Volume Title: Transportation Economics

Volume Author/Editor: Universities-National Bureau

Volume Publisher: UMI

Volume ISBN: 0-87014-308-5

Volume URL: http://www.nber.org/books/univ65-2

Publication Date: 1965

Chapter Title: The Commuting and Residential Decisions of Central Business District Workers

Chapter Author: John F. Kain

Chapter URL: http://www.nber.org/chapters/c7058

Chapter pages in book: (p. 245 - 274)

The Commuting and Residential Decisions of Central Business District Workers

JOHN F. KAIN

U.S. AIR FORCE ACADEMY AND THE RAND CORPORATION

I. Introduction

During recent years, people interested in the well-being of urban communities have given increasing attention to urban transportation problems. In particular, they have been concerned with the plight of central business district commuters and the difficulties and costs confronting large central cities that wish to provide highway access facilities for the increasing numbers of automobile commuters. Many people regard automobile commuting to central areas as prohibitively expensive for both the individual and the community. Noting the apparent ability of rapid-transit systems in Chicago, Cleveland, New York, and elsewhere to maintain peak-hour ridership (even though suffering declines in over-all ridership), planners and community leaders in San Francisco-Oakland, Washington, D.C., Los Angeles, and a number of other urban areas have proposed the construction of new rail rapid-transit systems for their cities.[1]

NOTE: Views expressed in this paper are those of the author. They should not be interpreted as reflecting the views of the U.S. Air Force Academy or the U.S. Air Force, The RAND Corporation, or as the official opinion or policy of any of its government or private research sponsors.

The author thanks the sponsors and participants of the Detroit Area Traffic Study and the Chicago Area Transportation Study for making available IBM decks and other data, and for the assistance given by staff members. In particular, the author acknowledges the assistance of Douglas Carroll, Jr., director of the Chicago study; of Albert Mayer, director of the Institute for Regional and Urban Studies, Wayne State University, who made the data available; and of Sue Smock for help in interpreting the Detroit study data.

[1] Voters of three San Francisco-Oakland Bay area counties have approved a bond issue to finance a 75-mile trans-bay rail rapid-transit system with an estimated

Despite the hopes entertained for these plans, very little is known about the characteristics of central business district commuters or of their travel and residential behavior that would be crucial in determining the success of the plans. It is the purpose of this paper to examine and interpret these behavioral patterns, and in particular the interrelationships between them, for workers employed in the central business districts of Detroit and Chicago—the nation's second and fifth largest metropolitan areas—and to illustrate the usefulness of economic theory in explaining and predicting that behavior.

In Section II, below, a simple consumer-choice model is developed for analysis of the trade-off between housing cost and travel cost to explain residential choices, residential density, and commuting behavior of workers employed at high-density workplaces in major urban centers. Section II also includes a few simple and fairly obvious empirical tests of such models, using data obtained on these kinds of workers from the 1952 Detroit and 1956 Chicago transportation studies.[2] The primary

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capital cost of nearly $1 billion. The Los Angeles Metropolitan Transit Authority, emboldened by the success of the Bay Area rapid-transit district in obtaining tax support, has expanded its proposed $300 million, 22.7-mile "Backbone Plan" to a $649 million, 58-mile system. The National Capitol Transportation Agency submitted to the President its report on Nov. 1, 1962, which proposed construction of an 83-mile, $800 million rail-transit system for the Washington, D.C. region and a substantial curtailment of the region's highway program. New rail-transit systems are being seriously proposed for Atlanta and Pittsburgh and, less seriously, for a number of other large metropolitan areas. Moreover, Philadelphia, Boston, Chicago, and New York are seeking Federal subsidies for expansion of existing rail facilities.

[2] The data describe the attributes and work-trip behavior of nearly 4,000 interviewed households representing approximately 110,000 of Detroit's central business district workers (about 100,000 whites and 10,000 nonwhites); nearly 17,000 interviewed households representing approximately 247,000 of Chicago's central business district workers; and approximately 296,000 workers employed in the area just adjacent to the Chicago central business district.

