LOCATIONAL PREFERENCES AND THE PATTERN OF RESIDENTIAL CHANGE IN THE LANSING - EAST LANSING, MICHIGAN, METROPOLITAN AREA

By

Barry Martin Moriarty

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Geography

1970

ABSTRACT

LOCATIONAL PREFERENCES AND THE PATTERN OF RESIDENTIAL CHANGE IN THE LANSING - EAST LANSING, MICHIGAN, METROPOLITAN AREA

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The central theme of this study is the investigation of the degree to which the urban residential spatial pattern is structured by the different locational preferences of residential decision makers. The fundamental purpose of the study is to identify the relevant locational preferences revealed by the spatial behavior of household location seekers and to determine a normative spatial allocation model utilizing these preferences to distribute total household growth to residential areas of the urban region.

Two alternative propositions are found to explain the different spatial distribution of social class groups residing in the urban region: the "economic competition" and "social choice" hypotheses. The more commonly applied "economic competition" hypothesis proposes that the different distribution is due to differences in the budget costs and income resources of the different groups. The lesser known "social choice" hypothesis proposes that the different distribution is due to differences in the values, needs, and desires of the social class groups. Studies are cited to show that different social class groups possessing similar income resources have different residential locational patterns, and that groups possessing different income resources have

similar travel costs - the major budget cost determining locational behavior according to the "economic competition" hypothesis. Additional studies are cited to show that residential decision makers tend to choose household locations which are accessible to their employment and close to households of individuals possessing equal or more prestigeous social status than their own.

The spatial behavior of residential decision makers suggests that the multi-attributes of alternative household opportunities are evaluated against four preference structures. Of these, the most important in dimensioning locational choices, for the urban population as a whole, are social distance preferences and employment accessibility preferences. To a lesser extent residential locational choices are dimensioned by racial or ethnic preferences and life style preferences, the study of which is beyond the scope of this investigation. Employment accessibility preferences are associated with the "economic competition" hypothesis since the "journey to work" is the most important factor determining a location seeker's travel costs. Social distance preferences are associated with the "social choice" hypothesis because they define the character of the social interaction that location seekers belonging to different social class groups are willing to undertake with decision makers in their own or other social class groups possessing perceived sets of values, needs, and desires. The investigation of whether employment accessibility preferences or social distance preferences are the major factor dimensioning locational choices is tested in the Lansing - East Lansing, Michigan, Metropolitan Region: an area in which the income resources of the upper, middle, and working

class groups do not differ too substantially from each other.

Two hypotheses are quantified and tested for the urban population as a whole. One proposes the existence of a relationship between the accessibility of an area to total employment opportunities and the potential intensity of residential growth in the area. The other proposes the existence of a relationship between the accessibility of an area to total social opportunities weighted by the objective social distance preferences of location seekers and the potential intensity of residential growth in the area. Tests of the hypotheses show that while a significant correlation exists between both accessibility indices and potential residential growth, the relationship associated with social accessibility is significantly higher. Given that the income resources of the different social class groups are similar, the results tend to support the general proposition that "social choice" is a more important factor than "economic competition" in dimensioning household locational choices for the urban population as a whole.

Both relationships are used as the basis for a residential land use model to distribute total household growth to areas of the urban region. Tests of the spatial allocation model, while not producing estimates of sufficient reliability for practical use, show that by combining both accessibility indices significant estimates of the pattern of residential development are achieved. Significant estimates are also achieved by use of the social accessibility index alone, but not by use of the employment accessibility index alone. The spatial allocation model renders better estimates for urban areas in which decision makers belonging to the working class group predominantly reside than it does

for middle and upper class areas. The significantly better estimates for working class areas are due to the similarity of attractiveness rankings calculated for the working class group with the attractiveness rankings calculated for the urban population as a whole.

Methods of refining the basic spatial allocation model through a consideration of individual social class group locational preferences are outlined for future research when adequate time-series and small-area data become available.

ACKNOWLEDGMENTS

Whatever contribution this study makes to the understanding and modeling of the spatial distribution of residential land in the urban area is, in part, attributable to my wife, Lorraine Chouinard Moriarty, my mother, Patricia Barry Moriarty, and to my associations with many individuals at Michigan State University and elsewhere.

Of those academic individuals one deserves particular recognition - my dissertation advisor, Dr. Gerard Rushton. Professor Rushton has constantly inspired my interest in theoretical geography and introduced me to relevant concepts by scholars in other disciplines, as well as directing my efforts on this study. His interest in this study, his assistance and encouragement, and mainly his persistence that this study should contribute more than it does has made my work highly profitable and enjoyable. The fact that the study falls short of its expectations is no fault of his.

The assistance of other individuals is also gratefully acknowledged. I thank Dr. Lawrence M. Sommers for making the facilities of the Department of Geography at Michigan State University available to me. Dr. Baruch Boxer provided many original ideas about urban land use development, and the late Dr. Paul C. Morrison was a constant source of inspiration.

Finally, for their willingness to listen and to offer constructive criticism I thank Dr. James O. Wheeler, and Professor Myles Bolan

and Professor Charles W. Barr of the Department of Urban Planning at Michigan State University. I also thank Dr. Richard Duke, Thomas Borton, Paul Ray, and Stewart Marquis of the Environmental Simulation Laboratory at the University of Michigan; and Dr. Bart J. Epstein, Dr. Saul B. Cohen, and Dr. Howard F. Hirt, all former faculty members of the Department of Geography at Boston University where I first became interested in Urban Geography.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

CHAPTER I

INTRODUCTION

> There is no science but tells a different tale, when viewed as a portion of a whole, from what it is likely to suggest when taken by itself, without the safeguard, as I may call it, of others . . .
>
> John Henry Newman

Residential land is the main space consumer in the urban area. As such, most locational and travel behavior in the urban area is based upon people making decisions dealing with residential locations.[1] These locational decisions affect public and private capital expenditure programs, which in turn influence the locational decisions of all other land users.[2] Consequently, residential location decisions constitute a major force in determining the spatial structure of cities. The impact of this force has resulted in different land use configuration patterns through time because of adjustments in spatial behavior to space-transforming technological innovations and social changes. Spatial behavior has two dimensions: locational behavior and travel behavior. Locational behavior is the action of a decision maker in

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[1]Frank B. Curran and Joseph T. Stegmeier, "Traffic Patterns in 50 Cities," Public Roads - A Journal of Highway Research, Vol. 30, No. 5 (December, 1958), (Washington, D. C.: U.S. Department of Commerce, Bureau of Public Roads, 1958).

[2]William L.C. Wheaton, "Public and Private Agents of Change in Urban Expansion," Explorations into Urban Structure, edited by M.M. Webber, et. al. (Philadelphia: University of Pennsylvania Press, 1964), pp. 154-196.

choosing a household site from which he can facilitate his interaction with those spatially distributed opportunities deemed necessary by him to satisfy his preferred set of values, needs, and desires. Travel behavior is the action of a decision maker in making a trip to overcome separation from the different types of spatially distributed opportunities deemed necessary by him to satisfy his preferred set of values, needs, and desires.

The spatial behavior of decision makers and the spatial processes which give rise to city spatial structure are of vital concern to geographers and others interested in explaining the spatial orderliness of urban land uses.[3] First, an understanding of the spatial behavior of residential decision makers contributes to the problem of explaining the areal distribution of households in the city. Secondly, an understanding of the orderliness of urban residential land as revealed by the spatial behavior of residential decision makers makes a contribution to the task of constructing a general land use model of urban spatial structure.[4] However, in order to understand the spatial behavior of individuals it is first necessary to understand the relevant preferences by which decision makers evaluate alternative household locations.

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[3]Donald L. Foley, "An Approach to Metropolitan Spatial Structure," Explorations into Urban Structure, edited by M.M.Webber, et. al. (Philadelphia: University of Pennsylvania Press, 1964), pp. 21-78.

[4]Knowledge of consistent patterns of spatial behavior on the part of residential decision makers not only contributes to the problem of explaining the areal distribution of households in the city but also contributes to the problem of explaining the urban population density distribution and the distribution of social class groups within different subareas of the city.

CENTRAL QUESTIONS OF THE INVESTIGATION AND THE STUDY DESIGN

This study seeks to examine the problem of explaining the pattern of residential land development related to the Lansing - East Lansing, Michigan, Metropolitan Area from 1960 to 1965. Figure I.1 shows the location of the nine township study area in the Lansing - East Lansing Standard Metropolitan Statistical Area. The issues around which the investigation is organized may be formulated in three major questions as follows:

1) On the macroscopic level what is a good way to describe the locational preferences associated with the residential spatial structure of American cities?

2) Given a particular description of the locational preferences and the residential spatial structure, how adequate are existing household allocation models in utilizing these behavioral principles in explaining this structure?

3) What is the relationship, if any, between the pattern of residential land development and the hypothesized locational preferences of residential decision makers?

In addition to attempting to formulate at least partial answers to these substantive questions, the efficiency of a procedure designed to reveal the form of spatial orderliness in urban residential locations from a consideration of locational preferences will be examined.

Specifically, the second chapter will examine the problems involved in explaining the pattern of residential growth and development giving particular consideration to the empirical and theoretical literature in which the problems have been discussed.

The proposition that residential location decisions constitute a major force in determining the spatial structure of cities suggests the first objective of this investigation: to provide a description of the nature and impact of this force on the spatial structure. This

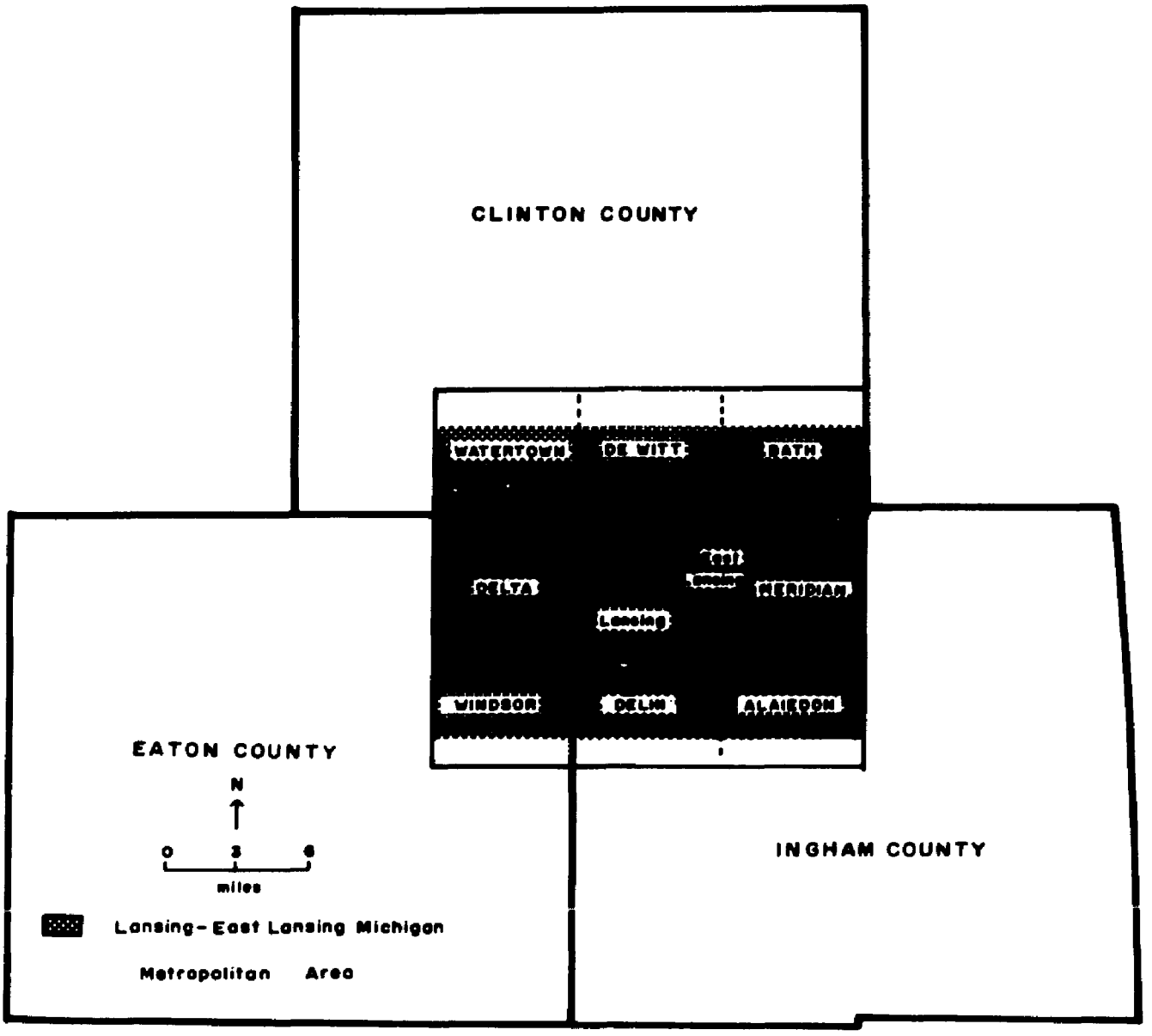

FIG. 1-1

Lansing – East Lansing Standard Metropolitan Statistical Area

description should determine the essential behavioral properties associated with the growth and development of the residential spatial pattern. These behavioral properties relate to the relevant preferences exhibited by individuals in choosing household locations from among alternative opportunities. This part of the study will be accomplished through an investigation of the literature to empirically derive generalizations about the locational preferences of residential decision makers.

Given this description of residential locational behavior, Chapter Four will examine the problem of whether or not existing household allocation models possess the properties that are consistent with the revealed behavior of individuals to produce the residential spatial pattern of cities.[5] The chapter will examine the manner in which locational behavior of different socio-economic groups is included in the models.

Chapter Five will determine a household allocation model based upon the derived principles of behavior and Chapter Six will evaluate its efficiency in revealing the form of spatial orderliness in residential locations in two ways. The first test of its efficiency will be through a comparison of the model's predicted allocation of households to subareas of the city between 1960 and 1965 to the actual residential development in the subareas for the same period of time. The second

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[5]Two basic approaches have been employed in the development of land use models: 1) trend models and 2) logic models. Trend models use empirical data, defining what events have occurred in the past, and then extrapolates this information into the future. Such models utilize the techniques of a) graphic extrapolation, b) multiple regression equations, or c) simultaneous equations. Logic models mathematically define how events occur and serve as a means to calculate what will happen in the future. Two basic approaches are used: a) linear programming and b) simulation.

test will examine the efficiency of the model in comparison to alternative household allocation models.

Chapter Seven will review the results that may be drawn from this approach to explain the location and distribution of residential land uses and indicate areas of future empirical research deemed necessary for the further development of a set of general rules of spatial behavior from which relevant spatial theory can be formulated.

GENERAL CONCEPTS AND A FRAME OF REFERENCE

Urban Land Use Theory

There is abundant evidence that land uses of a given type are consistently situated at similar locations in urban space with respect to other land use locations to produce corresponding spatial patterns in American cities as they evolve over time.[6] Theories that account for the empirical regularity of urban land use locations have been advanced since, at least, Marshall's analysis of urban land values.[7]

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[6]Ernest W. Burgess, "The Growth of the City," The City, edited by Robert E. Park, Ernest W. Burgess, and Roderick D. McKensie (Chicago: University of Chicago Press, 1925), pp. 47-62; Homer Hoyt, The Structure and Growth of Residential Neighborhoods in American Cities (Washington, D. C.: Federal Housing Administration, 1939); Chauncy Harris and Edward L. Ullman, "The Nature of Cities," The Annals of the American Academy of Political and Social Science, Vol. 242 (November, 1945), pp. 7-17.

[7]Marshall is perhaps the first economist to concern himself with urban land use which he viewed as being dependent on land values that allocated the uses to different areas of the city. He emphasized the importance of locational situation within the urban place in determining land value and, also, considered the attributes of the site as being important. He argued that the value of a piece of land is the sum of its situation value plus its site value where the site value is equal to the agricultural value of the land. Although Marshall did not extend his analysis to residential land, he was among the first to consider intensive and extensive land use in the urban area. He stated that "If land is cheap (the land user) will take much of it; if it is dear he will take less and build high." (p. 448). Alfred Marshall, Principles of Economics (7th ed., London: MacMillan Company, 1916).

The theories, largely the contribution of land economists, offer a reasonably coherent, though highly generalized, account of the process by which urban land is allocated to produce the characteristic spatial structure of cities. At the present time no alternative theory exists that could provide serious intellectual competition to the economic explanation of the land use allocation process.[8]

In the allocation process land economists emphasize the relationship between land use and land value and argue that the location of all land use is dependent on land values that allocate the uses to different areas of the city. Almost without exception since Marshall's analysis, land use theories have postulated that the unit area value associated with any location is primarily a function of the location's accessibility to all other locations.[9] While the validity of this fundamental

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[8]Ira S. Lowry, Seven Models of Urban Development: A Structural Comparison (Santa Monica: The RAND Corporation, 1967), p. 9.

[9]Land economists such as Hurd and Haig ignore the influence of the size of the site in determining urban land values, and their analysis closely resembles that of von Thunen; i.e., they emphasize the friction of distance concept. Hurd asserts that as a city grows, more remote inferior land must be utilized producing higher land rents at the more accessible sites. Richard M. Hurd, Principles of City Land Values (New York: The Record and Guide, 1924), pp 11-12. In keeping with the mainstream of economic thought concerning urban land values Haig asserts that rent appears as the charge which the owner of a relatively accessible site can impose because of the savings in transport costs which the use of the site makes possible. Robert M. Haig, "Towards an Understanding of the Metropolis," Quarterly Journal of Economics, Vol. 40 (May, 1926), p. 421. Neither Hurd nor Haig give detailed attention to residential land use. Present day theories by Wingo and Alonso conclude that residential land use is a function of land rent which, in turn, is determined by the transportation cost from the central core of the city, the quantity of land consumed by the household and all other costs (conceived as a composite good) incurred by the household. With some modification between their theories Wingo and Alonso point out that any particular household can substitute between these variables so as to maximize its satisfaction by owning and consuming the goods it prefers and avoiding those it does not prefer within the limiting constraints of its budget. Lowdon Wingo, Jr., Transportation and Urban Land (Washington,

postulate is not being questioned in this investigation, the adequacy of the postulate as presently conceived in terms of transport costs or physical distance from the central core has been found deficient particularly in explaining the location and distribution of residential land.[10] The contention in this study is that while accessibility is a primary variable in explaining the use that an urban site can be put to, it is incorrect to assert that accessibility, measured in terms of transport costs or mere physical distance, is the only attribute of a location considered by decision makers in their choice of a residential

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D.C.: Resources for the Future, 1961); William Alonso, Location and Land Use: Toward a General Theory of Land Rent (Cambridge: Harvard University Press, 1965).

[10]Residential land use theory is based on the assumption that individuals with limited income exercise a preference for central locations in order to reduce their transportation costs to the various activity units with which they wish to interact. People with higher income, on the other hand, are more able to absorb higher transportation costs and therefore exercise a preference for noncongested locations near the periphery. However, Tomazinis has revealed that there is no systematic relationship between the trip lengths of people and the distance they reside from the central core in Detroit and Chicago. Instead he found that people living intermediately between the core and the periphery have the shortest trip lengths while trips originating at the center and the periphery have increased trip lengths. Anthony Tomazinis, "Transportation Inputs of Urban Activities: An Investigation of the Basic Assumptions of Urban Location Theories Concerning the Transportation Inputs of Urban Activities" (unpublished Ph.D. dissertation, University of Pennsylvania, 1963). Tomazinis and Gabbour found that in small cities (Lexington and Madison) as the residential distance from the central core increased the trip length increased, but that in larger cities having numerous spatially distributed sub-centers (Pittsburgh and Philadelphia) or cities having great geographic variation in land use (Puget Sound) no systematic pattern between trip length and distance from the central core could be found. Anthony Tomazinis and Iskandar Gabbour, "Trip Length Variations Within Urban Areas," (Institute of Environmental Studies, University of Pennsylvania, 1966); Iskandar Gabbour, "Travel Cost Variations and the Size of Urban Areas" (unpublished Ph.D. dissertation, University of Pennsylvania, 1967); Robert C. Brown, "The Use and Misuse of Distance Variables in Land Use Analysis," The Professional Geographer, Vol. 20 (September, 1968), pp. 337-340; James A. Quinn, Human Ecology (New York: Prentice-Hall, 1950), p. 282.

site. Urban land economists themselves recognize this deficiency in explaining household locations but continue to use transport costs and physical distance as measures of accessibility.[11] Among them Alonso states that,

> Since distance can be measured directly, while accessibility implies some subjective pattern of preference (or nuisance value of distance) which may vary from one individual to another, it is better . . . to use distance as the variable.[12]

The inconclusiveness of many attempts to model the location of residential land is a result of basing the attempts upon such deficient propositions to account for the subjective pattern of preferences exhibited by individual decision makers in exercising their choice of a residential location from among the array of available alternative opportunities they perceive.

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[11]Hurd, Haig, and Ratcliff each support the contention that there is more to the problem of determining residential locations than economic considerations alone. Hurd states that "the basis of residential land is social and not economic - even though the land goes to the highest bidder." Hurd, op. cit., p. 77. Haig claims that the "theoretically perfect site for an activity is that which furnishes the desired degree of accessibility at the lowest cost of friction." Extending this idea to household locations he points out that "in choosing a residence purely as a consumption proposition one buys accessibility precisely as one buys clothes or food. He considers how much he wants the contacts furnished by the central location weighing the costs of friction involved - the various combinations of site rent, time value, and transport costs; he compares this want with his other desires and resources, and he fits his scale of consumption and he buys." Haig, op. cit., pp. 422-423 Hence, Haig views the problem of explaining residential location as one of a location seeker's quest for accessibility to other locations within the framework of his individual subjective preferences and resources. Ratcliff indicates the importance of subjective influences in determining urban land values He states, "It is the total effect of the competition for sites to minimize the aggregate of inconvenience and frictions as evaluated in terms of the local value system." Richard U Ratcliff, Urban Land Economics (New York: McGraw-Hill Book Co., 1949), p. 385.

[12]Alonso, op. cit., p. 27.

Subjective Preference as a Behavioral Factor in Residential Choice

Geographers have shown a concern for developing spatial models that are structured on more general variables than such purely economic factors as land costs and transportation costs. Casetti, Curry, Rushton, and Wolpert argue that spatial theory formulated in these economic terms is not relevant to explaining diverse spatial systems in different periods in time.[13] They claim that variables in terms of the subjective preferences that individuals exhibit by their residential locational behavior, such as a preference for a site having a central location or for an uncongested site, rather than the economic costs and values associated with a site provide a more meaningful approach to the problem of deriving universal rules of spatial behavior.[14] This suggests that decision makers decompose the over-all utility of residential sites into separate attributes, each of which contributes some part-worth to their evaluation of the sites. However, because of the subjective preferences of decision makers the separate attributes are weighted differently by the location seekers. Urban land use theory considers the situation of the site with respect to the central urban functions and the spaciousness of the site to be the relevant attributes evaluated by decision makers in their choice of a residence with the situation attribute contributing the greater part-worth to the over-all evaluation. Shepard suggests that residential locational behavior may be better explained if the part-worth attributed to the locational situation was "further analyzed into two part-worths: one attributable

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[13]Emilio Cassetti, personal communication, Michigan State University, East Lansing, Michigan, December 3, 1968.

[14]Emilio Cassetti, "Urban Population Density Patterns: An Alternative Explanation," Canadian Geographer, Vol. 11, 1967, pp. 96-100.

to desirability of neighborhood per se and another attributable to distance from work."[15] Shepard's suggestion is in keeping with Park's postulate that "social relations are so frequently and so inevitably correlated with spatial relations."[16] The postulate is supported by a creditable amount of sociological literature which reveals that residential locational behavior exhibits a preference for sites accessible to compatible neighbors who share the same values, needs, and desires and that possibly this subjective preference overrides other preferences. Consequently, there exists a framework within which an alternative theory of the household allocation process can be formulated. This framework considers subjective preferences that lie inside the economic land use allocation mechanism to be more fundamental to an explanation of residential locational behavior. Such preferences are synonymously termed locational or space preferences in this investigation.

Isard describes space preferences in terms of the social and psychic properties which induce location seekers to aggregate or disperse over space.[17] Marble suggests that the incorrectly predicted portion of household locational behavior can be explained in terms of variables representing space preferences that are exogenous to the

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[15]R.N. Shepard, "On Subjectively Optimum Selections Among Multi-Attribute Alternatives," Decision Making, edited by Ward Edwards and Amos Tversky (Harmondsworth, England: Penguin Books Ltd., 1967), pp. 257-283.

[16]Robert E. Park, "The Urban Community as a Spatial Pattern and a Moral Order," The Urban Community, edited by Ernest W. Burgess (Chicago: University of Chicago Press, 1926), p. 18.

[17]Walter Isard, Location and Space Economy (Cambridge: The MIT Press, 1958), pp. 83-88.

spatial system under investigation and reflect the social and psychological characteristics of the location seekers irrespective of the spatial system.[18] Rushton views space preferences in terms of a given level of social contact on the part of decision makers which are maintained regardless of their spatial situation.[19]

Social distance, the key subjective space preference in terms of which this analysis is formulated, is postulated to be such a social and psychological characteristic of residential location seekers. Social distance is defined as a subjective "attitude of ego toward a person (or group) with a particular status attribute (in this investigation, occupation) on the part of a decision maker that broadly defines the character of the interaction that the decision maker would be willing to undertake with the attitude object."[20] Social distance, while not possessing the metric characteristics in the rigorous sense that physical distance does, tends to order social interaction opportunities along an ordered continuum of the relative ease of access to the social opportunities ranging from a close intimacy to a distant probability that interaction will occur. The concept provides a measure of the worth that location seekers belonging to different socio-economic groups assign to social interaction opportunities regardless of their location in urban space. Since some urban

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[18]Duane F. Marble, "Transport Inputs at Urban Residential Sites," Papers and Proceedings of the Regional Science Association, Vol. 5, 1959, p. 254.

[19]Gerard Rushton, "Spatial Pattern of Grocery Purchases by the Iowa Rural Population" (Studies in Business and Economics, Iowa City: University of Iowa, 1966), p. 64.

[20]Edward C. Laumann, Prestige and Association in an American Community: An Analysis of the Urban Stratification System (Indianapolis: The Bobbs-Merrill Co., Inc., 1966), p. 4.

neighborhoods provide greater opportunities for social interaction because of the status characteristics of the decision makers residing there, these neighborhoods will be preferred over others.

Although space preferences are conceived to be exogenous to any particular spatial system, they help to determine the spatial behavior of decision makers when placed in the context of a given set of interaction opportunities. Typically an individual's opportunities for interaction are restricted to the limited environment which he perceives and with which he has contact. The perceived environment within which the decision maker selects to move is his "opportunity space" or "action space."[21] A decision maker's "action space" does not include all of the available opportunities in the urban space with which he could interact, and therefore, an individual's "action space" is a mental image of the real urban space. The "action space" consists of a number of spatially located opportunities from among which the decision maker might choose to interact. Since some of the spatially distributed opportunities he perceives are preferred over others, the decision maker assigns some measure of utility to all conceivable opportunities and ranks them according to his particular set of preferences. Social distance, then, provides a means of expressing the differential spatial behavior exhibited by individuals interacting with alternative spatially located social opportunities according to their ranked preference to interact or not to interact with decision

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[21]Julian Wolpert, "Behavioral Aspects of the Decision to Migrate," Regional Science Association Papers, Vol. 15, 1965, pp. 159-172; Frank E. Horton and David R. Reynolds, "Urban Environmental Perception and Individual Travel Behavior" (Department of Geography, Special Publication No. 2, Iowa City: University of Iowa, 1968); Lawrence A. Brown and Eric G. Moore, "Intra-Urban Migration: An Actor Oriented Framework" (unpublished paper, University of Iowa, 1968).

makers possessing particular status attributes.

Subjective Accessibility and Residential Growth

The social distance preference ranking must be placed within the context of a given set of spatially distributed opportunities before it can affect the spatial behavior of location seekers. Presently there is only one method devised to orient decision makers to all spatially distributed opportunities. The method, termed subjective accessibility, provides a way of implementing the social distance rankings of location seekers. It is a formulation related to Stewart's index of accessibility and is a measure of the spatial distribution of different types of interaction opportunities about a location adjusted for the ability and desire of decision makers to overcome spatial separation.[22]

The subjective accessibility measure ranks residential areas of the city in terms of their attractiveness to location seekers belonging to different socio-economic groups. Areas of high attractiveness are those which provide a given group of location seekers the best chance to facilitate their interaction with those spatially distributed opportunities deemed necessary by them to satisfy their preferred set of values, needs, and desires. Consequently, while some residential areas may have high subjective accessibility indices for some groups of location seekers, they may possess relatively lower indices for other groups.

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[22]This definition was advanced by Hansen. Walter G. Hansen, "How Accessibility Shapes Land Use," Journal of the American Institute of Planners, Vol. 25 (May, 1959), pp. 73-81. However, Hansen's measurement in no way takes into account the desire of individuals to overcome spatial separation.

Subjective accessibility differs from other indices of accessibility in that it measures the locational situation of a residential area with respect to: 1) its orientation to employment opportunities in the location seeker's occupation category and 2) its orientation to other decision makers with whom location seekers in particular occupation categories reveal a preference to confine their social relationships.

This investigation proposes that a significant relationship exists between a residential area's indices of subjective accessibility and the intensity of residential construction in the area. This general proposition expressed in terms of variables associated with the spatial behavioral characteristics of location seekers belonging to different socio-economic groups can be modeled in a probabilistic manner to generate a pattern of residential growth and development. A comparison of the predicted land use pattern with the actual pattern can be made to test their degree of correspondence. The degree of correspondence provides a means of ascertaining the validity of the locational preferences hypothesized as being relevant to the process of residential land use allocation. Close correspondence between the predicted and observed pattern would allow for changes in the magnitude of the variables on the bases of planned changes in order to ascertain the residential pattern under different policy considerations, under different social and economic conditions, and under different space-transforming innovations.

CHAPTER II

THE PROBLEM OF ALLOCATING HOUSEHOLDS TO RESIDENTIAL AREAS OF THE CITY

NATURE OF THE PROBLEM

A problem exists in predicting the spatial allocation of households to different areas of the city because each residential location seeker can choose from among alternative opportunities, each of which possesses a number of subjectively disparate attributes related to its site and situation.[1] To date a suitable method of quantifying these attributes or of expressing how they interact with one another to predict future household locations has not been determined. A major reason for this failure is that the process by which residential location seekers weigh and combine or "trade off" the component attributes among the alternatives to arrive at household choices is not understood. Presumably, they evaluate the attributes associated with the alternatives

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[1] Shepard, op. cit., p. 257. Shepard points out that decision makers experience little difficulty in evaluating alternative opportunities with respect to any one component attribute by the process of elementary comparison. The difficulty occurs when evaluating a large number of component attributes (p. 257). The results of experiments by Shepard and others indicate that decision makers exhibit a consistent tendency to overcome this difficulty by making decisions "on the basis of one or two factors, while in effect, ignoring the significant contribution of other factors." Consequently, "in making an evaluative judgment a subject can take account of only a very limited number of factors at any one time." (p. 266) This tendency toward factor reduction provides a basis for the determination of relevant variables considered by household location seekers in choosing residential sites.

against some unknown set of preferences. A major purpose of this investigation is to derive a set of common attributes revealed by the spatial behavior of residential decision makers and examine their relevance to the household allocation process.

While the lack of success in predicting the spatial allocation of households seems to deny uniformity in the pattern of residential locational behavior, the actual urban land use pattern suggests that the behavior does, in fact, conform to some degree of order. There is ample evidence that land uses of a given type are situated at similar locations in space with respect to other land use locations so that corresponding spatial patterns are found in cities as they evolve over time. Certainly this orderly distribution of land use implies an orderliness in the pattern of locational behavior on the part of location seekers. Confirmation and discussion of these patterns have been the subject of studies dealing with land use theory, social area analysis, tripmaking behavior, and social physics.[2]

Spatial Interaction and Land Development

To explain the orderly pattern of land use, theorists postulate that the type and intensity of land use at a location is determined by,

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[2]See, for example: Harland Bartholomew, Land Uses in American Cities (Cambridge: Harvard University Press, 1955); Burgess, op. cit.; Hoyt, op. cit.; Harris and Ullman, op. cit.; Albert Z. Guttenberg, "Urban Structure and Urban Growth," Journal of the American Institute of Planners, Vol. 26 (May, 1960), pp. 104-110; Robert B. Mitchell and Chester Rapkin, Urban Traffic: A Function of Land Use (New York: Columbia University Press, 1954); Wingo, op. cit.; Alonso, op. cit.; Theodore Anderson and Janice Egeland, "Spatial Aspects of Social Area Analysis," American Sociological Review, Vol. 26 (June, 1961), pp. 392-398; Eshref Shevky and Wendell Bell, Social Area Analysis (Stanford, Calif.: Stanford University Press, 1955); John Q. Stewart and William Warntz, "Macrogeography and Social Science," Geographical Review, Vol. 48 (April, 1958), pp. 167-184.

and in turn determines, the type and intensity of spatial interaction at that location. Quinn, for example, observes that the greater the frequency of interaction between a land use activity and complementary land use activities, the greater will be the tendency to maximize its accessibility to the complementary activities.[3] Hawley observes that land use activities having the largest accessibility requirements tend to occupy central locations while all other land use activities distribute themselves about central locations with distance away proportional to their accessibility requirements.[4] Wingo observes that the orderly spatial pattern is determined by the land market process of competition among land users for the most accessible site that will allow them a realization of profits or satisfactions over costs.[5] In support of these empirical generalizations, land theorists propose the existence of a relationship between the accessibility of a location and the intensity of land use at that location so that the more accessible an area is to the various land use activities the greater will be its development potential.[6]

However, while the locational behavior of non-residential decision makers tends to conform to this proposition, its presumed lawfulness is not readily distinguished in the locational behavior of residential decision makers. Studies concerned with both the household

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[3]James Quinn, op. cit., p. 286.

[4]Amos Hawley, Human Ecology (New York: Ronald Press, 1950), Chapter 12.

[5]Wingo, op. cit., p. 26.

[6]Hansen, op. cit., p. 73.

and traffic assignment problems have found that residential decision makers exhibit geographical bias in both their locational and travel behavior which conflicts with the prescribed order.[7] This inconsistency results from the fact that even though no two residential decision makers exhibit the same spatial behavior, in the sense that each occupies different household locations from which he chooses to interact with different spatially distributed activities, many location theorists ascribe to each the same accessibility preferences they ascribe to non-residential location seekers. However, the complementary activities that non-residential decision makers seek to be accessible to (that is, their consumers) are not the same complementary activities to which residential decision makers seek to increase their accessibility. Residential decision makers seek to be accessible to those activities deemed necessary by them to satisfy their day to day needs. The unique feature of the household allocation problem is that, not only do residential location seekers' accessibility preferences differ from those of non-residential location seekers, but they differ according to the socio-economic characteristics of the residential location seekers themselves.

