PREFACE

This is one of several studies made to provide research approaches in different problem areas of rural poverty and economic development. These studies were initiated by the Economic Research Service to assist in program planning and guidance for future research. Generally, each one provides an outline of the problem of concern, a survey of previous research, evaluation of applicable research methods, and specific research proposals. Results are being used in expanding and reorienting the research program of the Economic Research Service. They should also be of value to other researchers in the areas covered.

This report was prepared by the author under contract. The author's opinions do not necessarily reflect the views of the Economic Research Service, or the U.S. Department of Agriculture.

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Washington, D.C. June 1966

ANALYSIS OF URBAN AGGLOMERATION AND ITS MEANING FOR RURAL PEOPLE

By

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INTRODUCTION

Urban "agglomeration," as used in this paper, is an economic term meaning the clustering of people, businesses, or structures within an area. Although this definition may seem synonymous with such terms as "city" or "urban complex," the term is often used because it focuses on the clustering or density aspect of economic activities.

Research on the process of agglomeration is needed to understand its historical process, and perhaps to suggest a basis for changing the process by future planning. We know that urban agglomeration affects not only the urban inhabitants but also inhabitants of nonagglomerated or rural areas. Our country's historical development can be seen in terms of internal migration patterns--largely migration of people from rural to urban areas--and increased industrialization. Early in the industrialization of an area, the urban sector is small compared with the rural sector, and the movement of people to cities is only relative, as the rural area still continues to grow along with the growing cities. But later in the industrialization process, rural farm areas experience declines in population and employment, when increased agricultural productivity releases people from the farms and nonagricultural activity concentrates in urban areas.

The economic prospects of rural areas as affected by the migration of their inhabitants to the cities is of great interest to the U.S. Department of Agriculture which, through its Economic Development Division, Economic Research Service, has requested the author to explore the literature of agglomeration for information on urban clustering. For example, perhaps we may find the degree to which agglomeration is the natural outcome of the competitive system, or conversely, the degree to which agglomeration has been caused by avoidable inefficiencies and obstacles to industrial development in the sector. Research may indicate how rural areas can adapt to agglomeration; how much the agglomeration process can be interfered with, and what will be the cost of so doing; and finally, whether the migration of rural people to urban places is the best way of adapting the rural sector to the urban.

The research covered by this report has been oriented to these objectives--first, exploring the literature for the purpose of defining the nature of agglomeration and erecting a suitable theory; and second, suggesting further research which will help to improve the economic well-being of rural people by developing appropriate actions based on new knowledge.

This report not only surveys the literature, but also analyzes it to determine gaps to be filled by further study. A large gap exists on relationships between the rural situation and urban agglomeration, because the literature has been written exclusively from the urban and not the rural point of view. Accordingly, suggestions for further research emphasize the rural point of view, as well as the need to develop a theory and a model for optimizing the spatial allocation of resources.

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URBAN STRUCTURE, FUNCTIONS, AND PATTERNS OF GROWTH

The Region as a System of Cities

In the past, regional planning was concerned with natural-resource development as the means for improving the economic welfare of people; regions were delineated according to the location of the resources being considered (the Appalachian coal mining areas, river basins, watersheds, and so forth) (30, p. 512). 2/ The emphasis is now shifting from natural-resource development to human-resource development. In this context, the region should be delineated to take into account (1) the spatial organization of human activities such as places of living, working, and shopping and (2) functions of production, transportation, and trading. For proper planning of these activities, the concepts of central place, hinterland, and city hierarchies replace river basins and watersheds in the vocabulary of regional planning. For example, Berry, in a study now in process, makes the strong claim that the region may be defined as a system of interrelated central places and their hinterlands.

Central place theory was formulated by Walter Christaller "to explain the size, number and distribution of towns (8, p. 121)." The theory was further developed by August Losch, whose Location of Industry was intended to integrate the principles of industry agglomeration with those of urban structure. His definition of a city as a "punctiform agglomeration of nonagricultural locations" established the basis for unifying the theory of industry location with that of urban structure (47, p. 68).

Losch's theory of urban structure may briefly be summarized as follows: The minimal sizes of the market areas for different commodities need not coincide. At the point of minimal market size, agglomeration economies begin, inducing a compromise in the size of the various market areas so that a common hierarchy of distribution centers can be sustained. A link is then found between the size of the market areas for the various industries on the one hand, and of the size of the cities on the other hand. The role of cities as central places for distribution is taken up by Losch in this connection and is further developed. The rationale of cities on a hexagonal lattice, rather than some other geometric distribution, is as follows: It permits a maximum number of cities that lie a fixed distance apart, and it requires a minimum number of cities meeting the requirement that the distance between a city and its nearest neighbor does not exceed a given distance. Competition for land makes the hexagonal system the most logical. In the set of places created by the hexagonal pattern, centers of the second order may then be chosen so that each first order city has as its neighbor a city of the second order. These centers again form a hexagonal lattice; that is, they are arranged like the vertices of honeycomb. In this manner, a complete hierarchy of places may be built up, culminating in one center of the highest order, the metropolis. According to Losch, the location of firms is guided solely by the motive of profit maximization.

The hierarchal system expounded by Losch implies certain size and trade relationships among the places in the system. Berry put forth the following set of relationships to explain central place systems: The magnitude of a trade area served by a central city depends upon the population of the central city; the total population served by a central place is a function of the density of the population in the trade area and the population of the central city; the population of the central city is a function of the number of central functions performed by that city (that is, the number of separate types of businesses) (9). The essence of central place theory is that transport costs create varying geographic ranges for manufactured goods; the wider the range, the more the output tends to concentrate in large places.

2/ Underlined numbers in parentheses refer to Selected Bibliography, p. 19.