Original card records were obtained from the Detroit area traffic study and the Chicago area transportation study. The work presented here is part of a larger RAND research project, sponsored by the Ford Foundation, analyzing samples of travel data for approximately 40,000 Detroit and 50,000 Chicago households. The study considers only the "first work trip" made by each sampled household member belonging to the labor force on the day interviewed, and analyzes the journey from home to work, rather than the trip from work to home or the round trip. The morning trip was chosen over the evening trip because it is less often "distorted" by side trips for shopping and other purposes, and thus is more "normal." In addition, the study included only "internal trips," defined as trips having both ends within the study area. Since the study area is very large, workers residing outside it make only a small percentage of the total person trips: 5.3 per cent in Chicago and perhaps 7 per cent in Detroit. The percentage of such trips analyzed in this paper is of course very much smaller, with the exception of the relatively large number of rail trips entering the Chicago central business district from outside the cordon.

purposes of these simple empirical tests are to illustrate more clearly the logic of the theoretical framework used in this paper and to illustrate its consistency with widely-accepted empirical facts.

In Section III, the simple model is elaborated in order to incorporate the substantial effects of racial segregation on the residential and commuting behavior of both white and nonwhite workers employed at high-density work places. In particular, it tries to examine how discrimination affects the operation of the housing market and the spatial distribution of urban housing costs. Section III also presents empirical data illustrating some of the substantial effects of racial discrimination on the commuting behavior and residential choices of both whites and Negroes.

Section IV presents more substantial tests of hypotheses obtained from the more elaborate model, incorporating market imperfections and racial constraints. These tests deal primarily with relationships between residential space consumption and the length of the journey to work, and with relationships between housing costs and the space consumption of whites and nonwhites. The worker populations of both the Detroit and Chicago central business districts are stratified by structure type (used as a measure of residential space consumption), by city and workplace location, and by race, to examine the effects of these variables on journey-to-work length and the consumption of residential space. Journey-to-work length is measured in both elapsed time and distance in order to permit evaluation of households' trade–offs between travel and money expenditures.

Finally, in Section V the choice of transportation mode is examined in the context of the substitution of time and money costs in commuting, and in terms of the interrelationship between the choice of residential density and the costs in time and money of the alternative travel modes and combinations of modes.

II. A Model of Household Residential and Travel Behavior

The behavioral hypotheses used here to explain the residential and travel behavior of workers employed in central locations are relatively few and simple. It is assumed that households try to maximize their total real income in what is undoubtedly an imperfect way; that is, they try to obtain their preferred set of consumer services at lowest possible cost. It is also argued that the length of a worker's journey to work, and thus the distance he resides from his workplace, largely

depends on a cost trade-off between transportation costs and housing costs.[3]

The essence of this trade-off is that, while workers employed at central locations can lower their housing costs by living farther from their workplaces, they increase their travel costs by doing so. The second relevant aspect of this trade-off is the fact that the magnitude of such savings in housing cost increases with the amount of residential space the worker uses, greater space consumption being associated with residence in lower-density structures. The utility-maximizing worker lives at that distance from his workplace where the money he saves in housing costs by undertaking a longer journey to work is just offset by increased travel costs.

The assumption that the portion of housing costs variously referred to by other authors as "location," "site," or "position" rents declines with distance from major workplace agglomerations is crucial to the explanation of household travel behavior developed in this paper.[4] These location or site rents are economic rents which landlords may obtain from households for sites more accessible to major workplaces agglomerations. The rents exist because of households' collective efforts to economize on transportation expenditures. Location rent surfaces having these properties have been obtained in a number of theoretical writings.[5]

It seems probable that a surface of location or site rents would be very complex and that location rent surfaces might differ for various types of accommodations (those of varying quality, density, age, etc.). The quasi-rents obtainable in one submarket defined by, say, quality differences, might differ substantially from those obtainable in another. Market disequilibrium may well be the rule rather than the exception,

[3] A more complete and rigorous presentation of this model may be found in John F. Kain, *Commuting and Housing Choices: An Empirical Study*, The RAND Corporation, Memorandum RM-3738-FF (in press); and *idem*, "The Journey-to-Work as a Determinant of Residential Location," *Proceedings of the Regional Science Association*, 1961.

[4] See, for example, Edgar M. Hoover and Raymond Vernon, *Anatomy of a Metropolis*, Harvard University Press, 1959; William Alonzo, "A Theory of the Urban Land Market," *Papers and Proceedings, Regional Science Association*, University of Pennsylvania, 1960; John D. Herbert and Benjamin H. Stevens, "A Model for the Distribution of Residential Activity in Urban Areas," *Journal Regional Science*, Fall 1960; Lowdon Wingo, Jr., *Transportation and Urban Land* Resources for the Future, Washington, 1961; and Ira South Lowry, "Residential Location in Urban Areas," unpublished Ph.D. dissertation, University of California, 1960.