Locational Preferences and the Attributes of Residential Areas

So far attempts to model these differences to arrive at a realistic assignment of residential growth to various areas of the city have been unsuccessful. One reason the attempts have failed is because

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[7]Richard J. Bouchard and Clyde E. Pyers, "Use of Gravity Model for Describing Urban Travel," Highway Research Record, No. 88: Traffic Patterns (Washington: Highway Research Board, 1965), pp. 2-3, p. 32; Walter G. Hansen, "Accessibility and Residential Growth" (unpublished MCP thesis, Massachusetts Institute of Technology, Cambridge, 1959), p. 1.

of the problem of not being able to classify location seekers into groups exhibiting similar spatial preferences. A more important reason for the failure is that undue emphasis is placed on the situation attribute of residential areas, and the site attributes contained in the models have proven to be insignificant to the household locational choice process. Certainly the determination of attributes found to be shared in common by most location seekers in their evaluation of residential areas would contribute to the accuracy of household allocation models. This investigation contends that such common attributes are to be found in the tendency of residential location seekers to choose housing in compatible neighborhoods located where spatial separation from the activities in which they frequently participate is at a minimum.

If it was possible to find a large number of location seekers who exhibited similar locational preferences (such as a preference to be accessible to the central urban functions), then it would be possible to compare their household locational choices with those exhibiting different preferences (such as a preference to be accessible to compatible friends and neighbors). It would then be possible to make inferences concerning the probability of the location seekers choosing alternative housing opportunities in areas possessing the combinations of these attributes that would attract them there. Total residential growth can also be distributed on the basis of these probabilities. Implied here is that the accuracy of the predicted allocation serves to test the significance of the attributes hypothesized as being relevant to the residential decision maker's choice of a household location.

Nearly without exception household allocation models are based on

the proposition that residential decision makers substitute journey-to-work expenditures for household site expenditures with the rate of substitution depending upon the location seeker's preference for "more spacious living conditions,"[8] "low density housing,"[9] or "better housing."[10] This investigation argues that the attributes of residential areas expressed in these terms have less significance to the location seeker's evaluation of alternative opportunities since the attributes have failed to account for the distribution of households in the city. Unlike models that transform the attributes of areas into transportation and household site expenditures, the present investigation seeks to determine attributes associated with the social aspects of the areas and to weight these attributes by the revealed preferences of location seekers to generate a distribution of households to residential areas of the city. The proposition underlying this study holds that residential decision makers substitute accessibility to work for household sites with the direction of the substitution depending on the location seeker's preference to reside close to the households of compatible neighbors.

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[8]Lowdon Wingo, Jr., "An Economic Model of the Utilization of Urban Land for Residential Purposes," Papers and Proceedings of the Regional Science Association, Vol. 7, 1961, pp. 191-205; William Alonso, "A Theory of the Urban Land Market," Papers and Proceedings of the Regional Science Association, Vol. 6, 1960, pp. 149-158.

[9]Cassetti, op. cit., pp. 96-100.

[10]Richard F. Muth, "The Spatial Structure of the Housing Market," Papers and Proceedings of the Regional Science Association, Vol. 7, 1961, pp. 207-220.

The Distribution of Residential Growth in the Study Area

Figure II.1 illustrates the location and net change in the number of household units in the Lansing - East Lansing, Michigan, area between 1960 and 1965. Some areas, particularly those close to the central core, have declined in the number of dwelling units while other areas, more distant from the central core, have experienced an increase. A distinct directional bias is evident. The figure illustrates the ability of higher-ordered land uses (or those having high rent paying ability) to pre-empt accessible locations from lower-ordered uses and the importance of vacant land, or land at a lower use, to attract dwelling units. The problem with which this study is concerned is to determine site and situation attributes considered significant to the location seeker's evaluation of alternative household opportunities and formulate them into a model to simulate this pattern. The accuracy of this allocation mechanism in replicating the distribution in comparison with other models serves to test both the relevancy of the attributes to the residential decision making process and the preference structure by which the attributes are weighted.

OUTLINE OF THE RELEVANT LITERATURE

Approaches to the Study of Residential Spatial Structure

In recent years two main avenues of research have characterized studies of residential spatial structure: 1) determination of the location and distribution of different types of residential areas delimited by the housing quality and the socio-economic characteristics of their inhabitants, and 2) development of general (macro) models designed to generate patterns of residential land use. The first group of studies have developed empirical instruments, by analytical

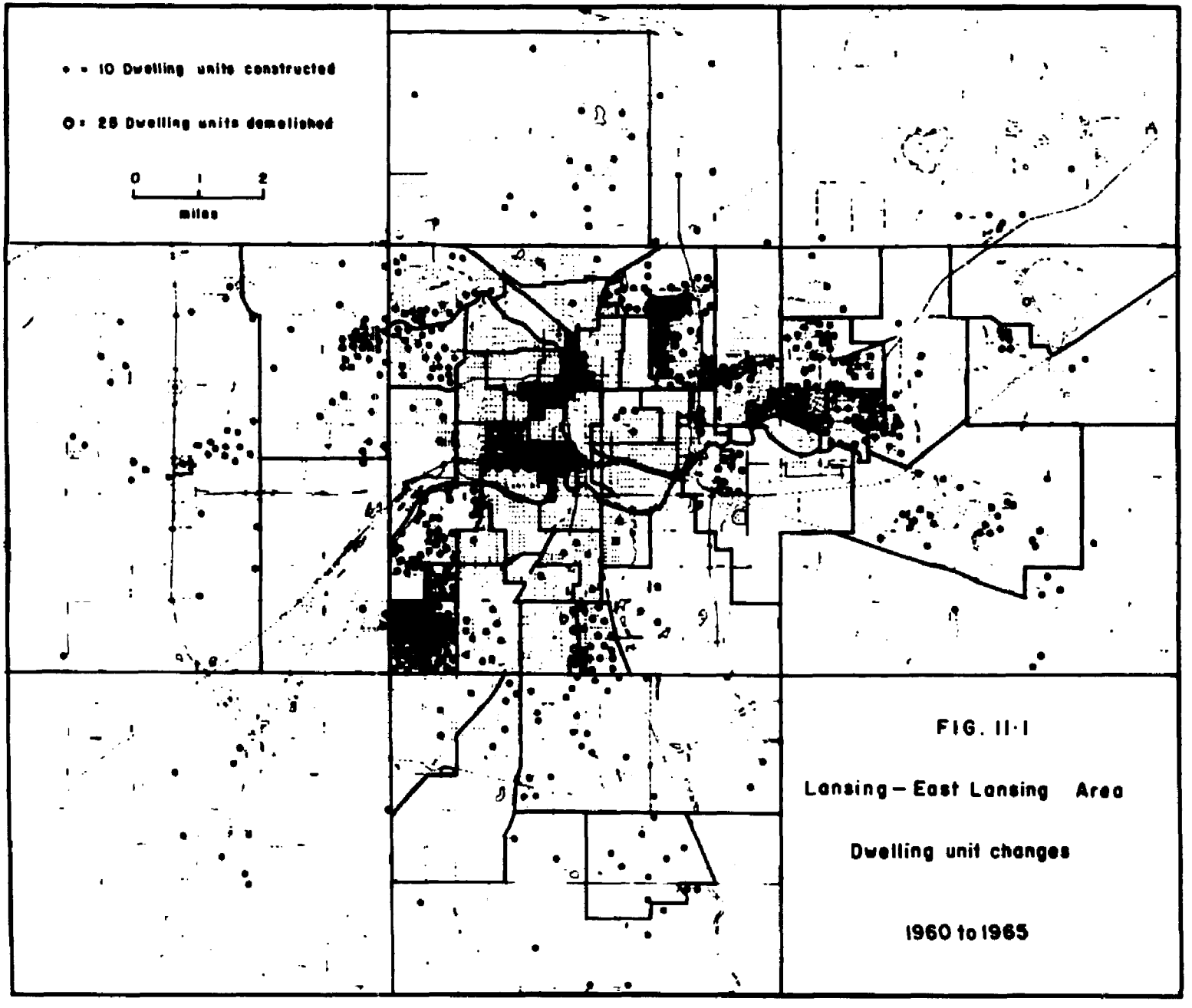

FIG. II-1

Lansing – East Lansing Area

Dwelling unit changes

1960 to 1965

methods, that would be useful in describing different residential areas and in explaining the orderliness of the residential spatial pattern. The second group of studies have attempted to duplicate residential growth patterns, usually in terms of the land market mechanism whereby urban space is allocated to the most efficient user. Because of two limitations neither of these approaches has been successful in determining the residential allocation process from which relevant spatial theory can be formulated. The first limitation is that the majority of studies ascribe the decision making behavior associated with an individual non-residential location seeker to the collective behavior of all location seekers, both non-residential and residential. The result is that the residential decision maker's locational behavior is completely determined by the land market rather than merely constrained by the market. The second limitation is that the approaches tend to ignore that the residential location seeker's locational behavior, like any form of behavior, is a response conditioned by a set of preferences which grow out of past experience. The result is that the social goals and social processes underlying residential decision making behavior are not treated. While the approaches provide a great deal of insight into the residential allocation process, they lack the consideration that household choice is an individual matter insofar as it is the individual decision maker, not the aggregate, that is motivated (or not motivated) to reside in a particular area.

Description of Residential Spatial Structure

A basis for understanding the relevant preferences by which location seekers make decisions in choosing from alternative residential opportunities was set forth by Park and Burgess as early as 1926 when

they observed that residential decision makers exhibited a tendency toward choosing households in areas containing groups belonging to their same social class. Park discovered, and subsequent investigations validate, that the greater the similarity of the socio-economic characteristics of decision makers the more intimately will they be related socially and the less will be the physical distance separating them residentially. Conversely, the less similar are the socio-economic characteristics the greater will be the physical distance separating their residences.[11] At the same time Burgess revealed that the lower socio-economic groups tended to occupy centrally located sites while upper socio-economic groups were more conspicuously located near the periphery of the city.[12] Some years later Hoyt qualified this observation by asserting that the actual distribution of socio-economic classes was confined to different sectors of the city although there was a general tendency for the groups to be distributed as Burgess had revealed.[13] Hence, ecologists state that the city is divided into "natural social areas," each of which is made up of nearly-similar ethnic, racial, or social status groups living in dwelling units of similar quality.

Alternative Explanations of Residential Spatial Structure

There exists two alternative postulates to explain the process by which socio-economic equality is transformed into residential proximity

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[11] Robert E. Park, Human Communities (Glencoe, Ill.: Free Press, 1952), p. 231; see also Park, "The Urban Community as a Spatial Pattern and as a Moral Order," p. 18.

[12] Burgess, op. cit., Chapter 2.

[13] Hoyt, op. cit., p. 23 and Chapter 6.

to achieve "natural social areas." Feldman and Tilly term these postulates the "economic competition" hypothesis and the "social choice" hypothesis.[14] Present-day land use allocation models confine their attention to the purely economic postulate.

The "Economic Competition" Hypothesis

Advocates of the "economic competition" hypothesis, such as Wingo, Alonso, and Lowry, view the spatial distribution of all land uses as being governed by the impersonal process of competition for locations with fixed differential values.[15] In this competition all land users, both residential and non-residential, possess similar preferences (because they share the same goals) but differ in their budget costs and available resources. The hypothesis stresses that ability to pay is the basic factor in explaining the distance of all land uses from the central core, and the quality, size, and location of households that different location seekers choose to occupy. Changes in the residential pattern occur when market competition forces the most accessible land, near the central core, out of residential use. At the same time transportation improvements can reduce the costs associated with peripheral locations so that even though the decision maker experiences higher travel costs, he realizes more spacious living conditions at a lower cost. Transportation and site costs are deemed to be the major determining factors considered by decision makers in their choice of a household so that at designated, market-determined prices a location

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[14]Arnold S. Feldman and Charles Tilly, "The Interaction of Social and Physical Space," American Sociological Review, Vol. 25 (December, 1960), p. 877.

[15]Lowry, op. cit., pp. 5-13; Alonso, "A Theory of the Urban Land Market"; Wingo, Transportation and Urban Land, pp. 64-65.

seeker would be indifferent to his location. Residential decision makers, although they may possess similar housing preferences, compete for the locations of their choice on the basis of their financial resources. Consequently, advocates of this hypothesis propose that the differences in the locational behavior of residential decision makers are due to differences in their available resources and that it is this difference that determines the spatial distribution of socio-economic groups in urban space.

The "Social Choice" Hypothesis

A substantial body of literature supports the "social choice" hypothesis which argues that residential decision makers choose to locate their households on the basis of more fundamental behavioral propositions than economic costs alone. Garrison and others point out that:

> from one urban site to another, differences in travel costs may be relatively small compared to differences in the costs of sites occasioned by other considerations. A variety of neighborhood amenities plays a large role in residential site selection as do prestige, discrimination and other factors that may override locational travel questions.[16]

In support of this view numerous studies claim that residential location seekers are not indifferent to their locations but are greatly influenced in their housing choices by the character of established residential areas.

Advocates of the "social choice" hypothesis, such as Firey, the Duncans, and Feldman and Tilly, assert that the spatial distribution of land uses is an indicator of social values, governed in part by

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[16]William L. Garrison, "Difficult Decisions in Land Use Model Construction," Highway Research Record No. 126: Land Use Forecasting Concepts (Washington: Highway Research Board, 1966), p. 21.

sentimental, non-economic, or cultural factors.[17] The hypothesis stresses that the selection of a household involves the conscious social choice of residential decision makers who vary in their preferences because of different values, needs, and desires. These choices tend to create relatively homogeneous "natural social areas" containing similar types of people because they seek to increase their accessibility to compatible neighbors who share the same values, needs, and desires. To explain this phenomenon Park proposed that household locational choices from alternative opportunities are a function of the social-distance preferences of decision makers toward different socio-economic groups.[18] To date the use of the social-distance concept has not been attempted in a household allocation model. This investigation attempts to use this concept to explain the household assignment problem.[19]

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[17]Walter Firey, Land Uses in Central Boston (Cambridge: Harvard University Press, 1947); Walter Firey, "Sentiment and Symbolism as Ecological Variables," American Sociological Review, Vol. 10 (April, 1945), pp. 140-148; Otis Dudley Duncan and Beverly Duncan, "Residential Distribution and Occupational Stratification," The American Journal of Sociology, Vol. 60 (March, 1955), pp. 493-503; Feldman and Tilly, op. cit., pp. 877-884.

[18]Park, "The Urban Community as a Spatial Pattern and as a Moral Order," p. 18.

[19]Changes in the residential pattern of the city take place when changes occur either in: 1) the distribution of opportunities decision makers choose to interact with to meet their day to day needs or 2) the social structure of the city's inhabitants. The change in the distribution of opportunities is largely a response to changing technology, particularly space-transforming technology. Changes in social structure occur as a result of in-migration and social mobility, both of which can greatly affect the proportion of decision makers belonging to any one socio-economic group. In this case even if the distribution of opportunities was to remain the same they would be evaluated differently because the values, needs, and desires, and hence the locational preferences of the decision makers, would have changed in keeping with

Inconsistency of Locational Behavior with the "Economic Competition" Hypothesis

While the "economic competition" hypothesis holds that it is the financial resources of individuals that determine the locational preferences of decision makers (in that as income increases the quantity of land they consume increases), the findings of the Duncans and Feldman and Tilly do not support this proposition. They found that blue collar workers and white collar workers at the same income levels have different residential patterns and by inference different locational preferences not explained by the "economic competition" hypothesis.[20] The apparent inconsistency of the "economic competition" hypothesis with the locational behavior of residential decision makers has led investigators to consider more carefully the social goals of location seekers in their choice of a household location.[21] This approach to the problem of allocating households to residential areas of the

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their social status. The social distance concept used as a locational preference is a means of expressing this different evaluation. See: Barry M. Moriarty, "Human Interaction Patterns and Evolving Urban Spatial Structure," (unpublished paper presented at the Annual Meeting of the Association of American Geographers, Washington, D. C., August, 1968), Abstract in Annals of the Association of American Geographers, Vol. 59 (March, 1969), p. 195.

[20]Duncan and Duncan, op. cit.; Feldman and Tilly, op. cit.

[21]Wolpert has suggested that locational choice is conditioned by preferences which are a function of the family life style of the decision maker. See: Wolpert, op. cit., pp. 159-172. Berry has indicated the importance of social group intimacy which suggests social distance preferences. See: Brian J.L. Berry, "The Factorial Ecology of Calcutta," The American Journal of Sociology, Vol. 74 (March, 1969), pp. 445-491. Chapin has investigated the importance of frequently engaged in activities as factors related to the choices of location seekers. See: F. Stuart Chapin, Jr. and Henry C. Hightower, Household Activity Systems - A Pilot Investigation (Institute for Social Science Research, Chapel Hill: University of North Carolina Press, 1966); F. Stuart Chapin, Jr., Urban Land Use Planning (second edition; Urbana: University of Illinois Press, 1966), pp. 221-253.

city is adopted in this investigation.

The nature of the problem dictates that the locational preferences revealed by the spatial behavior of different socio-economic classes must be measured and the relationship which exists between them and the growth and structure of residential areas examined. Specifically the study is concerned with understanding and quantifying locational behavioral patterns with respect to: 1) accessibility and social-distance preferences which may condition the behavior; 2) the available opportunities that exist in the urban space that may satisfy these preferences; and 3) the manner in which the site and situation attributes associated with the opportunities may be weighed and combined or "traded off" in the light of these preferences. This information can then be used to estimate the allocation of households to residential areas and the hypothesis that a relationship exists between the subjective accessibility of an area and the intensity of residential growth in that area may be tested. Such an approach would give credence to either the "economic competition" or "social choice" explanations of the process by which socio-economic equality is transformed into residential proximity.

MAJOR ASSUMPTIONS AND DEFINITIONS

A principal assumption underlying this investigation is that an understanding of how residential location seekers' social goals interact with the spatial system in which they find themselves is of crucial importance in explaining their choice of a household location. The interaction of social goals and physical space results in what is termed a location or space preference. Subjective accessibility, or the measure of the spatial distribution of different types of

interaction opportunities about a household location adjusted for the ability and desire of residential decision makers to overcome spatial separation from the particular opportunities they may be more likely to interact with, is hypothesized as being related to this space preference. The measure provides a means by which decision makers weigh, combine, or "trade off" the site and situation attributes associated with alternative household opportunities to derive an index of the attractiveness of different residential areas.

Locational Preferences

A study of the literature describing different residential areas suggests that decision makers reveal space preferences in their choice of a household location. The preferences can be related to specific site and situation attributes of the areas, and by weighting or ordering the attributes by the preferences, a subjective accessibility index of its attractiveness for residential development for different types of location seekers can be made. Households may then be allocated to areas on the basis of a total projected demand and the attractiveness of the areas.

The following preferences are revealed by residential decision makers in their choice of household locations:

An accessibility preference is an attitude of desire or need on the part of residential decision makers to choose households at locations from which they may facilitate their interaction with the major urban functions (essentially work places).

A social-distance preference is a non-spatial attitude of desire or need on the part of residential decision makers to confine their social relationships with others of approximately equal rank or status.

This preference helps to define the geographical bias exhibited by decision makers of different socio-economic classes in their locational and travel behavior by determining the neighborhood type that different decision makers will be more likely to locate their households wherever found in urban space.

A family life-style preference is an attitude of desire or need on the part of residential decision makers to choose household types that are deemed necessary by them because of their life-style stage. This preference helps to define the housing type required by decision makers depending on their marital status and family size. Although a treatment of this preference is beyond the scope of this investigation, it serves to further limit the number of available household opportunities that decision makers perceive in the urban space.

A racial or ethnic preference refers to an attitude of desire or need on the part of residential decision makers to confine their household choices to areas having people of approximately similar racial or ethnic backgrounds. Such a preference would be similar to social-distance preferences except that decision makers' attitudes toward people of different racial and ethnic backgrounds change regardless of their social rank or status. A treatment of this preference is also outside the scope of this investigation.

Subjective accessibility, therefore, results from an attitude of desire or need on the part of residential decision makers to choose a particular housing type in a compatible neighborhood located where spatial separation from their particular set of interaction opportunities is at a minimum. In this investigation these opportunities relate to employment and such social relationships as may be involved with friends, kin, neighbors, and informal social groups.

Occupation as a Cue to Socio-Economic Status

Research has shown that occupation is one of the most important determinants of socio-economic status in the American community.[22] Moynihan points out, "In the United States, what you do is what you are. By and large, status is distributed through the occupational structure."[23] Although not denying the importance of other variables, it appears that occupation provides an easily obtained symbol by which people may define their attitudes toward and expectations of a decision maker or his family. In discovering the close correlation between occupation, and income, housing, and education, investigators point out that both income and education to a great extent determine the preferences which govern the manner by which people behave and live their lives. Laumann and others conclude that occupation serves as a realistic condensed cue by which other decision makers categorize a person or family according to their own set of preferences and elect to imitate or not to imitate the behavior associated with the person or family.[24] Whether it be spatial behavior, or any other type of

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[22]Lloyd W. Warner, et. al., Social Classes in America (New York: Harper Torchbooks, 1960). Warner found that occupation alone had a coefficient of correlation of .91 with all the characteristics of families used to establish social classes. Investigators have concluded that from the standpoint of scientific parsimony, occupation yields an index of stratification sufficiently accurate for most practical purposes.

[23]Daniel F. Moynihan, A statement attributed to Moynihan by Joseph Alsop. The statement appears in Moynihan's forthcoming book, the publication of which has been reportedly deferred until he leaves his position as chief United States advisor on urban problems. Lansing, Michigan, State Journal, February 10, 1969.

[24]Laumann, op. cit.

behavior, people will tend to imitate what they consider to be successful behavior and not to imitate what they consider unsuccessful behavior. Relative high status occupations are associated with successful behavior and low status occupations with less successful behavior. For this reason this investigation will use occupation as a cue to the differential spatial behavior exhibited by residential decision makers. A description of the socio-economic status types (or household types) found in the Lansing - East Lansing, Michigan, area is presented in Appendix A.

LIMITATIONS OF THE INVESTIGATION

It is recognized that all the characteristics associated with the behavior of residential location seekers cannot be defined, objectively measured, or evaluated because of the present state of the knowledge about the behavior. Even if the behavior were understood, it would be difficult to simulate the behavior to generate a household development pattern because of the lack of compatible time-series data. Consequently while researchers interested in the household allocation problem would like to be more concerned with the spatial behavior of individuals, their studies deal only with aggregates of population. While the same is true of this investigation, an attempt is made to disaggregate the decision makers into major social class groups and to isolate particular hypotheses about the locational preferences exhibited by the spatial behavior of these groups. In this way it is possible to determine whether or not the specified preferences are systematically related to the process of allocating households in urban space.

CHAPTER III

DESCRIPTION OF RESIDENTIAL DECISION MAKERS' LOCATIONAL PREFERENCES

The previous chapter argued that residential allocation models lose their power to predict the assignment of dwelling units to different areas of the city by aggregating all household location seekers into one homogeneous category and by ascribing to the residential decision makers the same locational preferences as non-residential decision makers. The effect of the aggregation is to attribute to the individual residential decision maker a wider range of locational opportunities from which to choose a household than he actually perceives in his action space. In models which disaggregate types of decision makers, the effect of ascribing similar locational preferences creates relatively large areas of homogeneous land use, despite important exceptions to the contrary. It was suggested that a more efficient household allocation model must possess at least two qualities to eliminate these problems. First, it must divorce itself from the locational preferences revealed by the spatial behavior of non-residential decision makers and, instead, treat the locational preferences revealed by the spatial behavior of residential decision makers. Secondly, it must not deny the individual decision maker the chance to exercise his conditioned preference to choose or not to choose a compatible location that is consistent with his values, needs, and

desires from among the alternative household opportunities he is likely to perceive in his action space. The present chapter is designed to describe the locational preferences of different groups of household decision makers as revealed by their spatial behavior. Subsequent chapters will be concerned with both modeling and testing specific hypotheses considered relevant to the household allocation process.

RESIDENTIAL PREFERENCES REVEALED BY THE CLASSICAL MODELS OF URBAN SPATIAL STRUCTURE

A classic approach to the problem of explaining the growth of residential land has been to describe the location of residential areas by household type and to formulate generalizations about the nature of future development patterns. Hurd, as early as 1903, introduced the idea that urban growth proceeded according to two patterns: central growth and axial growth. He observed that,

> A continual contest exists between axial growth, pushing out from the centre (sic) along transportation lines, and central growth, constantly following and obliterating it, while new projections are being made further out the various axes.[1]

Hence, urban growth tends to occur in all directions outward from the center of the city, and it occurs more rapidly along major transportation routes. Although Hurd discusses the location of different types of residential areas, paying particular attention to the income and rent payments of household decision makers, he does not use the concept of central and axial growth to systematically generate patterns of residential growth and development. He does, however, say,

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[1]Hurd, op. cit., p. 59.

> The main consideration in the individual selection of a residence location is the desire to live among one's friends or among those whom one desires to have for friends . . . and the ultimate aim in residence location is to be as close as possible to those of the highest social position.[2]

A few decades later, in the early '20s, the compact circular urban form led Burgess to stress the central growth aspect of Hurd's concept to generate the well-known concentric zone distribution of residential areas by household type.[3] He described residential areas according to the density of dwelling units and the socio-economic characteristics of the residential decision makers. Burgess found that the two variables were inversely related to each other so that proceeding outward from the central core the zones become progressively less dense in dwelling units but increase in the socio-economic status of the decision makers. He and Park argued that the dominance of a particular land use in a zone, and consequently urban form, was the result of competition among different interest groups. Land use changes take place through the invasion into the zone by a competing interest group which may lead to the ultimate succession to dominance of the new land use in the area. This process receives its energy from population increase and generally manifests itself in older population groups migrating from original sites near the congested central core

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[2] Ibid., p. 78.

[3] Ernest W. Burgess, "The Growth of the City: An Introduction to a Research Project," Publications of the American Sociological Society, Vol. 18, 1924, pp. 85-97. Reprinted in Robert E. Park, Ernest W. Burgess and Roderick D. McKenzie (eds.), The City (Chicago: University of Chicago Press, 1925), pp. 47-62. See also: Ernest W. Burgess, "Urban Areas," Chicago: An Experiment in Social Science Research, T. V. Smith and L. D. White, editors (Chicago: University of Chicago Press, 1929), pp. 114-123.

toward less-crowded sites closer to the periphery as their socio-economic status improves. Residential location seekers, new to the city or with little or no family responsibilities, are able to find more numerous household opportunities in the vacated residences near the central core that have not been demolished for higher-order, non-residential land uses.[4]

The spatial behavior of residential decision makers, as viewed by Burgess, reveals a locational preference for a more spacious living environment away from the overcrowded conditions near the central core as real income increases. Residential decision makers having lower incomes choose sites that exhibit a locational preference to be more centrally situated with respect to the major urban functions, particularly employment opportunities.

Nearly two decades later, in the late '30s, the star-shaped urban form caused Hoyt to emphasize the axial pattern of Hurd's concept. In an empirical study of sixty-eight cities he found,

> the highest rental area is in every case located in one or more sectors on the side of the city (and)

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[4]Ernest W. Burgess, "Residential Succession in American Cities," Annals, Vol. 140 (November, 1928), p. 112. See also: Lawrence A. Brown and David B. Longbrake, Migration Flows in Intra-Urban Space: Place Utility Considerations (paper presented at the Annual Meeting of the Association of American Geographers, Washington, D.C., August, 1968). Additional studies dealing with residential succession are: Paul F. Cressy, "Population Succession in Chicago: 1898-1930," American Journal of Sociology, Vol. 44 (July, 1938), pp. 59-68; Richard G. Ford, "Population Succession in Chicago," American Journal of Sociology, Vol. 56 (September, 1950), pp. 156-160; Otis Dudley Duncan and Stanley Lieberman, "Ethnic Segregation and Assimilation," American Journal of Sociology, Vol. 64 (January, 1959), pp. 368-369; Stanley Lieberman, "Suburbs and Ethnic Residential Patterns," American Journal of Sociology, Vol. 67 (May, 1962), pp. 673-682; Stanley Lieberman, Ethnic Patterns in American Cities (New York: The Free Press of Glencoe, 1963).

> low rent areas, extending from the center to the edge of the city are found in practically every city.[5]

In contrast to Burgess, Hoyt showed that both high and low rent neighborhoods occupy distinct sub-areas of the city and that they are not aligned concentrically about the central core but are distributed in a sector fashion. He proposed that city form is determined by the residential location seekers who can best afford to pay the highest rent. These location seekers pre-empt land along "the best existing transportation lines," "high ground... free from the risk of floods," and "land along lakes, bay, river and ocean fronts where such water-fronts are not used for industry."[6] They also tend to locate on the side of the CBD where office buildings, banks, and stores are located and away from the side where warehouses and industries are found. In turn all other socio-economic groups tend to locate their households in the direction of the residences of these "community leaders" or other prestigeous leaders with whom they "identify" themselves.[7] This development continues in the same direction for a long period of time.

The spatial behavior of residential decision makers, as viewed by Hoyt, reveals a social attraction to prestigeous neighborhoods as

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[5]Hoyt, op. cit., pp. 75-76.

[6]Ibid., p. 117. Lloyd Rodwin, in applying Hoyt's model to the City of Boston in 1950, found that most of the characteristics dealing with residential growth and form proved generally to be true although he discovered inconsistencies with some of Hoyt's propositions. See: Lloyd Rodwin, "The Theory of Residential Growth and Structure," Appraisal Journal, Vol. 18, 1950, pp. 295-315. See also: Homer Hoyt, "Residential Sectors Revisited," Appraisal Journal, Vol. 18, 1950, pp. 445-450; Walter Firey, "Residential Sectors Re-Examined," Appraisal Journal, Vol. 18, 1950, pp. 451-453.

[7]Hoyt, Structure and Growth of Residential Neighborhoods in American Cities, p. 120.

the fundamental locational preference, with accessibility to employment opportunities a secondary locational preference.

No new, significant descriptive model of the residential spatial structure has been formulated since those of Burgess and Hoyt, except that Firey has argued that residential location seekers who share the same cultural values and goals will place the same significance on the various sub-areas of the city and tend to cluster in urban space.[8] Polynuclei descriptions of urban spatial structure are considered to be metropolitan forms rather than city forms and tend to over-emphasize the role of transportation technology on changing land use patterns.[9] It is important to note that advocates of the "economic competition" hypothesis tend to support the Burgess model, while the Hoyt model is closely associated with the "social choice" hypothesis.

RESIDENTIAL PREFERENCES REVEALED BY SOCIAL AREA ANALYSIS STUDIES

It was not until another two decades had passed, in 1960, that the zonal and sector models were compared and tested statistically. Prior to this comparison, however, a means of empirically measuring the relevant characteristics of residential areas needed to be determined. Such empirical instruments were developed by Shevky and

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[8]Firey, "Residential Sectors Re-Examined," pp. 451-453. Firey's work is of limited value in predicting patterns of residential growth and development. He argues that urban land use is both a function of 1) past and present cultural systems and social systems; and 2) community goals, values, and sentiments.

[9]Harris and Ullman, op. cit., pp. 7-17. See also: Edward L. Ullman, "The Nature of Cities Reconsidered," The Regional Science Association Papers and Proceedings, Vol. 9, 1962, pp. 7-23.

Williams in 1949 and consist of three indices designed to describe the population and housing characteristics of urban census tracts using from one to three census variables each.[10] The indices allow the census tracts to be differentiated into "social areas" and measure: 1) social rank or socio-economic status; 2) urbanization or family life-style; and 3) segregation or minority group isolation. Subsequent investigations have shown that the indices effectively summarize the residential characteristics of census tracts and possess a relatively stable structure from city to city.[11]

The first to statistically test and compare the zonal and sector models in terms of the Shevky-Williams-Bell indices were Anderson and Egeland in 1960.[12] Using analysis of variance they found that both the Burgess and Hoyt descriptions of the residential spatial structure have validity; that is, census tracts, when classified according to their degree of urbanization or family life-style status are distributed

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[10]Eshref Shevky and Marilyn Williams, The Social Areas of Los Angeles, Analysis and Typology (Berkeley and Los Angeles: University of California Press, 1949); Eshref Shevky and Wendell Bell, op. cit., pp. vi and 70. It must be remembered that these indices pertain to spatial units rather than individuals and describe the environmental attributes of census tracts. Socio-economic variables deal with the level of occupation, education, income, rental value, and the quality of housing. Family life style variables are the number of women in the labor force, family size, and age of household members. The ethnic variables deal with minority group concentrations. For a discussion of these indices and an extensive bibliography of work done using them, see: Wendell Bell, "Social Areas: Typology of Urban Neighborhoods," Community Structure and Analysis, Marvin B. Sussman, editor (New York: Thomas Y. Crowell Company, 1959), pp. 61-92.

[11]Maurice D. Van Arsdol, Jr., Santo F. Camilleri and Calvin F. Schmid, "The Generality of Urban Social Area Indexes," American Sociological Review, Vol. 23 (June, 1958), pp. 277-284.

[12]Anderson and Egeland, op. cit., pp. 392-398.

in a zonal pattern, whereas when differentiated on the basis of their social rank or socio-economic status they are distributed in a sector pattern.[13] Other investigations support this finding and suggest that each "social area" index captures the essential features of one of the classical spatial models: 1) Burgess' concentric zone model depicts family life-style patterns; 2) Hoyt's sector model is characterized by socio-economic status patterns; and 3) Firey's social cluster model portrays ethnic status patterns. Several researchers have argued that the three models are independent additive contributors to the total structuring of urban neighborhoods. Berry, for example, states,

> This basic triad of spatially arranged social dimensions can be super-imposed to form, at the intersections of sectors, zones, and segregated areas communities of similar social, family and ethnic status.[14]

While the social area analysis methodology provides some knowledge about the relevant locational preferences of residential decision makers, it lacks the ability to determine the degree of importance that can be placed on them; that is, the relative weight attached to each preference. It is essential to be able to determine whether household decision makers are more influenced in their choice of a residential location because of 1) a preference to be close to the households of

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[13] Anderson and Egeland found that areas characterized by high dwelling density, families with few children, and families in which the wife works are more frequently near the city center and gradually decline in relative frequency toward the periphery; i.e., these variables were distributed in a concentric zone fashion. Variables associated with the prestige of residential areas, as measured by occupation and education of the inhabitants, were distributed in sector fashion, although the position of the sectors varied from city to city.

