatial Aspects of an Economic System", Economic Development and Cultural Change, Vol. 3, 1954-5, pp. 147 - 195. E.M. Hoover, "The Concept of a System of Cities: A Comment on Rutledge Vining's Paper", Economic Development and Cultural Change, Vol. 3, 1954-5, pp. 196 - 198.

[68] B.J.L. Berry, "Cities as Systems Within Systems of Cities", Papers of the Regional Science Association, Vol. 13, 1964, pp. 147 - 164.

[69] The concept of entropy originates in the second Law of Thermodynamics.

If two systems with entropy S_1 and S_2 are united then $S_1 = S_2 = S$. The entropy of a closed physical system tends therefore to increase as long as the system has not yet reached equilibrium and entropy may thus be taken as a measure of the degree of equilization reached within a system. Entropy of a closed system is maximized when the system is in equilibrium. Boltzmann's Law of Entropy argues that lower temperature should be understood as a statistical equalization of differences in molecular speed.

Let physical entropy $S = C_v \log T + {}^R/_m \log V$ --------------(1)

Where V = Volume of gas whose mass equals 1 unit.
C_v = Specific heat at constant volume.
T = Absolute temperature.
m = Molecular weights of the gas.
R = General gas constant.

Also let $S = \text{entropy} = -k \sum_{i=1}^{n} p_i \log p_i$ and $\sum_{i=1}^{n} p_i = 1$ ------(2)

Where p_i = probability of finding an idealized physical system in the state i of n possible states, and k = a constant.

Now the probability that molecules in a gas container can be distributed among n possible states in p ways is:

$$p = p! / \prod_{i=0}^{n} p!_i \qquad (0 \leq i \leq n) \text{ -----------(3)}$$

Thus if the system is large then:

$$S = \log P = p \log p - \sum_{i=1}^{n} p_i \log p_i \text{ -----------------(4)}$$

$$\text{Thus since } S = -k \sum_{i=1}^{n} p_i \log p_i - k(\log p_i) \text{ -----------------(5)}$$

$$\text{Then} \qquad S = -k(p \log p - \sum_{i=1}^{n} p_i \log p_i) + C \text{ -------------(6)}$$

$$\text{Hence} \qquad S = (p \log p - k \sum p_i \log p_i) \text{ -----------------(7)}$$

(4) and (5) both hold only if $\sum k = 1$

70 Berry and Garrison, op. cit., p. 89.

71 Curry, op. cit., p. 144.

72 M. Maruyama, "The Second Cybernetics: Deviation Amplifying Mutual Causal Processes", American Scientist, Vol. 51, 1963, pp. 164-179.

73 Morphostasis is a "... deviation counteracing mutual causal relationships ...." See Maruyama, op. cit., p. 164.

[74] G. Myrdal, Economic Theory and Underdeveloped Regions (London: 1954).

[75] Maruyama, *op. cit.*, pp. 167 - 168.

[76] *Ibid.*, p. 165 - 166. Cf. Myrdal's vicious circle concept.

[77] A measure of order may be $R = 1-(^{H'}/H)$ where H = maximum entropy in a system under no structural relations (i.e. individuals in isolation). H' = maximum entropy in a system with a given level of structural relations. Hence $0 \leq R \leq 1$ are two limiting cases. When R = 0 then H' = H (i.e. no structure exists), when R = 1 then H' = 0 and a system is developed into a single lightly clustered web of activities. Now in a closed physical system, entropy will increase with time and order decrease. However, a self-organizing system will by definition be increasing order and decreasing entropy. See Curry, *op. cit.*, p. 145.

[78] Curry, *op. cit.*, p. 145.

[79] C.D. Harris and E.L. Ullman, "The Nature of Cities", Annals of the American Academy of Political and Social Science, Vol. 242, Nov. 1945, pp. 7 - 17.

[80] Robert Redfield and Milton Singer, "The Cultural Role of Cities", Economic Development and Cultural Change, Vol. 3, 1954, pp. 53 - 73.

[81] B.F. Hoselitz, "Generative and Parasitic Cities", Economic Development and Cultural Change, Vol. 3, April 1955, pp. 278 - 294.

[82] B.J.L. Berry, "Urban Growth and Economic Development of Ashanti", in Forrest Pitts (ed.), Urban Systems and Economic Development, pp. 52 - 54.

