INTERNAL STRUCTURE OF THE CITY

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I

INTRODUCTION: EXTERNAL DETERMINANTS OF INTERNAL STRUCTURE

Cities are the central elements in spatial organization of regional, national, and supranational socioeconomies by virtue of the interregional organization in a total "ecological field" of the functions they perform.[1] In a specialized society economic activities are undertaken by design, or survive in the market place, at those locations which afford the greatest competitive advantage. Among these activities, those most efficiently performed in limited local concentrations provide the basic support for cities. The location theorist commonly classifies locally-concentrated economic activities into those which are raw material oriented, those located at points which are intermediate between raw materials and markets, and those which are market oriented.[2] Raw material orientation includes direct exploitation of resources and the processing of raw materials, and its character is that of the developed resource endowment of different places. Activities in intermediate locations are usually of a processing kind, involved in intermediate and final processing and transformation of raw materials, and most frequently locate at some favorable spot on the transport network, such as an assembly point, a gateway, a break-of-bulk point, or a port. Market oriented activities may be secondary (for example, where there is a weight gain involved in the final processing of raw materials on intermediates prior to delivery), but are dominantly tertiary, concerned with the direct service of the consuming population through wholesale, retail, and service functions. The consuming population comprises the workers in the other specialized activities, of course, plus the local population supported by the tertiary trades. Thus, market orientation implies a location best suited to serve demands created by prior stages of the productive process. The three classic principles of urban location derive from the three types of locational orientation of economic activities: cities as the sites of specialized functions; cities as the expressions of the layout and character of transport networks; and cities as central places.[3] All three principles, or some combination of them, may operate in the case of any particular city. However, whereas all cities

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[1] J. R. P. FRIEDMANN & W. ALONSO, REGIONAL DEVELOPMENT AND PLANNING (1964); Pappenfort, *The Ecological Field and the Metropolitan Community*, 64 AM. J. SOCIOLOGY 380-85 (1959).

[2] W. ISARD, LOCATION AND SPACE ECONOMY (1956).

[3] Harris & Ullman, *The Nature of Cities*, 242 ANNALS 7-17 (1945).

will have a central business district providing retail and service functions to the city and surrounding populations, the role of the other two principles will vary greatly from one city to another.

In the internal structure of cities these specialized functions have priority. The central business district is a point of focus about which land uses and densities, the spatial patterning of the urban population, subsidiary retail and service locations, transportation and commuting patterns, and the like, have evolved. When other specialized activities are performed, they create supplementary or additional nodes. Thus, cities are supported by "basic" activities ("staples") whose locations are determined exogenously to the city by comparative advantage in larger regional, national, and international economic systems. These always include the central business district, the focus not only of the city itself but also of its tributary region, and may include other specialized activities. The skeleton of the city comprises the locations of these basic activities, plus the urban transport network. Flesh is provided by residential site selection of workers with respect to the skeleton, and blood comes from the daily ebb and flow of commuters. Further patterning is provided by the orientation of subsidiaries and business services to the basic activities, and by local shopping facilities to the workers. Shopping trips create another ebb and flow. Further "second-" and "third-round" effects can be described, but these follow logically from the first. The question to be answered here is that of the nature and bases of residential, socioeconomic, and retail patterns within cities. Because the discussion is concerned with the internal structure of the city it thus perforce takes as given the exogenously determined skeleton. Further, it will focus upon the flesh rather than the blood, although the latter is implicit in the discussion of the former.

II

THE RESIDENTIAL PATTERN: URBAN DENSITIES

A simple expression summarizes the population density pattern of cities:

$$d_x = d_o e^{-bx} \qquad (1)$$

where d_x is the population density d at distance x from the city center, d_o is density at the city center, e is the natural logarithmic base, and b is the density gradient. The "city center" is, of course, the central business district, so that when the natural logarithm of population density of small areas within the city is calculated, along with their distance from the central business district, and a scatter diagram is constructed with distance along the abscissa, the points in the diagram lie around a straight line with downward slope b, or:

$$\ln \cdot d_x = \ln \cdot d_o - bx \qquad (2)$$

The gradient b may be considered an index of the "compactness" of the city, just as differences in central density d_o index the overall level of "crowding." Equation (2)

has been shown to be universally applicable to cities regardless of time or place.[4] Why should this be so? Muth has shown how this negative exponential decline of population densities with increasing distance from the city center is a condition of locational equilibrium which stems logically from the operation of a competitive housing market.[5] Seidman has shown it to be a natural consequence of Alonso's locational theory of land use.[6] The theoretical bases of the empirical regularity are thus readily available.