[14] Berry, op. cit.

equal or more prestigeous decision makers vis-a-vis a preference to be accessible to the major urban functions as postulated by Hoyt's socio-economic, sector model or 2) a preference for more spacious living conditions vis-a-vis a preference for a location that is accessible to the major urban functions as postulated by Burgess in his family life-style, zonal model.[15]

RESIDENTIAL PREFERENCES REVEALED BY FACTORIAL ECOLOGY METHODS

Studies using factor analysis to determine the validity of the social area analysis indices as measures of the socio-economic, family life-style and segregation attributes of census tracts indicate that socio-economic status is the more important factor in dimensioning the preferences by which household choices are made to produce the residential spatial structure.[16] Shevky and Bell have shown that, in the United States, factorial ecology revealed that the relevant preferences which result in household choices are dimensioned cumulatively: first, by socio-economic status; second, by family life-style status; and third, by the constraints of race and ethnicity.[17] An investigation of

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[15]It is the pattern of preferences described by Burgess that is being treated in the work of Muth, Cassetti, Wingo, and Alonso.

[16]Factorial ecology is the term used to characterize studies involving the application of factor analysis to ecological investigations.

[17]For a review of this literature see: Berry, op. cit. A slightly different factor structure exists between cities of the United States' North and South, and between cities of developed and underdeveloped countries. The different factor structures generally occur with respect to the race and ethnicity dimensions. In several cities of the South no factor separation can be found between indicators of socio-economic status and indicators of ethnic status. This not unexpected

the locational behavior revealed by the residential spatial structure of Pittsburgh in 1950 and 1960 cause Lee to conclude, if one factor alone

> could be used to predict the locations of households the single dimension ... which we would choose ... would be socio-economic status.[18]

This study will focus on Hoyt's socio-economic status description of the urban residential spatial structure while, at the same time, recognizing that accessibility to the major urban functions, family life-style, and ethnic considerations have a part in dimensioning the locational preferences that result in household choices.

RESIDENTIAL PREFERENCES REVEALED BY CONSUMER BEHAVIOR

The "economic competition" hypothesis argues that household decision makers budget their expenses on the basis of satisfactions they receive from the consumption of goods and services within the constraints of their income. However, these satisfactions cannot be measured purely in terms of the quantity of land they utilize at some

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factor linking indicates that a decision maker's ethnic status (Negro or non-Negro) is fundamental in defining the socio-economic preferences he exhibits by his household locational behavior in southern cities. Despite similar situations that appear in Montreal, Chicago, and Toledo, all studies show socio-economic status as the more important factor in structuring residential choice than family life-style status.

[18]Douglass B. Lee, Jr., "Household Disaggregation in Urban Models," (paper presented at the Annual Meeting of the Regional Science Association, Cambridge, Massachusetts, November, 1968). Lee found that socio-economic status explained 37 per cent of the total variance in 1960 and 35 per cent in 1950; family life-style status explained 18 per cent of the variance in 1960 and 23 per cent in 1950; and ethnic status explained 14 per cent of the variance in both 1960 and 1950. His analysis also suggests that socio-economic status is becoming more of a factor in dimensioning residential spatial structure and family life-style status less of a factor as time goes on. See Appendix B.

distance from the central core as evidenced in the work of Muth, Cassetti, Wingo, and Alonso.[19] Veblen, as early as 1899, and more recently Galbraith, have pointed out that the consumption habits of household decision makers reveal that they consume their total range of goods and services for two purposes.[20] First, they need the product or service to satisfy the basic requirements of food, clothing, and shelter. Second, they need the product or service for the purpose of identifying themselves with a particular reference group. Advocates of the "social choice" hypothesis argue that it is the satisfactions that decision makers receive from identifying with their reference group that determine how they choose to budget their income and where they choose to locate their households.

Several conclusions can be derived from consumer identification patterns that are applicable to the problem of allocating households to residential areas of the city. First, there must be other people nearby belonging to the reference group that establish the pattern of consumption to be followed by decision makers desiring to identify with the group. Second, since every act of consumption is at least status conserving, and in favorable circumstances status enhancing, there must be people around from the reference group to validate the status sought by the decision maker. Consequently, decision makers seeking, or

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[19]Muth, op. cit., pp. 207-220; Cassetti, op. cit., pp. 96-100; Wingo, "An Economic Model of the Utilization of Urban Land for Residential Purposes," pp. 191-205; see also: Wingo, Transportation and Urban Land; Alonso, "A Theory of the Urban Land Market," pp. 149-158; Alonso, Location and Land Use.

[20]Thorstein Veblen, The Theory of the Leisure Class, An Economic Study of Institutions (New York: The Macmillan Company, c1912). John K. Galbraith, The Affluent Society (Boston: Houghton Mifflin Co., 1958).

attempting to maintain a particular social status, tend to cluster together to establish and verify particular consumption patterns.[21]

The concentric zone proposition based on "economic competition" does not allow for the reference group conduct revealed by consumer behavior as well as does the sector pattern based on "social choice." Hoyt's proposition is consistent with consumer reference group identification behavior in that it shows how decision makers of lower socio-economic status either identify with people in the same strata or, in the case of the upwardly mobile decision makers, identify with people in higher status groups. Hoyt's proposition is also consistent with the invasion-succession process of land use change and with the avoidance-acceptance proposition found in psychological studies of interpersonal and intergroup behavior. Consumer reference group identification behavior can be stated in terms of whether a decision maker belonging to one socio-economic group wishes to avoid decision makers of other socio-economic groups or wishes to be accepted by them. The probable level of acceptance or avoidance between the different status groups is hypothesized in Table III.1. Laumann's findings of the propensity of a decision maker in a particular occupation category is in remarkable agreement with this hypothesized level (See Table III.2).[22] Finally Hoyt's proposition is consistent with the results of moving behavior and residential choice as found recently in a survey by Butler, et. al. The survey revealed that household decision makers

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[21] Chapter Five will treat the probable level of interaction between different status groups to generate household locations.

[22] Laumann, op. cit., p. 71.

TABLE III.1

REFERENCE GROUP IDENTIFICATION BY OCCUPATION CATEGORY OF DECISION MAKERS
(HYPOTHESIZED LEVEL OF ACCEPTANCE OR AVOIDANCE)

LEVEL OF IDENTIFICATION DESIRED: BY VIEWING GROUP	OF REFERENCE GROUP				
Occupation Category	Professional, Technical	Proprietors, Managers & Salesmen	Clerical Workers	Skilled Workers	Semi & Unskilled
Professional & Tech.	XX	X	-	--	---
Props., Mans., & Salesmen	XXX	XX	X	-	--
Clerical Workers	XX	XXX	XX	X	-
Skilled Workers	X	XX	XXX	XX	X
Semi & Unskilled	-	X	XX	XXX	XX

XXX = Great Acceptance

XX = Acceptance

X = Some Acceptance

- = Some Avoidance

-- = Avoidance

--- = Great Avoidance

TABLE III.2

PER CENT DISTRIBUTION OF OCCUPATIONAL STATUS OF NEXT-DOOR NEIGHBORS BY OCCUPATIONAL STATUS OF DECISION MAKERS

DECISION MAKERS' OCCUPATIONAL STATUS	NEXT-DOOR NEIGHBORS' OCCUPATIONAL STATUS				
Occupation Category	Professional Top Business	Semi-Prof. Mid. Bus.	Clerical Small Bus.	Skilled Workers	Semi & Unskilled
Profess. Top Bus.	48.6	23.9	14.5	6.5	6.5
Semi-Prof. Mid. Bus.	24.5	26.6	25.9	10.8	12.2
Clerical Small Bus.	8.1	21.5	23.0	14.8	32.6
Skilled Workers	7.6	12.6	18.5	19.3	42.0
Semi & Unskilled	4.9	4.1	12.2	22.8	56.1

Source: Laumann, Prestige and Association in an American Community, p. 71.

overwhelmingly preferred

> better neighborhood quality with either a less desirable housing unit or less accessible location over a less desirable neighborhood with either a better housing unit or better accessibility (70 per cent to 27 per cent).[23]

The study also revealed that location seekers prefer

> a place that has a very nice appearance inside and less desirable outside appearance to a place that presents a very nice outside appearance but less desirable inside appearance (80.4 per cent to 14.2 per cent).[24]

The lack of concern for outside appearance coupled with a concern for neighborhood quality suggests that the major preference of decision makers in choosing a household location is not spacious living conditions as proposed by the "economic competition" hypothesis. Rather, neighborhood prestige is a more critical preference in choosing household locations from among alternative opportunities.

RESIDENTIAL CHOICE REVEALED BY SOCIAL-DISTANCE PREFERENCES

Hoyt's proposition that residential choice is a function of the differential prestige associated with socio-economic groups has been confirmed by a number of studies. Duncan and Duncan found a close relationship between what they termed spatial and social distance in an investigation of the differential distribution of occupations by

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[23]Edgar A. Butler, et. al., Moving Behavior and Residential Choice: A National Survey (Center for Urban and Regional Studies, Institute for Social Science Research, Chapel Hill: University of North Carolina Press, March, 1968), p. 5; see also: Michael A. Stegman, "Accessibility Models and Residential Location," Journal of the American Institute of Planners, Vol. 35 (January, 1969), pp. 22-29.

[24]Butler, et. al., loc. cit.

census tracts in Chicago. They concurred with Park's proposition that residential proximity is associated with social equality so that the physical distance at which socio-economic groups of different status reside from each other is positively related to their social distance apart.[25] Feldman and Tilly attempted to assess the relative importance of income and education in explaining the differential distribution of occupations in Hartford, Connecticut's census tracts. They found that the residential distribution of occupations was comparable to the pattern observed by the Duncans in Chicago and also concurred with Park's formulation.[26] Both studies lend support to Hoyt's proposition that non-economic factors are important in explaining the differential residential distribution of the socio-economic classes.

Additional support for Hoyt's proposition can be found in Laumann's investigation of the social-distance relationships of a sample of Belmont and Cambridge, Massachusetts, residents. Laumann defines social distance in terms of subjective preferences and objective choices.

> Subjective social distance is an attitude of ego toward a person (alter) with a particular status attribute (in this and Laumann's study occupation) that broadly defines the character of the interaction that ego would undertake with the attitude object.[27]
>
> Objective social distance is the actually observed likelihood of having a friend, neighbor or kin

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[25]Duncan and Duncan, op. cit., pp. 493-503.

[26]Feldman and Tilly, op. cit., pp. 877-884.

[27]Laumann, op. cit., p. 29.

relation with persons of different occupational background.[28]

Two facts are evident from Laumann's study of social-distance preferences: 1) each socio-economic class differs with respect to their social-distance preferences from the different occupations, and 2) social-distance preferences are highly correlated with the prestige ordering of the different occupations regardless of the socio-economic class of the decision maker; that is, the expressed preference of all classes is to associate intimately with the higher status types and to maintain relatively greater distance from lower status types.[29] The general trend of the three lines in Figure III.1 from the upper left-hand corner to the lower right-hand corner dramatically illustrates this finding with respect to the social-distance preferences of the upper, middle, and working class groups. Laumann has found a nearly total diffusion of occupational prestige as a factor which dimensions the preferences by which decision makers choose their friends, spouses, and household locations.[30] Although not considering the spatial relations

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[28] Ibid., p. 30.

[29] Ibid., p. 45.

[30] Studies by Centers and Hunt, although not concerned with the residential spatial structure, tend to support the hypothesis that there is a higher rate of intimate interaction and communication within the same occupational category and a lower rate between different occupational categories. See: Richard Centers, "Marital Selection and Occupational Strata," American Journal of Sociology, Vol. 54 (May, 1949), pp. 530-535; and T. C. Hunt, "Occupational Strata and Marriage Selection," American Sociological Review, Vol. 5 (August, 1940), pp. 495-504. Several other studies find support for Hoyt's proposition that decision makers choosing others for close social relationships tend to name those of somewhat higher socio-economic status than themselves. For example, Loomis and Beegle reported that rural church members of upper or middle class in a small Michigan community chose persons of the same or higher socio-economic status more often than

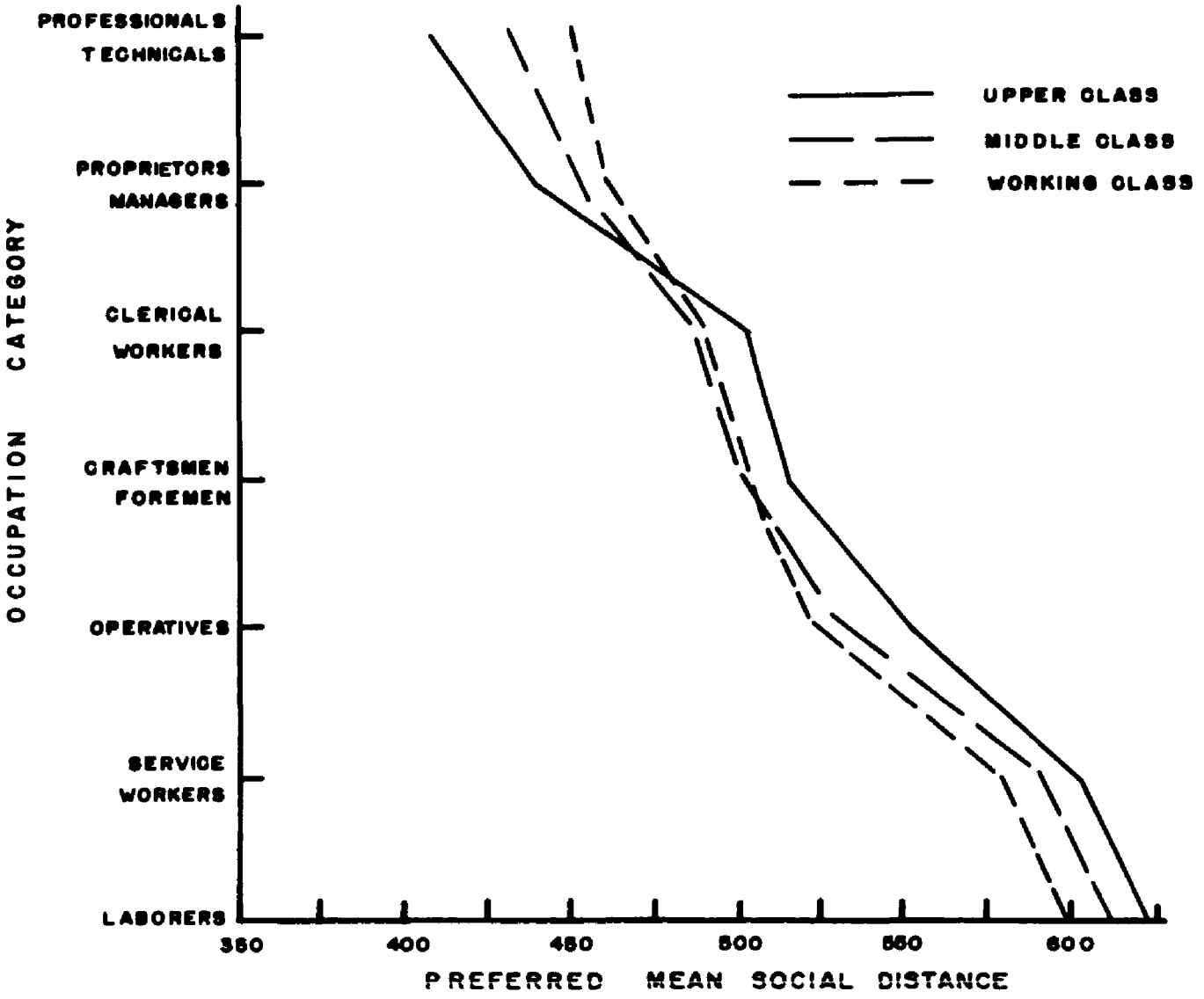

FIG. III·1

Preferred mean social distance for males by self-identified social class for seventeen occupational categories in a sample of Cambridge and Belmont Massachusetts residents

SOURCE: Edward O. Laumann, Prestige and Association in an Urban Community p 42

of friend and kin associations, he found the likelihood of having next-door neighbors belonging to the same occupation category to be generally quite high although there was a slight tendency for the respondent's occupation to be a little more prestigeous than that of his neighbor.[31]

Despite significant methodological differences between Laumann's study and that of the Duncans, both found that the residential distribution of occupations exhibits a pattern which corresponds to the different social-distance preferences of each socio-economic class, but only in the case of the upper class is the distribution highly correlated to the prestige ranking revealed by their social-distance preferences.[32] A comparison of the line trend in Figures III.2 and III.3

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would be expected by chance, and those beneath them in socio-economic status less often than would be expected by chance. See: C. P. Loomis and J. A. Beegle, Rural Social Systems (New York: Prentice Hall, 1950). For a review of additional studies which support the prestige hypothesis see: Henry W. Riecken and George C. Homans, "Psychological Aspects of Social Structure," Handbook of Social Psychology, G. Lindzey, editor, Vol. 2 (Reading, Massachusetts: Addison-Wesley, 1954), pp. 786-832; see also: Morton B. King, "Socio-economic Status and Sociometric Choice," Social Forces, Vol. 39 (March, 1961), pp. 199-206.

[31] Laumann, op. cit., p. 72. It must be remembered that a household location seeker, regardless of his class, exercises only a passive control over the status of the next-door neighbor because of the limited chance that an available household opportunity will present itself next-door to the neighbor of his choice. In order to reduce the possibility of getting an obnoxious neighbor, location seekers exercise an active control over their choice of a neighborhood and take their chance on what the status of the neighbor is. By their selection of a slightly more prestigeous neighborhood the chance of locating next to an undesirable neighbor is lessened.

[32] In comparing Figures III.1, III.2, and III.3 it is of less importance to be concerned with the particular values noted than with the slope and character of the curves. For example, the relationship of the lines to each other in all three figures is approximately the same, and they cross each other at approximately the same occupation categories in each figure.

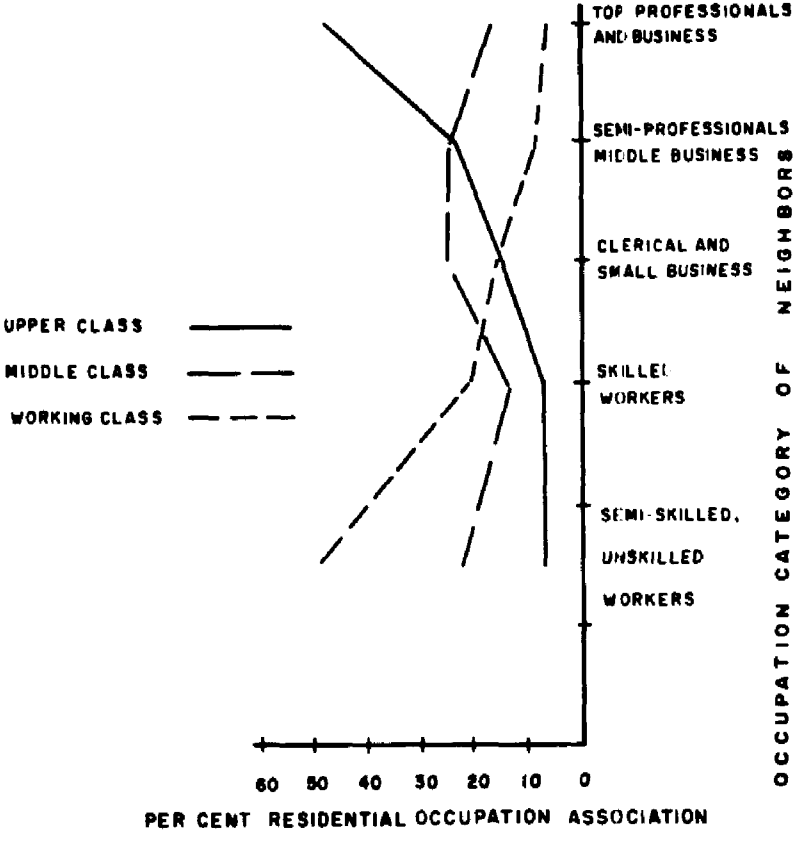

FIG. III-2

Occupation category of next door male neighbors for social groups in a sample of Cambridge and Belmont, Mass. residents

SOURCE: Edward O. Laumann, Prestige and Association in an Urban Community, p. 71

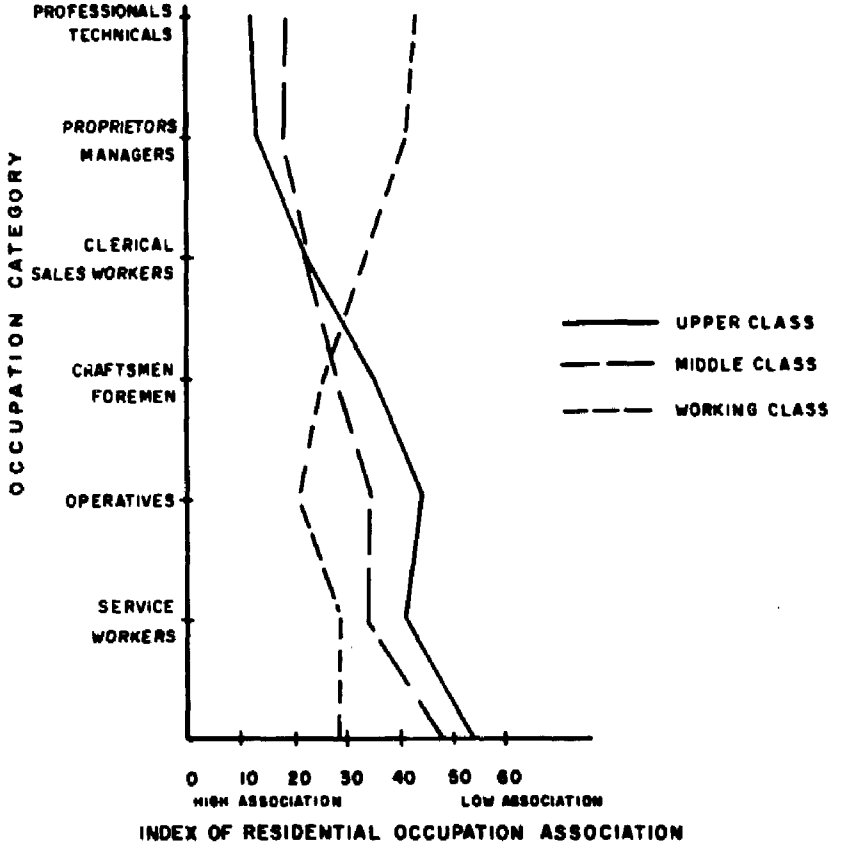

FIG. III-3

Residential association of male occupation categories for social class groups in Chicago, Illinois census tracts - 1950

SOURCE: Otis D. Duncan and Beverly Duncan, "Residential Distribution and Occupational Stratification," p. 498

shows that only the upper class group reveals residential locational behavior that is highly consistent with their social-distance preferences shown in Figure III.1; that is, the line trend in all three figures is from the upper left-hand corner to the lower right-hand corner. The residential distribution of the middle class indicates a progressively poorer correlation with the prestige ranking and that of the lower class an inverse correlation with the prestige ranking. For the working class group a comparison of the two lines in Figure III.2 and III.3 representing their actual residential association with the line on Figure III.1 representing their social-distance preferences reveals that the residential association is in sharp conflict with their preferences as the lines cross to resemble an X. This conflict of preference with the actual residential association could be construed to mean that it is totally the economic circumstances of each class that determines the household locations, but the fact that the Duncans found blue and white collar workers at the same income level to have different residential patterns suggests that the prestige of neighbors is less of a locational preference to lower status decision makers than is a preference to be accessible to the major urban functions.[33] Arguments to the effect that blue collar workers reside close to the major urban functions because of lower trip costs while white collar workers can more easily absorb trip costs are likewise invalid since studies by Tomazinis and Gabbour found that decision makers residing close to the central core have similar costs to those residing at the periphery. They found that decision makers residing at

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[33] Duncan and Duncan, loc. cit.

intermediate locations realized lower trip costs.[34] While not denying that economic circumstances are involved, the findings of Laumann, Feldman and Tilly, Tomazinis and Gabbour, and the Duncans tend to present a good case for Hoyt's "social choice" proposition that the socio-economic classes are highly influenced in their choice of a household location because of a preference to be close to the residences of equal or more prestigeous decision makers rather than they are because of a preference for more spacious living conditions. Figure III.4 shows the residential location by census tracts of the upper, middle, and working class groups in the Lansing - East Lansing Area for 1960 as determined by the location quotient technique. In accordance with the findings of Laumann and the Duncans the technique reveals that the upper class group is the more highly segregated, followed by the working class group. The middle class group shows less of a tendency to be segregated.

SUMMARY

This chapter has provided an overview of the literature which describes the household locational preferences of residential decision makers as revealed by their spatial behavior. The discussion centered on the "social choice" hypothesis as an alternative approach to the "economic competition" hypothesis in explaining the differential residential distribution of socio-economic groups in urban space. The analysis found that occupations assume a kind of hierarchical arrangement in terms of the prestige they may confer on decision makers, so that certain occupations become identified with particular socio-economic

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[34]Tomazinis, loc. cit.; Gabbour, loc. cit.; Tomazinis and Gabbour, loc. cit.

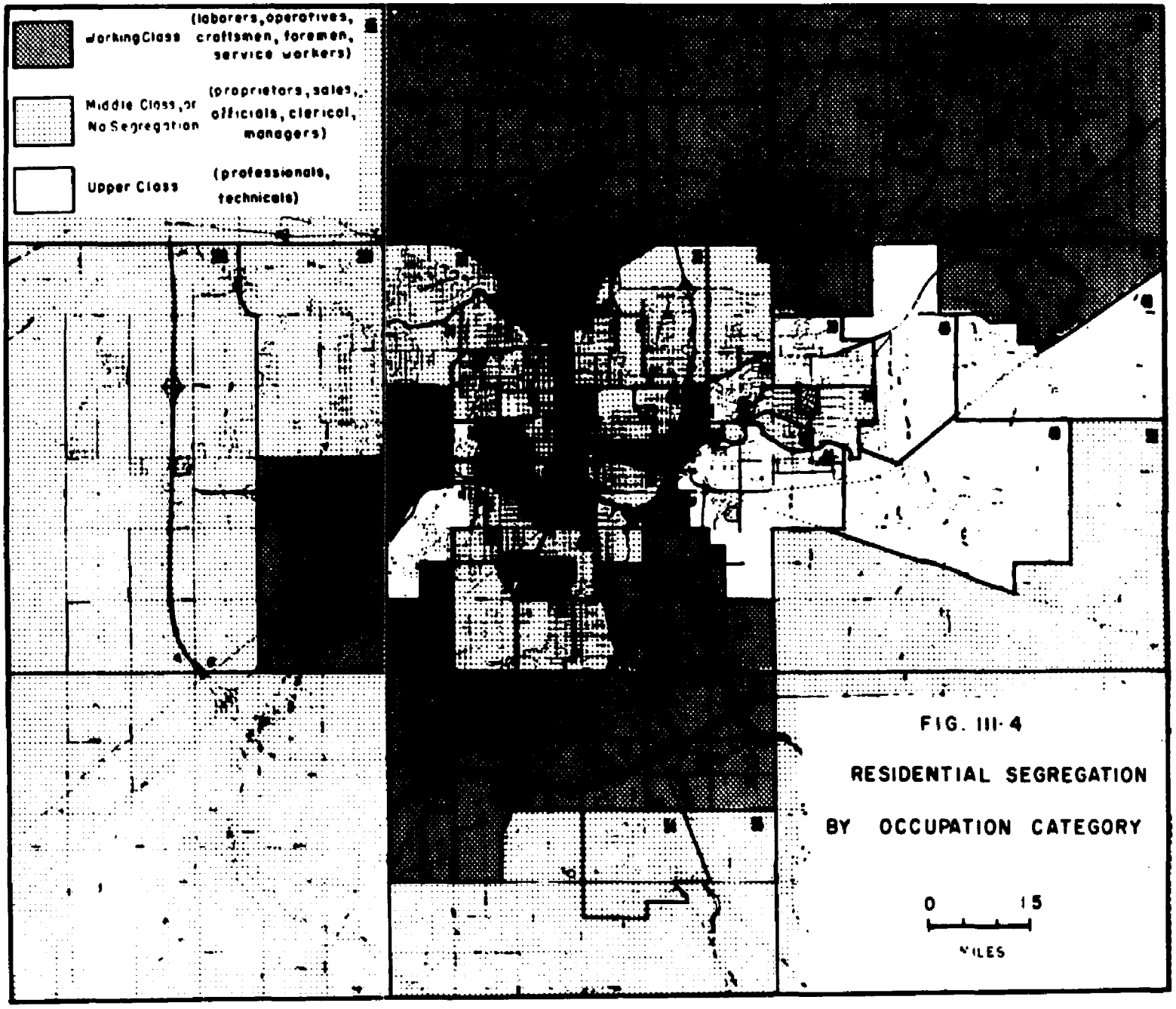

FIG. III-4

RESIDENTIAL SEGREGATION BY OCCUPATION CATEGORY

classes. It was pointed out that the actual existence of socio-economic status groups and the houses in which they choose to live depends in considerable measure upon the level of income derived from these occupations so that the occupations themselves have considerable status significance. However, it was stressed that the location of the households in urban space has considerably less to do with the income level of the decision makers. Instead it was found that residential location seekers exhibit a primary preference to reside close to the households of equal or more prestigeous decision makers and consequently they are not indifferent to their locations at designated prices as purported by the "economic competition" hypothesis. This social-distance preference was more obvious with respect to the locational behavior of upper socio-economic classes. Secondly, the locational behavior of decision makers revealed a preference to choose locations with respect to the various urban functions deemed necessary by them to maintain their livelihood. This accessibility preference was more obvious with respect to the locational behavior of the lower socio-economic groups and more affluent young married couples, recent arrivals to the city, and older couples beyond the child rearing stage. Thirdly and to a much lesser extent, location seekers reveal a preference for more spacious living conditions. This life-style preference was more obvious with respect to decision makers in the family rearing stages. Finally, residential locational behavior revealed a preference for decision makers to reside close to households of similar minority group status. This ethnic or racial preference was found to be more significant in cities where the proportion of ethnics to the total population was generally quite high and consequently

relegated the ethnics to very low status. Decision makers belonging to similar socio-economic, family life-style and ethnic status weigh these preferences in the order described above, and the additive weights contribute to the total structuring of residential spatial patterns. It is significant to note that this notion is a possible aid to the problem of allocating residential growth to different areas of the city.

The residential locational preferences described in the chapter differ in both quality and degree from those exhibited by the spatial behavior of non-residential location seekers. The locational preferences of non-residential location seekers are primarily, accessibility and secondly, spaciousness. However, in some cases, it can be seen that non-residential location seekers also exhibit a preference to be close to prestigeous neighborhoods and ethnic groups.

CHAPTER IV

MODELING OF RESIDENTIAL DECISION MAKERS' LOCATIONAL PREFERENCES

The principal findings of urban residential location studies have yielded two guiding hypotheses to account for the distribution of households in urban space: the "economic competition" and "social choice" propositions. In the previous chapter it was argued that residential decision makers' locational preferences appeared to be more a matter of "social choice," whereas "economic competition" characterized the locational preferences of non-residential decision makers. Both hypotheses propose that decision makers will choose locations that provide maximum geographic utility or satisfaction from among the alternative opportunities perceived in their action spaces. (Geographic utility refers to both site or place utility and situation utility.)

Land use allocation models in their purest form are devices that attempt to measure the geographic utility of urban areas in terms of decision makers' locational preferences and assign site choices on the basis of the attractiveness of the opportunities in the areas. Residential decision makers' locational choices reveal that they make selections by evaluating a number of attributes associated with alternative residential opportunities. Household allocation models attempt to account for the many attributes which are assumed to be the

most relevant to this decision-making process. To predict locational choices the various attributes are weighted and combined in what is presumed to be the manner in which the decision makers trade off the attributes between alternative opportunities according to their preferences. Both the determination of the part-worth that each attribute contributes to the over-all evaluation of alternative household opportunities and the appropriate rules for combining the component attributes are determined by experimentation or by observation of the residential decision making process.[1] The part-worth that each attribute contributes is differentially associated with the locational preferences of the decision makers and is presumably independent of the particular set of opportunities, the particular spatial system, or the particular moment in time. The household allocation model implements the decision makers' locational preferences by placing them in the context of a particular set of opportunities located in a particular spatial system at a particular moment in time.[2]

While in theory the models seek to represent the household decision making process, in practice the process is not known and households are allocated to locations on the basis of mathematical parameters determined by the aggregate past spatial behavior of decision makers as determined by multiple regression procedures, for example. The short history of household allocation models reflects an effort to overcome this problem.

The present chapter will examine these models to determine the

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[1]Shepard, op. cit., pp. 269-270.

[2]Ibid., p. 279.

attributes considered by model builders to be relevant to the decision makers' evaluation of alternative household opportunities, particularly with respect to whether they inherently ascribe to the "social choice" or "economic competition" preference structures. The examination will be confined to operational and quasi-operational models whose efficiency has been evaluated to some degree and which are used, in original or modified form, by a great number of planning agencies.[3]

THE DEVELOPMENT OF HOUSEHOLD ALLOCATION MODELS

Household allocation models developed as an adjunct to traffic assignment models about a decade ago, and with few exceptions this influence has persisted until the present time. This transportation orientation of household allocation models developed as a result of both a need for land use growth models in transportation studies and the mathematical modeling capability of transportation planners - a capability not found among land use planners until recently.[4]

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[3]Since household allocation models hardly existed prior to 1960 and many of them are in a more or less continuous state of revision, the documentation of particular models is incomplete. Consequently, this investigation may not be aware of recent innovations in their development.

[4]For an excellent compendium of methods utilized in predicting urban transportation demand including land use forecasting methods up until 1960 see: Brian V. Martin, Frederick W. Memmott, III, and Alexander J. Bone, Principles and Techniques of Predicting Future Demand for Urban Area Transportation (M.I.T. Report No. 3, Cambridge: M.I.T. Press, June, 1961). Particularly see pp. 75-96 for land use forecasting methods. Exceptions to the transportation based modeling efforts are the San Francisco CRP Urban Renewal Model developed by Arthur D. Little, Inc., the recent research models used at the University of North Carolina, and the Pittsburgh CRP Model designed by the University of Pittsburgh and CONSAD Research Corporation.

Transportation planners, concerned with the problem of predicting intraurban traffic patterns during the period 1945 - 1955, found that the gravity-type model introduced by Reilly in 1929 to describe the interurban movements of tripmakers could be used to approximate intraurban travel behavior as well.[5] Although principally devoid of behavioral considerations, this methodological advance became the basis of land use growth models. The approach is based directly on the empirical observation that the type and intensity of land use at a location is reciprocally related to the type and intensity of travel behavior at that location so that as the city grows the pattern of land use is modified; that is, the more accessible a location becomes in relation to all other locations, the more likely it will be more intensively used.[6] This observation has been explained by the "principle of least effort" which proposes that individuals prefer to choose household locations whose orientation in space or distance separation from other major urban activity locations is at a minimum. Curry points out that "the only method for describing the orientation of an individual in space is that due to Stewart."[7] Stewart's method renders an index of accessibility for any location and is expressed:

$$A_i = \sum_{j=1}^{n} \frac{S_j}{d_{ij}^{\,b}} \qquad \text{(IV.1)}$$

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[5]William J. Reilly, "Methods of Studying Retail Relationships," University of Texas Bulletin, No. 2944, 1929.