[5] See, for example, Alonzo, "Urban Land Markets," and Wingo, *Transportation and Urban Land.*

since there are major imperfections in the market for real property, and since housing is both durable and nonhomogeneous.

Although there is apparently no empirical information that permits direct evaluation of the hypothesis that location rents in the various submarkets differ, there is some inferential evidence. For one thing, some kinds of residential services may be difficult or impossible to secure by renovating single units of the existing stock of housing. For example, if large lots, high levels of community services, and other than gridiron street patterns are highly preferred residential attributes, wholesale demolition and redevelopment would probably be necessary to achieve them in the older built-up portions of cities. Since large lots are rare in old residential areas near central business districts, the price of large-lot residential services might vary by a greater amount with distance from the central business district and other workplace agglomerations than the price of small-lot residential services would. Thus, if there are two submarkets, one characterized by modern, high-quality, large-lot residential structures and another, by obsolete, low-quality, small-lot structures, the incremental savings obtainable with distance from major workplaces might well be much greater in the former than the latter. In either case, however, we would expect the price for units in either submarket to decline with distance from the central business district. Furthermore, even given the above reservation, there is no obvious reason systematic price differentials between the various submarkets, in the absence of serious market imperfections, should persist for long periods. Housing services can be either upgraded or downgraded. Downgrading can occur through density-increasing conversions, permissive deterioration, and failure to maintain and renovate structures. Upgrading can occur by renovation, demolition, and reconstruction, and by other forms of private market renewal.[6]

Since the workers dealt with in this paper are employed in the central areas of Chicago and Detriot, where urban employment densities are highest, we would expect their housing costs per unit of residential space to decline with distance from the center. Because Chicago and Detroit differ in size and in the numbers employed in their central business districts (about two and one-half times as many in Chicago as in Detroit), it would seem reasonable to expect—assuming

[6] Society Hill and Rittenhouse Square, in Philadelphia, and Capitol Hill and Georgetown, in Washington, are frequently cited examples of private market renewal. In all instances, however, housing located in these areas is extremely expensive.

the above provisional hypotheses about the determinants of location rents are valid—that location or site rents would be higher in Chicago than in Detroit at each distance from the central business district. Specifically, for the purpose of the empirical testing in this study, it is postulated that the price per unit of residential space of a stated quality and amenity decreases monotonically with distance from the center, but that the price is consistently higher for Chicago. Thus it is postulated that centrally employed workers in both cities may reduce their housing costs per density unit by commuting longer distances, but that the savings per mile will be larger for Chicago workers.

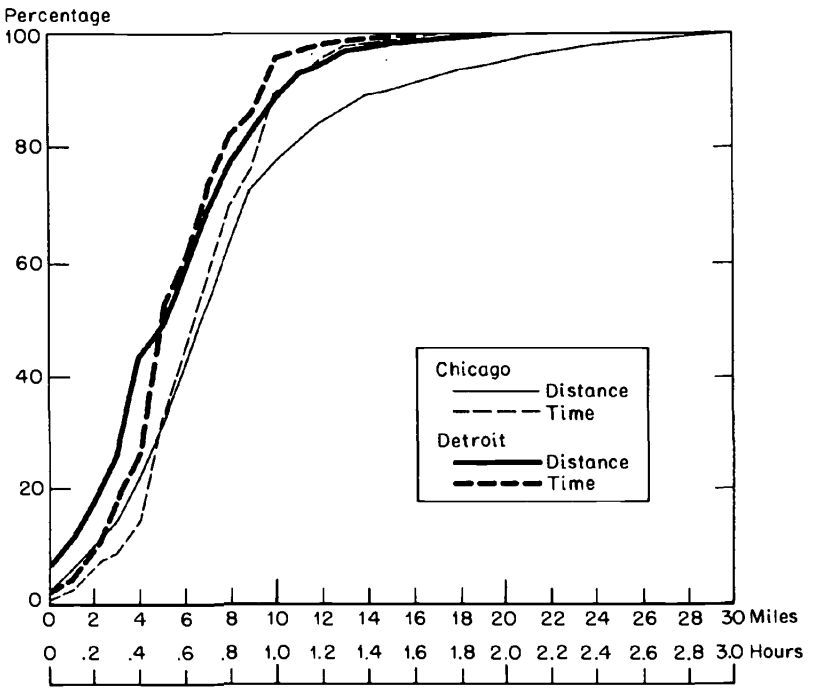
It is also crucial that, in making longer journeys to work, households incur larger costs in both time and money. Since time is a scarce commodity, workers should demand some compensation for the time they spend in commuting.[7] Both the commuting distance and time a central business district worker will spend thus depend on his valuation of commuting time, the money cost of his commuting, and the savings in housing cost he is able to obtain from a longer journey to work. He will extend his distance only so long as his savings in location rent offset or just equal his increased expenditures of time and money.