The density gradient b, like the densities it indexes, also shows consistent behavior. For example, in any country at a particular point in time, it falls consistently with city size as follows:

$$\ln \cdot b_j = \ln \cdot P_o - c \cdot (\ln \cdot P_j) \tag{3}$$

so that cities have experienced progressive "decompaction" with increasing size. Further, since in the United States, recent expected growth of metropolitan areas between two time periods t and $t+1$ is a constant proportion of size[7] such that

$$\ln \cdot P_{t+1} = k + \ln \cdot P_t \tag{4}$$

which further implies exponential growth of population with time

$$P_t = P_o e^{kt} \tag{5}$$

then

$$b_t = b_o e^{-ckt} \tag{6}$$

which states that the density gradient diminishes through time in a negative exponential manner, which is the case.[8]

Newling has shown, additionally, that the two generalizations that population density declines exponentially with increasing distance from the city center and that the density gradient itself falls through time in a negative exponential manner, together lead to a third regularity, which he calls the "rule of intra-urban allometric growth."[9] This is that the rate of growth of density is a positive exponential function of distance from the city center:

$$(1 + r_x) = (1 + r_o) e^{gx} \tag{7}$$

[4] Clark, *Urban Population Densities,* 114 J. ROYAL STAT. SOC'Y 490-96 (1951).

[5] R. MUTH, THE SPATIAL PATTERN OF RESIDENTIAL LAND USE IN CITIES (in preparation).

[6] D. E. SEIDMAN, AN OPERATIONAL MODEL OF THE RESIDENTIAL LAND MARKET (1964).

[7] This "law of proportionate effect" may be seen by plotting populations of U.S. cities in 1950 against their populations in 1960. The scatter of points is linear and homoscedastic with a slope of +1.0 on double logarithmic paper. Satisfaction of this assumption means that in steady-state the distribution of towns by size will be lognormal so that Zipf's rank size rule for city sizes holds: $P_r = P_1/r^q$ or $\text{Log} \cdot P_r = \text{Log} \cdot P_1 - q \cdot \text{Log} \cdot r$. In these equations P_r is the population of the city of rank, r, P_1 is thus the largest city, and q is an exponent.

[8] Berry, Simmons & Tennant, *Urban Population Densities: Structure and Change,* 53 GEOG. REV. 389-405 (1963).

[9] Newling, *Urban Growth and Spatial Structure: Mathematical Models and Empirical Evidence* (processsed, Cornell University, 1965).

where r_x is the percentage rate of growth of density at distance x, r_0 is percentage growth at the center, and g is the growth gradient, measuring the rate of change of the rate of growth as distance from the center of the city increases. He goes on to show that since both density and the rate of growth are functions of distance from the city center, the rate of growth may be expressed as a direct function of density:

$$(1 + r_x) = mD^{-q}$$

where r_x is as above, m is a constant, D is initial density and q relates the rate of change of the rate of growth to the rate of change of density. As density increases, the rate of growth drops. Moreover, Newling argues for the existence of a "critical density" above which growth becomes negative, *i.e.*, population declines. In several cases he shows a convergence upon 30,000 persons per square mile as this critical density, and in one study he concludes:[10]

> The inverse relationship between population density and the rate of growth, the identification of a critical density, and the observation that negative growth, occurring as it does above the critical density, is not solely attributable to competition between commercial and residential use of land, all lead one to speculate that perhaps there is indeed some optimum urban population density to exceed which inevitably incurs social costs. We may speculate that certain events in the history of the city will cause this optimum to be exceeded (for example, heavy immigration without a commensurate expansion of the housing stock and supply of social overhead capital), with deleterious consequences for the areas concerned (such as blight, crime and delinquency, and other social pathological conditions) and leading to an eventual decline in the population of the affected areas. . . .

If this is so, then consistent relationships are available between size of city and the pattern of population densities within cities, between growth of the urban population and change of densities within. Further, there is the strong suggestion that this chain provides direct links between an overall urbanization process and the occurrence of pathological social conditions in particular parts of particular cities.

III

SOCIAL AND ECONOMIC PATTERNING OF THE RESIDENTS

The generalizations in the preceding section are strong. Equally strong generalizations are now possible concerning the social patterning of the urban residents who live at the density patterns in the changing ways already described.

There has been a long tradition of research by sociologists, geographers, and economists dealing with the social and economic characteristics of urban neighborhoods. Among the earliest descriptive generalizations were those of Hurd, who related neighborhood characteristics, especially income and rentals, to two simultaneous patterns of growth which he called *central* and *axial* growth.[11] Later, Burgess em-

[10] *Ibid.*

[11] RICHARD M. HURD, PRINCIPLES OF CITY LAND VALUES (1903).

phasized the importance of outward growth from the center which caused concentric zonations of neighborhoods.[12] Change occurred by the outward movement of the wealthier to the periphery, and the continued expansion of inner zones upon the outer in a process of invasion and succession by the lower status groups living closer to the city center. Hoyt, on the other hand, emphasized the significance of axial growth when he developed his sector concept.[13] According to this notion, status differences established around the city center are projected outwards along the same sector as the city grows, thus creating a wedge-shaped distribution of neighborhoods by type with the higher status groups following scenic amenities and higher ground. In addition, the literature of sociology has been replete with studies of the segregation of ethnic groups in particular localities conforming neither to the concentric nor to the axial schemes.