[6]Hansen, "Accessibility and Residential Growth" and "How Accessibility Shapes Land Use."

[7]Leslie Curry, "Central Places in the Random Spatial Economy," Journal of Regional Science, Vol. 7, No. 2 (Supplement, 1967), p. 236.

where:

S_j = a measure of the intensity of opportunities in an area j (employment, social, or retail trade opportunities although most household allocation procedures use employment opportunities only);

d_{ij} = the distance between area i and area j usually expressed as minutes of travel time to take into account space-transforming technological innovations between different periods of time; and

b = an empirically determined exponent describing the effect of distance on the attenuation of trips for the particular urban region under study.[8]

Accessibility measures of this type implicitly relate the household allocation process to the spatial behavior of location seekers by indicating the relative intensity of travel observed between spatially distributed opportunities and household locations as decision makers attempt to satisfy their day to day demands for goods, services, and social intercourse. In all household allocation models except one some index of accessibility is either the only attribute or the major attribute contributing to a location's level of geographic utility.

Investigations of the variation between travel patterns generated by gravity-type formulations and actually observed travel behavior reveal that the distance-decay exponent (b) varies according to: 1) the size and density of the opportunities located in different areas, 2) the purpose of the trip, 3) the distance of the area from the CBD in which the trip originates, 4) the socio-economic characteristics of the tripmaker, 5) the distance between areas, and 6) the level

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[8]John Q. Stewart, "Empirical Mathematical Rules Concerning the Distribution and Equilibrium of Population," Geographical Review, Vol. 37, 1947, pp. 461-483. See also: Stewart and Warntz, "Macrogeography and Social Science."

of technological development of the society.[9] The result of these investigations shows that gravity-type formulations require considerable manipulation of proportionality factors in order to achieve results comparable to observed travel behavior. This finding has generated considerable debate among land use forecasters in their search for an efficient residential allocation procedure. Much of this controversy has centered on the appropriateness of accessibility measures used in the procedures. Most transportation oriented investigators such as Marble feel,

> that a significant relationship exists between desired movement patterns and the amount individuals are willing to bid for specific locations as permanent residential sites.[10]

Consequently, improvement in predicting residential spatial patterns is believed to be related to improving the method of determining the desired movement patterns of decision makers. In general transportation oriented investigators agree that the gravity-type model has

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[9]A review of these findings can be found in the following sources: Gerald A.P. Carrothers, "An Historical Review of the Gravity and Potential Concepts of Human Interaction," Journal of the American Institute of Planners, Vol. 22, 1956, pp. 94-102; Walter Isard, et. al., Methods of Regional Analysis: An Introduction to Regional Science (Cambridge: M.I.T. Press, 1960), pp. 493-568; Fred Lukermann and Philip W. Porter, "Gravity and Potential Models in Economic Geography," Annals of the Association of American Geographers, Vol. 50, 1960, pp. 493-504; Gunner Olsson, "Central Place Systems, Spatial Interaction and Stochastic Processes," Regional Science Association Papers, Vol. 18, 1966, pp. 13-45.

[10]Duane F. Marble, "A Theoretical Exploration of Individual Travel Behavior," Quantitative Geography, edited by William L. Garrison and Duane F. Marble (Part I: Economic and Cultural Topics, Evanston: Northwestern University, Department of Geography, 1967), p. 36. See also: John D. Nystuen, "A Theory and Simulation of Intraurban Travel," Quantitative Geography, edited by William L. Garrison and Duane F. Marble (Part I: Economic and Cultural Topics, Evanston: Northwestern University, Department of Geography, 1967), pp. 54-83.

little to do with describing desired movement patterns but argue that it is able to approximate aggregate travel patterns, or at least render an index of the latent accessibility of a location with respect to spatially distributed opportunities.

Demographic oriented investigators, although agreeing that residential choices are related to desired movement patterns, maintain that gravity-type accessibility measures are so intertwined with the spatial system of land uses that it is too much a part of the dependent variable to be treated as an ordinary variable. Chapin and Weiss have argued that complex variables such as the gravity measure of accessibility tend "to obscure or average out the influence of otherwise dominant variables" relevant to the household allocation process.[11] Harris, recognizing the importance of other attributes in the choice of a residential location, suggests that "quite possibly an arbitrary definition of tripmaking could be applied which would produce usable results" for household allocation models.[12] Wolpert claims that the distance-decay exponent in the gravity model is the major factor hindering progress in the development of principles of spatial behavior because it provides little explanation of the actual behavior involved.[13] Schneider claims that a fundamental procedure more related to human

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[11]F. Stuart Chapin, Jr. and Shirley F. Weiss, Factors Influencing Land Development (Institute for Research in Social Science, Chapel Hill: University of North Carolina Press, 1962), pp. 8-9.

[12]Britton Harris, "Note on Residential Location in a Subnucleated Region" (unpublished paper, Institute for Environmental Studies, University of Pennsylvania, Philadelphia, March, 1966), p. 2.

[13]Wolpert, op. cit., p. 159.

behavior than the gravity model is needed.[14] Curry and Rushton suggest that a more fundamental behavioral approach, not tied to the particular spatial system under study, but possessing greater long-run stability than the distance-decay exponents in gravity models is needed.[15] Stewart and Warntz, the major proponents of the gravity-type measure of accessibility, have themselves long contended that the distance-decay exponent should be unity and the spatially distributed opportunities be manipulated by behavioral factors.[16] This investigation suggests that social distance is such a fundamental behavioral factor.

Each of these criticisms has generated research endeavors designed to produce more efficient household allocation procedures. While only a few of these are operational or quasi-operational, many of the procedures exhibit 1) a consideration of additional household locational attributes, 2) disaggregation of either travel behavior or locational behavior, and in the case of a few 3) the abandonment of the gravity measure of accessibility in favor of other methods, principally the opportunity measure. In essence the research endeavors recognize the importance of accessibility to complementary activities as an important attribute in residential choice but are seeking to understand and model attributes that render equally accessible

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[14]Morton Schneider, "Gravity Models and Trip Distribution Theory," Papers and Proceedings of the Regional Science Association, Vol. 5, 1959, pp. 51-58.

[15]Curry, op. cit., p. 219; Gerard Rushton, "The Scaling of Locational Preferences," (Research Report, Computer Institute for Social Science Research, Michigan State University, April, 1969), p. 1.

[16]William Warntz, "The Topology of Socio-Economic Terrain and Spatial Flows," Regional Science Association Papers, Vol. 17, 1966, p. 48.

locations (under present measurement methods) different levels of utility for different residential decision makers.

HOUSEHOLD ALLOCATION MODELS

The Accessibility Model

The first person to use the gravity-type model as an index of accessibility to predict the spatial allocation of households was Hansen in 1959.[17] His model is based on findings by Carroll and Bevis and Voorhees that the journey from employment locations to household locations decays in an orderly manner which can be described for any city by varying the exponential value (b) in the gravity model.[18] Figure IV.1 illustrates the influence of distance on the attenuation of trips for different exponential values. Hansen, using this evidence, reasoned that as a city grows new dwelling units would be constructed on vacant land within the most accessible distance to employment opportunities described by the distance-decay exponent.

Hansen's household allocation procedure proposes that the proportion of the total urban increase in dwelling units that can be expected to be located in a given residential area is equal to the product of the vacant land in the area times the accessibility of that area divided by the summation of the similar products for all

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[17]Hansen, "Accessibility and Residential Growth."

[18]Alan M. Voorhees, "A General Theory of Traffic Movement," Proceedings of the Institute of Traffic Engineers, 1955, pp. 46-56; J. Douglas Carroll and Edward W. Bevis, "Predicting Local Travel in Urban Regions," Papers and Proceedings of the Regional Science Association, Vol. 3, 1957, pp. 183-197.

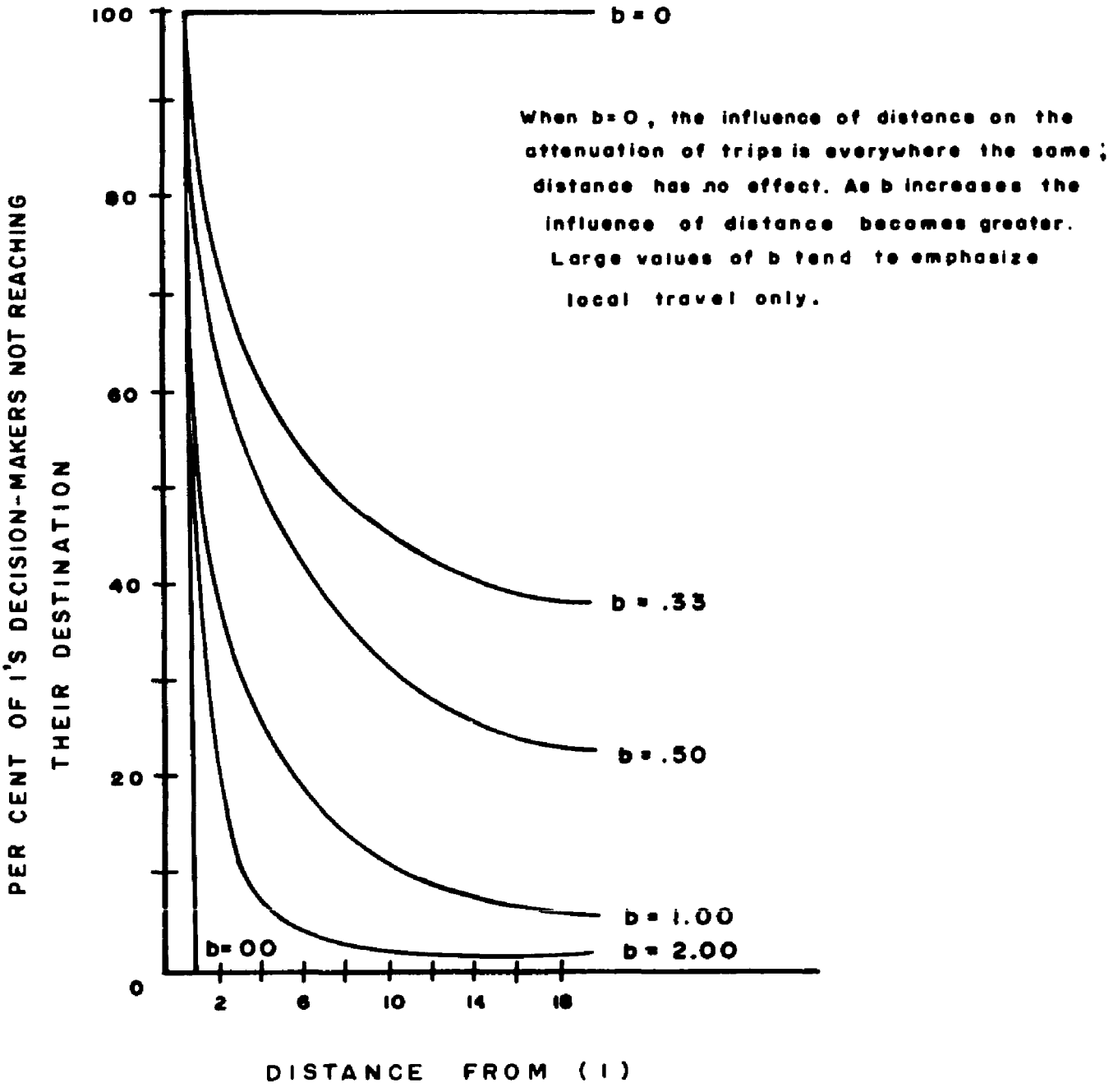

FIG. IV-1

Gravity or impedance model distribution of trip attenuations with distance from i

areas in the urban region.[19] The generalized form of the model is:

$$\Delta H_i = H_t \frac{A_i^{\,c} V_i}{\sum_{i=1}^{n} A_i^{\,c} V_i} \qquad \text{(IV.2)}$$

where:

ΔH_i = the predicted proportion of total urban growth (in dwelling units) in a given residential area i;

H_t = the total urban increase in dwelling units;

V_i = the available vacant land in area i;

A_i = the accessibility index to employment opportunities for area i; and

c = an empirically determined exponent describing the effect of the accessibility index on the allocation of households for the particular urban region under study.

Lowry's "Model of Metropolis" allocates households in much the same manner as Hansen's procedure except that Stewart's index of accessibility only is used, and households are allocated to residential areas subject to a maximum density constraint (zoning restrictions) which sets a ceiling on the number of households that can be assigned to an area

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[19] Hansen's model does not contain any constraint to limit the total number of household units that can be assigned to an area. The model serves as a probability function similar to the competing accessibility models used in retail trade allocation studies. The probability model can be stated:

$$P(H_i) = \frac{\sum_{j=1}^{n} \left(\frac{S_j}{d_{ij}^{\,b}}\right)^{a} V_i}{\sum_{i=1}^{n}\sum_{j=1}^{n} \left(\frac{S_j}{d_{ij}^{\,b}}\right)^{a} V_i}$$

during any period thus forcing surplus households to be allocated elsewhere.[20] The constraint may be expressed:

$$H_i \leq (V_i + D_i) Z_i \qquad \text{(IV.3)}$$

where:

H_i = the total number of dwelling units that can be contained in a residential area i during an iteration period;

V_i = the amount of usable vacant land in an area i in an iteration period;

D_i = the amount of developed residential land in an area i in an iteration period; and

Z_i = the number of dwelling units permitted per unit of residential space in area i in an iteration period.

Tests of the Hansen model show that the two attributes, accessibility to employment opportunites and availability of vacant land, do not produce estimates of sufficient reliability for practical purposes.[21] The same may be said for the Lowry model. Despite this, a number of theorists believe that the model possesses several creditable features which can provide a structure for a more accurate allocation procedure.[22]

The Regression Model

The vast majority of household allocation models developed are linear formulations which estimate residential growth by regression techniques utilizing a number of attributes found relevant to land development as viewed by those making locational decisions. The

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[20] Ira S. Lowry, A Model of Metropolis (Santa Monica: The RAND Corporation, August, 1964).

[21] Hansen, "Accessibility and Residential Growth," p. 1.

[22] Wingo, Transportation and Urban Land, pp. 15-16.

procedure is to determine the attributes and their weights which in a linear combination can be related to the amount of growth which has been observed to take place over a past period. The model can be applied to the individual analysis areas to forecast the magnitude of growth. Such models have the form:

$$\Delta H_i = a_o + b_1X_1 + b_2X_2 + \ldots + b_nX_n \qquad \text{(IV.4)}$$

where:

$X_1, X_2, \ldots X_n$ = the attributes found relevant to the household allocation process; and

$a_o, b_1, \ldots b_n$ = proportionality coefficients to be determined by regression.

Lakshmanan, for example, found that the residential growth that could be expected in a given area was a function of the following attributes:

1) the available (vacant) residential land in the area;

2) the accessibility of the area to employment opportunities;

3) the per cent of the area possessing sewer and water services;

4) the value of housing in the area, measured by the product of the median housing value and prevailing density of housing in the area;

5) the prestige level of the area, measured by the income of families and unrelated individuals;

6) the per cent of new houses built in the area during the previous decade; and

7) the per cent of non-whites living in the area.[23]

Chapin, Weiss, and others have found essentially the same factors to be significant attributes in the residential decision making process although they argue that greater disaggregation of decision makers and

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[23] T. R. Lakshmanan, "An Approach to the Analysis of Intraurban Location Applied to the Baltimore Region," Economic Geography, Vol. 40, No. 4, 1964, pp. 348-370.

more specific attributes of residential areas are needed to filter out the distinct preferences of location seekers.[24] They contend that concentration on the desired movement patterns of decision makers as they go about their daily activities will contribute to solving the problem.

Intervening Opportunity Models

The evidence that the single exponent gravity-type model of accessibility produced poor estimates of the actual distribution of household growth led to the development of new procedures to determine the accessibility attributes of different residential areas. The procedures are based on a firm conviction that accessibility is the most important attribute considered by decision makers in their choice of a household location but that gravity-type measures are inappropriate for determining the level of accessibility of an area. Although more commonly applied to the traffic assignment problem, intervening opportunity measures of accessibility have been used in regression and other formulations to simulate residential growth. Figure IV.2 illustrates the manner in which trips attenuate over distance using this measure of accessibility. Both the Stouffer and Schneider formulations have been used although the latter has received greater attention.[25]

The general notion behind both formulations is that the probability that a vacant household location opportunity will be chosen by a

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[24]Chapin and Weiss, op. cit., p. 9; Chapin and Hightower, op. cit., pp. 54-74.

[25]Samuel A. Stouffer, "Intervening Opportunities: A Theory Relating Mobility and Distance," American Sociological Review, Vol. 5, No. 6, (December, 1940).

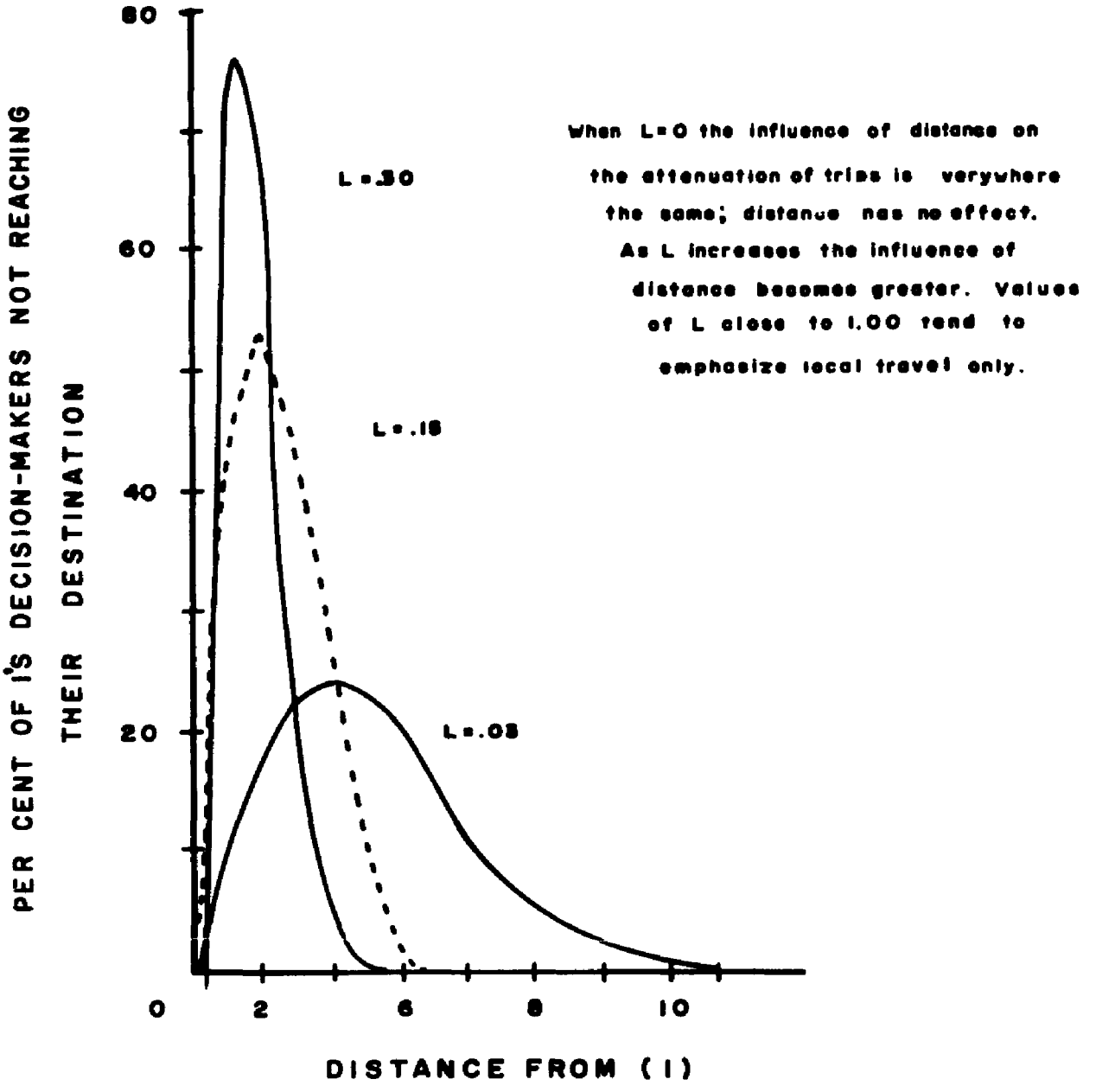

FIG. IV·2

Opportunity model distribution of trip attenuations with distance from I

decision maker decreases as some function of the number of intervening household opportunities ranked in order from the central core of the city. As applied to the distribution of residential growth by Hamburg and Lathrop, the Schneider model can be expressed:

$$H_t - H^i_{j-1} = H_t e^{-LV^i_{j-1}} \qquad \text{(IV.5)}$$

where:

H_t = the total urban increase in dwelling units to be allocated;

H^i_{j-1} = the cumulative number of dwelling units already allocated ranked from the central zone i up to zone j;

V^i_{j-1} = the cumulative number of vacant household sites available for residential purposes ranked from the central zone i up to zone j;

e = the base of the natural logarithm; and

L = an empirically determined model parameter expressing the probability that vacant household opportunities will be chosen for residences.[26]

Consequently the growth (ΔH_i) to be allocated to any one zone is:

$$\Delta H_i = (H_t - H^i_{j-1}) - (H_t - H^i_j) \qquad \text{(IV.6)}$$

As a necessary condition for applying this model the parameter value (L) must be stipulated. The (L) value, like the (b) value in gravity-type measures, is a function of the characteristics of the particular spatial system under study. Experience with the intervening opportunity model shows that like the gravity-type accessibility model at least two (L) values must be used, one for the central city zones and one for

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[26] J. R. Hamburg, G. T. Lathrop, and G. F. Young, "An Opportunity-Accessibility Model for Allocating Regional Growth," (Highway Research Record 102, Washington: Highway Research Board, 1965), pp. 54-66; J. R. Hamburg and G. T. Lathrop, "An Opportunity-Accessibility Model for Allocating Regional Growth," Journal of the American Institute of Planners, May, 1965, pp. 95-103.

more suburban zones.[27]

Interactance Household Allocation Models

Interactance models are devices that use more than one measure of accessibility, usually in a regression format, to allocate households to residential areas.[28] The idea, suggested by Hansen and Lowry and modeled by Crecine, is an attempt to take into account both the observed variation in travel and locational behavior of different categories of decision makers.[29] Recognizing the Duncans' findings that decision makers belonging to different occupational categories exhibited different residential location patterns, Lowry found that tripmakers belonging to different occupational categories attenuated trips differently (Figure IV.3). Crecine's Time-Oriented Metropolitan Model

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[27]It has become standard practice to determine values of (L) for short trips and long trips in applying the Schneider formula as a trip distribution model.

[28]The interactance index of accessibility of an area was suggested by Hansen and developed by Tomazinis. The index represents the sum of three partial accessibilities (s = social, c = commercial, and e = employment) and is expressed:

$$A_i = \sum_{j=1}^{n} (A_s + A_c + A_e)$$

Interactance models are linked gravity models which describe the relationship between spatially distributed opportunities and distance for different trip purposes. Travel patterns simulated by this model are considerably more accurate than those produced by the simple gravity model. See: Anthony R. Tomazinis, "Spatial Parameters Affecting Urban Traffic," (paper presented to the Origin and Destination Survey Committee Meeting of the Highway Research Board, January 9, 1961), pp. 27-32.

[29]John P. Crecine, A Time-Oriented Model for Spatial Location (Technical Bulletin No. 6, Pittsburgh: Department of City Planning, January, 1964). See also: John P. Crecine, A Dynamic Model of Urban Structure (Santa Monica: The RAND Corporation, March, 1968).

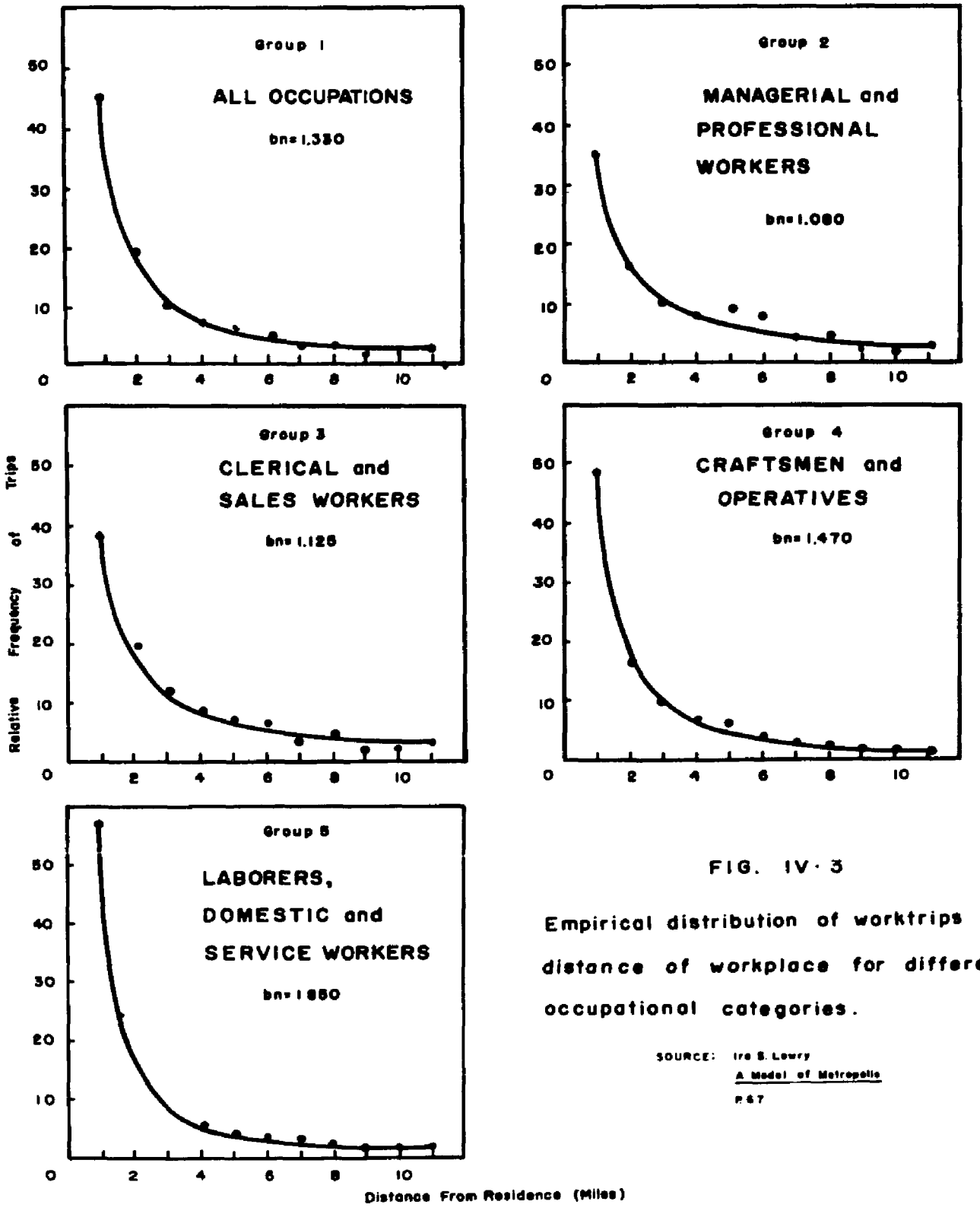

FIG. IV·3

Empirical distribution of worktrips by distance of workplace for different occupational categories.

SOURCE: Ira S. Lowry
A Model of Metropolis
P.67

(T.O.M.M.) utilizes this information to allocate households. The model disaggregates decision makers into three employment categories and determines the journey-from-work distance-decay parameter for each category. The model also disaggregates households into six types although little indication is given as to what the types should be.[30] In effect, the T.O.M.M. model states that household locations for a particular household type depend upon the following attributes of an area: 1) the presence of similar type households, 2) the level of the amenities supplied by the municipality, and 3) the nearness of sources of employment. By disaggregating decision makers and household types Crecine has reduced the level of abstraction found in earlier models and at the same time increased the descriptive aspects of the household allocation process. Lee, however, has argued that Crecine's household types, as well as those in other models, are unrealistic.[31] He derived a classification of household types using factorial ecology methods described previously and employed a version of the T.O.M.M. model to test its efficiency as an allocation mechanism using this classification. Lee's model is:

$$\Delta H_{ki} = a_o + b_1 H_{ki} + b_2 \left| \frac{H_{ki}}{\sum_{k=1}^{n} H_{ki}} \right| + b_3 A_{ki} + b_4 A_{ei} \qquad (IV.7)$$

where:

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[30] Crecine suggests that households should be stratified by income, A Dynamic Model of Urban Structure, p. 15.

[31] Douglass B. Lee, Jr., "Household Disaggregation in Urban Models," (unpublished paper presented at the annual meeting of the Regional Science Association, Cambridge, November, 1968).

ΔH_{ki} = the increase in the number of households of type k allocated to area i;

H_{ki} = the number of households of type k presently located in area i;

$\frac{H_{ki}}{\sum_{k=1}^{n} H_{ki}}$ = the ratio of the number of households of type k presently located in area i compared to the total number of households of all types located in the area;

A_{ki} = the accessibility of area i to all type k households; and

A_{ei} = the accessibility of area i to employment opportunities. (In Crecine's model three such measures are used.)

The total increase in the number of households to be allocated to an area is:

$$\Delta H_i = \sum_{k=1}^{6} \Delta H_{ki} \qquad \text{(IV.8)}$$

The model is of particular interest because it contains the notion that residential location is a function of the location of complementary activities; that is, a decision maker will tend to choose a household location that will facilitate his interaction with employment opportunities and status equals. Since it does not permit interaction with more or less prestigeous decision makers, however, it violates a necessary condition of the "social choice" hypothesis. The "social choice" hypothesis does not confine social interaction to status equals only but proposes that decision makers interact selectively with all status groups depending on their social-distance preferences. The degree of selective interaction is well illustrated in Laumann's study of the propensity of decision makers belonging to different occupation categories to confine their social relationships to individuals belonging

to similar or different occupation categories.[32]

THE EFFICIENCY OF HOUSEHOLD ALLOCATION MODELS

There is a dearth of information pertaining to the efficiency of household allocation procedures. Only with models operationalized prior to 1965 has there been any comparative evaluation of their predictive powers. While there is little information available that indicates the efficiency of interactance models, Swerdloff and Stowers have determined the relative accuracy of the other procedures discussed in this chapter by testing their efficiency to predict the spatial growth of households in Greensboro, North Carolina, between 1948 and 1960.[33] Among the procedures tested were the accessibility, opportunity, and regression type models.

Swerdloff and Stowers conclude that each of these models "are sufficiently accurate to be recommended for use in relatively small metropolitan areas of 100,000 population or larger" providing that the disaggregated analysis areas contain a population of about 2,000 persons.[34] Efforts to forecast growth for areas containing smaller populations are less efficient. They found that "differences in accuracy among the forecasting methods are not large enough to warrant a strong

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[32] Neither does Lee's model take into account the fact that location seekers may incorrectly perceive the existence of decision makers belonging to different status groups to reside in an area. Laumann's social distance findings allow for this behavior.

[33] Carl N. Swerdloff and Joseph R. Stowers, "A Test of Some First Generation Land Use Models," (Highway Research Record No. 126, Washington: Highway Research Board, 1966), pp. 38-59.

[34] Ibid., p. 56.

recommendation for any single one in preference to others."[35] However, "the simple accessibility model yielded the most accurate forecast of all methods used without benefit of calibration to time-series data."[36] They go on to state that "none of the multiple linear regression models tested offered improvement over two-variable fitted models despite the fact that five or more factors were included in the regression equation."[37] They also felt that the efficiency of opportunity models could be improved "by allocating growth from all major centers of employment rather than from just one single point."[38]

While it is interesting that the accessibility model was found to be the most reliable, even to the point of being relatively insensitive to small changes in the distance-decay exponent, Hansen concluded that the model did not produce estimates of sufficient reliability for practical purposes. He found that:

> a comparison of the estimated growth to the actual growths showed that 40 per cent of the zonal estimates were within 30 per cent of the actual growths and 70 per cent of the zonal estimates were within 60 per cent of the actual figures.[39]

Harris suggests that sixty-six per cent of the estimates should be within ± twenty per cent of the actual growths to be considered useful

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[35] Ibid.

[36] Ibid.

[37] Ibid.

[38] Ibid.

[39] Hansen, "How Accessibility Shapes Land Use," p. 75.

but that even this much error is too great for planning purposes.[40]

SUMMARY

The household allocation procedures discussed in this chapter are representative of operational residential simulation models. The models are essentially descriptive in character and are hueristic devices based on empirically observed correlations rather than theoretical cause and effect explanations.

The empirically observed correlation which forms the basis for each model discussed is that the journey from work of the aggregate labor force declines in relative frequency with distance from the place of employment; and this decline has a strong resemblance to both the negative exponential decline of population and the negative exponential decline of urban land values with distance from the central core of the city.[41] As a consequence of this correlation allocation models are

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[40]Britton Harris, Quantitative Models of Urban Development: Their Role in Metropolitan Policy-Making, (Institute for Environmental Studies, Philadelphia: University of Pennsylvania, May, 1967), p. 24.

[41]Theorists that would incorporate a social choice dimension in allocation models agree that the pattern of urban land values and land uses clearly indicate that the urban land market is dominated by non-residential location seekers, but they point out that most residential land has a land value density which is less than five per cent of the city's peak value land and generally greater than one per cent. Since residential land accounts for most of the urban space, they claim that land values cannot have the same effect in allocating residential sites as they do in allocating non-residential sites. The population density distribution itself pertains to a technological era that doesn't exist anymore but remains relatively stable because of historical development and institutional rigidities; that is, 1) the permanency of the transportation route grid, 2) the manner in which decision makers discount existing structures, 3) sentimental ties to existing locations, and 4) zoning restrictions. Most of our cities were initially developed at a period in time when the technology and social structure could allow economic equilibrium explanations, but space-transforming technological innovations and evolving social structure make these explanations suspect today.

highly transportation oriented and tend to view the spatial behavior of decision makers as revealing locational preferences associated with the "economic competition" hypothesis; that is, household location seekers substitute accessibility to work expenditures (situation utility) for household site expenditures (place utility) with the rate of substitution depending upon the decision makers' preference for "low density housing," "more spacious living conditions," or "better housing." The chapter noted, however, that the models did not consider these preferences but that in all likelihood they are somehow tied up in the proportionality factors used to calibrate and adjust the models. This was found to be particularly true with the accessibility and opportunity-type models. While it is also true with regression models, the inclusion of certain amenities found to be important site attributes, such as the prestige level of the area, suggests the "social choice" hypothesis; that is, household location seekers substitute accessibility to work for household sites with the direction of the substitution depending upon the decision makers' preference to be close to the households of compatible or more prestigeous decision makers.