His reductions in housing cost, however, depend not only on his commuting distance, but also upon the quantity or the amount of residential space he consumes. If he lives in very low-density residential quarters, his cost savings per unit of residential space are multiplied by a large number of units; if he chooses very high-density quarters, his savings may be small. For many people housing-cost savings obtained from longer journeys to work may be quickly offset by increasing travel costs.

Unless the labor forces of Detroit's and Chicago's central business districts differ greatly in their socioeconomic composition, the simple economic model used in this paper would predict that Chicago workers'

[7] The problem of valuing travel time is extremely complex. Nearly all benefit-cost analyses of urban transportation systems include a value of travel time as part of an analysis of alternative systems. Savings in travel time invariably swamp all other benefits in such analyses. Nonetheless, no one has devised an adequate empirical measurement of the value of time. Transportation studies invariably use some wage rate to value travel time, on the assumption that the value of commuting time is equal to the wage rate. Moses and Williamson have pointed out the theoretical difficulties inherent in such a procedure in two papers, which represent the best theoretical statement of the problem (see Leon Moses, "Economics of Consumer Choice in Urban Transportation," presented at Dynamics of Urban Transportation a symposium sponsored by Automobile Manufacturers Association, 1962; and Moses and Harold F. Williamson, Jr., "Value of Time, Choice of Mode, and the Subsidy Issue in Urban Transportation," unpublished; see also Fred Hoffman, "Route Choice and Valuation of Travel Time," unpublished.).

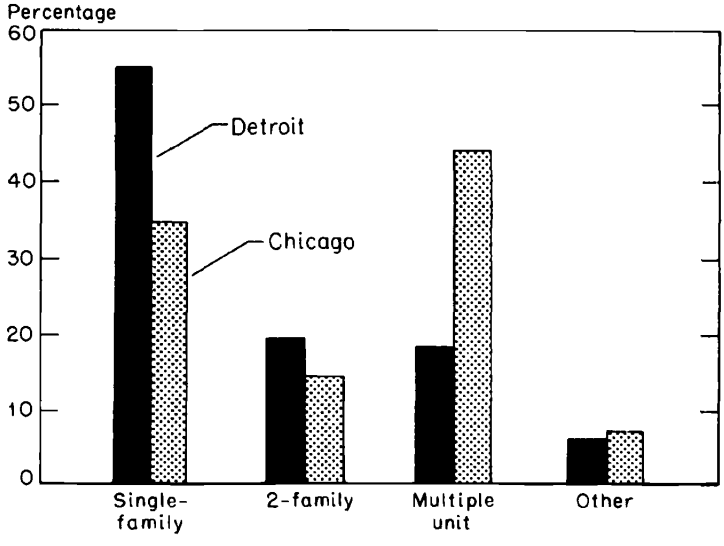
Figure 1
Cumulative Percentage Travel Times and Distances for Chicago and Detroit Central Business District Workers



trips, measured by either elapsed time or distance, should exceed those of Detroit workers. As noted previously, we would expect larger savings in housing costs to be obtainable by commuting a given distance in Chicago than in Detroit, at every level of residential space consumption. Thus, if transportation costs in Chicago and Detroit are at all comparable, Chicago workers would be expected both to commute farther and to spend more time commuting. Precisely this relationship is shown in Figure 1: 50 per cent of Detroit's central business district workers can get home by traveling five miles or less, and thirty minutes or less; only 32 per cent of their Chicago counterparts live that nearby, and only 34 per cent can get home within that length of time.

Just as certainly, the simple consumer-choice model predicts that Detroit workers will consume more residential space since it costs less than in Chicago. Figure 2 illustrates the comparison, measuring residential space consumption according to the structure type of

Figure 2
Percentage of Chicago and Detroit Central Business District Workers Residing in Each Structure Type



residence. It is assumed that the greatest amount of space is consumed by single-family units, followed by two-family units and multiple units. Both findings are well known and obvious empirical relationships. They are presented here because they are consistent with the consumer-choice model previously discussed, and because they illustrate the trade-off between housing cost and travel cost.