Considerable debate has taken place about the relative merits of each of these models. A succession of large-scale factor analytic studies conducted since the end of the Second World War now make it possible to state definitively that the three models are independent, additive contributors to the total socioeconomic structuring of city neighborhoods. Factor analysis is a multivariate procedure which permits a mass of data (an example would be the 100+ census characteristics of each of the 800+ census tracts of Chicago) to be examined to determine exactly how many dimensions of variation are expressed by it. In each of the studies the answer is the same: there are just three dimensions of variation. These are (a) the axial variation of neighborhoods by socioeconomic rank; (b) the concentric variation of neighborhoods according to family structure; and (c) the localized segregation of particular ethnic groups.

Neighborhood characteristics involving educational levels, type of occupation, income, value of housing, and the like, are all highly correlated, as they should be, for undoubtedly they are also functionally related. Each varies across the city in the same way: according to sectors. High status sectors search and follow particular amenities desired for housing, such as view, higher ground, and so on. Lower status sectors follow lower lying, industrial-transportation arteries that radiate from the central business district and which, together with that district, form the exogenously-determined skeleton of the city. This is consistent with the idea, also, that the lower the income the closer is home to work in the contemporary American city.

Conversely, the age structure of neighborhoods changes concentrically with increasing distance from the city center, along with age of housing, densities, existence of multiple unit structures, incidence of ownership by residents, participation of women in the labor force, and the like. Thus, at the edge of the city are newer, owned, single-family homes, in which reside larger families with younger children

[12] Burgess, *The Growth of the City*, in ROBERT E. PARK, THE CITY (1925).

[13] HOMER HOYT, THE STRUCTURE AND GROWTH OF RESIDENTIAL NEIGHBORHOODS IN AMERICAN CITIES (1939).

than nearer the city center, and where the wife stays at home. Conversely, the apartment complexes nearer the city center have smaller, older families, fewer children, and are more likely to be rentals; in addition, larger proportions of the women will be found to work. This "family structure" pattern is consistent with the ideas of Burgess, and has been called by sociologists the "urbanism-familism" scale.

Thirdly, particular ethnic groups will be found to reside in segregated parts of the city. The most obvious case of segregation today in the American city is that of the Negro, although every new migrant group has also experienced this pattern of living. Along with segregation go such other variables as lack of household amenities, deterioration of housing, overcrowding, and the like.

If the concentric and axial schemes are overlaid on any city, the resulting cells will contain neighborhoods remarkably uniform in their social and economic characteristics. Around any concentric band communities will vary in their income and other characteristics, but will have much the same density, ownership, and family patterns. Along each axis communities will have relatively uniform economic characteristics, and each axis will vary outwards in the same way according to family structure. Thus, a system of polar coordinates originating at the central business district is adequate to describe most of the socioeconomic characteristics of city neighborhoods. The exception is in patterns of segregation, which are geographically specific to the particular city, although segregation is a phenomenon which is found in them all. The three classic principles of internal structure of cities are thus independent, additive descriptions of the social and economic character of neighborhoods in relation to each other and to the whole. Although it has yet to be done, it should not be difficult to write the transformation equations from d_x in equation (1), to place the Burgess scheme consistently in the framework of the previous discussions of population density. Addition of an angular specification would then permit use of polar coordinates to specify more fully social and economic conditions. One then speculates whether Newling's constraint leading to negative growth rates is the constraint which is imposed by segregation of new migrant groups into limited areas at high densities ultimately crossing the critical "density threshold." If this is so, then it is possible to package much of the literature concerning social pathology into the same whole, with at least the first contacts made with processes of change in the city and the relationship of these processes to change in the system of cities, and with the particular form in the particular city prescribed by the exogenously determined skeleton of central business district, basic industry, and transport system.