If interurban trading relationships posited by central place theory are correct, then there should also be some stable size relationship among cities. According to Berry, two kinds of size distributions of cities are recognized: (1) Rank-size, according to which the distribution of cities by population size class within countries can be characterized as declining log normal; and (2) primate, wherein a stratum of small towns and cities is dominated by one or more very large cities and there is a deficiency of cities of intermediate sizes (6).

The rank-size rule states that a city's population can be determined by its rank in a set of related cities, given only the population of the first ranked city and the rank of the city in question; that is,

$$Pq = K/r \qquad (1)$$

where P is the population of the city in question, K is the population of the largest city, r is the rank of the P city, and q is a constant. After considerable study of city structures, Berry concluded the following:

> ...the rank-size regularity applies throughout the world for countries which are highly developed with high degrees of urbanization, for large countries, and for countries such as India and China which in addition to being large also have long urban traditions; conversely, "primate cities" or some stated degree of primacy obtains if a country is very small, or has a "dual economy." Moreover, additional studies have recently shown that many distributions with some degree of primacy take on more of a rank-size form as level of development and degree of urbanization increase (8, p. 119).

Further, it appears that countries with rank-size distributions have many factors operating in many ways, whereas rank-size distributions are not generally found when few factors mold the urban system. For the United States, Vining found both statistical validity and stability over time for a system with q = 1 (74). This, according to Vining, lends support to Losch's central place theory. Edgar Hoover, however, criticized Vining's conclusions by noting that despite some statistical verification, the cities comprising the systems are continually changing their rank over time. He concluded that, since nothing in the central place theory helps to explain these shifts, the rank-size rule is devoid of predictive value for the population of any one city (39).

Duncan and others, in a major study of metropolitan areas, concluded that "the differentiation and specialization of service trades with increasing city size can be explained to only a small degree by principles stemming from the central place scheme (26, p. 80)." Using a 41-industry classification, they found that the hierarchal pattern relates inversely to city size for extractive, processing, and local service industries, and directly to city size for fabricating and nonlocal service industries (26, p. 66). As evidence that characteristics other than size determine the functions performed in a city, Chinitz noted that the proportion of employment in service industries is much greater in New York than in Pittsburgh. He attributed the difference mainly to the nature of the industries in each area. Pittsburgh is dominated by a small number of very large firms, whereas New York has a great number of small enterprises. The latter tend to purchase many of the services that large enterprises perform for themselves (22). Thus, small firms in Pittsburgh have fewer services available to them than similar firms in New York.

Chinitz' investigation discloses a difficulty in using census data for analysis. Since the census statistics relate to industy classifications and not functional classifications, perhaps a functional similarity between Pittsburgh and New York is disguised by having many business service functions included in the "manufacturing" category in Pittsburgh. Thus, proper testing of the central place theory may require detailed

surveys that will distinguish between production and other functions, especially where business services are important.

In several studies of small towns, where business services are of lesser importance, very high correlations were found between number of functions performed and city population (11). In a study of southern Illinois towns, Stafford found a very rapid increase in number of functions by size of town for small towns with population under 2,500 (67). In general, cities with less than 5,000 population appear to contain almost exclusively local service functions. The number of such functions may increase with population; however, as indicated in the Berry and Stafford studies, the functions increase in a declining log-linear relationship (that is, $\log y = a - b \log x$). In cities of large sizes, where other types of activities (for example, manufacturing) enter, local functions decline as a proportion of the total functions performed in the city. This decline conforms to Duncan's finding that over a large population range, the hierarchal pattern for local service industries is inversely related to size. On the other hand, Ullman concluded that the percentage of employment in local service activities increases with size of community (71). The contradiction arises because Duncan's definition of local service refers to a type of industry and not to the market served. As an area grows, manufacturing and business service sectors become more oriented to serving the local market.

On balance, it would appear that central place theory can provide a first approximation, or general guideline for delineating regions, but is not specific enough for planning in individual areas. The hierarchal nature of the city system is important in regional development planning, for it dictates the spatial allocation of investment. For example, should the region be developed with a single major center and a system of satellites? Or, should the region be developed with a system of interlinking major centers, each with its own system of satellite communities, linked together through trade? The latter represents the "polynucleated" system found by Chapin in the Piedmont area of North Carolina; and also represents the essential nature of the structure of Megalopolis. 3/ The major center-and-satellites system is more consistent with the rank-size distribution postulated by central place theory. Apparently, delineation of regions cannot be dictated by a single rule, but will depend upon the nature of the economic activities in the area, and on the urban growth process.

Perhaps those who plan activities should think in terms of a variety of city systems rather than in terms of a single type.

The City and the Hinterland

For a system of cities to provide the basis for a meaningful regional delineation, the rural areas near the urban system must have coherent relationships to those cities. Such a relationship was postulated by T. W. Schultz, who claimed that development will be generated in specific industrial-urban locations, and that agricultural prosperity will directly depend on proximity to these development areas (61). In support of this thesis, Duncan and others found that per acre values of farm products varied inversely with distance from a metropolitan center (26, p. 181). They also noted that soil quality was not an enforcing characteristic, being insignificantly correlated with distance from metropolitan centers. Gottman claimed that the high values of farm products near the population centers of Megalopolis resulted from such farms specializing in high-value production--for example, growing market vegetables, fruits, or nursery materials, or grade A dairying (32, p. 260).

3/ Megalopolis is the almost continous stretch of urban and suburban areas from southern New Hampshire to northern Virginia and from the Atlantic shore to the Appalachian foothills. See Gottmann (32). The economics of the Piedmont area of North Carolina is described in Chapin and Weiss (21).