III. Housing-Market Discrimination and the Commuting of Negroes and Whites

In the absence of serious housing-market imperfections, it is possible that the simple model presented in Section II could explain household behavior adequately, especially if elaborated in terms of the heterogeneity of residential services according to attributes other than location, and in terms of the effect on travel and housing costs of other trips made by household members.[8]

[8] As an example of the latter, the housing-cost/travel-cost trade-offs of households with two or more wage earners must include all of their combined journey to work costs. Similarly, other kinds of frequently made trips may significantly affect the level of combined travel and housing costs for some households.

A far more serious omission in the model as presented thus far is the failure to consider explicitly the effects of racial discrimination on commuting and residential location. Any theory or model of the work trip and the residential-location behavior of urban households, if it pretends to be realistic and reasonably complete, should explicitly consider these effects, since racial discrimination in the housing market is a potentially enormous market imperfection with great influence on the commuting and residence patterns of both whites and nonwhites.

Racial discrimination may be thought of as a constraint on the housing-cost/transportation-cost trade-off model discussed previously. Discrimination limits the range of choice in which nonwhites are able to exercise the market calculus described above. In addition, the division of the market into two submarkets (a "free market" for whites, with unrestricted location choices, and a "segregated market" for nonwhites) affects the prices of housing services at various locations. Where such imperfections prevail, the schedule of location- or site-rents would be expected to differ from that postulated previously or obtained in the theoretical writings previously mentioned.[9]

Price levels in both submarkets are determined largely by supply and demand forces, but the determinants of these forces differ considerably between the two. The salient feature of both submarkets is the fact that existing housing stock makes up most of the supply. Each year's new construction is but a fraction of the total. A second important feature of the supply schedule is that the housing services represented by the stock are fixed by location and all but impossible to move to other locations. Urban development has usually occurred incrementally with distance from a single dominant center; as a result, the age distribution of the housing stock varies systematically with location.

Chicago and Detroit contain a single dominant nucleus and several much smaller subcenters around which some peripheral growth has occurred and around which, as a result, some older structures are located; but the overwhelming majority of older structures are found in and around the central business districts. The segregated market in Detroit and Chicago, as in most United States metropolitan areas, is mostly located around the dominant center, frequently referred to as "the grey area." Thus nearly all the structures in the nonwhite market are of prewar construction. Recent additions to the housing stock have been predominantly of two kinds: new lower-density structures on the periphery, and high-rise and other high-density structures at more central locations.

[9] Wingo, *Transportation and Urban Land*; and Alonzo, "Urban Land Market."

A ceiling on free-market rents and housing prices is established by the cost of providing new housing services, i.e., the cost of new construction. Of course, the costs of producing new housing vary considerably from one location to another. The greatest differences are due to variations in land costs, and the greatest of these are between the costs of vacant and nonvacant land. Site costs of developed sites are equal to the discounted value of the income streams of existing properties plus demolition costs. Thus it is hardly surprising that demolition is seldom carried out by the private market except to provide sites for very high-density and high-quality apartment developments in areas where there is substantial excess demand for them, or to provide sites for industrial or commercial use.

In any case, a price ceiling exists for any type of free-market housing, dependent on the costs of providing the desired services in a new structure or location and the differential travel costs between each site and peripheral sites. The earlier discussion makes clear that price differences equal to travel-cost differences may exist between two locations without providing an incentive for a household to locate in the lower-cost area. The critical importance of the available stock also causes a certain asymmetry in this market; price ceilings exist for each type of housing service, but no floor, except the chain of substitutes and the ability to modify the supply characteristics of the existing stock. Conversions, renovations, redecorating, and permissive deterioration are methods used by landlords and home-owners to change the configuration of the supply of housing services to correspond to changes in the configuration of demand in order to maximize their rental income.

Since nonwhites are almost entirely banned from outlying residential locations, price determination in the segregated market differs in a number of important ways from that in the free market. The price ceiling established by the cost of new fringe construction is almost entirely absent from the segregated market. The ceiling established by the cost of new construction in built-up areas still exists but, as in the free market, it is likely to be operative only at price levels considerably above those established by new construction on vacant land.

Demand for residential services in the segregated market is determined by forces similar to those in the free market. The major demand determinants for housing services in metropolitan areas during the postwar period have been increases in metropolitan populations, increases and redistribution of employment, rising incomes, and cheaper

and more available housing credit. Increases in the nonwhite demand for residential services in urban areas were especially substantial during and after the war as large numbers of rural southern Negroes and of Puerto Ricans migrated to cities. Unlike whites, who can locate anywhere, nonwhites are mostly confined to areas allocated to them by convention, collusion, and the like.