The trend in model building suggested by the interactance model and other non-operational attempts reveals a belief that the key to improving forecast accuracy lies in the model's ability to simulate the spatial behavior of subpopulations. Improvements introduced in interactance models and other non-operational models include: 1) more complex statistical estimating procedures, 2) the stratification of residential location seekers into several distinct groups, and 3) the incorporation of behavioral relationships in the model formulation.

Chapter Three proposed that a consideration of the behavioral relationships revealed by the empirically observed correlation between the differential social-distance preferences of decision makers and the differential residential segregations of occupations in the city may constitute such an improvement.

A residential household allocation model that considers this correlation will be presented in the next chapter and tested in the following chapter.

CHAPTER V

A MODEL FOR PREDICTING THE SPATIAL ALLOCATION OF HOUSEHOLDS TO RESIDENTIAL AREAS OF THE CITY

Previous chapters have discussed the locational preferences of residential decision makers and attempts to model residential locational behavior. Chapter Three proposed the "social choice" hypothesis as an alternative approach to the "economic competition" hypothesis to explain the differential residential distribution of socio-economic groups in urban space. In that chapter it was argued that the spatial behavior of residential location seekers revealed they substituted household sites close to compatible or more prestigeous decision makers for accessibility to the major urban functions (essentially places of work). Chapter Four found instead that virtually all land use allocation models are based on the proposition that a significant relationship exists between the accessibility to employment opportunities of a location and the intensity of land use at that location. Consequently, the more accessible an area is to employment opportunities, the greater will be its potential for residential development. As can be expected models based on this approach, such as Hansen's and Lowry's, tend to underestimate total suburban residential growth. On the other hand the inclusion of some measure of the level of amenities or prestige of an area such as in Chapin's and Weiss' model tends to overestimate total suburban growth.

More recently proposed interactance and linear programming models attempt to account for the differential locational behavior of different groups of decision makers. Despite the fact that these models are based on the "economic competition" hypothesis, three major problems exist in operationalizing them: 1) the lack of compatible time-series data; 2) the lack of a suitable mathematical formulation to treat the hypothesized behavioral relationships; and 3) the difficulty of disaggregating decision makers into groups that reveal similar locational behavioral patterns. The present chapter proposes a household allocation model containing the behavioral patterns discussed in Chapter Three, without an inordinate amount of mathematical complexity and data stratification but at the same time allowing for several groups of decision makers believed to have characteristically similar locational behavior and preference patterns. The model is sensitive to the "subjective" accessibility patterns of the different groups of residential location seekers, the household unit capacity of the urban region's residential areas, and land use competition between residential and non-residential decision makers. The following chapter will evaluate this household allocation model along with two other models to test their efficiency in predicting the spatial assignment of households to different socio-economic areas of the urban region. The degree of correspondence between the actual pattern of residential growth and the predicted pattern provides a means of verifying the "social choice" hypothesis (that is, the locational preferences associated with this hypothesis) as being relevant to the household decision maker's choice of a residential site.

BASIC PREMISES AND THE CHOICE OF SIGNIFICANT VARIABLES

The choice of significant variables, as well as a quantitative statement to express the relationship between them, has proven to be a major problem in the simulation of the household allocation process. Most model builders choose variables on the basis of hypothesized relationships they believe to be relevant to the problem. Their principal concern is to establish whether or not they actually are. At other times the variables are chosen on the basis of past investigations and experimentation. These model builders argue that the variables have been found relevant to the allocation procedures and, therefore, should be taken into account. Characteristically, in all cases variables are chosen on the basis of limiting conditions: either they result from simplifying model assumptions deemed necessary to test specific hypotheses, or they result from the lack of availability of data. Characteristically also, models require the calibration of variables to fit the forecast values to the actual real-world values. The model presented here will, in part, utilize variables that have been found relevant to the allocation procedure in the past and, in part, utilize variables hypothesized as being relevant to a more efficient allocation procedure.

Household allocation models are based on the premise that residential construction is market-determined and is a function of the number and character of employment opportunities found in the urban region. Evidence indicates that employment in the basic economic activities provides the primary impetus in determining the number, quality, and location of households. In turn, the location, type, and size of the non-basic economic activities, such as stores and shopping

centers, are dictated by the location, number, income, and buying habits of the consumers located in the area.[1] The employment opportunities found in the non-basic activities give rise to additional residential construction distributed with respect to the location of these activities and the availability of space. Location seekers choose household sites on the basis of space preferences associated with their ability and desire to overcome spatial separation from their subjective set of complementary activities. Similarly the location and size of public facilities, such as schools, utility lines, streets and thoroughfares, are controlled by the same market determinants of supply and demand and are distributed in urban space in an attempt to satisfy the variable and competing demands of residential, commercial, and industrial land users. Consequently, the urban spatial structure is related to both the historical development of an area and the different functions found there.

Variables Related to Vacant Land and the Real Estate Developer

Although residential decision makers choose household sites from among the alternative opportunities they perceive in the urban space, it is clear from the above discussions that it is not generally the individual decision maker who is directly responsible for the location of household units constructed in space. Usually it is a real estate speculator who develops a large tract of vacant land during one period of time based on his knowledge of the local housing market. Several household allocation studies have found vacant land to

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[1]See for example: Arthur Getis, "The Determination of the Location of Retail Activities with the Use of a Map Transformation," Economic Geography, Vol. 39 (January, 1963), pp. 14-22.

be a significant variable in the residential development process.[2] Evidence indicates, however, that only certain amounts of vacant land are released in each area during any single period of time. This amount is contingent on variables, such as zoning restrictions, speculative holding, and deterioration of the existing building stock.

The accounting for vacant land release is a major problem in land use allocation models because if all the vacant land is released for development purposes, areas close to the central core would rapidly be depleted of all their vacant land. However, central core areas do contain vacant land, although it is a small portion of their total area. The release of vacant land can be partially accounted for by the use of three constraints that restrict the amount of residential construction in each area.[3] The constraints are: 1) an areal density

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[2]Land use inventory data for the years 1960 and 1965 are not available in the study area. The data used in the investigation was estimated from the 1955 and 1962 land use inventories. The estimating formula used to determine the amount of projected, higher-ordered, non-residential land use changes for each analysis area was:

$$PTOT_i = 5/7(1962\ APIC_i - 1955\ APIC_i)$$

where: $APIC_i$ = the amount of land in acres in an area developed for public, industrial, and commercial use.

The estimating formula used to determine the 1960 land use inventory for each area in acres for each individual category was:

1960 Land Use = (1955 Land Use) + 5/7(1962 Land Use - 1955 Land Use).

[3]The mechanism used to determine the amount of vacant land released for development purposes has a number of imperfections. For example, it does not take into account that new vacant land is continuously being created in areas by the demolishing of existing structures. Neither does the mechanism allow housing to be constructed at a higher residential density than presently exists in each area. The first problem can be solved by determining a deterioration and demolition sub-model, and the second by allowing housing units allocated to an area to be developed up to the maximum density allowed in the area by the zoning code. Since data pertaining to these problems are not

constraint that controls the household holding capacity of each area during the period; 2) a residential density constraint that controls the density of housing in each area; and 3) a zoning constraint that controls the maximum amount of land in each area that can be used for residential purposes.

The areal density constraint limits the total number of new dwelling units that can be assigned to each area during the period. The value of the constraint changes from period to period as more dwelling units are constructed or demolished in the area. The areal density constraint is calculated by the equation:

$$ZH_i^{t+1} = \frac{DU_i^{t+0}}{ATOT_i - AUNUSE_i^{t+0}} \qquad (V.1)$$

where:

ZH_i^{t+1} = the dwelling unit density per acre of total usable land in an area during the period;[4]

$ATOT_i$ = the total amount of land in acres in an area;

$AUNUSE_i^{t+0}$ = the amount of unusable land in acres in an area at the beginning of the period (such as rivers and lakes); and

DU_i^{t+0} = the total number of dwelling units in an area at the beginning of the period.

If it is assumed that real estate developers will construct dwelling units at the existing residential density in each area, the total

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readily available in the study area, and the forecast period is short, an accounting of vacant land made available by their consideration may not affect the model output too seriously.

[4] In essence the constraint does not allow beginning-of-the-period densities to be exceeded. While this is an unrealistic constraint over the long run, it can be used to approximate short run conditions. Consequently the length of the iteration period should also be used to determine the value of the areal density constraint.

number of households will be developed on only a portion of the total vacant land in an area. To determine this portion the residential density constraint must first be determined by calculating:

$$ZR_i^{t+1} = \frac{DU_i^{t+0}}{ARES_i^{t+0}} \qquad (V.2)$$

where:

ZR_i^{t+1} = the maximum number of dwelling units that can be constructed on an acre of land in an area during the period;

$ARES_i^{t+0}$ = the amount of residential land in acres in an area at the beginning of the period; and

DU_i^{t+0} = the total number of dwelling units in an area at the beginning of the period.

Hence, the amount of residential land in acres for each area at the end of the time period can be determined by calculating:

$$ARES_i^{t+1} = ARES_i^{t+0} + \frac{\Delta H_i^{t+1}}{ZR_i^{t+1}} \qquad (V.3)$$

where:

$ARES_i^{t+1}$ = the updated amount of residential land in acres in an area;

$ARES_i^{t+0}$ = the amount of residential land in acres in an area at the beginning of the period;

ΔH_i^{t+1} = the number of household units allocated to an area during the period; and

ZR_i^{t+1} = the maximum number of household units that can be constructed on an acre of land in an area during the time period.

However, if it is also assumed that the total amount of residential land cannot exceed the amount of land zoned for household use, the number of new dwelling units that can be assigned to an area is further constrained by zoning restrictions. The problem here is that zoning restrictions are subject to change, especially under demand

pressures. The constraint is expressed:

$$ARES_i^{t+1} \leq ZRES_i^{t+0} \qquad (V.4)$$

where:

$ARES_i^{t+1}$ = the amount of residential land in acres in an area at the end of the time period; and

$ZRES_i^{t+0}$ = the amount of land in acres zoned for residential use in an area.

The updated amount of vacant land can then be calculated by the equation:

$$AVAC_i^{t+1} = AVAC_i^{t+0} - \left(\frac{\Delta H_i^{t+1}}{ZR_i^{t+1}} + APIC_i^{t+1} \right) \qquad (V.5)$$

where:

$AVAC_i^{t+1}$ = the updated amount of vacant land in acres in an area;

$AVAC_i^{t+0}$ = the amount of vacant land in acres in an area at the beginning of the period;

$\frac{\Delta H_i^{t+1}}{ZR_i^{t+1}}$ = the newly developed amount of residential land in acres in an area; and

$APIC_i^{t+1}$ = the updated amount of previously vacant land in acres in an area developed for public, industrial, and commercial use during the period.

Finally, the amount of vacant land released in each area during the time period is calculated by the equation:

$$RVAC_i^{t+1} = AVAC_i^{t+0} - AVAC_i^{t+1} \qquad (V.6)$$

where:

$RVAC_i^{t+1}$ = the amount of vacant land in acres released for development purposes in an area during the period;

$AVAC_i^{t+1}$ = the updated amount of vacant land in acres in an area; and

$AVAC_i^{t+0}$ = the amount of vacant land in acres in an area at the beginning of the period.

Hansen's model, the more accurate of the operational household allocation procedures, is one that treats the likelihood that real estate developers choose large tracts of vacant land accessible to employment opportunities. However, the formulation has no statement that would account for the differential types of decision makers likely to choose households developed on the tracts or the amount of land released for development purposes in the area, nor does it allow market competition for the vacant space between residential and non-residential decision makers.

Variables Related to Land Use Competition Between Non-residential and Residential Developers

In order to treat land use competition, it is necessary to assume a "pecking" order in land use activities based on the relative rent paying ability of the various uses. The urban land use allocation process reveals that higher-ordered non-residential location seekers are able to pre-empt sites from residential location seekers because of their higher rent paying ability. In turn residential location seekers are able to pre-empt sites from lower-ordered non-residential land users.

In the spatial allocation model industrial, commercial, and public land users are assumed to be able to bid land away from any or all residential, agricultural, and vacant land users if necessary (even though in some areas of the urban region during some periods of time some land uses, such as high-rise apartments, may possess a higher pecking order than is commonly associated with them). Residential land users, on the other hand, are assumed to be able to bid away any or all of the remaining cropland, woodland, pasture land, or vacant

land in the area.

For this reason and the sequential development pattern exhibited in the growth of cities, household allocation models should follow a recursive procedure which first assigns exogenously projected, higher-ordered, non-residential land use changes to the various areas of the urban region.[5] This assignment can then be followed by an increment of residential growth allocated on the basis of the attractiveness of the areas to residential location seekers and the holding capacity of the areas. The holding capacity of each area is updated at the end of the iteration period according to the new distribution, and a second increment of residential growth is allocated based on the new exogenously specified changes, a new holding capacity, and a re-evaluated index of attractiveness. This procedure continues for as many iteration periods as is deemed necessary.

The recursive procedure helps to account for land use competition by usually reducing the amount of available land that otherwise may be allocated for residential purposes. The reduced available vacant land for residential purposes is calculated according to the equation:

$$VAC_i^{t+0} = AVAC_i^{t+0} - PTOT_i^{t+1} \qquad (V.7)$$

where:

VAC_i^{t+0} = the available vacant land in acres in an area for residential purposes after pre-emption by non-residential location seekers;

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[5] A recursive procedure consists of a series of sequential forecasts where output from one forecast is used as input for the next in the series. An iteration period (also called recursive in time) consists of a series of sequential forecasts, each of a different point in time and each using about the same functional relationships between input and output, where output from the forecast of one point in time is used as input for the forecast of the next point in time.

$AVAC_i^{t+0}$ = the available vacant land in acres in an area at the beginning of the forecast period; and

$PTOT_i^{t+1}$ = exogenously projected non-residential land use changes in acres in an area.[6]

The recursive procedure allows residential land users to pre-empt land from lower-ordered, non-residential land users although this land is usually marginal agricultural land which is considered as vacant.

Variables Related to the Attractiveness of Areas for Residential Location Seekers

Many first-generation spatial allocation models assume that all location seekers evaluate alternative household opportunities in a similar way; that is, all location seekers choose locations that maximize their accessibility to employment opportunities. Current computer generated household allocations are limited to this single space preference of location seekers so that a residential area's attractiveness is dependent on its degree of accessibility to all employment opportunities in the urban region. The level of simplicity and the accuracy achieved by the models demonstrate the importance of the location of

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[6] In some urban areas where the land requirements of non-residential location seekers exceed the amount of available land for development purposes, household units are "demolished" by land use competition according to the equation:

$$-\Delta H_i^{t+1} = -VAC_i^{t+0}(ZH_i^{t+1})$$

where:

$-\Delta H_i^{t+1}$ = the number of household units demolished in an area;

VAC_i^{t+0} = the additional non-residential land use requirement in acres that is greater than the amount of vacant available land in an area; and

ZH_i^{t+1} = the maximum number of household units that can be constructed in an area during the time period.

employment opportunities in conditioning the spatial distribution of households. However, the evidence of residential segregation by occupation categories has prompted several researchers to maintain that the incorrectly predicted portion of the household locational behavior can be explained by stratifying the location seekers by the occupation categories. Such a stratification takes into account the difference in the size and location of different categories of employment opportunities distributed in the urban region. Consequently, some employment opportunities, such as sales, clerical, and managerial, are more concentrated in the central core, while others, such as professional and working class employment opportunities, are more dispersed throughout the urban region.[7]

A model based on this stratification not only may provide a more accurate allocation procedure, but, more important, it can serve to clarify the problem of which occupational groups reveal the greater tendency toward an accessibility to work space preference. In the present investigation an urban area's attractiveness for potential residential development is partly accounted for by the area's accessibility to employment opportunities in the location seeker's occupation category and is expressed by the following constructed variable:

$$AE_{ki} = \sum_{j=1}^{n} \frac{EMP_{kj}}{(D_{ij}+T)^{b_k}} \qquad (V.8)$$

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[7]James O. Wheeler, "Some Effects of Occupational Status on Work Trips," Journal of Regional Science, Vol. 9 (April, 1969), pp. 69-77; James O. Wheeler, "Occupational Status and Work Trips: A Minimum Distance Approach," Social Forces, Vol. 45, 1967, pp. 508-515; James O. Wheeler, "Work-Trip Length and the Ghettos," Land Economics, Vol. 44, 1968, pp. 107-112.

where:

AE_{ki} = an index of the potential accessibility of an area i to all employment opportunities in the location seeker's occupation category k;

EMP_{kj} = the number of employment opportunities in category k existing in an area j (k = 1, 2, . . . m);

D_{ij} = the time-distance between area i and area j (It has been found that the accounting for five or six minutes of terminal-time T added to the travel-time produced better household allocation predictions); and

b_k = an exponent describing the attenuation of trips over distance for decision makers in occupation category k.[8]

The accessibility to work locational preference is generally recognized as not providing an adequate basis for residential decision makers' locational behavior in that it does not allow for the achievement of social goals or for social processes to take place.[9] It has been argued that while some location seekers reveal a work-place accessibility locational preference, most residential spatial behavior

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[8]This equation is similar to other measures of accessibility to employment in that:

$$A_i = \sum_{k=1}^{m} AE_{ki}$$

where: A_i = the total potential accessibility to employment opportunities for all classes of decision makers.
k refers specifically to opportunities for interaction defined by an occupation category. In the employment accessibility index it refers to spatially distributed employment opportunities by occupation category. In the social accessibility index o refers to the spatial distribution of social opportunities by the occupation category of the heads of households.

[9]Britton Harris, "Report of Dartmouth Conference on Urban Development Models" (Institute for Environmental Studies, Philadelphia: University of Pennsylvania, 1968).

reveals an innate propensity to reside close to compatible neighbors that are their friends or whom they would like to have for friends.

In addition to the accessibility to work preference three additional space preferences have been hypothesized to account for the geographical bias revealed by residential location seekers in their choice of a household regardless of the spatial system in which they exist: 1) the family life-style preference; 2) the racial or ethnic preference; and 3) the social-distance preference. These locational preferences have been defined as attitudes or desires on the part of location seekers that limit their choices of household sites from among the available household opportunities. With respect to the "social choice" hypothesis the more important of these is the social-distance preference. Through the use of Laumann's findings of the degree of propensity for location seekers to confine their social relationships to decision makers in the various occupation categories, a method of treating social-distance preferences in the household allocation process can be undertaken.[10] The procedure also takes into account the fact that location seekers may incorrectly perceive the existence of a particular social group or several different groups in a residential area.

The method utilizes the reference group identification matrix described in Chapter Three to adjust the social opportunities found in each residential area. This is accomplished by using Laumann's objective social-distance probability of a location seeker in a particular occupation category to interact with decision makers in similar or different occupation categories. The procedure renders

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[10]Laumann, op. cit., pp. 63-87.

an index of the attractiveness of an area based on the probability of having a neighbor in a particular occupation category. Such a procedure can serve to clarify the problem of which occupational categories reveal the greater tendency toward a social-distance space preference. The index of accessibility to social opportunities is expressed by the following constructed variable:

$$AS_{ki} = \sum_{j=1}^{n} \sum_{o=1}^{m} \frac{SOC_{oj} P_{ok}}{(D_{ij}+T)^{b_k}} \qquad (V.9)$$

where:

AS_{ki} = an index of the potential accessibility of an area i to all decision makers belonging to different occupation categories o based on the propensity for interaction with individuals in the occupation category by a location seeker in occupation category k;

SOC_{oj} = the number of male decision makers residing in an area j employed in category o (o = 1, 2, . . . m);

P_{ok} = a reference group identification matrix expressing the probability of a male location seeker in occupation category k having a male neighbor in employment category o; and

D_{ij}, T and b_k = the time-distance, terminal-time, and distance-decay exponent explained previously.

THE SPATIAL ALLOCATION MODEL

Derivation of the Model

The attractiveness of an urban area for residential development is hypothesized to be related to the amount of available vacant land in the area and its proximity to employment opportunities and compatible neighbors for different groups of location seekers.[11] To develop

[11]Through experimentation with the land use allocation model, it has been found that vacant land refers to woodland, cropland, and pasture land as well as unused land. It does not treat unusable land such as water bodies.

this proposition into a model which determines the number of new households which will be allocated to a particular residential area, a simple probability point of view may be taken. Suppose there is an urban region in which ΔH_t new household units are to be allocated. Let the region be divided into numerous residential areas j. Let there also be known the amount of vacant land VAC_t in the urban region, so that each residential area differs in its amount of vacant land. Further, let there be no significant differences among residential areas in the socio-economic status, family life-style, or racial and ethnic preferences of the resident population. In addition assume that there are no costs involved for the household unit or in interacting with other areas of the urban region either in terms of money, time, or effort. Hence, the friction of distance is zero, and the resident population does not exhibit any difference in their accessibility preferences.

On the basis of these assumptions it may be expected that for a representative household unit the probability that it will be located in a particular residential area i will be equal to the ratio VAC_i/VAC_t, which is the amount of vacant land in the residential area i divided by the total amount of vacant land in the urban region. For example, if the total amount of vacant land in the urban region is 1,000,000 acres and that of the residential area 50,000 acres, it may be expected that the housing unit will have a five per cent chance of being allocated to the residential area. However, this reasoning applies to the probability that a single housing unit will be allocated to the residential area. Since there are ΔH_t new housing units to be allocated in the urban region, the expected number of new housing units $P(H_i)$ that will be allocated to a residential area will be ΔH_t

times the probability that a single household will be allocated to the area so that

$$P(H_i) = \Delta H_t \frac{VAC_i}{VAC_t} \qquad (V.10)$$

In like manner the expected total number of household units that will be allocated to each jth residential area can be estimated. Thus, for the urban region a set of hypothetical allocations based on the availability of vacant land for each residential area can be obtained.

The next step is to determine the possible effect of a residential area's accessibility on the number of household units constructed in the area. By dividing the actual number of dwelling units DU_i constructed in an area for a given period of time by the expected or probable residential growth in the area $P(H_i)$ for the same period of time, a residential development ratio D_i is obtained; that is,

$$D_i = \frac{DU_i}{P(H_i)} \qquad (V.11)$$

Plotting both the development ratio D_i and accessibility index A_i for each residential area on a graph with a logarithmic scale along each axis as illustrated in Figure V.1 suggests a linear relationship. A straight line may be fitted to the plotted data by the least squares method. Since the development ratio (the dependent variable) and accessibility index (the independent variable) are transformed logarithmic variables, the equation of the line is:

$$\log \frac{DU_i}{P(H_i)} = a + b \log A_i \qquad (V.12)$$

Removing the logs from the equation and letting a^1 equal the antilog of a, the equation becomes:

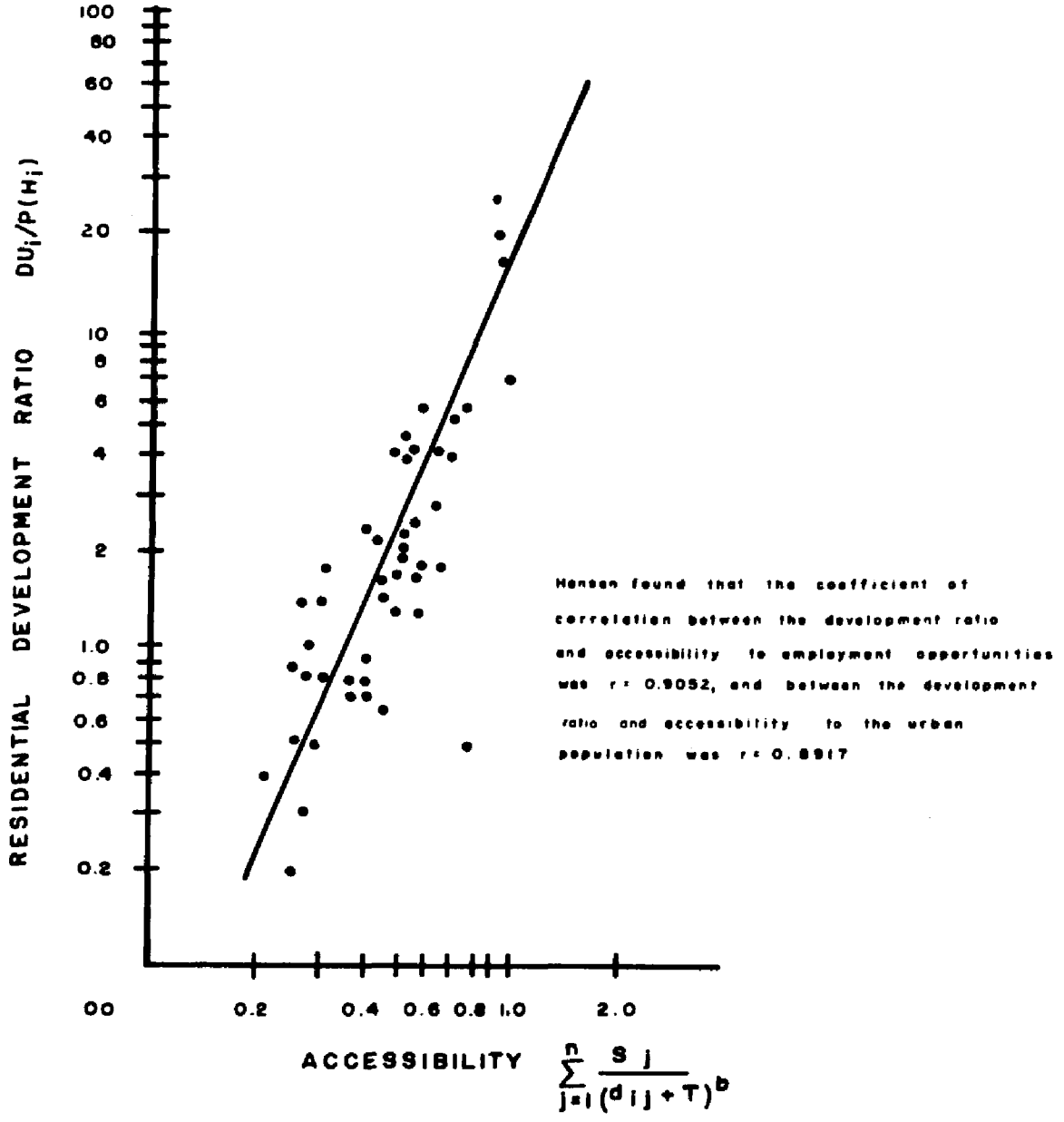

FIG. V-1

RELATION BETWEEN ACCESSIBILITY AND THE RATIO OF ACTUAL TO EXPECTED RESIDENTIAL DEVELOPMENT

SOURCE: W G. Hansen "How Accessibility Shapes Land Use" P 75

$$\frac{DU_i}{P(H_i)} = a^1 A_i{}^b \qquad (V.13)$$

Following the practice of Isard and Hansen a^1 and b may be expressed by the collective constant c so that:[12]

$$\frac{DU_i}{P(H_i)} = A_i{}^c \qquad (V.14)$$

or $$DU_i = P(H_i)A_i{}^c \qquad (V.15)$$

This relationship may be used to predict the spatial allocation of household units to residential areas of the city by substituting the predicted distribution H_i for the value of the actual distribution DU_i so that equation V.15 becomes:

$$\Delta H_i = P(H_i)A_i{}^c \qquad (V.16)$$

But:

$$P(H_i) = \Delta H_t \frac{VAC_i}{VAC_t} \qquad (V.17)$$

Therefore equation V.16 can be written:

$$\Delta H_i = \Delta H_t \frac{VAC_i}{VAC_t} A_i{}^c \qquad (V.18)$$

Also:

$$\Delta H_t = \Delta H_1 + \Delta H_2 + \ldots + \Delta H_n \qquad (V.19)$$

By substituting equation V.18 into V.19 the total urban increase in household units may be calculated by:

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[12] Isard, et. al., Methods of Regional Analysis, p. 497. Swerdloff and Stowers have attempted to estimate optimal coefficients of accessibility using three different versions of Hansen's model by linear regression on the transformed logarithmic variables and by an iterative, nonlinear least squares fit of the untransformed variables. They conclude that the best results were achieved by the iterative procedure. For this reason the procedure is adopted in this investigation.

$$\Delta H_t = \Delta H_t \frac{VAC_1}{VAC_t} A_1^c + \Delta H_t \frac{VAC_2}{VAC_t} A_2^c + \ldots + \Delta H_t \frac{VAC_n}{VAC_t} A_n^c \qquad (V.20)$$

By collecting terms equation V.20 reduces to:

$$VAC_t = VAC_1 A_1^c + VAC_2 A_2^c + \ldots + VAC_n A_n^c \qquad (V.21)$$

Substituting this value for VAC_t in equation V.18 above:

$$\Delta H_i = \Delta H_t \frac{VAC_i A_i^c}{VAC_1 A_1^c + VAC_2 A_2^c + \ldots + VAC_n A_n^c} \qquad (V.22)$$

So that Hansen's equation below is proved:

$$\Delta H_i = \Delta H_t \frac{VAC_i A_i^c}{\sum_{i=1}^{n} VAC_i A_i^c} \qquad (V.23)$$

This equation has been used to predict roughly the spatial allocation of households to residential areas of the city. To more accurately predict this assignment the measure of accessibility must take into account the attractiveness of each residential area, both with respect to its accessibility to employment opportunities in a location seeker's occupation category (AE_{ki}) and its accessibility to socio-economic groups whom location seekers in a particular occupation category reveal a preference to associate with (AS_{ki}), so that for each category of location seekers the number of households allocated to a residential area is calculated by:

$$\Delta H_{ki} = \Delta H_{kt} \frac{VAC_i A_{ki}^c}{\sum_{i=1}^{n} VAC_i A_{ki}^c} \qquad (V.24)$$

where:

k = the occupation category of the location seeker ($k = 1, 2, \ldots m$).[13]

Herein exists a basic problem because the method of combining the two measures (AE_{ki} and AS_{ki}) in the model to determine the part-worth that each contributes to the over-all evaluation of residential areas for each group of location seekers is not known. Presumably the measures are combined in an additive manner as found in interactance models; that is, $A_{ki} = (AE_{ki} + AS_{ki})$. However, they could equally be combined in a multiplicative manner or in some more complicated relationship. Since the spatial behavior of location seekers reveals how they "trade off" one attribute of a residential area for another attribute in their evaluation of alternative residential opportunities, in the final analysis it is this behavior that determines the rule by which the measures are combined. The following chapter will devote some attention to determining this rule.

Assumptions of the Model

The purpose of the model is to predict the spatial allocation of households by occupation category of the location seekers to residential areas in the Lansing - East Lansing, Michigan, Metropolitan Area for the period 1960 to 1965. It is constructed on the premise that the amount of vacant land in an area as well as its level of accessibility to employment opportunities and compatible friends and neighbors are the critical variables in explaining the intensity of

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[13]This is equivalent to Hansen's equation in that:

$$\Delta H_i = \sum_{k=1}^{m} \Delta H_{ki}$$

residential development in an area. The model is largely based on aggregate land development activity rather than on development by individual location seekers. Residential growth is constrained by both the existing housing density in the area and residential zoning.[14] Non-residential location seekers are able to pre-empt available vacant land causing the existing housing stock to be demolished if the demand requires. The predicted allocation assumes an in-migration of location seekers based upon an increase in the urban region's employment opportunities so as to create an increase in the number of housing units. The output further assumes that different classes of location seekers will move from an initial location to a new location before the end of the iteration period. The model also assumes uniformity of family life-styles, housing types, and social and ethnic composition of the population and that the occupation category of decision makers is the only cue to their social status.

Input Data Used in the Model

The data used in the model is shown in Appendix B and essentially describes the state of the urban system at the beginning of the iteration period. The desired inputs are: 1) the location and number of male decision makers residing in the urban region categorized by their occupation (These categories have been maintained as closely as possible to Laumann's categories.); 2) the location and number of male

[14]It should be noted that when the areal density constraint or the residential zoning constraint is violated in a particular residential area, the household units involved are reassigned to other residential areas that have not had a constraint violated. This reassignment or reallocation is made on the basis of the original calculations of the attractiveness of the residential areas; that is, it is assumed the location seekers will locate their households as near as possible to their "desired location" without violating the constraints.

employment opportunities classified according to the occupation categories of the decision makers; 3) the location and number of existing housing units by occupation category of the male inhabitants; 4) the location and amount of land in each area designated by current use (vacant, crop, and woodland, unusable, residential, commercial, industrial, public, and total land area); 5) projected non-residential land use changes; 6) projected household unit changes; 7) time-distance between urban areas; and 8) the social-distance propensity of a location seeker in a particular occupation category to have a neighbor in the same or some other occupation category.

Description of the Model

In the model the urban region is divided into forty-five areal units. Variables are located spatially within particular areal units. Superimposed on this system of variables is a transportation system providing travel accessibilities between various activities in the areal units. An objective social-distance structure provides a means of expressing the attractiveness of the residential areas with respect to the compatibility of its inhabitants as viewed by the location seeker.

The model simulates the residential growth process using the potential interactance technique and disaggregates independent variables to a greater extent than the models discussed in the previous chapter. Since the potential interactance model becomes unstable if disaggregation results in small groups of decision makers, location seekers have been stratified into five groups. This grouping is similar to that of Laumann. The model calculates an index of attractiveness for each of the five groups and allocates households to areas in descending order

of the social status of the group so as to allow upper status groups to pre-empt the most attractive sites.

The effect of the three priming factors on residential development: accessibility to employment opportunities, accessibility to friends and neighbors, and the availability of land, depends on a time-lag element which is simulated in the model by use of the recursive and iterative procedures previously discussed. The output of the model is a spatial distribution of household units by occupation category of the location seekers subject to the residential holding capacity of each area as determined by existing household development and density restrictions.

The allocation model utilizes distance-decay exponents (b) derived for the Tri-County Regional Transportation model of which the Lansing - East Lansing Area is a part. The model is calibrated by determining the best value of the accessibility decay exponent (c) so that the predicted allocation describes as closely as possible the actual growth of residential areas.

Limitations on the Proposed Model

While considerable time-series data are available in the Lansing-East Lansing Area, it is not sufficient to fully calculate the proposed model. Perhaps the severest data limitation encountered is the lack of information on employment opportunities, both by the location and occupation category of the opportunities. Small-area data to be collected in the 1970 Census for resident-work place pairs should help alleviate this critical problem. An equally severe data limitation is the lack of information on the number of new household units to be allocated to residential areas by the occupation category of their

inhabitants. By using 1960 and 1970 small-area data, estimates can be made of the number of household units assigned to each area by occupation type for the decade 1960 - 1970. These and other data limitations require that the forecast period used in this investigation be from 1960 to 1965. Hence, the model will pass through only one iteration period and project the total number of household units for each area rather than by the occupation categories of location seekers. Despite these limitations a test of the existence and influence of locational preferences on the growth of residential areas can be made. This consideration will be taken up in the next chapter along with an evaluation of the efficiency of the spatial allocation model.