There is evidence that the development of urban centers is not dependent upon trade flows between the urban center and its rural hinterland. It is true that there is a strong tendency for the farm products to flow to the nearest urban center, but Duncan and others concluded that "there is little support for a characterization of the metropolis as a center for non-resource-oriented industries whose markets are in its hinterland. Instead, it would be more consistent to hypothesize that other metropolises are the major markets for metropolitan industries...(26, p. 226)." The major function of the hinterland is not to serve as a market for goods produced at the center, but to supply labor. Inversely, the strongest influence exerted by the central city on the rural hinterland is as a source of off-farm employment. Parker and Davis concluded that the strongest factor in raising incomes of farm families in the Piedmont area of North Carolina was the provision of off-farm jobs, permitting farm residents to exchange idleness and low-productivity farming for cash income (21, ch. 5).

Several studies indicate a relatively new and expanding function of the rural areas adjacent to urban centers; that is, the provision of living space for rural nonfarm people who work exclusively at urban jobs, for the most part in the urban center (15, 27, 32). These are people who either prefer the lower density of rural living or cannot afford urban residence costs. Thus, the interchange between the urban center and the hinterland appears to take primarily the form of the hinterland providing food and workers and the urban center providing employment.

Functions (Internal Structure) of Cities

To understand the process of agglomeration, it is necessary to determine the functions performed in cities, and the relationship between function and size. Eric Lampard, in a pioneering paper on the history of cities, stated that the growth of cities and industrialization in western civilization both stemmed from the same force--the trend toward specialization. The necessity to integrate the work of specialists was a major centralizing force (45). The expansion from city to metropolis has brought a new dimension into focus: diversification.

Several studies show that extreme specialization is usually found in small metropolitan areas, while larger cities and metropolitan areas are characterized by diversified economic structures (26, 54, 71). For example, Morrissett found that in manufacturing, small cities tend to specialize, either having a very high or zero percentage of employment in a given industry. This pattern was found in the North and East for cities below 25,000 population and in the West and South for cities below 50,000 population (54). As city size increases, manufacturing, wholesale trade, financial, and other business services become more generalized; whereas, utilities (except for communications), retail trade, and personal services tend to be generalized or ubiquitous in small as well as large cities. Ullman and Dacey found that manufacturing employment increased somewhat less rapidly than city size, while retail trade and professional services increased somewhat more rapidly (71).

Duncan and others separate industries into functional classes as follows (26, p.205).

1. Primary resource extractors; production for nonfinal market
2. First stage resource users; production for nonfinal market
3. First stage resource users; production for final market
4. Second stage resource users; production for nonfinal market
5. Second stage resource users; production for final market
6. Resources of indirect significance; production for nonfinal market
7. Resources of indirect significance; production for final market
8. Service industries; local
9. Service industries; nonlocal
10. Service industries; may be local or nonlocal
11. Construction
12. Industry not reported

They found that categories 1 and 2 are strongly concentrated in nonmetropolitan areas; categories 4, 8, and 10 are somewhat concentrated in metropolitan areas; and the others are strongly concentrated in metropolitan areas. Within the metropolitan areas of over 100,000 population, however, there is no consistent pattern of increasing concentration as size increases (26, p. 205).

Ullman and Dacey are much less cautious than Duncan and others or Morrissett in estimating the portion of employment that serves the local market in each city size category. They construct an "export internal" ration of employment which rises from about 1:0.5 for areas of 10,000 population to 1:1 for areas of about one-half million (71). They even extrapolate these crude curves beyond the observed range. Despite their crudity, these measures are indicative of the fact, substantiated by other findings, that large areas are more self-sufficient than small ones. However, the true relationship between size and degree of self-sufficiency has not been adequately explored in the literature to date.

The Pattern of Urban Growth

The increasing tendency toward agglomeration in the United States is reflected in the national urbanization. The decade of the 1950's saw an acceleration of the urbanization trend which has been characteristic of U.S. growth for many decades. As shown in table 1, the proportion of the population residing in metropolitan areas increased from 51 percent in 1940 to 63 percent in 1960. From 1950 to 1960, total U.S. population increased by 18 percent, while metropolitan population increased 31 percent. Many investigators expect that by 1980, about 75 percent of the population will reside in metropolitan areas. Of course, some of the increase has occurred and will continue to occur because of formerly nonmetropolitan cities reaching metropolitan status.

In addition to the tendency for an increasing percentage of U.S. population to live in metropolitan areas, there has been a tendency toward an increased size, according to a report of the Outdoor Recreation Resources Review Commission (57), of metropolitan areas. The decade growth rates of the metropolitan areas with population over 1 million have exceeded those of the other Standard Metropolitan Statistical Areas (SMSA's); from 1950 to 1960, these growth rates averaged 32 percent and 28 percent, respectively. 4/

The upper Midwest Economic Study, which threw considerable light on the nature of urban growth patterns, found that most cities above 25,000 population had substantial growth rates unless they were in subregions plagued by resource problems, for example, the iron ore areas of upper Michigan. Smaller cities, except those in the southeastern corner of Minnesota, had substantial growth only when they were major shopping centers for wider areas. Hamlets and small convenience shopping centers generally grew very slowly, or declined, because major shopping centers penetrated their trading areas (14, p. 21). The exceptional pattern of small towns in southeast Minnesota was explained as follows:

> This is the part of the upper Midwest with a unique combination of relatively small farms, slow increase in farm size, high productivity in agriculture, large number of cities and large manufacturing employment in comparison to other parts of the region. The agricultural situation here has been relatively favorable to the maintenance of farm trade centers. Meanwhile the degree of urban and industrial development has permitted the growth of commutation from these communities to neighboring larger centers of employment (13, pp. 17-18).

4/ There is some conflict in the literature on this point. Ullman, for example, contends that all SMSA's have grown in population at about the same percentage rate (70).