[83] Hoselitz, *op. cit.*, p. 280.

[84] Particularly interesting, as well as of great informative value are the proceedings of the two seminars on urbanization in Asia and Latin America sponsored jointly by the United Nations and its agencies. See P.M. Hauser (ed.), Urbanization in Asia and the Far East (ECAFE Region, Bangkok, 8 - 18 August, 1956, Calcutta, 1957). P.M. Hauser (ed.), Urbanization in Latin America (UNESCO, Santiago, Chile, 6 - 18 July, 1959, New York, 1961).

[85] T.G. McGee, The Southeast Asian City (New York: F.A. Praeger, 1967). See also P.M. Hauser, Urbanization in Asia and the Far East, p. 31.

[86] B.F. Hoselitz, "A Survey of the Literature of Urbanization in India", in Roy Turner (ed.), India's Urban Future (Berkeley: University of California Press, 1962), pp. 425 - 443.

[87] See N.V. Sovani, "The Analysis of Over-Urbanization", _Economic Development and Cultural Change_, Vol. 12, No. 2, 1964. See also N.V. Sovani, _Urbanization and Urban India_ (New York: Asia Publishing House, 1966). Also J.F. Bulsara, _Problems of Rapid Urbanization in India_ (Bombay: Popular Prakashan, 1964).

[88] A.K. Lokanathan, "Market Towns and Spatial Development in India", _National Council of Applied Economic Research_ (New Delhi, 1965).

[89] J.P. Lewis, _Quiet Crisis in India_ (Washington, D.C.: The Brookings Institute, 1962). Especially Chapter 7 "The Role of the Town in Industrial Location".

BIBLIOGRAPHY

Aitchison, J. and Brown, J. A. C. The Log-Normal Distribution. Cambridge: The University Press, 1957.

Brazer, H. E. City Expenditure in the United States. (New York: National Bureau of Economic Research, 1959).

Bulsara, J. F. Problems of Rapid Urbanization in India. (Bombay: Popular Prakashan, 1964).

Christaller, W. Die Zentralen Orte in Suddeutschland. (Jena: Gustav Fischer, 1933).

Friedmann, J. and Alonzo, W. Regional Development and Planning. (Cambridge, Mass.: The MIT Press, 1964).

Garrison, W.L. (ed.) Quantitative Geography. (New York: Atherton Press, 1967).

Hauser, P. and Schnore, L.F. (eds.) The Study of Urbanization. (New York: John Wiley and Sons, Inc., 1965).

Hauser, P. (ed.) Urbanization in Latin America. (New York: Proceedings of UN seminar on Urban Problems in Latin America; UNESCO, Santiago, Chile, 6 - 18 July, 1959; 1961).

Hauser, P. (ed.) Urbanization in Asia and the Far East. (Calcutta: ECAFE Regional Seminar, Bangkok, 8 - 18 August, 1956; 1957).

Hirschman, A.O. The Strategy of Economic Development. (New Haven: Yale University Press, 1958).

Howard, E. Garden Cities of Tomorrow. (London: Faber and Faber, 1964).

Isard, W. Location and Space Economy. (New York: John Wiley and Sons, 1956).

Lakanathan, A.K. Market Towns and Spatial Development in India (New Delhi: National Council of Applied Economic Research, 1951).

Lewis, J.P. Quiet Crisis in India. (Washington D.C.: The Brookings Institute, 1967).

Margolis, J. (ed.) The Public Economy of Urban Communities. (Resources for Future, Baltimore: John Hopkins Press, 1965).

McGee, T.G. The Southeast Asian City. (New York: F.A. Praeger, 1967).

Mumford, Lewis. The Culture of Cities. (New York: Harcourt-Brace, 1938).

Myrdal, Gunnar. Economic Theory and Underdeveloped Regions. (London: George Allen and Unwin, 1954).

Neutze, G.M. Economic Policy and the Size of Cities. (Canberra, The Australian National University, 1965).

Pitts, Forrest R. Urban Systems and Economic Development. (Eugene, Ore.: University of Oregon, School of Business Administration, 1962).

Simon, H.A. Models of Man. (New York: John Wiley and Sons, Inc., 1957).

Sovani, N.V. Urbanization and Urban India. (New York: Asia Publishing House, 1966).

Turner, Roy (ed.) India's Urban Future. (Berkeley: University of California Press, 1962).