CHAPTER VI

EVALUATION OF THE SPATIAL ALLOCATION MODEL

Experiments with a modified subjective accessibility spatial allocation model were conducted on Michigan State University's CDC 6500 computer over a period of three months in 1969.[1] A major portion of

[1]The modified model is expressed:

$$\Delta H_i = \Delta H_t \frac{VAC_i\left(AE_i^{c1} + \sum_{k=1}^{m} AS_{ki}^{c2}\right)}{\sum_{i=1}^{n} VAC_j\left(AE_i^{c1} + \sum_{k=1}^{m} AS_{ki}^{c2}\right)}$$

where:

ΔH_i = the number of dwelling units to be allocated to a residential area i;

ΔH_t = the total urban increase in dwelling units = 7007;

VAC_i = the amount of land in acres in an area used as woodland, cropland, and vacant land;

AE_i = the area's accessibility to total employment opportunities in the urban region;

$\sum_{k=1}^{m} AS_{ki}$ = the area's accessibility to total social opportunities in the urban region weighted by the objective social distance preferences of decision makers belonging to five social class groups;

c1 = an exponent expressing the effect of total employment accessibility on the pattern of residential development = 2.4; and,

this effort went into a search for "bugs" in the program and for ways of increasing the efficiency of the model to assign household units to residential areas of the urban region. Experience with the model showed weaknesses in the data.[2] All parameters were obtained independently of the model, but in several experiments some of them were varied in order to test the sensitivity of the spatial distribution to such changes. It was found that small parameter changes did not drastically alter the distributions.

The final version of the model has been run in three ways:

> Experiment A: Given as initial data inputs the 1960 land use and dwelling unit inventory, the projected 1965 spatial distribution of total employment opportunities, the 1965 higher-order non-residential land use changes, and 1965 intraurban travel times, an employment accessibility model was run through one complete iteration to distribute residential growth to the urban region.
>
> Experiment B: Given as initial data inputs the 1960 spatial distribution of male residents by their occupation category, the 1960 land use and dwelling unit inventories, the projected 1965 higher-order, non-residential land use changes, and 1965 intraurban travel times, a social accessibility model which weights residential areas by the objective social-distance preferences of the occupational groups was run through one complete iteration to distribute household growth to the urban region.

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c2 = an exponent expressing the effect of total social accessibility on the pattern of residential development = 4.00.

[2] A major data deficiency is the amount of exogenously-projected, higher-order, non-residential land use changes to be allocated to each area. No attempt, however, is made to improve the efficiency of the model by manipulating these data, even though it is known that, in some areas, the arithmetically derived acreage is in disagreement with the actual amount of higher-order land use development that has occurred during the forecast period. Additional land use data currently being collected in the study area should aid greatly in correcting this deficiency.

> Experiment C: Given as initial data inputs all information used in the employment and social accessibility models, a combined accessibility model was run through one complete iteration to spatially distribute household growth to the urban region.

In experiments A and B the combined accessibility model is partitioned into its two major components so that the results for each are uncontaminated by failure in the other component. This procedure allows insights into the influence of the two components on the allocation of residential growth. The spatial assignment of households to residential areas of the city determined by the three experiments is summarized in the present chapter along with statistical tests of the relative significance of the models.

The nine township study area comprises approximately 324 square miles and is nearly square in shape. The region has been subdivided into forty-five residential areas for computational convenience.[3] The aggregate number of household units to be allocated to the region is predetermined by the actual 1960 - 1965 net dwelling unit changes for each area. Thirty-five areas had a net gain of 7,007 dwelling units and ten areas had a net decline of 2,185 units during the period. Distance-decay exponents (b) of 2.20 for employment trips and 2.35 for social trips were used in the final calculation of the accessibility indices.[4] Successive iterations of each experimental model found that

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[3]The residential areas' sizes generally increase from the central core to the periphery of the region and range from a low of 250 acres to a high of 23,908. The four corner areas are complete townships comprising approximately thirty-six square miles each.

[4]The distance-decay exponents in the accessibility calculations must be considered as tentative since they only represent the portion of the trip attenuation curve that lies between five and twenty minutes of travel time for person automobile trips.

TABLE VI.1

RELATIVE SIGNIFICANCE AND EXPLANATORY POWER OF ACCESSIBILITY TO EMPLOYMENT AND SOCIAL OPPORTUNITIES ON THE PATTERN OF RESIDENTIAL DEVELOPMENT

INDEPENDENT VARIABLE		DEPENDENT VARIABLE							
ACCESSIBILITY RATIO $A_i / \sum_{i=1}^{n} A_i$		DEVELOPMENT RATIO $DU_i / H_t(VAC_i / \sum_{i=1}^{n} VAC_i)$							
		Coef. of Cor. (r)	Coef. of Det. (r^2)	Std. Err. of Est.	F Stat. r=b=0	Sign. Prob. of F Stat.	Part. Coef. of Cor.	F. Stat. r=b=0	Sign. Prob. of F Stat.
Residential Growth (n=35)	Accessibility to Employ. Opportunities	0.741	0.548	0.1479	40.066	0.0005	-0.055	0.099	0.76 N.S.
	Accessibility to Social Opportunities	0.774	0.598	0.1156	49.155	0.0005	0.337	4.091	0.05
	Accessibility to Social & Employ. Opportunities	0.774	0.600	0.5906	45.000	0.0005			
Residential Decline (n=10)	Accessibility to Employ. Opportunities	0.851	0.724	0.1032	20.951	0.002	0.640	4.861	0.06 N.S.
	Accessibility to Social Opportunities	0.769	0.592	0.0802	11.958	0.009	-0.358	1.029	0.34 N.S.
	Accessibility to Social & Employ. Opportunities	0.871	0.759	0.6495	0.735	0.420 N.S.			

the actual residential development pattern could be "best fitted" by a distribution parameter (c) of 2.40 for the employment accessibility model and 4.00 for the social accessibility model.[5] Various methods of combining the employment and social accessibility indices were attempted in the modified subjective accessibility model, the most satisfactory being $(AE_i^{2.40} + AS_i^{4.00})$.

ANALYSIS OF THE RELATIONSHIP BETWEEN THE PATTERN OF RESIDENTIAL DEVELOPMENT AND ACCESSIBILITY TO SOCIAL AND EMPLOYMENT OPPORTUNITIES

The degree of association between the residential development ratio (dependent variable) and the social and employment accessibility indices (independent variables) was calculated by standard (log log) correlation analysis to determine the relative significance of accessibility to employment and social opportunities on the pattern of residential development. In addition statistical F tests were undertaken to show the significance of the relationships. The tests show that several of the relationships found in Table VI.1 are significant and the probability of their being due to chance factors is less than five in 100.[6]

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[5]The employment accessibility distribution parameter of 2.40 is the same found by Swerdloff and Stowers for Greensboro, North Carolina, a city having approximately the same population and area as the Lansing - East Lansing area. Hansen, on the other hand, found the parameter to be 2.70 for Washington, D. C., a much larger city.

[6]The F tests are equivalent to testing the null hypothesis that the simple correlation between the development ratio $(DU_i/P(H_i))$ and accessibility index is zero against the alternative hypothesis that the correlation is not zero. Low values of F result in acceptance of the null hypothesis while large values of F result in rejecting the null hypothesis and acceptance of the alternative hypothesis. Following

Residential Growth

The summary in Table VI.1 shows that of the variables tested, accessibility to social opportunities is the best single indicator of residential growth. The correlation coefficient of 0.774 can be interpreted to mean that accessibility to social opportunities alone explains nearly sixty per cent of the variation found in the residential development ratios.[7] Considering the quality of the data and the numerous factors which could influence residential development, coefficients of this magnitude must be considered to be very good. On the other hand, accessibility to employment opportunities has a correlation coefficient of 0.741 and explains only fifty-five per cent of the variation found in the ratios.[8] The difference in the coefficients reveals that the strength of the relationship between residential development and accessibility to employment for the urban population as

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the usual social sciences practice correlations having a significance probability greater than .05 are considered not to be significant in the present investigation and those having probabilities less than .05 are deemed to be significant.

[7]The residential development ratio was calculated both by using vacant land only and by combining vacant land, woodland, and cropland together as a measure of the amount of acreage in an area that could be used for urban development purposes. The correlation coefficients were in the order of sixty to seventy points higher using the latter measure.

[8]One of the reasons for the high correlations is a result of the statistical procedure itself and requires explanation to avoid misinterpretation of the results. In the type of analysis used the correlations are not determined from the actual numerical values of the variables themselves, but rather, as explained in Chapter Five, on the basis of the logarithms of the values. Therefore, the coefficients of correlation and determination are a measure of the association between the logarithms of the variables. Inasmuch as the variation between the logarithms of two values is numerically much less than the numerical variation between the actual untransformed values, the coefficients between the logarithms of the variables will be higher than the coefficients between the actual variables.

a whole is not as strong as the relationship between residential development and accessibility to social opportunities when weighted by the objective social-distance preferences of decision makers. The evidence is in sharp contrast with the several studies that have found accessibility to total employment to be the major factor influencing the intensity of residential growth. It suggests, as does the "social choice" hypothesis, that while both accessibility to compatible friends and neighbors and accessibility to employment are important factors in dimensioning household locational choices, proximity to desired social relationships is a somewhat more important factor, at least for the urban population as a whole. Figures VI.1 and VI.2 illustrate the relationship between the development ratios and accessibility to social and employment opportunities for thirty-five areas in which residential growth took place.

By combining both accessibility measures in a multiple regression format to determine the relationship between the measures and the development ratio, no appreciable increase in the coefficients is obtained. However, the partial correlation coefficient associated with accessibility to social opportunities is substantially greater than that associated with accessibility to employment opportunities, the former being 0.337 while the latter is -0.055. The probability levels of the F statistics show that only the partial correlation associated with accessibility to social opportunities is significant and that the partial correlation associated with accessibility to employment opportunities is likely to be due to chance factors.[9]

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[9]Residuals from regression were analyzed to determine if any regularity existed such as to suggest the effect of other variables. The

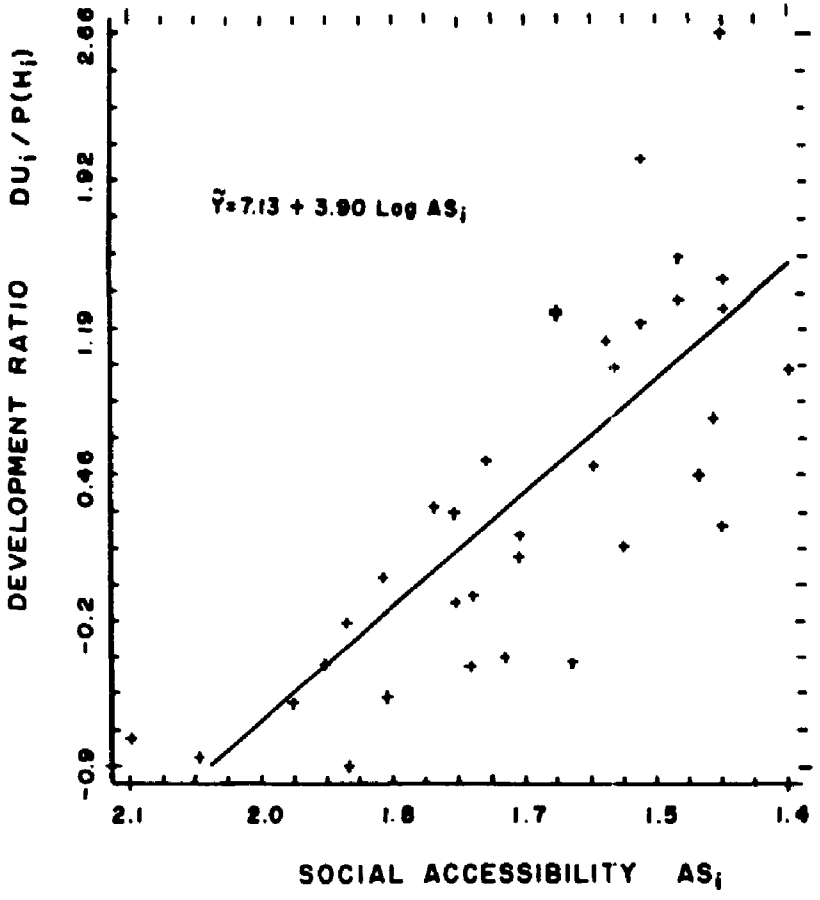

FIG. VI-1

RELATIONSHIP BETWEEN DEVELOPMENT RATIO AND ACCESSIBILITY TO SOCIAL OPPORTUNITIES

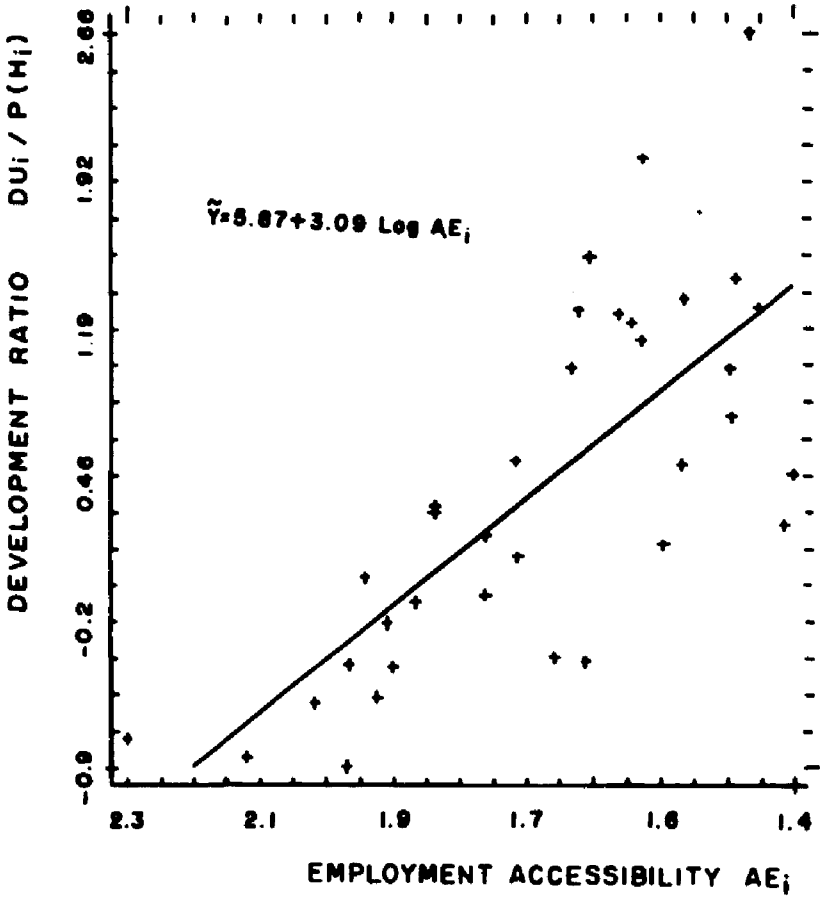

FIG. VI-2

RELATIONSHIP BETWEEN DEVELOPMENT RATIO AND ACCESSIBILITY TO EMPLOYMENT OPPORTUNITIES

(35 AREAS HAVING AN INCREASE IN DWELLING UNITS)

Considering that the inter-correlation coefficient between the two accessibility indices is 0.060 the substantial difference in the partial correlation coefficients requires explanation. The high inter-correlation is due to the presence of a single factor that both indices share in common and which produces an internal consistency between the measures. This factor is the time-distance each residential area is from all other areas in the urban region appearing in the denominator of both indices. An examination of the accessibility measures calculated for each residential area reveals that both indices have their highest values in areas close to the central core of the city and gradually decline toward the periphery. This similarity accounts for the high inter-correlation between the accessibility indices. The gradient of the employment accessibility index, however, is steeper than that of the social accessibility index. This is understandable since the major employment areas are located close to the central core, whereas the major residential areas are located intermediately between the central core and the periphery. In the process of octagonalizing the two accessibility indices with the development ratios in the multiple regression equation, the difference in the employment and social accessibility gradients becomes significant. When employment accessibility is allowed to explain all of the variance in the development ratios that it can, a direct partial correlation

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only regularity that could be found was that in nine out of the ten residential areas in which decision makers belonging to the working class group predominate, negative residuals were obtained. This implies that for working class areas the model can be expected to overpredict residential growth. Of interest also, although no regularity exists, is that for two upper class areas extremely high positive residuals were obtained. This means that the amount of residential growth allocated to these areas will be highly underestimated.

coefficient (0.337) exists between social accessibility and the ratios. Relatively speaking residential development is high in areas of high social accessibility and low in areas of low social accessibility. On the other hand, when social accessibility is allowed to explain all of the variance in the development ratios that it can, an inverse partial correlation coefficient (-0.055) exists between employment accessibility and the ratios. Considering that residential development in the Lansing - East Lansing region is low in areas of high employment accessibility, the inverse partial correlation is understandable. The reason for the inverse relationship becomes more apparent when areas in which the number of dwelling units declined during the period are considered. Most of the decline occurred in areas having the highest employment accessibility measures. The evidence shows a relationship between residential development and both accessibility indices but suggests the existence of a causal relationship between the more moderate gradient produced by the social accessibility index rather than to the steep gradient generated by the employment accessibility index.

Residential Decline

Table VI.1 also shows that of the variables tested accessibility to total employment is the best single indicator of the decline in the number of dwelling units in residential areas. The correlation coefficient of 0.851 can be interpreted to mean that accessibility to employment opportunities explains seventy-two per cent of the variation found in the residential development ratios. Accessibility to social opportunities appears as less of a factor with a coefficient of correlation equal to 0.769 so as to explain only fifty-nine per cent of the

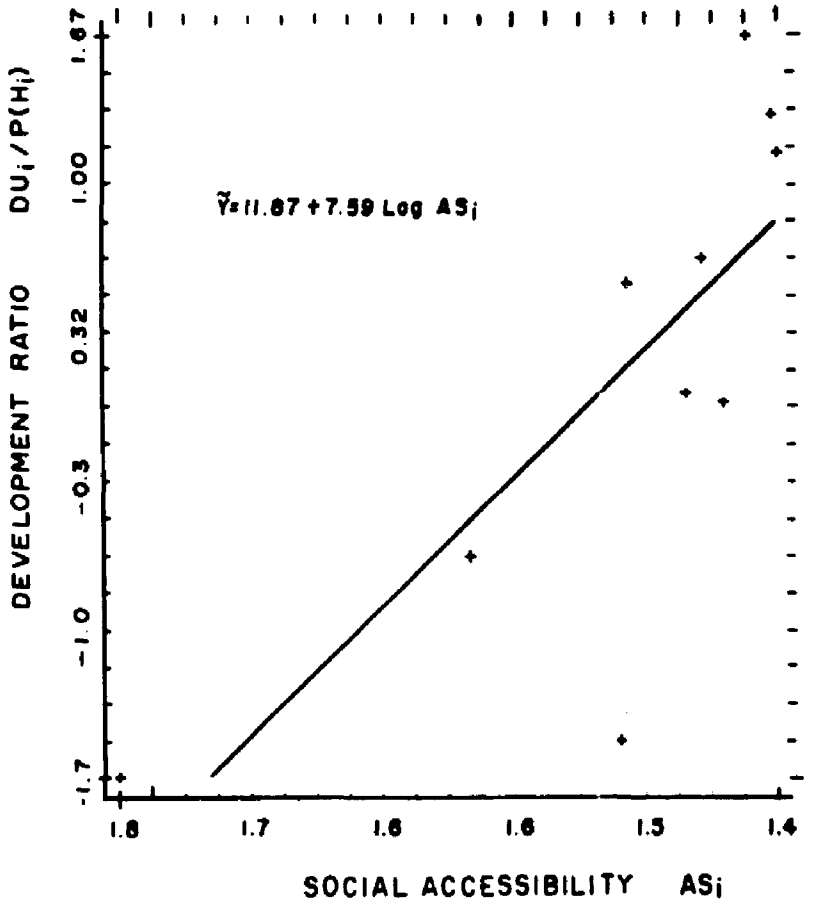

FIG. VI-3

RELATIONSHIP BETWEEN DEVELOPMENT RATIO AND ACCESSIBILITY TO SOCIAL OPPORTUNITIES

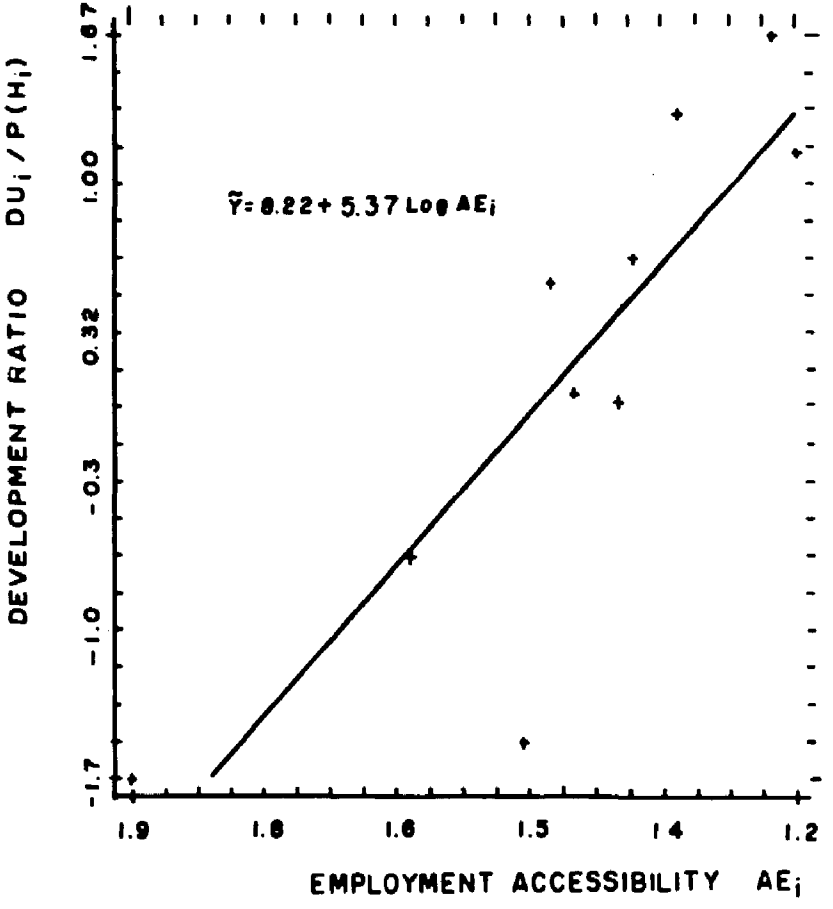

FIG. VI-4

RELATIONSHIP BETWEEN DEVELOPMENT RATIO AND ACCESSIBILITY TO EMPLOYMENT OPPORTUNITIES

(10 AREAS HAVING A DECREASE IN DWELLING UNITS)

variance. Figures VI.3 and VI.4 illustrate the relationship between the development ratios and accessibility to social and employment opportunities for ten areas in which there was a decrease in the number of dwelling units during the forecast period.

When both accessibility indices are combined in a multiple regression format the coefficient of correlation is raised slightly to 0.871 so as to explain seventy-six per cent of the ratio's variance.[10] The partial correlation coefficients show that both accessibility to employment (0.640) and accessibility to social opportunities (-0.358) contribute to explaining the variance although the contribution made by accessibility to social opportunities is only three and one-half per cent. The significance probability of the F statistics, however, show that both the multiple and partial correlations may be due to chance factors since they are greater than the 0.05 level. In all likelihood the small number of residential areas in which there was a net decline in dwelling units contributes to these inconclusive results. None the less, residential areas in the Lansing - East Lansing region that have experienced a net loss in dwelling units are highly accessible to expanding employment opportunities.

ANALYSIS OF THE RELATIONSHIP BETWEEN THE PATTERN OF RESIDENTIAL DEVELOPMENT AND THE PREDICTED HOUSEHOLD ASSIGNMENT FOR THE URBAN REGION

Three methods were used to evaluate the efficiency of the models to forecast the spatial distribution of household units: 1) a

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[10] The inter-correlation coefficient between the two accessibility indices is 0.964.

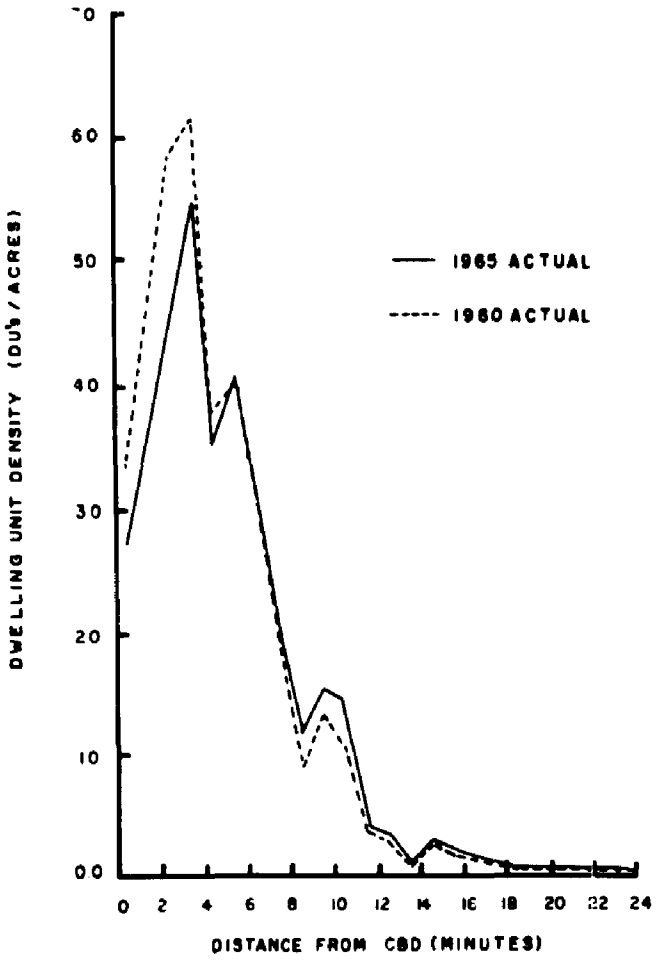

FIG. VI-5

Actual 1965 and 1960 dwelling unit density with distance from the CBD: Lansing-East Lansing area

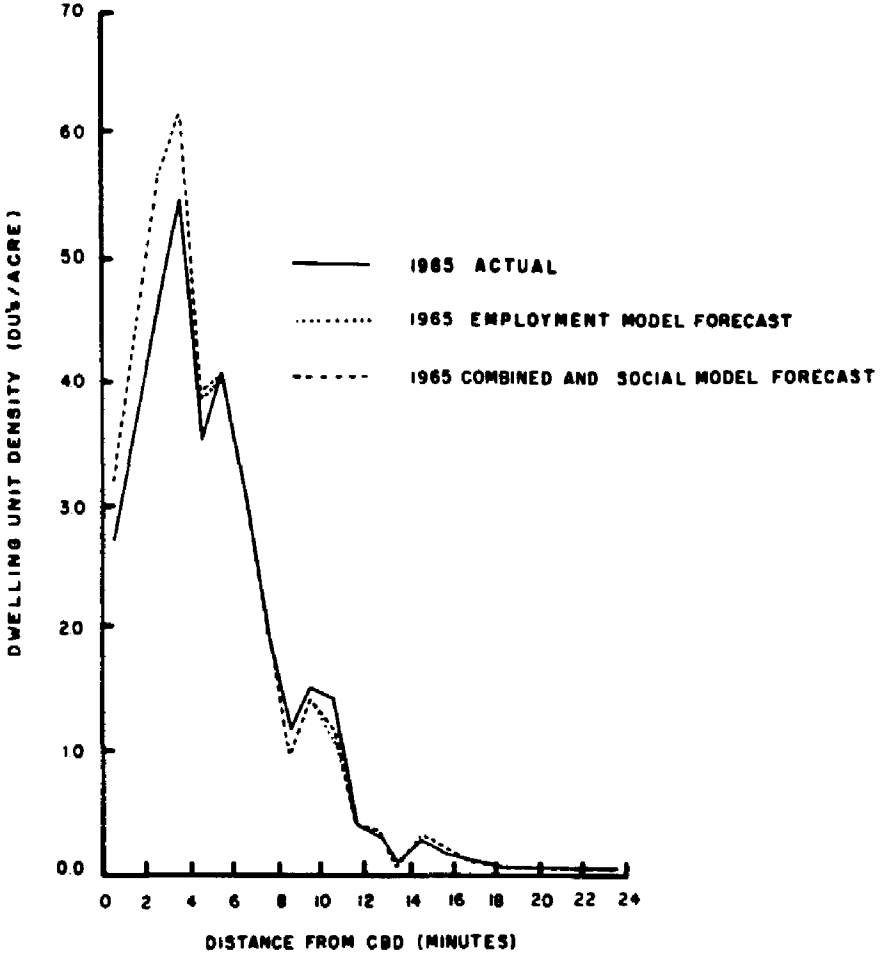

FIG. VI-6

Actual 1965 dwelling unit density with distance from the CBD compared with the 1965 dwelling unit density forecast by the employment, social and combined accessibility models: Lansing-East Lansing area

comparison of the actual and predicted household density distribution profiles for the urban region with distance from the CBD; 2) an analysis of the degree to which the predicted patterns of development deviated from the actual pattern in each residential area; and 3) correlation analysis of the degree of correspondence between the actual and predicted pattern.

Household Density Distribution Analysis

Figure VI.5 shows a profile of the actual distribution of households per acre of total usable land in each residential area for 1960 and 1965 with distance from the Lansing - East Lansing Central Business District. During the five year period there was a substantial decline in the number of dwelling units located within five minutes travel time of the CBD. The residential pattern remained stable between five and eight minutes of travel time during the period. The major zone of residential growth was from eight to twelve minutes distance from the CBD with only insignificant increase beyond.

Figure VI.6 profiles the 1965 actual distribution of dwelling units compared to the 1965 forecast generated by the employment, social, and combined accessibility models. Two features are apparent from a comparison of the profiles. First, the spatial allocation of households generated by the three models do not differ substantially from each other. As a point of fact the allocations forecast by the social and combined accessibility models are nearly the same for each residential area although the combined model renders a slightly better approximation of the actual distribution. The employment accessibility model is the least accurate of the three. Second, a comparison of the three predicted distributions with the actual 1960 distribution illustrated

TABLE VI.2

PERCENTAGE DEVIATION OF PREDICTED FROM ACTUAL RESIDENTIAL DEVELOPMENT IN 45 AREAS FOR THE EMPLOYMENT, SOCIAL, AND COMBINED HOUSEHOLD ALLOCATION MODELS

Spatial Allocation Model	Deviation Ratio Tolerance Limit				
	±20%	±30%	±40%	±50%	±60%
	Per Cent of Residential Areas Within Deviation Ratio Tolerance Limit				
Employment Model	.07	.09	.11	.18	.20
Social Model	.04	.09	.18	.24	.36
Combined Model	.07	.09	.18	.24	.36

TABLE VI.3

RELATIVE SIGNIFICANCE AND EXPLANATORY POWER OF THE EMPLOYMENT, SOCIAL, AND COMBINED HOUSEHOLD ALLOCATION MODELS

Spatial Allocation Model	Exp.	Coef. of Cor. (r)	Coef. of Det. (r^2)	Std. Er. of Est.	F Stat. r=b=0	Sign. Prob. of F Stat.
Employment Model	2.40	0.266	0.071	176.294	3.279	0.08 N.S.
Social Model	4.00	0.336	0.113	178.215	5.480	0.02
Combined Model	2.40 4.00	0.336	0.113	177.789	5.475	0.02

in Figure VI.5 shows that the forecasts do not differ substantially from the earlier actual pattern. All three models produce a decline in the number of dwelling units within four minutes of travel time from the CBD, maintain the relatively stable residential pattern in the five to eight minute distance zone, and generate growth beyond the eight minute distance zone. Not enough growth, though, is allocated to the eight to twelve minute zone and not enough decline is generated within five minutes of the CBD.

Deviation Analysis

The degree to which the predicted household allocation deviated from the actual residential development pattern in each area was calculated to determine the over-all accuracy of each model. The results presented in Table VI.2 show that in only seven per cent of the residential areas are the models accurate within ±20 per cent of the actual residential development and in only twenty-four per cent of the areas are they accurate within ±50 per cent. The combined model is slightly more efficient than the social model, and the employment model is the least efficient. One major conclusion that can be reached at this point is that, at the present time, none of the models is useful for practical purposes.