Table 1.--Urbanization trend in the United States, 1940-60 1/

MILLIONS OF PERSONS

Area	1940 2/	1950 2/	1950 3/	1960 3/
	Millions	Millions	Millions	Millions
Metropolitan----------	67.1	85.5	89.0	112.4
Central cities------	41.5	49.2	52.1	57.7
Rings----------	25.6	36.8	36.8	54.7
Urban----------	---	4/ 24.7	---	41.4
Rural----------	---	11.6	---	13.3
Nonmetropolitan-------	64.6	65.2	61.7	66.1
Urban----------	---	15.8	---	25.6
Rural----------	---	49.4	---	40.6
Total United States---	131.7	150.7	150.7	178.5

PROPORTION OF POPULATION

	Percent	Percent		Percent
Metropolitan----------	51.0	56.7	---	63.0
Central cities------	31.5	32.6	---	32.5
Ring----------	19.5	24.1	---	30.5
Urban----------	---	16.4	---	23.1
Rural----------		7.7	---	7.4
Nonmetropolitan-------	49.0	43.3	---	37.0
Urban----------		10.5	---	14.3
Rural----------		32.8	---	22.7
Total United States---	100	100	100	100

1/ Conterminous States.
2/ Current definition of areas.
3/ 1960 definition of areas.
4/ Estimated by applying the percentage urban in SMSA's, except those in New England, to total SMSA population.

U.S. Census of Population.

Southeast Minnesota is dominated by the Twin Cities, and much of the small town growth is related to their economy. In the Upper Midwest Economic Study, half the population growth projected for the upper Midwest was in the Twin Cities. Population in small incorportated places under 2,500 population was expected to decline, with all growth occuring in presently urbanized areas (15).

Another aspect of the urban growth pattern is the suburbanization of population and industry. Table 1 shows that most of the growth in metropolitan areas is occurring in the urban ring rather than in the central city of the metropolis. Central city population, although unchanged as a share of total population, has declined as a percentage of the metropolitan population. A corresponding shift of industry from the central city to the suburbs was reported for the period of 1939-54 by Wilbur Zelinsky (78). He further noted that most of this shift remains within the confines of the metropolitan areas. He reported the following percentage distribution of value added by shift of industry (78, p. 261).

	1939	1954
	Percent	
Metropolitan	77.3	75.6
Central cities	47.6	42.0
Rings	29.7	33.6
Cities of more than 10,000	15.6	14.6
Rural and small cities	14.1	19.0
Nonmetropolitan	22.7	24.4
Cities of more than 10,000	8.3	9.5
Rural and small cities	14.0	14.9

A shift from the metropolitan areas occurred during World War II. Since 1947, there has been a reverse trend, with the proportion of value added in metropolitan areas increasing from 75.2 percent in 1947. The suburbanization trend accelerated during the latter period. Zelinsky also noted that the rate of suburbanization was directly correlated with the size of the central city. That is, the largest cities experienced the fastest relative loss to their suburbs. The findings of Zelinsky confirm the patterns of population dispersal found in the Upper Midwest Economic Study and evident in the census data.

The patterns of growth emphasize the drawing power of the metropolitan areas. Yet, the Upper Midwest Economic Study and census data reported in table 1 show considerable growth in nonmetropolitan cites. Southern reported that cities of the 10,000-50,000 population class were the fastest growing between 1950 and 1960 (65). Many of these were in nonmetropolitan growth areas. To date, metropolitan growth has been at the expense of rural area populations. A key question involves the viability of nonmentropolitan cities.

THEORY OF AGGLOMERATION

Agglomeration and Location Theory

According to location theory, much of the clustering tendency of businesses can be explained in terms of enterprises seeking profit-maximizing locations. It can be shown that under conditions of proportionate costs and inelastic demand, a firm serving several cities will tend to maximize profits by locating in the largest city, which tends to be at the median distance from markets, thus minimizing shipping costs (2, p. 81). Further, the Hotelling solution for a linear market area (with perfectly inelastic demand and elastic supply) demonstrates that two competitors free to move will tend to

cluster approximately at the center, because if one firm occupies any other spot, a competitor by locating nearer the center, can capture more than a proportionate share of the market. Losch refutes the Hotelling solution by claiming it to be based on very unrealistic assumptions (47, p. 75).

Most important, however, is the finding that the structure of transportation costs tends to create clustering. Terminal costs, freight rates less than proportionate to distance, and transshipment all create discontinuities in the transport cost function. These discontinuities encourage concentration at (1) the location of the major raw material for weight-losing materials such as iron ore, or (2) at the market for weight-gaining materials such as beer, or (3) at transshipment points if several materials are to be gathered or if further processing is to take place there.

Unfortunately, recent theoretical works have shown that optimum or stable equilibrium solutions to the location problem are unlikely when the complexities of the real world enter the calculations. Tiebout showed that the maximum profit location for a firm with several sources of raw materials and a given market can be mathematically determined only under the following conditions:

1. Gross revenue from sales is constant regardless of location.
2. Nontransport costs are independent of location.
3. Transport costs are a linear function of distance (68).

The first condition generally implies a cost, insurance, and freight price that includes production costs less transportation costs. If prices are allowed to vary in the different markets, the smooth curve that relates profits to location is turned into a very bumpy curve with a variety of profit subpeaks at several locations, and only trial and error can show if any one peak is truly the maximum. Determining the maximum profit location for a firm becomes even more complicated when both production costs and prices vary with location. In this case, there may not be a maximum profit curve. Moses stated that if inputs are substitutable, there is no single optimum location (55). Optimum location will depend upon the scale of operation and the shape and slope of the price curve. Even if these conditions are known, there may well be no stable equilibrium solution to the locational pattern of a multifirm industry. Koopmans has shown mathematically that it always pays one firm to move (44). Location theory alone, therefore, is inadequate to explain the strong tendency toward agglomeration prevailing in the U.S. economy.