IV

SERVICES FOR THE RESIDENTS: LOCAL BUSINESS

The central business district provides a range of goods and services for the entire urban population and for the larger tributary region served by the city. In addition,

a system of smaller business centers exists within the city to serve the city population with the commodities they require on a weekly or monthly basis. Such purely internal or endogenous business appears even in small towns of less than 1,000 population. It does not begin to assume any identifiable structure until the level of county seats, however, and a variety of internal forms is only clearly distinguishable in the cities which serve as centers for multi-county "functional economic areas." At this stage the structural differentiation of centers and ribbons is clear. Ribbons follow the major section and half-section streets and the radial highways, performing a variety of service functions (building materials and supplies, household requirements), automobile oriented activities (gas, repair, parts), and with many large single-standing, space-consuming stores (discounters, furniture, appliances), in addition to being interspersed with convenience shops (food, drugs, cleaners) for adjacent neighborhoods. Certain stretches of ribbon are devoted to the activities of "specialized functional areas" such as automobile row. At the major and minor intersections of the street system are business centers, differentiated from the adjacent ribbons by the functions they perform, the ways consumers shop in them, and by land values. The centers provide both convenience and such shopping goods as food, drugs, clothing, shoes, and luxuries. Consumers generally shop on foot from store to store, in contrast to their single-purpose trips to ribbon establishments. Land values within the city fall with increasing distance from the city center, but commercial values add extra texture. The ribbons create ridges that rise above the adjacent residential areas. Steeply-rising cones at the intersections of ridges clearly indicate the location and extent of centers. Four levels of outlying centers have been identified beneath the central business district: neighborhood and community shopping centers at the convenience level, and shoppers' and regional centers of a larger kind. The differentiation between these levels is made in terms of the number and variety of functions performed, in the size of trade area served, and the like.[14]

It is axiomatic that retail and service activities are consumer-oriented, since internal business has developed entirely to serve the population residing within the city. Consistent with the earlier sections of this paper, it is also possible to place internal business provision within the same frame. Consider a city divided by the concentric-axial scheme described above, and let R indicate the total retail and service provision of any of the cells defined, with P representing total population of the cell, D the population density, F an index of its family structure, and S an index of its social rank,[15] then

$$R = sP^{u}D^{v}F^{w}S^{z} \tag{8}$$

[14] BRIAN J. L. BERRY, COMMERCIAL STRUCTURE AND COMMERCIAL BLIGHT (1963).

[15] The social rank and family structure indexes will generally be factor scores produced in a factor analytic study of social and economic differentiation of the city. BRIAN J. L. BERRY, THE CHANGING RETAIL STRUCTURE OF NORTHEASTERN ILLINOIS (1965).

which yields an extremely close fit in every city studied. Moreover, the provision of local business, and local business change, may clearly be related back to the socioeconomic pattern of the city. Similar expressions may be developed for ribbons and centers separately, although in the case of centers certain problems emerge concerning the use of arbitrary cells instead of the market areas of the centers as the units of observation,[16] even though a properly drawn set of circles and radii will, by their intersections, locate the outlying business centers of many cities.

As in the case of socioeconomic structure, however, segregation creates problems for generalization. In Chicago, for example, retail systems assume not one, but two equilibrium positions.[17] In segregated non-white residential areas there is a two-level hierarchy of business centers comprising the neighborhood convenience type and the smaller shoppers' goods type, whereas in the rest of the city a four-level hierarchy of outlying centers exists. All retailing is experiencing changes due to increased scale of retailing, increasing consumer mobility, and rising real incomes. Yet as the non-white residential area expands outwards, still another element of retail change is added. Simply, neighborhood transition means loss of markets, since real income among the non-white population is approximately one-third lower than that of the population displaced. The effects are felt in several stages:

(a) Anticipation of neighborhood transition. In this phase the normal replacement of businesses which fail, or which close because the businessman retires or dies, ceases. Vacancy rates begin to rise. Also, a "maintenance gap" appears because property owners, increasingly uncertain about prospective revenues, reduce normal maintenance expenditures. Dilapidation grows.

(b) During turnover. Demands drop precipitously, especially for higher quality goods, and the specialty shops in the larger business centers fail. Vacancies in centers rise to levels as high as one-third to one-half of the stores.

(c) Stabilization phase. The neighborhood settles down into its lower income character. Because incomes and revenues are lower, it is almost impossible to eliminate the effects of the earlier maintenance gap, and so a general run-down appearance persists. Rents in the business centers drop and activities from the ribbons and new businesses directed at the changed market move in and fill up the centers once again. Vacancies mount in the abandoned ribbons, settling down in excess of twenty per cent of the stores, but concentrated in the older buildings which, through lack of use, deteriorate more. Zones of segregated housing are thus criss-crossed with ribbons of unwanted, blighted, commercial property. Much that is critical to an understanding of business within the city thus depends less upon the structuring implicit in use of a model such as equation (8) than upon the existence and nature of segregation in the housing market.

[16] Berry, *The Retail Component of the Urban Model*, 31 J. AM. INST. OF PLANNERS — (1965).
[17] BERRY, *op. cit. supra* note 14.

CONCLUSION

Although the skeleton of the city is determined by broader regional and supra-regional forces, the flesh shows certain simple systematic regularities which are tightly knit into a locational system of simultaneous concentric and axial dimensions. Segregated housing patterns are responsible for the current inability to develop a single model of the whole covering both spatial structure and change.