Correlation Analysis

This conclusion is borne out by a statistical analysis of the actual and predicted pattern of residential development. The summary found in Table VI.3 shows that both the social and combined models are best able to approximate the actual assignment of dwelling units with a coefficient of correlation equal to 0.336 so as to explain eleven per

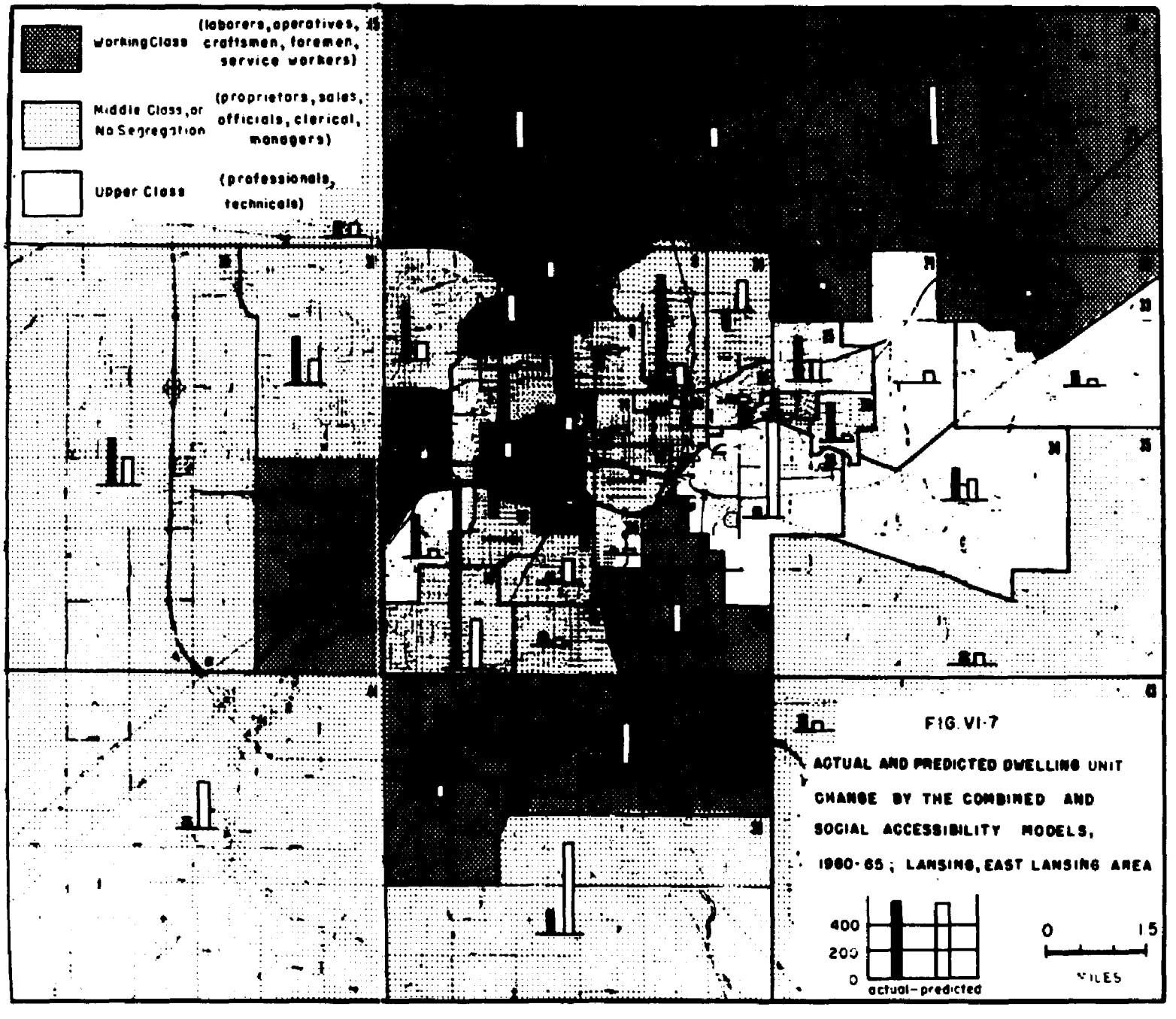

FIG. VI-7

ACTUAL AND PREDICTED DWELLING UNIT CHANGE BY THE COMBINED AND SOCIAL ACCESSIBILITY MODELS, 1960-65; LANSING, EAST LANSING AREA

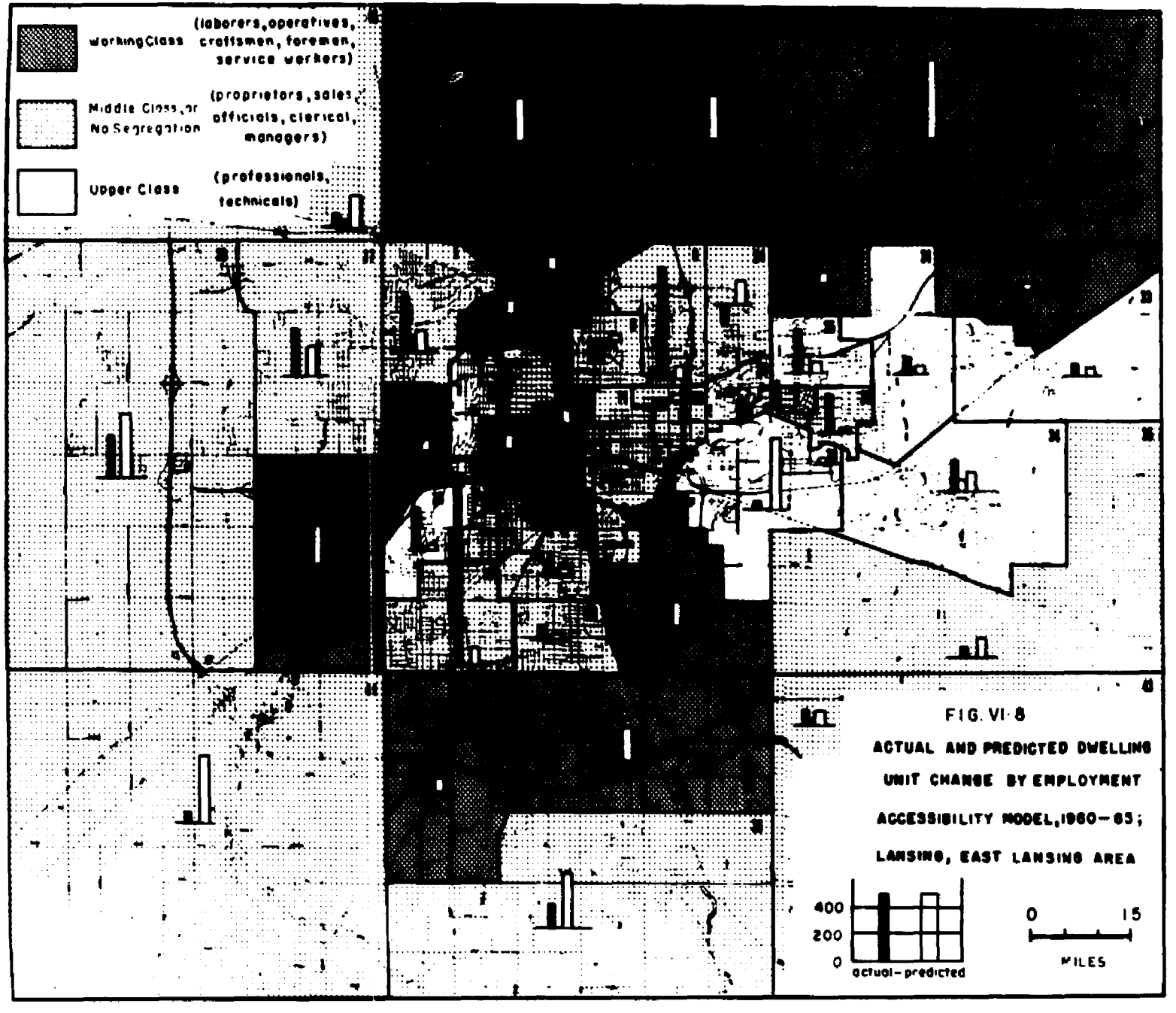

FIG. VI-8

ACTUAL AND PREDICTED DWELLING UNIT CHANGE BY EMPLOYMENT ACCESSIBILITY MODEL, 1960-65; LANSING, EAST LANSING AREA

cent of the variance found in the actual pattern of development. The employment model produces even less satisfactory results having a coefficient of correlation of 0.226 and an ability to explain only seven per cent of the variance. The household allocations generated by the social and combined models, however, prove to be significant at the 0.02 level, whereas those generated by the employment model fall outside the accepted 0.05 level.

Two conclusions appear valid at this juncture. First, for the urban population as a whole social accessibility weighted by the social distance preferences of decision makers is a more important factor in the household allocation process than is accessibility to employment. Second, factors other than accessibility to social and employment opportunities, and the amount of land that may be developed for urban use are relevant to the household allocation process.

ANALYSIS OF THE RELATIONSHIP BETWEEN THE PATTERN OF RESIDENTIAL DEVELOPMENT AND THE PREDICTED HOUSEHOLD ASSIGNMENT BY SOCIAL CLASS GROUP

Correlation analysis was used to evaluate the efficiency of the three models to predict residential development for major social class groups. Although the proportion of the actual residential development variance explained is only significant in the case of residential areas where decision makers belonging to the working class predominate, there is substantial evidence that disaggregation of social class groups will increase the accuracy of household allocation models.

Figures VI.7 and VI.8 illustrate the actual and predicted pattern of development generated by each of the models for the urban region.

TABLE VI.4

RELATIVE SIGNIFICANCE AND EXPLANATORY POWER OF THE EMPLOYMENT, SOCIAL, AND COMBINED HOUSEHOLD ALLOCATION MODELS BY SOCIAL CLASS OF AREAS

Spatial Allocation Model	Social Status of Areas	Coef. of Cor. (r)	Coef. of Det. (r^2)	Std. Err. of Est.	F Stat. r=b=0	Sign. Prob. of F Stat.
Employment Model	Upper	-0.203	0.041	187.781	0.344	0.57 N.S.
	Middle	0.220	0.048	176.112	0.914	0.35 N.S.
	Working	0.728	0.529	140.476	14.623	0.002
Social Model	Upper	-0.182	0.033	252.047	0.273	0.62 N.S.
	Middle	0.386	0.149	173.345	3.157	0.09 N.S.
	Working	0.735	0.540	115.108	15.277	0.002
Combined Model	Upper	-0.182	0.033	251.071	0.275	0.61 N.S.
	Middle	0.386	0.149	172.601	3.153	0.09 N.S.
	Working	0.736	0.541	115.246	15.320	0.002

Each residential area is classified by its major social class group, and while there exist few areas completely dominated by any one group, location quotients were calculated to determine the predominant one residing in each area. For the fifteen areas where the quotients are high for the working class group each of the three models exhibit their highest reliability and are significant at the 0.002 per cent level. Table VI.4 shows that the best result is obtained with the combined accessibility model although that obtained by the social accessibility model is nearly as efficient. The coefficient of correlation of 0.736 produced by the combined model can be interpreted to mean that for residential areas in which working class decision makers predominate the combined accessibility index and the amount of land at a lower-order use explain fifty-four per cent of the variance in the actual residential development pattern.

The efficiency of the models to predict residential development in twenty middle class areas is substantially lower than their ability to forecast development in working class areas. Still, all the models are slightly more reliable in predicting residential development in middle class areas than they are for the urban region as a whole. For the middle class areas both the social and combined models are able to explain nearly fifteen per cent of the variance in the actual pattern of development, whereas for the urban region as a whole they explain only eleven per cent of the variance. With a significance level of 0.09, though, the correlations of 0.386 are in all probability due to chance factors.

In the ten areas where the location quotients were high for upper class groups each of the three models showed an inverse relationship

between the patterns of actual and predicted residential development. The strongest inverse relationship is produced by the employment model which obtained a coefficient of correlation equal to -0.203. The inverse correlations could be taken to mean that accessibility and the amount of land at a lower-order use are not important factors in upper class decision makers' choice of household locations. Such an interpretation is premature for two reasons: first, the correlations are highly suspect since their significance values are greater than 0.57; and second, the inverse relationship actually attests to the need for disaggregating social class groups to account for their individual locational preferences.

The results of the analysis shown in Table VI.4 indicate that the relative importance of accessibility to social and employment opportunities varies with the social status of the decision makers. It must be remembered, however, that the household forecasts are based upon aggregated variables rather than by social class group. That is, the models compute an index of accessibility to total employment opportunities, a combined index of accessibility to social opportunities, and allocate the total number of household units to residential areas without respect to social class.

ANALYSIS OF THE RELATIONSHIP BETWEEN RESIDENTIAL AREA RANKINGS AND THE LOCATIONAL PREFERENCES OF SOCIAL CLASS GROUPS

An examination of the rankings of residential areas calculated by the models reveals the influence of locational preferences on the pattern of residential development. It is evident that if the

individual social class group rankings for each area could have been used to allocate dwelling units, the accuracy of the predicted distribution would be greatly improved. The examination shows that most residential areas are differently ranked with respect to their accessibility to total employment opportunities and to total social opportunities. Only ten of the forty-five areas possess the same rank although the trend of both sets is similar so as to account for the high inter-correlation coefficient between the two indices.

Social-Distance Preferences

Table VI.5 shows the existence of a relationship between the average residential area rankings calculated for each social class group and the predominant class of decision makers residing in the area. For the ten areas where the upper class group predominantly resides the average rankings are highest for the upper class (1.4) and lowest for the working class (2.6). The average rankings of fifteen working class residential areas are relatively low for the upper class (2.1), but the same areas have a higher average rank for the working class (1.3). An exception can be found in the average rankings of twenty middle class areas where a different order than expected is obtained. Working class areas have the highest average rank (1.5) rather than middle class areas which are ranked second (1.7). Upper class areas are ranked third (2.0). The range between the average rankings for middle class areas is small, however, and working class areas possess the same average ranking for the middle class group (1.7) as do middle class areas. In all likelihood the closeness of the average rankings is due to the difference in the methods used by Laumann and the U.S. Census

TABLE VI.5

AVERAGE RANKING OF RESIDENTIAL AREAS CALCULATED FOR SOCIAL CLASS GROUPS BY SOCIAL STATUS OF AREA[a]

		Social Status of Residential Area		
	Social Class Group	Upper	Middle	Working
Social Status of Ranking Group	Upper	1.4	2.0	2.1
	Middle	2.0	1.7	1.7
	Working	2.6	1.5	1.3

[a]Low values have highest rank - lowest value = 3.0, highest value = 1.0.

Bureau to classify occupational groups.[11]

It is of considerable importance to note that the pattern of average rankings shown in Table VI.5 has essentially the same relationship as the pattern of values found in Laumann's table expressing the probable residential association of occupational groups presented in Chapter Three. It is apparent that the social-distance preference weights used in the model are able to rank residential areas in close accord with those revealed by the different class groups. The model fails as a predictive instrument since for nearly two-thirds of the areas the aggregate total social accessibility rankings are the same as the rankings calculated for the working and middle class groups. This is shown in Table VI.6 along with the fact that in only two areas are the aggregate social rankings the same as calculated for the upper class group. This fact alone helps to explain the poor performance of the model to predict the spatial allocation of dwelling units to upper class areas and its higher reliability in predicting the assignment in middle and working class areas.

Employment Accessibility Preferences

Even though the model does not rank residential areas according to accessibility to employment opportunities in the occupation categories associated with the different social class groups, a limited analysis can be made of the influence of employment accessibility

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[11]It should be remembered that in the investigation the number of decision makers in an area belonging to a social class group is based on 1960 U.S. Census data, but the social-distance preference weighting is based on Laumann's findings in a sample of Cambridge and Belmont, Massachusetts, residents and that his classification of social class groups differs somewhat from the Census Occupational classifications.

TABLE VI.6

RANKED TOTAL EMPLOYMENT ACCESSIBILITY, TOTAL SOCIAL ACCESSIBILITY AND SOCIAL ACCESSIBILITY FOR UPPER, MIDDLE, AND WORKING CLASS GROUPS BY SOCIAL STATUS OF 45 RESIDENTIAL AREAS

Area ID	Major Social Status Group	Ranked Total Employment Access.	Ranked Total Social Access.	Ranked Social Accessibility By Class		
				Upper Class	Middle Class	Working Class
1	Middle	20	23	21	23	23
2	Working	17	24	25	24	21
3	Upper	5	13	15	13	10
4	Working	2	4	9	4	4
5	Middle	3	3	4	2	3
6	Working	7	5	8	5	5
7	Working	18	20	23	20	18
8	Middle	23	27	24	26	27
9	Middle	12	14	16	14	11
10	Middle	9	7	6	7	8
11	Middle	8	8	10	9	7
12	Middle	15	15	17	15	12
13	Working	1	2	7	3	2
14	Working	4	6	12	6	6
15	Middle	16	17	18	17	17
16	Middle	14	1	5	1	1
17	Middle	13	12	13	12	9
18	Upper	26	26	28	27	26
19	Middle	24	16	20	16	16
20	Middle	27	21	22	22	19
21	Working	25	25	27	25	25
22	Working	32	28	30	29	28
23	Working	36	34	28	35	34
24	Middle	22	22	19	21	24
25	Upper	21	19	14	18	20
26	Upper	11	9	3	8	13
27	Upper	10	11	2	11	15
28	Upper	6	10	1	10	14
29	Upper	19	18	11	19	22
30	Working	29	29	26	28	30
31	Upper	33	36	31	36	37
32	Working	35	37	33	37	36
33	Upper	40	39	36	38	40
34	Upper	34	35	29	33	35
35	Middle	43	43	41	43	43
36	Middle	37	33	35	34	33
37	Middle	30	31	34	31	31
38	Working	28	30	32	30	29

TABLE VI.6 (cont'd.)

Area ID	Major Social Status Group	Ranked Total Employment Access.	Ranked Total Social Access.	Ranked Social Accessibility By Class		
				Upper Class	Middle Class	Working Class
39	Middle	38	41	40	41	41
40	Working	31	32	37	32	32
41	Working	41	42	43	42	42
42	Working	39	38	39	39	38
43	Middle	45	45	45	45	45
44	Middle	42	40	42	40	39
45	Middle	44	44	44	44	44

preferences on household locational choices. The conclusions are based upon personal knowledge of the location of employment opportunities in the Lansing - East Lansing Area.

The analysis reveals that residential areas that are ranked high in terms of their accessibility to social opportunities for each social class group are also areas in close proximity to employment opportunities in the group's occupation category. Several cases may be cited to illustrate this fact. Table VI.6 shows residential areas ranked by the social accessibility model as first, second, and third for the upper class group are all areas in which upper class decision makers predominate. The three areas are located in East Lansing adjacent to Michigan State University, the major employment area in the urban region for upper class groups. Two of the three residential areas having the highest social rankings for the middle class group contain a concentration of middle class decision makers. All three top ranked areas are in the City of Lansing and either contain or are adjacent to large shopping facilities and office complexes. Four of the six areas having the highest social accessibility rankings for the working class are areas in which working class decision makers predominate. All six areas are located in Lansing either close to the CBD or close to manufacturing plants. It appears that while decision makers exhibit a preference to reside close to compatible friends and neighbors, many are able to do so and at the same time reside close to their employment. The analysis aids in explaining the ability of the employment accessibility model to predict residential development in working and middle class areas, and its poor reliability in upper class areas. When a comparison is made between the total employment

accessibility rankings and the individual social accessibility rankings for each social class group, it is found that the rankings are approximately similar for the higher ranked middle and working class area. On the other hand there is a wide range between the employment and social accessibility rankings for areas in which upper class decision makers concentrate. At the same time the employment accessibility rankings do not correspond with the areas in which the majority of upper class employment opportunities are found. Rather, the rankings closely match areas in which middle and working class opportunities are found. Since the middle and working class employment accessibility preferences are best met in the employment model and the upper class preferences are not met, it can be expected that the employment model should render its best performance in predicting residential growth in middle and working class areas. Disaggregation of the employment and social accessibility components to capture the individual social class group locational preferences should aid in correcting this problem.

SUMMARY

The analysis of the spatial allocation model finds that urban residential location seekers as a whole exhibit a preference to be accessible to compatible friends and neighbors, more so than they prefer to reside close to employment opportunities. The relationship between social accessibility and the residential development ratios proves to be more significant than the relationship between employment accessibility and the ratios. Similarly, the relationship between the actual pattern of residential development and the pattern predicted by the social accessibility household allocation model is more significant than the pattern forecast by the employment accessibility model.

These findings are significant since no researcher to this investigator's knowledge has found accessibility to social opportunities to be more significant than accessibility to employment opportunities in explaining the spatial distribution of residential land in the urban region.

These findings may be interpreted in the light of the "economic competition" and "social choice" hypotheses. Proponents of the "economic competition" hypothesis argue that the different residential locational patterns of the various social class groups are due to their economic stratification given that a high correlation exists between each group's occupation category and median family income. However, such is not the case in the Lansing - East Lansing area since the income levels of the various occupation groups do not differ significantly from each other. "There is a substantial overlap of income levels for all status groupings, hence income is a weak indicator for characterizing households in census tracts."[12] It is not unreasonable to claim, as have the Duncans and Feldman and Tilly in other cities, that in the Lansing - East Lansing area blue collar and white collar workers have similar income levels but possess different residential locational patterns. It may be argued that since little economic stratification exists in the study area, it is the social distance between decision makers belonging to different occupation categories that is the important factor in creating the different residential locational patterns of the status groups. The results of the analysis thus render

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[12] Tri-County Regional Planning Commission, M.E.T.R.O.: A Gaming Simulation, M.E.T.R.O. Project Technical Report #5, (Lansing, Michigan, January, 1966). See Appendix V - Household Types.

support for the "social choice" hypothesis that residential decision makers tend to choose household locations that are close to compatible friends and neighbors.

The fact that the spatial allocation models are best able to predict residential development in middle and working class areas and render their poorest forecast for upper class areas attests to the need for disaggregating decision makers belonging to different social class groups in order to capture their particular locational preferences. The analysis finds that the social-distance preference structure used in the social accessibility variable renders a satisfactory ranking of the attractiveness of each residential area for different social class groups. However, the spatial assignment of households is based on a combined social accessibility ranking that is nearly equivalent to the individual rankings calculated for the middle and working class groups. The social model allocates residential development with its poorest reliability to upper class areas because the combined social accessibility rankings differ substantially from those calculated for the upper class group. The employment accessibility model suffers from the same lack of being able to meet the locational preferences of residential decision makers.[13] Operationalization of the subjective accessibility model should rectify this matter to further the understanding of how locational preferences structure the spatial pattern of urban residential land.

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[13]An important feature of the social accessibility model that should be noted is that it requires little exogenously projected data such as is necessary in the employment accessibility model. The employment model is based on the location of t+1 employment opportunities, but the social model is based on the location of t+0 decision makers belonging to the different social class groups.

CHAPTER VII

CONCLUSIONS AND PROSPECTS

This study has been concerned with the household locational preferences of residential decision makers and the pattern of urban residential growth. In summarizing the investigation it may be profitable to recall the three fundamental questions posed in the introductory chapter:

> 1) On the macroscopic level what is a good way to describe the locational preferences associated with the residential spatial structure of American cities?
>
> 2) Given a particular description of the locational preferences and the residential spatial structure, how adequate are existing household allocation models in utilizing these behavioral principles in explaining this structure?
>
> 3) What is the relationship, if any, between the pattern of residential land development and the hypothesized locational preferences of residential decision makers?

The summary will not attempt to answer each of these questions in turn. Rather it seeks first to outline the conceptual scheme and the assumptions upon which the research rests, and second, to highlight the more important findings, all of which relate in some manner to these central questions.

The central theme of this study has been the investigation of the degree to which the urban residential spatial pattern is structured by the different locational preferences of residential decision makers. Its fundamental purpose has been to identify the relevant locational

preferences in terms of which the residential spatial pattern can be described and to determine a normative spatial allocation model utilizing these preferences to assign household units to residential areas of the city.

A decision maker's occupational category has been assumed to be a crucial factor influencing his spatial behavior; that is, occupation is regarded from two points of view in this investigation: first, as the principal determinant of a residential decision maker's values, needs, and desires that give rise to his particular set of locational preferences, and second, as a condensed piece of information or cue by which the decision maker perceives social and employment opportunities and ranks them into positions of relative attraction or repulsion based on his set of preferences. It has been further assumed that the different rankings placed on all conceivable spatially distributed opportunities by decision makers belonging to different occupation categories give rise to different patterns of spatial behavior by determining the decision maker's "action space" or mental image of the real urban space.

Within this general frame of reference subjective accessibility was hypothesized as playing an exceedingly important role. Subjective accessibility was defined as a measure of the spatial distribution of different types of interaction opportunities about a location adjusted for the ability and desire of decision makers to overcome spatial separation. By expressing in mathematical format the objective preference rankings revealed by decision makers belonging to different occupational groups the subjective accessibility measure orders residential areas of the city in terms of their relative attractiveness for the different

groups. Areas of high attractiveness are those which provide a given group of decision makers the best chance to facilitate their interaction with their preferred set of spatially distributed opportunities. It was hypothesized that decision makers would choose household sites in residential areas offering them maximum attractiveness provided that household sites were available in the areas. Consequently, as the city grows, new household units would be constructed on vacant land in areas providing maximum attractiveness for the different groups.

From the macroscopic standpoint the residential spatial structure was investigated to determine the relevant locational preferences manifested by household decision makers. Operational household allocation mechanisms were investigated to determine the manner in which the revealed locational preferences of decision makers were considered and modeled to distribute new dwelling units to residential areas of the city. Next, a household allocation model which considers the more important locational preferences was derived. Because of data limitations a modified version of this model was used to determine the attractiveness of areas and predict the spatial assignment of households to the urban region. The influence of the hypothesized locational preferences on the pattern of residential development was examined, and the dwelling unit assignment predicted by the model was tested against the actual household growth in each residential area.

With these general considerations in mind the following is a brief synopsis of the principal findings of the investigation.

SUMMARY OF THE PRINCIPAL FINDINGS

The first main set of findings concerns the relative impact of the "economic competition" and "social choice" hypotheses on the

residential spatial structure. The "economic competition" hypothesis proposes that the different distribution of social class groups in the urban region is due to differences in their budget costs and income resources. The "social choice" hypothesis proposes that the different distribution is due to differences in the values, needs, and desires of the social class groups. It was proposed that "economic competition" is the major process involved in spatially distributing broad categories of land use to various areas of the city. For example, higher-ordered, non-residential land users, because of their higher rent-paying ability, are able to pre-empt desirable locations from lower-ordered users. However, contrary to Alonso, Wingo, and others, it was proposed that "social choice" is the major process determining the residential distribution of different social class groups in the city. Studies were cited to show that different social classes possessing similar income resources had different residential locations and that groups possessing different income resources had similar travel costs, this latter cost being the major determinant of locational behavior according to the "economic competition" hypothesis. It was proposed that budget costs and income resources are important considerations determining the quality of the housing unit only and that social factors are responsible for the locational distribution of the social class groups in the city.[1]

An important related finding is that both hypotheses propose that residential as well as non-residential decision makers tend to

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[1]The different spatial distribution of social class groups in pre-industrial cities and in cities of "underdeveloped" countries as compared to the distribution found in cities of "developed" countries also supports this view.

choose locations that are accessible to their complementary set of interaction opportunities. In other words non-residential decision makers tend to choose locations that are accessible to their consumers, and residential decision makers tend to choose locations which are accessible to their employment and compatible friends and neighbors. This latter fact, however, has received little attention in the modeling of residential locations.

The second major set of findings relates to the analysis of the literature from which generalizations concerning the locational preferences of residential decision makers were drawn. It was found that the locational behavior of the decision makers revealed a fundamental preference to reside close to the households of individuals possessing equal or more prestigeous social status than their own, even more so than they preferred to reside close to their employment. However, this social-distance preference was more obvious with respect to the locational behavior of the upper class groups, and the work place accessibility preference was more obvious with respect to the locational behavior of the lower or working class group, young marrieds, and new arrivals to the city. It was argued that social distance, or the attitude of ego that defines the character of the social interaction that location seekers belonging to different social class groups are willing to undertake with decision makers in their own or other social class groups, provides a means of explaining how decision makers evaluate alternative household locations. That is, decision makers choose households in residential areas where they perceive the existence of individuals who are their friends or whom they would like to have as their friends and avoid residential areas in which they perceive

incompatible friends and neighbors. Consequently, for most residential location seekers it does not matter whether their household location is accessible to employment opportunities or not as long as it is in an area possessing individuals with whom the location seeker would like to identify himself. Social distance provides a means of ranking residential areas according to the subjective preferences revealed by decision makers belonging to different social class groups.

The analysis of the literature revealed to a much lesser extent that location seekers exhibited a preference for more spacious living conditions. This life-style preference was more obvious with respect to decision makers in the family rearing stages regardless of their social class. To an even lesser extent decision makers revealed a preference to reside close to the households of individuals belonging to similar minority groups. This racial or ethnic preference was found to be more significant in cities where the proportion of ethnics to the total population was generally quite high, and consequently relegated the ethnics to very low status. Although consideration of the latter two preferences is beyond the scope of this investigation, the attributes of alternative household opportunities are evaluated against the four preference structures to determine the part-worth that each attribute contributes to the over-all evaluation of the opportunities.

The third main group of findings concerns the adequacy of operational household assignment models in utilizing behavioral principles to allocate residential growth to areas of the urban region. The models were shown to deal mainly with the gross locational characteristics of the aggregate urban population and consequently, do

not provide an adequate basis for residential locational decision making. The models rest heavily upon economic speculations which regard the negative exponential decline of urban land values and population density with distance from the central core of the city to be explained by locational preferences for increased space, better housing, or less-dense housing vis-a-vis the convenience of increased accessibility to employment locations on the part of residential decision makers. Previous chapters have shown that such economic speculations are almost wholly unsupported by empirical studies of residential locational behavior.

None of the first generation models consider the basic social phenomenon that different status groups exhibit a preference to segregate themselves both socially and geographically from other status groups. More recent quasi-operational models attempt to solve this problem by disaggregating the residential population into groups of decision makers believed to exhibit similar social goals. While these expanded models reflect an increasing sensitivity to both social processes and decision making behavior, none the less they remain oriented to the "economic competition" hypothesis. No model was found that incorporated a treatment of the different locational behavior of status groups from a consideration of the social-distance preferences revealed by decision makers in interacting selectively with decision makers belonging to different status groups. In practice nearly all residential allocation models rely on descriptive methods dealing with aggregates of the urban population or subgroups of the population, are highly transportation oriented (employment - residence locations) and are based on economic behavior. It was also found that

the most substantial obstacle to the operationalizing of models is the assembling and organizing of relevant data.

Data restrictions in the Lansing - East Lansing area made it impossible to operationalize the subjective accessibility model derived in Chapter Five. Small area data are not available on the number of household units located in each residential area by the occupation category of the decision makers residing in them for 1965, or for the number of employment opportunities existing in each area by their occupation category for any period of time. An alternative spatial allocation model was used and its efficiency to predict residential development was analyzed.

The alternative model calculated an index of attractiveness for each residential area in terms of its accessibility to total employment opportunities and its accessibility to total social interaction opportunities. The social opportunities in each residential area were weighted by the objective social-distance preferences determined by Laumann for five social class groups and an index of attractiveness was calculated for each area for each group. The total social accessibility index for the area was determined by summing the five separate index rankings. Of the two variables, accessibility to total employment opportunities and accessibility to total social opportunities, social accessibility was able to explain nearly sixty per cent of the variation found in the ratio of actual to predicted residential growth. Employment accessibility was only able to explain fifty-five per cent of the variation. When the two indices are combined in a multiple regression format, social accessibility was again found to be more significant than employment accessibility. The results provide

evidence in support of the "social choice" hypothesis and attest to the validity of the proposition that the social-distance preference is a more important factor in household locational choice than is the accessibility to employment preference, at least for the urban population as a whole. On the other hand, a decline in the number of household units in a residential area was best explained by its accessibility to employment opportunities, a not too surprising outcome.

Three different spatial allocation models were used to predict residential development: 1) an employment accessibility model, 2) a social accessibility model, and 3) a combined employment and social accessibility model. The combined accessibility model proved to be slightly more efficient than the social accessibility model, and both were significantly more accurate than the employment accessibility model. However, the accuracy of even the combined model is too poor to be useful for practical purposes.

Each of the three models was evaluated in terms of its efficiency to predict household development for residential areas where decision makers belonging to major social class groups predominate. All three models were significantly able to predict residential development for working class areas, but substantially less so for the middle and upper class areas. The combined model was again the most reliable allocation mechanism although the social model was nearly as accurate. All three models allocated households to upper class areas in an inverse manner; the highest inverse relationship was produced by the employment accessibility model, again showing that accessibility to employment is a less significant factor in household locational choice.

The differing ability of the models to predict the spatial assignment of households for different social class groups attests to the need for disaggregating the groups to account for the variation in the manner in which they rank similar residential areas. An analysis of the separate index rankings for each residential area calculated by the social or combined accessibility models revealed a high degree of correspondence between the predominant social class group residing in each area and the manner in which it was relatively ranked by each group. Thus, social-distance preferences appear to be adequately expressed by the model but must await the availability of additional data for further testing.

FUTURE RESEARCH OPPORTUNITIES

The subjective accessibility spatial allocation model presented in this investigation is in a developmental stage. Adjustments to the model at this time without additional theoretical refinements and a more adequate data base would appear to have only marginal payoffs. This early version, however, demonstrates an approach to the modeling of residential site selection. Further efforts in its improvement should focus on three main objectives.

First and foremost, there is a need to develop a more appropriate data base. The 1970 Census provides small area data by residence-work place pairs and household unit data by the occupation category of the decision makers residing in the area. This information should make a substantial contribution to improvement of the model. The tabulation of recently collected land use inventory data in the study area should also contribute to its improvement.

Secondly, substantial theoretical and methodological refinements are needed to determine the creation and release of vacant land for developmental purposes in the various areas of the urban region. Theoretical refinements must take into account speculative holdings, zoning restrictions, and the deterioration of existing structures. Methodological refinements are needed in the method used to determine a more accurate land use inventory for the forecast period, particularly the amount of projected higher-ordered, non-residential land use acreage to be allocated to each area prior to the household assignment. The present simple arithmetic method of estimating the 1960 and 1965 land use inventory by using 1955 and 1962 data has proven to be quite inadequate. More recently collected land use data, when it becomes available, will allow more refined regression estimation methods to be used.

Thirdly is the problem of determining the rules by which decision makers evaluate and "trade off" the various attributes associated with alternative residential sites in their choice of a household location. Considerably more knowledge is needed about the employment accessibility and social-distance preferences of decision makers. A major direction for this research to take is to determine the subjective and objective preference structures of decision makers classified according to the Census occupation categories. Such a classification is necessary to be able to cross-classify the preferences with Census compiled information. Laumann's categories are possibly too inconsistent with the Census categories. Within this same objective is a need to know more about the "real" part-worth that the different attributes of residential areas contribute to the over-all evaluation of alternative

household opportunities at the same time the location seekers are doing the evaluating, rather than the "felt" part-worth claimed by respondents to questionnaires years after they have made their choices. There is evidence from a survey conducted in the study area that the part-worth assigned to the different attributes change with time after the household site has been selected. This is believed to be a psychological mechanism whereby decision makers rationalize their household choices to themselves. An additional requirement for organizing this information for use in a spatial allocation model is that it be collected by the occupational category of the responding location seekers.

With these objectives realized, one way in which the spatial allocation model can be improved would be to make an initial assignment of household units to residential areas on the basis of their accessibility to employment opportunities in the occupation categories of the location seekers and then allocate or reallocate the household units on the basis of the social distance probability that the location seekers belonging to the various categories interact socially with the inhabitants already residing there. If dwelling units of the type required by the life-style preferences of the location seekers are not to be found in the area, the household units are further reassigned to the next most accessible area in which can be found the preferred friends and neighbors and the preferred dwelling unit type. In addition the iteration period used in the model may be reduced so that small increments of growth may be distributed to areas at any one time. Several short forecast periods rather than a single extended period will produce a different allocation pattern and may produce a more realistic assignment of growth to residential areas of the urban region.

APPENDIX A

SOCIO-ECONOMIC STATUS TYPES

(OR RESIDENTIAL DECISION MAKER TYPES)

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SOCIO-ECONOMIC STATUS TYPES

(OR RESIDENTIAL DECISION MAKER TYPES)

It is essential to determine the locational preferences of residential decision makers who live within relatively homogeneous areas in order to quantify the subjective accessibility household allocation model. This investigation supports the proposition that these preferences vary along a dimension characterized by the socio-economic status positions of the decision makers.