Other works emphasize that the dynamic process and external advantages of agglomeration provide further rationale for extreme clustering. Friedmann began his TVA study with the thesis summarized below (27):

1. Industries may be considered of three types: Material-oriented, labor-oriented, or market-oriented. In advanced stages of economic development, there is a shift of emphasis from the first two types to the third.
2. Central places provide optimum access to markets; the shift to market-oriented industries will lead to rapid convergence of manfacturing employment at central places.
3. Convergence of manufacturing employment at central places gives rise to increasing division of labor and growing requirements for tertiary services. The demand for tertiary services increases most rapidly in central places with greater specialization and higher incomes than in rural areas and small towns.
4. The next stage of development consists of a dispersion from the central city into the suburbs to increase space and reduce costs. The dispersion is generally restricted within a commuting distance to the central city, regarded by Friedmann to be about 50 miles. The interrelated developments of centralization and dispersion tend to culminate in the emergence of the city region. Transportation and communication make possible the multitude of interrelationships which exist among these activities and bind the city region into a more or less integrated community.

5. At an advanced stage, several city regions may be joined by a high-speed transportation network (presumably forming a polynucleated structure, such as Megalopolis).

Friedmann's thesis that market-oriented industries are far more susceptible to agglomeration than labor-oriented or material-oriented industries was not substantiated by his investigation. He found that all types of industries were strongly attracted to metropolitan areas in the TVA region (27, p. 30). In the period 1929 to 1950, 56 percent of all new manufacturing employment in the TVA region located in metropolitan areas, even though two-thirds of the new employment in the region was in the so-called labor-oriented industries. Friedmann explained the extreme attractiveness of the metropolitan area in terms of the advantages of central locations (28, p. 36):

1. The city provides access both to markets and, through commuting, to a large labor supply. He noted that almost the entire TVA region lies within a 1-hour commuting distance of a central city (city with population in excess of 30,000).
2. The city provides flexibility of transportation. A city invariably lies on the connecting points of highways, plus at least one other major transportation node. Location at the transport hub of a radial network has the further advantage of increasing flexibility with regard to the sources of material inputs.
3. The city generates the environment for the creation of a skilled labor supply that can form the nucleus of a new manufacturing plant.
4. The city provides a fund of experience in finance, repair services, and so forth, that can be of great value to the businessman.
5. The city permits interindustry linkages in terms of geographic proximity which can be of advantage to many industries. Chemicals are a prime example.

In general, this set of advantages results in a clustering of activities around a metropolitan center which creates the general condition for further industrial growth in the same center.

Edwin von Boventer provides a hypothesis that emphasizes the role of wage differentials in the dynamic process of agglomeration (19, pp. 95-96):

1. The locations of primary and secondary activities are determined by raw material sites and traffic routes, as well as by "historical accidents," all of which have led to the growth of certain centers of demand, which in turn have attracted new industries and service activities.
2. As a result of the partial concentration of activities in cities of various sizes, the land values, housing rents, and a number of other prices and expenditures, such as for transportation, are higher in urban than in rural districts. For this reason, and in order to attract additional workers into the cities, nominal wages must be higher in the cities; and the greater the rate of growth, the greater the wage differential has to be.
3. As a consequence, urban centers have the advantage of greater local markets and of certain agglomeration economies of production, while rural areas can offer lower wage costs. The optimal site for a firm depends upon the relative importance of agglomeration economies, wage costs, and transport costs.
4. At first, these balances favor growth in all parts of a region and work toward the establishment of hierarchies of settlement. However, as agglomeration economies rise, and labor mobility increases, the spatial regularities diminish (and presumably the favored locations prosper relative to the others).

French economists have done considerable work in regional analysis and urban development. They emphasize the importance of geographic interindustry linkages and the emergence of growth poles (Perroux's poles de croissance). Two leading proponents of the "French" school are Francois Perroux (58) and J. R. Boudeville (17, 18). According to Perroux, growth starts at certain points in space, for a variety of reasons, mostly

related to the presence of an innovating spirit. A time sequence of geographic interindustry linages is generated that tends to cause further growth to occur at the points of innovation. Perroux stresses that these innovating growth poles are necessary for national development. National growth, therefore, must be geographically unbalanced; lagging regions will benefit through a trickle-out effect. Hirschman points out, however, that this trickle-out effect need not occur (37, p. 184).

Boudeville stresses that the kind of industry developed in an area will determine the rates at which various centers will grow. He defines the "propulsive industry" as one that precipitates growth either by causing other industries to expand in the area to serve its needs and absorb its products, or by creating larger possibilities for innovation in other industries or sectors.

Thus, we sense in the theories a divergent starting point for agglomeration. The "American" theorists (Friedmann, Hoover, Alonso) stress the role of access and transport cost minimization as the key elements of original agglomeration, with further agglomeration related to the buildup of external advantages. The French school, on the other hand, stresses the original role of innovation and the generative forces, with further agglomeration resulting from the technical forces of interindusty linkage.

We believe that evidence for the American viewpoint is somewhat more persuasive. Major centers appear to be highly oriented to transport nodes, expecially major transshipment points. On the other hand, not many such points have developed. Interindustry linkage is inadequate to explain the continual attractive force of the large metropolitan areas, nor does it explain the clustering tendency of footloose industries with weak interindustry requirements. 5/

A more comprehensive theory and quantitative verification are necessary to clarify the process of agglomeration. A possible framework for such a theory is suggested in the following section.

A Framework for a Theory of Agglomeration

A general equilibrium theory of agglomeration would explain the spatial allocation of people and economic activities in relation to one another on the basis of sets of conditions and assumptions about spatial behavior. By means of a general equilibrium theory, various models could be generated, depending upon the purposes of the investigation. For example, optimizing models could be devised that would determine the income tradeoffs among alternative spatial distributions. Such models would inform planners of the benefits sacrificed in a suboptimal spatial distribution of population and industry.

The works reviewed for this paper suggest that any theory of agglomeration should take into account the following elements:

1. Accessibility
2. Communication and information transfer
3. External economies in the private sector
4. Internal economies of scale and market structure
5. Economies of scale in the public sector
6. Decision-making and the historical process
7. Constraints on urban structure imposed by the regional growth prospects.