While many of the same possibilities for adjusting the supply exist in the segregated as in the free market—such as the widely used device of density-increasing conversions—supply determinants in the segregated market are still considerably different. Since new construction is insignificant in the segregated market, nearly all additions to its housing supply must come from spatial expansion of the segregated market. Such expansion primarily results from very substantial increases in the nonwhite demand for housing services; it usually consists of peripheral growth—almost never of the creation of "islands" in all-white areas. Thus, the prices and changes in their level in the segregated market depend almost entirely on the relative growth of the nonwhite demand within an urban area, and the rate at which the segregated market is permitted to expand.

If demand far exceeds supply in the segregated market, as it did during and immediately after World War II, rents and housing prices are sure to rise. Wartime controls on building materials and construction kept the supply of urban housing services relatively constant. At the same time, migration to cities and higher incomes caused demand to soar, especially in the segregated market, generating enormous increases in densities and sharp increases in price levels.

The postwar housebuilding boom slowly eased the supply situation, and larger peripheral expansions of the segregated market were allowed. Large price differentials between the two markets gave whites an incentive to put housing on the segregated market. They used the profits to purchase more or better housing services elsewhere. The result was a fairly rapid expansion and consolidation of the segregated market which may have erased the former price differentials. That a positive differential still remains, however, and undoubtedly will remain so long as effective segregation persists seems likely, the reason being that the nonwhite market expands only as the result of demand pressures. Unless a Negro is willing to pay somewhat more for a particular location than a white is, white owners and landlords are unlikely to sell or rent to him. Therefore, barring a sharp decrease in nonwhite demand, price levels in the segregated market will probably continue to be higher than in the free market.

This conclusion runs counter to views widely held and accepted by real estate brokers and white home-owners. For example, it is still commonly believed that property values plummet when Negroes move into a white neighborhood. Such beliefs are consistently refuted by all the systematic empirical investigations the author has encountered,[10] but they are still held by lenders and until recently have even been approved by the Federal Housing Authority in its appraisal policies. Their full acceptance—especially by mortgage lenders, whose attitudes so crucially influence the operation of the market—makes their becoming self-fulfilling prophecies an omnipresent danger.

The author proposes that discrimination raises the cost of Negro housing above that of similar free-market housing, but that housing prices in the segregated market vary inversely with distance from major workplace agglomerations, just as they do in the free market. For the empirical testing that follows, it is postulated that: (1) housing costs in the segregated market are higher at every distance from the central business district than they are in the free market; (2) that Detroit housing costs in the segregated market are lower than those in Chicago at each distance; and (3) that housing costs per unit of residential space of a given quality decrease with distance from the central business district in each of the four markets.

The nearly absolute restriction on nonwhite residential location is illustrated in Figures 3 and 4, depicting the residential areas of Detroit and Chicago. The data shown in the two figures represent the nonwhite percentages of the total number of workers residing in each area during the study years. Given these spatial patterns of housing segregation, the reader can easily perceive that whites and nonwhites in both cities differ significantly in the distances and elapsed times of their journey to work. The effects of these constraints on Negro residential choice are partly shown in Figure 5, which graphs the percentages of Chicago and Detroit whites and Negroes residing in each two-mile interval from the central business district in which they work. The similarity in the patterns for the two cities is almost uncanny. The only significant difference is that the peaks of the distributions are about two miles closer to the central business district in Detroit than in Chicago. In Detroit, 36 per cent of the Negro labor force in the central business district reside between two and four miles from the district; in Chicago, almost an identical percentage reside between four and six miles from

[10] For example, see William M. Ladd, "The Effect of Integration on Property Values," *American Economic Review*, Sept. 1962; and Luigi Laurenti, *Property Values and Race: Studies in Seven Cities*, University of California Press, 1960.

Figure 3
Negro Workers Residing in Each Detroit Analysis Area
as a Percentage of All Workers Residing in
the Analysis Area, 1953