As many sociologists have noted, the most important unit of social class analysis is the family or the household. Investigators of social class position, such as Barber, point out that all members of a familial unit share the same socio-economic status as the head of the household.[1] With some modifications sociologists generally agree that the easiest way to classify the socio-economic characteristics of household decision makers is to utilize the objective indicators containing the essential features that characterize American social class position. Lenski, for example, found that there are at least four main indicators that reveal the status position of the decision maker:

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[1]Bernard Barber, "Family Status, Local Community Status, and Social Stratification: Three Types of Social Ranking," Pacific Sociological Review, Vol. 4 (Spring, 1961), pp. 3-10.

education, occupation, income, and ethnic background.[2] Household type has been substituted for ethnic background in several studies, and since the present study's concern is the spatial allocation of households, this practice will be followed in this investigation.[3]

Using any one of these status indicators or a combination of the indicators to determine the socio-economic class of a decision maker or to determine the characteristics of an analysis area, rests on explicit assumptions about each indicator. These assumptions relate to the preferences which govern the manner by which people behave and live their lives. First, the amount of formal education undergone by the head of the household influences his preferences for goods and services, social relationships, and general style of living. Second, the occupation of the head of the household indicates the skill, power, and prestige he is likely to possess because of his level of formal education. Third, the income realized from the decision maker's occupation determines his ability to purchase the goods and services he prefers. Finally, the household type reflects or mirrors the decision maker's preferences and his ability to satisfy them. It is the tangible, conspicuous evidence of his status position. Hollingshead and Myers found that the social class position of decision makers could be predicted with a probability of .93 by use of a combined index of occupation and household type. When education was added to the index

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[2]Gerhard Lenski, "Status Crystallization: A Non-vertical Dimension of Social Status," American Sociological Review, Vol. 19 (August, 1954), pp. 405-464.

[3]Laumann, op. cit., p. 117; Tri-County Regional Planning Commission, loc. cit.

the predictive ability rose to .94.[4] Income has been found to be a progressively poorer indicator of social class position as time goes on. Warner found that occupation alone is the best indicator of the socio-economic status of a decision maker, having a predictive probability of .91.[5] Laumann, likewise, concluded that occupation serves as the most easily obtained attribute by which other people can categorize the social class position of a decision maker.[6] For these reasons the present investigation employs occupation as an indicator of the differential locational preferences of household location seekers.

The stereotype characteristics that pertain to the indicators of the relative socio-economic status of Lansing - East Lansing area household decision makers are shown in Table A.1. The table is derived from data obtained from the U.S. Census of Population and Housing: 1960 (Final Report PHC 1-73) and was developed by the M.E.T.R.O. staff. In presenting the five category classification the M.E.T.R.O. researchers state that there are too few households in the area that could be identified as "upper class" in the classic sense and consequently this class was included in the next lowest class.[7] The table shows that the professional and managerial groups clearly have the highest socio-economic rank, while semi-skilled operatives and service workers and

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[4]August Hollingshead and Fredrick Redlich, eds., Social Class and Mental Illness: A Community Study (New York: John Wiley & Sons, Inc., 1958).

[5]Warner, et. al., loc. cit.

[6]Laumann, op. cit., p. 3.

[7]Tri-County Regional Planning Commission, loc. cit.

TABLE A-1

CHARACTERISTICS OF SOCIO-ECONOMIC STATUS TYPES IN THE LANSING-EAST LANSING AREA - 1960

	Socio-Economic Status Group	Occupation	Income	Education	Household Type
Upper Class	Professional	Professional Technical Workers	½ Above $15,000 ½ $10,000-$15,000	Over 16- years	Value over $20,000 Rent over $150.00/month
Middle Class	Semi-Professional Business	Managers Officials Proprietors	$10,000-$15,000	16 years	Value over $20,000 Rent over $150.00/month
	Clerical Sales	Clerical Workers Sales Workers	$10,000-$15,000	12-16 years	Value - $15,000-$20,000 Rent - $100.00-$149.00/month
Working Class	Skilled	Craftsmen Foremen	$7,000-$10,000	12 years	Value - $10,000-$15,000 Rent - $80.00-$100.00/month
	Semiskilled	Operatives Nonhousehold Service Workers	$4,000-$7,000	8-11 years	Value - $5,000-$9,900 Rent - $20.00-$59.00/month
	Unskilled	Laborers Household Service Workers	Less than $4,000	Less than 8 years	Value less than $5,000 Rent Less than $20.00/month

unskilled laborers and household service workers are clearly lowest in socio-economic status. This ranking corresponds to schemes used in several studies, and despite the fact that there is disagreement on the placement of skilled craftsmen, clerical workers and salesmen, this scheme would probably be agreed on by most social scientists.[8]

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[8]Otis Dudley Duncan and Beverly Duncan, "Residential Segregation and Occupational Stratification," pp. 493-503; Otis Dudley Duncan, "A Sociometric Index for All Occupations" and "Characteristics of the Sociometric Index," Occupations and Social Status, edited by A.J. Reiss, Jr. (New York: Free Press, 1961), pp. 109-161; National Opinion Research Center, "Jobs and Occupations: A Popular Evaluation," Opinion News, Vol. 9 (September, 1947), pp. 3-13.

APPENDIX B

BASIC DATA USED IN THE ALLOCATION MODEL

BY RESIDENTIAL AREA

TABLE B-1

1960 LAND USE INVENTORY[1]

Area ID	Total	Vacant	Unusable	Residential	Commercial	Industrial	Cropland Woodland	Public
1	1692	721	19	495	52	54	10	341
2	986	237	0	292	46	46	67	298
3	600	40	2	243	27	44	0	244
4	518	18	18	209	42	76	0	155
5	635	29	10	291	36	4	0	255
6	932	297	50	227	53	72	0	233
7	1265	458	44	332	40	53	65	273
8	1557	885	23	180	36	43	241	149
9	709	59	0	231	18	44	5	352
10	591	77	9	162	80	9	0	254
11	421	48	0	141	31	1	0	200
12	693	96	17	225	10	40	0	305
13	653	38	34	96	135	42	0	308
14	397	27	19	137	26	58	2	128
15	398	15	43	107	2	1	2	228
16	787	110	0	354	29	28	5	261
17	663	33	7	320	13	41	0	249
18	1082	425	85	195	1	0	0	376
19	1811	888	0	552	62	18	0	285
20	957	240	2	359	37	12	4	303
21	2924	1022	258	220	15	151	729	529
22	4934	1048	43	561	59	30	2663	480
23	3732	593	0	498	19	5	2271	346
24	1136	702	0	106	3	0	261	64
25	1003	410	0	274	17	2	74	226

TABLE B-1 (cont'd.)

Area ID	Total	Vacant	Unusable	Residential	Commercial	Industrial	Cropland Woodland	Public
26	394	43	0	239	6	0	0	106
27	250	11	0	130	22	1	0	86
28	2369	485	23	252	97	59	682	771
29	419	64	2	248	13	0	2	90
30	960	661	1	140	3	1	19	135
31	2542	285	300	286	19	54	1279	319
32	2304	116	643	172	34	0	1224	115
33	2925	208	236	248	6	2	2000	225
34	4041	957	169	596	35	13	1859	412
35	8247	250	72	235	20	6	7336	327
36	14473	437	142	743	44	172	12173	761
37	4045	546	79	594	50	4	2130	642
38	3843	219	188	238	11	52	2491	644
39	16128	344	104	440	5	1	14430	804
40	7608	832	417	553	77	55	4437	1237
41	15497	450	337	416	19	140	13481	654
42	23908	52	2511	537	16	40	19416	1336
43	23690	168	556	406	2	1	21944	613
44	22824	409	594	588	23	50	20096	1064
45	22735	448	817	451	9	32	20122	856

[1] estimated acreage

TABLE B-2

EMPLOYMENT AND SOCIAL OPPORTUNITY INVENTORY

AREA ID	1965 EMPLOYMENT	1960 MALE RESIDENTS BY OCCUPATION					
	Total	Total	Professional & Technical	Managers, Officials, Proprietors, Salesmen	Clerical	Craftsmen & Foremen	Laborers Operatives & Service Workers
1	3498	1952	381	537	148	483	403
2	3010	928	80	114	51	289	394
3	5837	1673	413	394	137	244	485
4	14856	1701	113	128	134	296	1030
5	3087	2139	341	495	238	411	654
6	2859	1404	139	214	92	308	651
7	2773	1374	52	135	80	415	692
8	1549	438	79	148	23	95	93
9	4301	1758	150	314	143	431	720
10	2771	1083	91	254	119	235	384
11	2682	1338	159	288	178	291	422
12	998	1640	116	276	171	370	707
13	17179	1201	114	168	72	155	692
14	4176	1248	86	198	97	298	569
15	102	637	131	160	55	125	166
16	2412	2012	239	498	170	459	646
17	1804	2219	349	624	215	499	532
18	198	431	108	179	24	78	42
19	1297	1804	205	250	168	492	689
20	968	1761	222	274	123	516	626
21	762	463	33	79	26	119	206
22	976	1097	61	173	77	364	422
23	326	1015	45	113	83	289	485

TABLE B-2 (cont'd.)

AREA ID	1965 EMPLOYMENT	1960 MALE RESIDENTS BY OCCUPATION					
	Total	Total	Professional & Technical	Managers, Officials, Proprietors, Salesmen	Clerical	Craftsmen & Foremen	Laborers Operatives & Service Workers
24	123	529	104	175	47	75	128
25	244	895	407	330	30	33	95
26	279	1075	469	341	75	39	151
27	1749	1366	518	213	126	68	441
28	14508	2529	1088	294	246	151	750
29	296	924	434	224	46	62	158
30	8	285	16	28	22	47	172
31	395	558	151	134	34	111	128
32	100	416	45	54	40	113	164
33	243	654	160	186	59	106	143
34	439	1091	339	499	47	96	110
35	232	334	50	87	17	78	102
36	829	1729	141	335	128	468	657
37	361	1010	120	253	80	247	310
38	194	400	17	80	15	112	176
39	93	516	55	114	15	169	163
40	220	1115	83	192	65	364	411
41	269	658	39	122	22	211	264
42	219	759	46	113	41	208	351
43	71	591	55	194	11	126	205
44	194	839	65	200	64	189	321
45	69	507	38	140	18	177	134
TOTAL	99556	50096	8147	10321	3872	10512	17244

TABLE B-3

1960-1965 DWELLING UNIT INVENTORY AND LAND USE CHANGE

AREA ID	DWELLING UNITS[1]			LAND USE CHANGE[2]			
	1960	1965	1960-1965 Change	Total Ind., Comm., and Pub. Land	Industrial Land	Commercial Land	Public Land
1	2013	2439	426	57	2	2	53
2	1184	1226	42	26	0	5	21
3	2006	2011	5	23	-8	18	13
4	2929	2292	-637	35	0	30	5
5	3855	3409	-446	23	-3	13	13
6	1945	1725	-220	63	8	33	22
7	1698	1727	29	48	35	20	-7
8	576	1475	899	68	35	25	8
9	2287	2118	-169	13	-2	10	5
10	1478	1415	-63	-6	0	5	-11
11	1970	2011	41	24	0	7	17
12	2225	2223	-2	18	5	5	8
13	2066	1675	-391	68	8	52	8
14	2014	1916	-98	9	2	9	-2
15	769	785	16	-1	0	0	-1
16	2465	2513	48	-2	10	8	-20
17	2688	2696	8	28	3	5	20
18	555	907	352	35	0	0	35
19	2086	3434	1348	85	2	15	68
20	2128	2232	104	68	0	25	43
21	490	515	25	280	30	3	247
22	1343	1576	233	270	0	10	260
23	1316	1398	82	160	2	5	153
24	620	480	-140	10	0	0	10

TABLE B-3 (cont'd.)

AREA ID	DWELLING UNITS[1]			LAND USE CHANGE[2]			
	1960	1965	1960-1965 Change	Total Ind., Comm., and Pub. Land	Industrial Land	Commercial Land	Public Land
25	962	1310	348	38	0	5	33
26	1218	1269	51	0	0	2	-2
27	1245	1460	215	15	0	0	15
28	2454	2535	81	180	60	0	120
29	1055	1365	310	10	0	0	10
30	324	357	33	3	0	0	3
31	732	867	135	98	33	2	63
32	599	580	-19	54	0	0	54
33	713	797	84	64	0	0	64
34	1226	1454	228	30	0	12	18
35	405	472	67	59	0	0	59
36	2069	2239	170	23	8	13	2
37	1170	1560	410	175	2	33	140
38	441	482	41	93	35	3	55
39	593	929	336	288	0	0	288
40	1358	1521	163	293	35	13	245
41	826	1021	195	130	18	5	107
42	1025	1209	184	183	73	0	110
43	575	707	132	263	0	0	263
44	944	1032	88	205	10	0	195
45	592	690	98	218	25	0	193

[1]U.S. Bureau of the Census

[2]Estimated Acreage Calculated from 1955 and 1962 Land Use Inventories

TABLE B-4

LAND USE ZONING[1]

Area ID	Residential	Commercial	Industrial	Public	Agricultural	Unzoned
1	1422	68	203	0	0	0
2	701	59	227	0	0	0
3	510	18	72	0	0	0
4	357	36	124	0	0	0
5	546	70	19	0	0	0
6	419	37	475	0	0	0
7	1037	51	177	0	0	0
8	1309	62	93	0	93	0
9	581	43	85	0	0	0
10	478	106	6	0	0	0
11	345	76	0	0	0	0
12	596	14	83	0	0	0
13	170	209	274	0	0	0
14	258	36	105	0	0	0
15	398	0	0	0	0	0
16	700	63	24	0	0	0
17	590	20	53	0	0	0
18	1071	11	0	0	0	0
19	1702	54	54	0	0	0
20	843	67	48	0	0	0
21	1848	29	88	0	968	0
22	3947	99	888	0	0	0
23	3284	0	448	0	0	0
24	375	0	11	11	738	0
25	702	50	0	120	130	0
26	371	8	0	8	0	0

TABLE B-4 (cont'd.)

Area ID	Residential	Commercial	Industrial	Public	Agricultural	Unzoned
27	172	73	0	5	0	0
28	190	24	24	1990	142	0
29	381	29	0	8	0	0
30	951	96	0	0	0	0
31	2313	51	152	25	0	0
32	2142	69	92	0	0	0
33	2720	88	117	0	0	0
34	3710	242	81	0	0	0
35	7835	82	330	0	0	0
36	3908	5066	1158	0	4342	0
37	1658	121	0	0	2265	0
38	538	77	884	0	2344	0
39	1774	161	1290	0	12902	0
40	1598	2054	0	0	3956	0
41	1085	0	4184	0	10228	0
42	6455	263	2630	0	14584	0
43	474	474	0	0	22742	0
44	5021	1141	0	0	15749	913
45	2501	227	2728	0	17279	0

[1]Acres of land

TABLE B.5

1965 TRAVEL-TIME BETWEEN AREAS

AREA ID	1 17	2 18	3 19	4 20	5 21	6 22	7 23	8 24	9 25	10 26	11 27	12 28	13 29	14 30	15 31	16 32
1	1.00															
2	9.90	1.00														
3	8.20	4.50	1.00													
4	8.80	5.50	3.80	1.00												
5	5.80	7.50	4.40	4.50	1.00											
6	5.00	9.30	6.20	6.30	2.20	1.00										
7	7.50	12.60	9.50	9.60	5.60	4.20	1.00									
8	11.80	13.70	10.60	10.70	7.30	7.50	9.50	1.00								
9	9.00	11.90	8.80	8.90	5.50	4.70	6.70	8.80	1.00							
10	11.60	13.20	10.40	8.90	7.10	7.30	9.30	6.20	5.90	1.00						
11	10.30	11.60	9.00	7.70	5.80	6.00	8.00	6.50	4.60	4.20	1.00					
12	12.80	11.00	9.90	8.50	8.30	8.50	10.50	9.60	7.60	5.50	4.50	1.00				
13	8.60	7.40	5.10	3.50	3.80	5.00	7.40	9.40	6.50	6.90	5.30	6.10	1.00			
14	11.80	8.60	7.70	4.40	6.90	7.80	9.80	11.70	8.80	8.40	7.20	5.90	4.00	1.00		
15	13.30	11.10	10.30	7.00	8.80	9.00	11.00	11.70	8.80	8.40	7.20	5.80	6.50	4.30	1.00	
16	13.30	10.20	9.40	6.50	8.70	9.00	11.00	12.90	10.00	9.60	8.40	7.10	5.90	3.40	4.00	1.00
17	11.40	7.20	6.30	4.10	7.90	9.60	12.40	14.30	11.40	11.10	9.80	8.60	6.10	4.30	5.50	4.50
	1.00															
18	12.50	8.60	9.30	7.00	10.80	12.50	15.30	17.20	14.30	14.00	12.70	11.50	9.10	7.20	8.40	7.40
	5.30	1.00														
19	9.70	11.20	8.90	12.80	14.40	16.90	18.80	15.90	15.50	14.30	13.00	11.00	8.70	9.90	7.50	0.00
	7.20	5.40	1.00													
20	16.80	12.60	11.70	9.50	12.10	12.40	14.50	15.10	13.50	10.50	11.90	10.60	9.40	6.80	7.50	5.40
	7.70	8.50	8.10	1.00												
21	16.10	13.70	12.90	9.80	11.60	11.80	13.80	13.30	11.50	8.70	9.90	8.60	9.20	6.90	4.50	6.60
	8.00	10.90	12.50	8.90	1.00											
22	19.80	16.60	15.70	13.30	15.30	15.40	17.50	14.40	14.00	9.80	11.80	12.10	12.70	10.20	8.40	8.70
	11.30	12.20	11.70	8.30	6.70	1.00										
23	18.00	14.10	14.30	12.10	15.90	17.60	20.00	18.40	18.00	13.80	15.80	16.00	14.20	11.80	13.00	10.60
	10.30	10.80	10.30	8.70	12.70	9.00	1.00									
24	13.20	15.10	12.00	12.00	8.70	6.90	10.90	7.80	7.50	5.10	6.80	8.70	10.10	11.70	11.60	12.90
	14.30	17.20	18.80	13.90	12.10	13.20	17.10	1.00								
25	13.40	15.30	12.20	12.30	8.90	9.10	11.10	8.10	7.70	5.30	7.00	8.90	10.30	11.90	11.80	13.10
	14.60	17.50	19.00	14.10	12.30	13.40	17.40	4.10	1.00							
26	11.70	13.50	10.50	9.70	7.20	7.40	9.40	6.30	6.00	2.70	5.10	6.20	7.80	9.20	9.20	10.50
	11.90	14.80	16.30	11.50	9.70	10.70	14.70	4.50	4.70	1.00						
27	13.10	14.90	11.80	11.20	8.60	8.70	10.80	7.70	7.30	4.20	6.60	7.70	9.30	10.70	10.10	11.90
	13.40	15.30	17.80	12.90	10.30	12.20	16.20	5.00	4.20	3.30	1.00					
28	13.20	15.00	11.90	11.10	8.70	8.80	10.90	7.80	7.40	4.10	6.50	7.60	9.20	10.60	9.60	11.70
	13.10	16.00	17.50	12.80	9.80	12.10	16.10	5.10	4.90	3.40	1.90	1.00				
29	14.90	16.70	13.70	13.00	10.40	10.60	12.60	9.50	9.20	6.00	8.40	9.50	11.10	11.70	9.30	11.40
	12.90	15.80	17.30	13.70	9.60	12.90	18.00	6.80	4.30	5.20	2.60	3.70	1.00			
30	15.70	17.60	14.50	14.60	11.20	11.40	13.50	10.40	10.00	7.60	9.30	11.30	12.60	14.30	14.00	15.50
	16.90	19.80	21.30	16.50	14.30	15.80	19.70	5.30	2.90	7.00	6.60	7.20	6.60	1.00		
31	18.50	20.40	17.30	17.40	14.00	14.20	16.20	13.20	12.80	10.40	12.10	14.00	15.40	16.00	13.60	15.70
	17.10	20.00	21.60	18.00	13.90	17.10	21.70	9.20	6.50	9.80	7.70	9.10	6.50	8.10	1.00	
32	18.30	20.20	17.10	17.20	13.60	14.00	16.00	13.00	12.60	10.20	11.90	13.80	15.20	16.80	14.80	16.90
	18.40	21.30	22.80	19.00	15.10	18.30	21.20	9.00	6.30	9.60	9.10	9.80	8.60	7.40	7.10	1.00

TABLE B.5 (Cont.)

AREA ID	1 17 33	2 18 34	3 19 35	4 20 36	5 21 37	6 22 38	7 23 39	8 24 40	9 25 41	10 26 42	11 27 43	12 28 44	13 29 45	14 30	15 31	16 32
33	20.0021.9018.8018.9015.5015.7017.7014.7014.3011.5013.6015.5016.9017.6015.3017.40															
	18.8021.7023.2019.6015.5018.8021.7010.70 8.0011.3010.4011.50 9.20 9.10 7.50 4.40															
	1.00															
34	20.2020.4019.0014.4015.7015.8017.9014.8014.4011.3013.7014.8015.5013.5011.1013.30															
	14.7017.6019.1015.5011.4014.7017.5012.10 9.6010.50 7.90 9.00 6.7010.60 8.70 7.90															
	8.30 1.00															
35	23.5023.9021.8019.3019.0019.2021.2018.1017.8013.5015.5015.8017.4017.6015.3017.40															
	18.8021.6020.5015.4014.1013.9016.6016.5013.9014.3012.5013.6011.3015.8013.3011.70															
	12.20 8.50 1.00															
36	21.4017.5017.8015.5018.0018.2020.3017.2016.8012.6014.6014.9015.4012.8012.9011.30															
	13.7014.2013.70 8.9011.50 7.90 9.9016.1016.3013.4014.9015.0015.8018.6020.1020.00															
	20.5016.4015.50 1.00															
37	9.90 6.10 8.20 8.8010.9012.6015.5018.1015.2015.8014.2013.4010.7011.3013.9013.20															
	10.10 9.6010.7014.9016.6017.3014.7017.8018.0016.3017.7017.8019.5020.4023.0022.90															
	24.5023.3024.9018.10 1.00															
38	10.40 6.50 9.00 7.4011.2012.9015.8017.7014.8014.5013.2012.00 9.50 9.9012.5011.70															
	8.70 7.20 8.3012.2015.1012.6010.0017.5017.7015.3016.8016.9018.6020.0022.7022.60															
	24.1021.1020.2013.40 7.50 1.00															
39	12.90 9.2011.3011.9013.9015.6018.5021.1018.2018.8017.2016.5013.9014.4017.0016.30															
	13.2012.7013.8017.9019.8018.2015.6020.8021.0019.3020.7020.8022.5023.4026.0025.90															
	27.5026.4025.8019.00 6.3010.00 1.00															
40	11.7015.8012.7012.80 8.80 7.40 6.8013.8010.2012.7011.1014.0010.8013.1014.5014.40															
	15.8018.7020.2017.8017.2020.7023.4014.8015.0013.3014.6014.7016.5014.4019.8019.40															
	21.1021.7024.4023.5018.0018.5020.80 1.00															
41	11.0015.3015.6017.0013.1011.7011.2016.1014.5017.1015.5018.3015.2017.5018.8018.70															
	19.7019.7020.7022.2021.6025.0025.1017.1017.3017.6018.9019.1020.5016.8022.5021.80															
	23.5025.0028.7027.8017.7017.6019.90 9.10 1.00															
42	19.5021.3016.2018.3015.0015.1016.9014.1013.7011.3013.1015.0016.3018.0017.2019.20															
	20.6023.5025.0020.2017.4019.5023.4010.10 7.5010.8010.3010.90 9.80 7.6010.00 9.00															
	10.6012.2016.5022.2024.5024.6027.5014.9017.20 1.00															
43	29.2029.6027.6025.0024.7024.9026.9023.9023.5019.3021.3021.6023.1024.0021.6023.60															
	25.2026.7026.3024.2019.9020.4022.4022.8022.3020.1020.8021.5019.2023.5021.5021.10															
	21.5017.4016.5019.6030.6025.9031.6030.2034.5025.00 1.00															
44	16.1012.2013.7013.1016.9018.6021.6022.9020.6018.3019.0017.7015.2015.6017.6015.20															
	14.4012.9014.0013.3017.3013.6011.0021.8022.0019.2020.6020.7022.5024.4026.2025.80															
	26.2022.1021.2014.4012.80 8.1013.7024.2023.3028.1027.10 1.00															
45	12.5016.9017.1018.5015.6014.8017.3022.9019.0021.5019.9022.7018.1021.6023.2023.10															
	21.2021.2022.3024.5026.0027.7025.1023.5023.8022.0023.4023.5025.2023.6028.7028.60															
	30.2030.5033.2028.5016.6019.1019.2015.3010.0024.0038.9023.20 1.00															

APPENDIX C

COMPUTER PROGRAM OF THE SPATIAL ALLOCATION MODEL

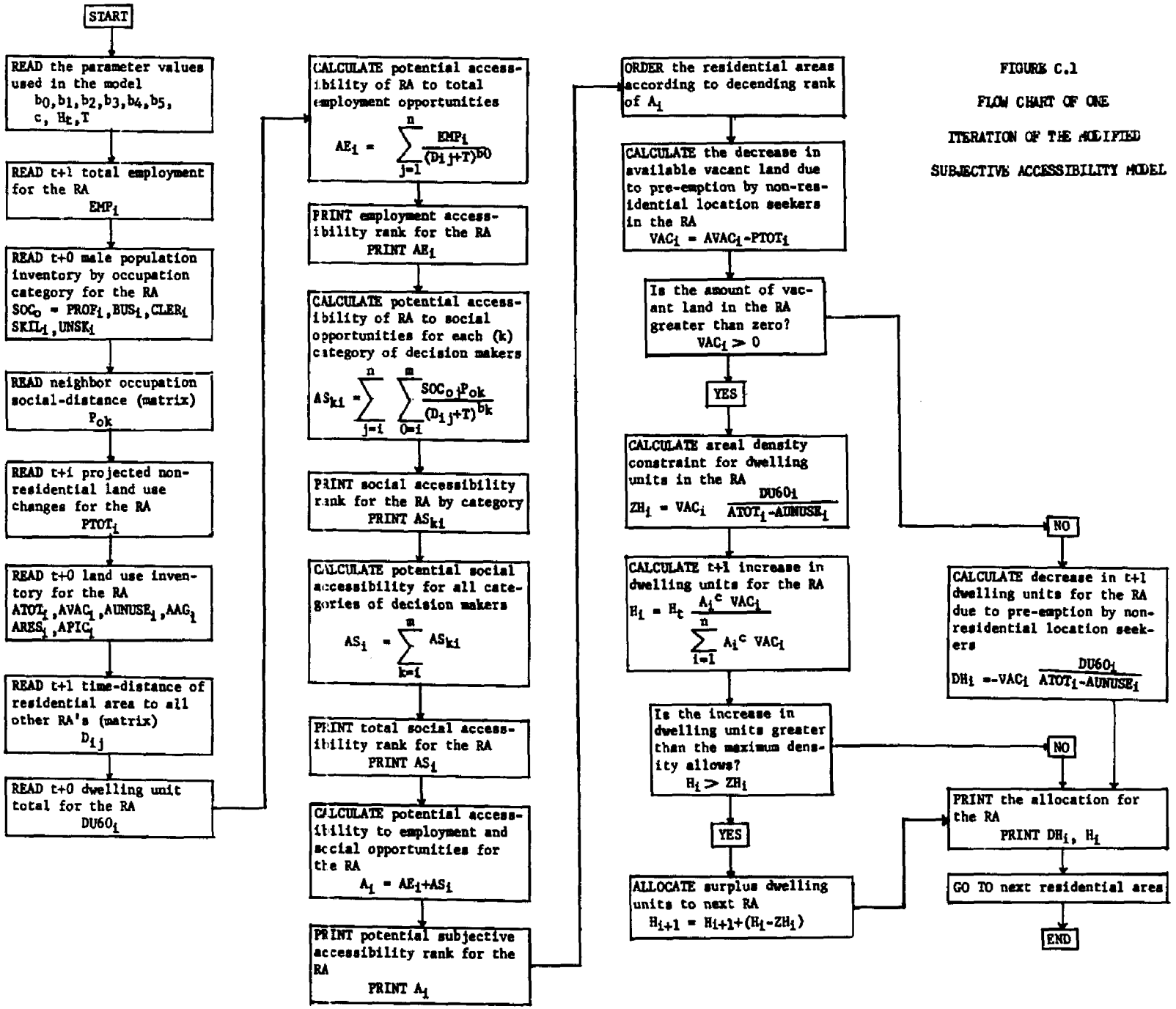

FIGURE C.1

FLOW CHART OF ONE ITERATION OF THE MODIFIED SUBJECTIVE ACCESSIBILITY MODEL

COMPUTER PROGRAM OF THE SPATIAL ALLOCATION MODEL

```
MODEL     PRIMAR EXTENDED VERSION 2.0
      PROGRAM MODEL(INPUT,OUTPUT,TAPE5=INPUT)
      COMMON A0,A(5),C,G,T,ITYPE,TOTEMP(45),WORKR(5,45),NEIGH(
     15,5),PTOT(45),AREA(3,45),TIM(45,45),DU60(45),AE(45),AW(45,5),Z(45)
     2,LRANK(45)
      REAL NEIGH
  999 READ 1,ITYPE,A0,A,C,G,T
      IF(EOF(1))9999,1000
    1 FORMAT(I1/9F8.2)
 1000 IF(ITYPE.NE.2)READ 2,TOTEMP
      PRINT 301,ITYPE,A0,A,C,G,T
  301 FORMAT(*1LIST OF INPUT DATA*/*0TYPEOF RUN IS*,I2/*0PARAMETERS*,9F9
     1.2)
      IF(ITYPE.NE.2) PRINT 302,TOTEMP
      IF(ITYPE.NE.1)READ 3,WORKR,NEIGH
      IF(ITYPE.NE.1) PRINT 303,WORKR,NEIGH
      READ 4,PTOT,AREA     $ AP=0.
      PRINT 304,PTOT,AREA
    2 FORMAT(9X,F8)
    3 FORMAT(45(10X,5F5/),4(10X,5F5.3/),10X,5F5.3)
    4 FORMAT(45(10X,F5/),44(10X,3F6/),10X,3F6)
      PRINT 305
      DO 10 I=1,45
      PRINT 306,I
   10 READ 11,(TIM(I,J),J=1,I)
   11 FORMAT(8X,16F4.2)
      DO 12 I=1,45
   12 PRINT 307,(TIM(I,J),J=1,I)
      DO 20 I=1,44
      J=I+1
      DO 20 K=J,45
   20 TIM(I,K)=TIM(K,I)
      PRINT 307,((TIM(I,J),I=1,45),J=1,45)
      READ 21,DU60
      PRINT 308,DU60
      IF(ITYPE.EQ.2) GO TO 100
  302 FORMAT(*0EMPLOYMENT*,45(/X,F8))
  303 FORMAT(*0WORKER*,45(/X,5F6)/*0NEIGH*,5(/X,5F6.3))
  304 FORMAT(*0PTOT*,45(/,F6)/*0AREA*,45(/X,3F8))
  305 FORMAT(*0*/*0READING TIMES*)
  306 FORMAT(*0READ ROW*,I3)
  307 FORMAT(X,16F5.2)
  308 FORMAT(*0*/*0DU60*,45(/X,F8))
   21 FORMAT(16X,F7)
      DO 30 I=1,45     $ AP(I)=0.
      DO 30 J=1,45
      IF(LEGVAR(TIM(I,J)).NE.0)GO TO 899
      IF(LEGVAR(I).NE.0)GO TO 899
      F=TIM(I,J)+T
      IF(LEGVAR(F).NE.0)GO TO 899
      IF(F.EQ.0.)GO TO 899
      IF(LEGVAR(60        ).NE.0)GO TO 899
      F=F**A0
      IF(LEGVAR(F).NE.0)GO TO 899
      IF(F.EQ.0.)GO TO 899
      IF(LEGVAR(TOTEMP(J)).NE.0)GO TO 899
      F=TOTEMP(J)/F
      IF(LEGVAR(F).NE.0)GO TO 899
      IF(LEGVAR(AP(I)).NE.0)GO TO 899
   30 AE(I)=AE(I)+F
      IF(ITYPE.EQ.3)GO TO 100
      PRINT 31
   31 FORMAT (*0RANKED EMPLOYMENT ACCESSIBILITY*)
      CALL RANKIT(AE,LRANK)
      GO TO 200
  899 PRINT 898,I,J,F,A0,T,TIM(I,J),AE(I),TOTEMP(J)
  898 FORMAT(2I5,6F12.3)
      CALL EXIT
```

```
      DO 110 I=1,5
      DO 110 J=1,45    ± A*(J,I)=0.
      DO 110 K=1,5
      DO 110 L=1,45
  110 AW(J,I)=AW(J,I)+ZONE(K,L)*WEIGH(K,I)/(TIM(J,L)+T)**B(I)
      PRINT 119
  119 FORMAT(*1SOCIAL ACCESSIBILITY FOR CLASSES*)
      PRINT 120,((AW(I,J),J=1,5),I=1,45)
  120 FORMAT(5F15.3)
      DO 130 I=2,5
      DO 130 J=1,45
  130 AW(J,1)=AW(J,1)+AW(J,I)
      IF(ITYPE.EQ.3)GO TO 150
      PRINT 131
      CALL RANKIT(AW,LRANK)
      GO TO 200
  131 FORMAT(*1RANKED SOCIAL ACCESSIBILITY*)
  150 DO 160 I=1,45
  160 AE(I)=AE(I)+AW(I,1)
      PRINT 161
  161 FORMAT(*1RANKED COMBINED ACCESSIBILITY INDEX*)
      CALL RANKIT(AE,LRANK)
  200 PRINT 171
  171 FORMAT(*1HOUSEHOLD ALLOCATIONS*/* AREA*,10X,*ALLOC.*)
      DO 250 II=1,45
      I=LRANK(II)
      AREA(2,I)=AREA(2,I)-PIOT(I)
      IF(AREA(2,I).GT.0)GO TO 210
            DRI= AREA(2,I)/(AREA(1,I)-AREA(3,I))*DU60(I)
      PRINT 201,I,DRI
      GO TO 250
  201 FORMAT(I5,F16.3)
  210 Z(I)=AREA(2,I)/(AREA(1,I)-AREA(3,I))*DU60(I)
      SUMA=0
      DO 220 J=1,45
      A=AE(J)
      IF(ITYPE.EQ.2)A=AW(J)
  220 SUMA=SUMA+A**C*AREA(2,J)
      A=AE(I)
      IF(ITYPE.EQ.2)A=AW(I)
      A=G*A**C*AREA(2,I)/SUMA*AP
      IF(A.LE.Z(I))GO TO 240
      AP=A-Z(I)
      PRINT 201,I,Z(I)
      GO TO 250
  240 AP=0
      PRINT 201,I,A
  250 CONTINUE
      GO TO 999
 9999 CONTINUE
      END

      SUBROUTINE RANKIT(A,K)
      DIMENSION A(45),B(45),K(45)
      DO 10 I=1,45
      B(I)=A(I)
   10 K(I)=I
      DO 20 I=1,44
      J=I+1
      DO 20 L=J,45
      IF(B(L).LE.B(I))GO TO 20
      ITEMP=B(I)
      ITEMP=K(L)
      B(L)=B(I)
      K(L)=K(I)
      B(I)=ITEMP
      K(I)=ITEMP
   20 CONTINUE
      PRINT 30
   30 FORMAT(* AREA ACCESS.*)
      PRINT40,(K(I),B(I),I=1,45)
   40 FORMAT(I5,F8.2)
      RETURN
      END
```

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