5/ See Spiegelman (66) for example of agglomeration tendency in a footloose industry, namely production of precision instruments.

Accessibility.--Acessibility is essentially a matter of transportation costs--commuting costs for labor and shipping costs for goods. The urban center provides a high-density market. From location theory, we have learned that once a single center provides an adequate market for more than half the output of an establishment, transfer costs are minimized by locating at that center. "Adequate market" may refer to final demand, principally consumption, as emphasized by Chauncey Harris (35) and by Ullman (69), or to the interindustry linkages stressed by Boudeville (18).

Accessibility to the appropriate labor force is also essential. Wage rates, degrees of skill among the members of the labor force, stability in employment, and ease of replacement of labor are all components of labor accessibility. It is generally considered that the supply of unskilled and semiskilled labor is better in the rural areas, whereas skilled labor is more accessible in the urban areas. The entire rural labor force in the northeast manufacturing belt is within a 50-mile commuting distance of central places (generally with populations 25,000 or more). This partly explains why even labor-oriented industries using low-skilled (generally nonurban) labor do not have to locate in the rural area to have an adequate labor supply.

In a generalized model, the factor of accessibility might enter as the purchasing potential of markets of given horizontal dimension, or as the available labor force in different skill or occupation categories within a commuting distance of centers of various sizes and densities.

Communication and information transfer.--Central place investigations make considerable use of the network of telephone calls as a measure of central place hierarchy. This is an easily quantifiable aspect of communication. More subtle aspects, such as the transfer of information at social gatherings or luncheon meetings, are difficult to quantify. Such means of information transferral and customer contact, however, are very important for some businesses, such as insurance, stock brokerage, or electronic systems design. Such contacts are maximized in the urban environment.

The person-to-person transfer of information and ideas within spatial systems has been recently studied, beginning with the pioneering work of Professor Torsten Hagerstrand of Sweden). 6/ Alonso also stressed the importance of contacts in increasing the attractive power of large urban centers (2, p. 101). Some work has been done to quantify the expression,

$$Y = kD^{-x}$$

where Y is the number of contacts per square mile, D is the distance from the residence, and k and x are constants for each region. In general, research to date reveals that most personal contacts occur at very short distances. The importance of these contacts in creating an agglomeration needs study. Richard Meier has attempted to develop a complete theory of the role of communications in urban growth (52), the application of which has yet to be evaluated.

External economies in the private sector.--External economies, referred to in the literature as technological external economies, exist wherever the output of a firm depends not only on its own factor utilization but also on the output and factor utilization of other firms (62). Scitovsky found only two examples in the literature that fit this definition: the case in which a firm benefits from the labor market created by other firms; and the case in which several firms use a resource which is free but limited in supply (62, p. 145).

6/ See Marble and Nystuen (50) for discussion of the theory and citations to the literature.

Another kind of external economy in the private sector recognized by Scitovsky is that which arises in economic development and is referred to as "pecuniary external economies." These occur whenever the profits of one producer are affected by the actions of other producers. The situations in which they occur were given by Scitovsky as follows (62, p. 149): "Expansion in industry A may also give rise to profits (i) in a industry that produces a factor used in industry A, (ii) in an industry whose product is complementary in use to the product of industry A, (iii) in an industry whose product is a substitute for a factor used in industry A, or (iv) in an industry whose product is consumed by persons whose incomes are raised by the expansion of industry A." In addition, there are external diseconomies.

In a spatial context, the pecuniary external economies may refer to the profit enhancement to other industries caused by industry A's expanding in a particular location, resulting generally from the reduced transport costs of the products of industry A, or from other advantages relating to the proximity to industry A.

With the exception of some studies in complex analysis of the petrochemical and synthetic fiber industries, there is little quantification of the value of locational external economies to industry (43).

Hirshman suspects that investors, and we believe researchers also, overestimate the external economies arising at the "growth poles" (37, pp. 185-186). The reason for this tendency is summarized in the statement, "nothing succeeds like success." The successful groups or regions will widely proclaim their superiority over the rest of the country. These claims tend to be self-fulfilling even if the original success was sheer luck, because a climate of success and enterprise is generated. Hirshman makes the amusing observation that perhaps the "Protestant ethic," instead of being the prime mover, is implanted ex post facto as though to sanctify and consolidate whatever accumulation of power and wealth has been achieved. This tends to create a climate conducive to further growth.

Thus, we are aware of external economies that can be expected to arise from agglomeration, we witness the success of agglomeration, and we conclude that external economies cause the agglomeration. In fact, there is almost no quantitative evidence as to the role of external economies in the agglomeration process. Such evidence must be forthcoming, if external economies are to be incorporated into a theory of agglomeration.

An aspect of external economies that appears more readily quantifiable than its effect on agglomeration relates to the number and kinds of services performed locally. Both central place theory and local multiplier theory provide a basis for quantifying the different abilities of areas of different size to provide local service. As Ullman points out, the advantage of internalizing these services is that as the city grows, it becomes more self-sufficient, and therefore more efficient, since it saves on the transport and communication costs to and from other places. By this measure, the larger the better (70, p. 10).

Internal economies of scale and market structure.--Harris points out that for firms distributing to a national market, location in or near Philadelphia is optimum (35, p. 108). His study emphasizes the importance of the northeast manufacturing belt as the major market for its own products. The internal economies of scale dictate the optimum size of plant, which in turn dictates the market requirements. The optimum location of a bakery, whose optimum size is relatively small, may be in a small city. An integrated steel mill requires a multi-State region for a market. Because of the importance of accessibility, and internal economies, a large metropolitan market is needed to justify the presence of many manufacturing enterprises.