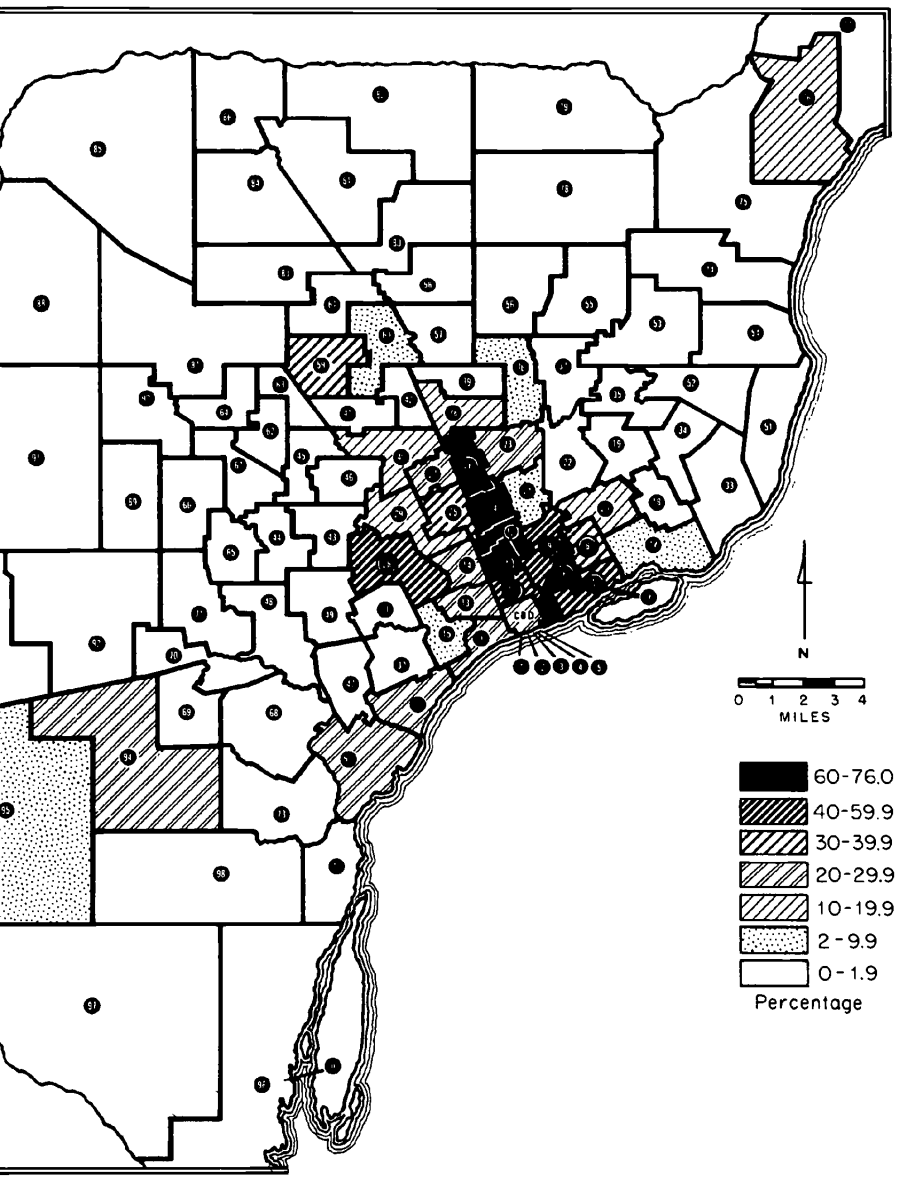


Figure 4
Negro Workers Residing in Each Chicago Analysis Area as a Percentage of All Workers Residing in the Analysis Area, 1956