Economies of scale in the public sector.--Several studies have attempted to quantify cost functions for community services. Investigations so far, however, do not indicate that economies of scale in public community services are very important to the explanation of agglomeration. We will quote at length from the conclusions reached by Werner Hirsch in this regard (36). 7/

> As governments in metropolitan areas grow, location, efficiency, and institutional considerations tend to cause services to be rendered in three different fashions. Public education, fire protection, police protection, refuse collection, etc., accounting for around 80-85 percent of all expenditures, will be furnished in horizontally integrated service plants. Growth and consolidation appear to have little, if any, significant effect on per capita expenditures for these services.
>
> The central administration of municipal or special district governments, accounting for 3-6 percent of total local government expenditures in metropolitan areas, is performed mainly in a circularly integrated plant. In the early growth stage, per capita expenditures for these services will tend to decline. Beyond a point found in medium-sized communities, growth or consolidation will tend to produce per capita expenditure in increases.
>
> Finally, water and sewage services, which often account for about 8-10 per cent of total expenditures, tend to be rendered in a vertically integrated plant. Growth and consolidation will lead to a decline in per capita exenditures until a very large scale is reached, so large that few city and metropolitan areas have achieved it.
>
> Efficiency considerations, thus, do not appear to warrant across-the-board consolidation of metropolitan area governments. Consolidation of water services and sewage services, preferably into a multi-purpose district, can be a move toward greater efficiency and lower expenses. Otherwise, economic efficiency may be highest in medium-sized communities of 50,000-100,000 residents.
>
> Our findings are consistent with those of two other recent studies. Stanley Scott and Edward L. Feder studied 196 California cities with populations over 2,500. [Factors Associated with Variations in Municipal Expenditure Levels,(Berkeley, 1957).] They concluded that per capita expenditures for all local government services taken together were not significantly affected by population size. A second study, made by Harvey Brazer, analyzed expenditures for fire protection, police protection, highways, recreation, sanitation, general control, welfare, and education. [City Expenditures in the United States, Nat. Bur. Econ. Res. Occasional Paper 66 (New York, 1959).] Results reveal no significant economies of scale. In some instances the net relation between per capita expenditures and population size are positive.

7/ See also (20, 25, 33, 59, 60, 64). The evidence regarding economies of scale refers only to dollar expenditures and does not consider the possibility that the quality of the service being rendered may have some relationship to urban size.

These two studies did not measure service levels which were found to significantly affect expenditure levels in the St. Louis area. While service levels are highly correlated with population size, this correlation is far from perfect.

Both might well have found different net relationships between per capita expenditures and population, if they had included service levels as an independent variable; most likely, they would not be significantly positive. Furthermore, Scott and Feder considered all local services taken together.

Decision making and the historical process.--Weberian location theory lacks historical perspective. Location decisions are regarded as being made in a world without the constraints of an existing location pattern. That this assumption is not warranted is brought out clearly by a theoretical contribution of C. M. Tiebout, which claims that agglomeration of firms in a small number of large metropolitan areas is mainly a result of firms hedging against uncertainty. Thus, says Tiebout, even if firms are acting randomly in making their location decisions, the economic system is evolving the locational pattern by granting success to those firms whose locations conform to an efficient economic pattern (68). Firms will therefore tend to locate where similar firms have been successful, rather than to take advantage of economic opportunities in other locations. The introduction of uncertainty as a location element, we believe, is an important advance from traditional location theory. Location in large metropolitan areas is a hedge against error; and the fact that metropolitan areas have expanded so tremendously is "proof," says Tiebout, that the economic environment has granted success to this kind of hedging activity.

Uncertainty is entering location theory through the use of probability analysis and decision theory. In general, these new theories try to estimate the costs and benefits of alternative decisions in the light of the probabilities of different events occurring. Thus far, says Alonso, one of the most interesting conclusions of these investigations is that there often is no single best strategy for the businessman (2, pp. 104-105). He may choose to act boldly for big gains or losses, or conservatively for smaller ones, both being rational possibilities, with the choice depending on his goals and attitudes.

Isard and others have attempted to bring the formal tools of decision theory to bear on this problem of location decisions, weighing together expected profits and risks of different location decisions (41, 42).

Policy variables can be introduced readily into the decision framework, to show, for example, how the decision to locate might be affected by government accepting some of the risk (through insurance, grants, and so forth) involved in locating in other than the metropolitan areas. Decision theory may provide a means for introducing risk aversion and inertia, in contrast to objective economic consideration, as causes of agglomeration.

Constraints on urban structure imposed by the regional growth prospects.--The above elements would enter into a theory of urban growth and agglomeration. No theory could claim realism, however, if it did not set the evaluation of city size and agglomeration in the context of the future of the region within which the city or set of cities belonged. The Upper Midwest Economic Study showed that cities of the same size and with the same central place role fared differently, depending upon the events in the region. Cities and towns of all sizes prospered and grew in the Twin Cities region where both industrial and agricultural progress occurred. On the other hand, cities of all sizes languished in the upper Michigan areas plagued by the economic depletion of the region's iron ore deposits.

Ullman concluded that the concentration of economic activity in the so-called industrial belt of the United States is easily explained: "...a combination of resources, early start, type of settlement, and what is most important, a self-perpetuating momentum resulting from a pyramiding of complementary activities and services to produce notable external exonomies of scale and the largest market in the country (69)." On the other hand, the prospects for the fringe or corner areas appear to Ullman to be "rather bleak," primarily because they are remote from the centers of the systems and the self-genereating momentum of these centers. Thus, the future of any urban area is constrained by that of the region of which it is a part. We may further note that without the constraints in total regional population, employment, and industrial structure, it is unlikely that the search for an optimum urban structure would result in a unique solution.

CONSIDERATIONS FOR PUBLIC POLICY

Planning Objectives

A possible aid in determining planning objectives is the distinction between developmental and adaptive planning, set forth by Friedmann (29). According to Friedmann, "the former is concerned with achieving a high rate of cumulative investment for a given area by activating unused resource capabilities; the latter is interested chiefly in qualitative adaptations to the changing interplay of economic forces within the area...Adaptive planning attempts merely to relieve temporary crises...which may be caused by exogenous changes (29, pp. 86-87)."

Friedmann cautions that developmental planning for a region is apt to have only limited effect on the longrun trends of income in the area unless the planners are able to affect national economic policy. He cites the TVA experiment as one having very limited success in raising incomes despite the heavy investment in water-resource development.

The research needs for developmental policy differ from those of adaptive planning in that the goal of the former is to establish criteria for action, whereas the goal of the latter is to understand and predict events. For developmental planning, an optimizing model is desired as a means of (1) determining optimum patterns and hence the the costs of pursuing a suboptimum policy, or (2) determining activities that will remove the obstacles to the optimum course. For example, a model to determine the optimum hierarchal structure of urban places in a region could be used either to help bring about such a structure, or to appraise the costs of creating another, and therefore suboptimum, structure.

If optimization is unobtainable, it is possible to devise less complete models that could still be applicable for developmental planning when the goal is to determine feasibility of a project, rather than actually to devise the project through research. For example, planners may have the predetermined goal of creating growth poles, or development nodes, with populations of 10,000 to 50,000. In this case, a model may be devised to determine an efficient, though not necessarily optimum, structure based on such nodes. There are three levels of effort that may be recognized for planning purposes: (1) a feasible plan--one that can be carried out, one that is internally consistent; (2) an efficient plan--one that is feasible and results in an income distribution wherein no individual income can be increased without someone else's income being reduced; and (3) an optimum plan--one that provides for a system that maximizes the return from investment in physical and human resources. The information level required of the model increases--and precipitously--with each increase in level of effort.

For adaptive planning (most city and regional planning to date in this category), models that describe the universe or project events are required. The goal of the research is to estimate the results of exogenous events so that plans may be made to accommodate these events. For example, most highway planning is of this kind. Research is aimed at determining where people will live and work, and at projecting their pattern of travel desires; road plans are then made to accommodate these desires.

Very sophisticated models incorporating dynamic and probabilistic elements can be used for adaptive planning. Indeed, for the complex task of accommodating the expected spatial distribution of activities in a large region, such elements should be introduced to assure reliable results. On the other hand, adaptive planning often uses extremely crude, singlepoint projections employing static techniques and few variables.

Instruments of Policy

The research is molded by the planning objectives and by the methods of instruments available for carrying out the objectives. If planners expect to operate directly on the decision-making apparatus of the private sector, then the model should incorporate this decision. For example, if the Government is prepared to assume some of the risk believed to exist in locating in nonmetropolitan areas, the model should incorporate knowledge of the risk premiums attached to such locations and the location distribution effects of Government assuming these risks (42). Another example is the planning objective of investment coordination requiring knowledge of the interindustry linkages and external economies. If the instruments relate primarily to the creation of infrastructure, then knowledge of industry and external factors is required in less detail, while knowledge of the infrastructure requirements and effects of infrastructure on development must be incorporated into the model.

In general, the instruments of policy and the way they are going to be used must be determined before constructing the research model, so as to assure that the questions relevant to the planners are asked, and that the information required for using the tools is produced by the model. In essence, it is a question of emphasis and detail. Foreknowledge of the tools would be unnecessary in a model that was as fully detailed as the economic process itself. Since such detail is not possible, knowledge of the tools will determine where detail is not possible, knowledge of the tools will determine where detail is essential and where it may be curtailed.

Sensitivity testing provides an important link between the policy maker's tools and the research model. The policy variables representing the proposed actions of the policy maker are introduced in the model in order to determine the effects of such variables on the system. If the policy being proposed does not substantially affect the solution, then it may be assumed that the system is not sensitive to that policy. Sensitivity testing requires less rigorous model building, because the answers are in terms of the general magnitude of response, rather than in terms of absolute answers. For example, will significantly more industry tend to locate in smaller cities and nonmetropolitan areas if the Government assumes a share of the risk? Will the building of major roads throughout Appalachia tend to increase, decrease, or not affect the agglomeration tendency? Can the property tax be used to bring about decentralization? Will per capita income in the region be positively or negatively affected by taxing policy that forces decentralization? These and other questions of sensitivity can be answered in terms of order of magnitude response to the policy variables.

SUGGESTIONS FOR FURTHER RESEARCH

Three broad areas of further research can be identified:

1. The structuring and development of a theory of agglomeration, incorporating elements along the lines of the seven previously outlined.

2. Determination of how the rural population can best adjust to the agglomeration process in the sense of maximizing incomes of rural people in the light of the present trends.

3. The courses of action that are open to rural areas as counter moves against agglomeration trends, and the cost of these actions.

Within this broad framework, more specific areas of research sould be undertaken:

1. Modeling and quantification of each of the elements of agglomeration theory.

2. Investigation of specific industries to determine (a) the patterns and changes in patterns, of industry location vis-a-vis metropolitanization and urban size, and (b) the factors that are influencing industry location. 8/

3. Determination of how the hinterlands relate to the urban centers, and how these relationships can be altered to increase incomes in the hinterlands.

4. Projections of the future of nonmetropolitan cities, with answers to the question of whether viable nonmetropolitan urban-rural systems can be developed.

5. Determination of the most efficient city sizes, manner in which efficient size relates to economic function, and costs associated with encouraging location in cities of less than optimum size.

6. Further research on determing whether there is an optimum hierarchal system of urban places that should be encouraged in regional planning.

7. Investigation of the relation between urban viability, rural viability, and regional growth.

8/ Investigation of this question is now being undertaken at Stanford Research Institute under contract with the U.S. Department of Agriculture.

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