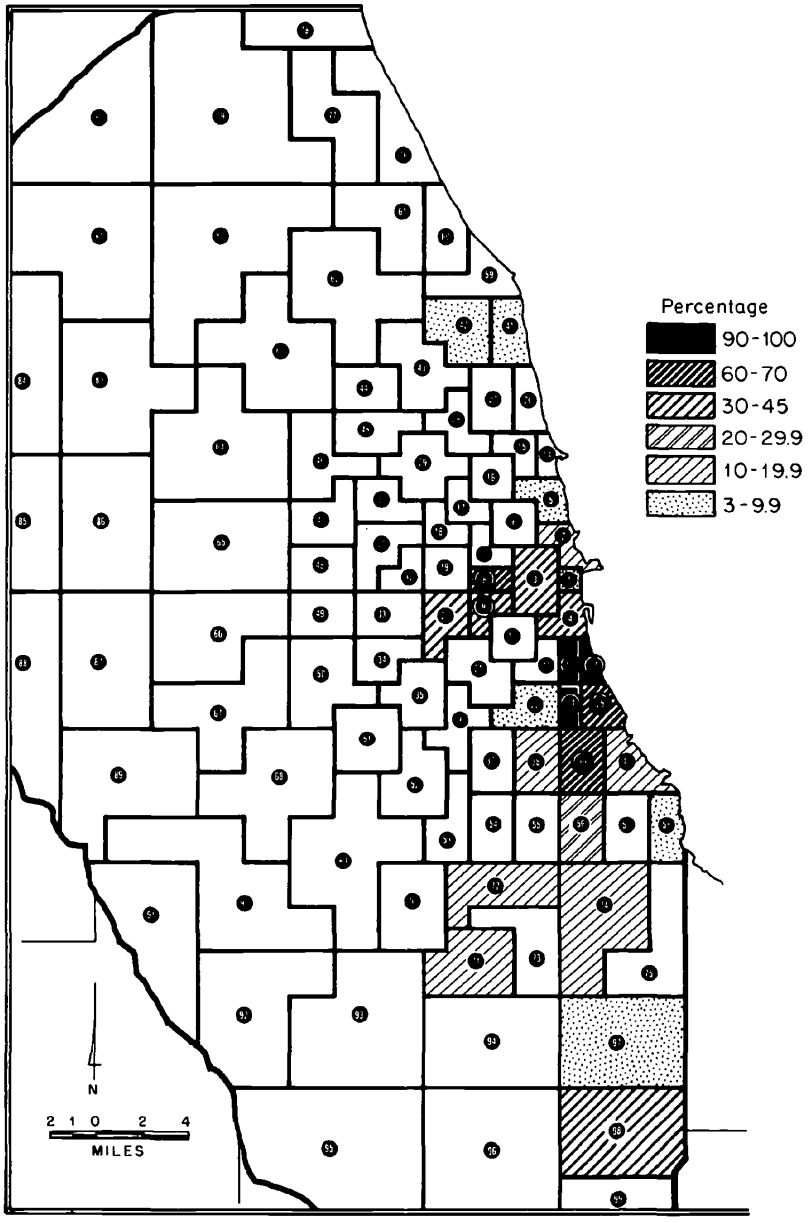
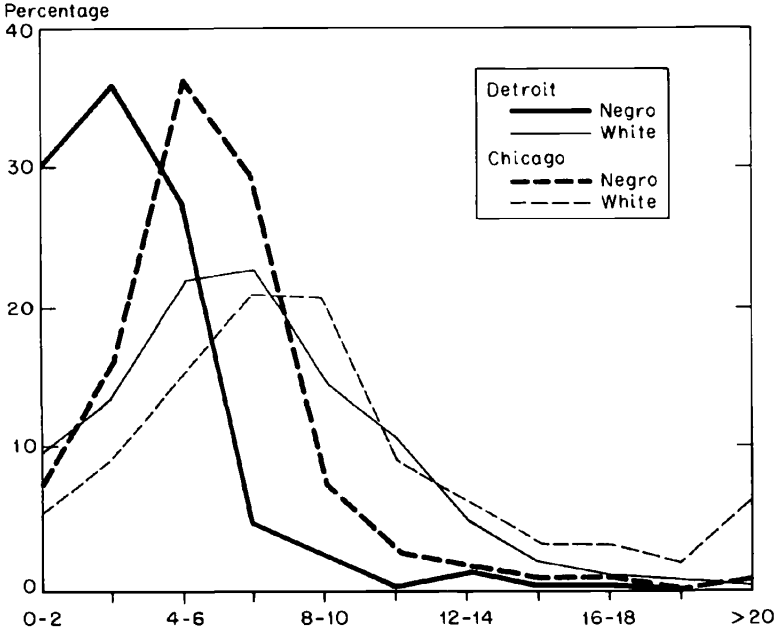


Figure 5
Percentage of White and Negro Central Business District Workers Residing in Each Two-Mile Distance Ring from the Chicago and Detroit Centers



the Loop. About 22 per cent of Detroit's white workers reside in each of the distance intervals, four to six miles and six to eight miles; only about 1 per cent less of their Chicago counterparts reside in each of the six to eight and eight to ten mile intervals. These striking similarities prevail despite the fact that the two cities differ substantially in metropolitan population, central business district employment, industrial composition, area, period of most rapid development, residential density, and most other attributes that affect travel and residential patterns.

The discrepancy in the distances at which the profiles peak is due largely to differences in central business district employment levels and in metropolitan scale. For the same percentages of central business district workers to live within a given distance in both cities, the residential density of Chicago's workers would have to be several times as great. This is accentuated by the fact that in Chicago the quantity and percentage of the total area devoted to nonresidential use near the central business district are several times as great as in Detroit.

Figure 6
Percentages of Chicago White and Nonwhite Central Business District Workers Residing in Each Sector, 1956

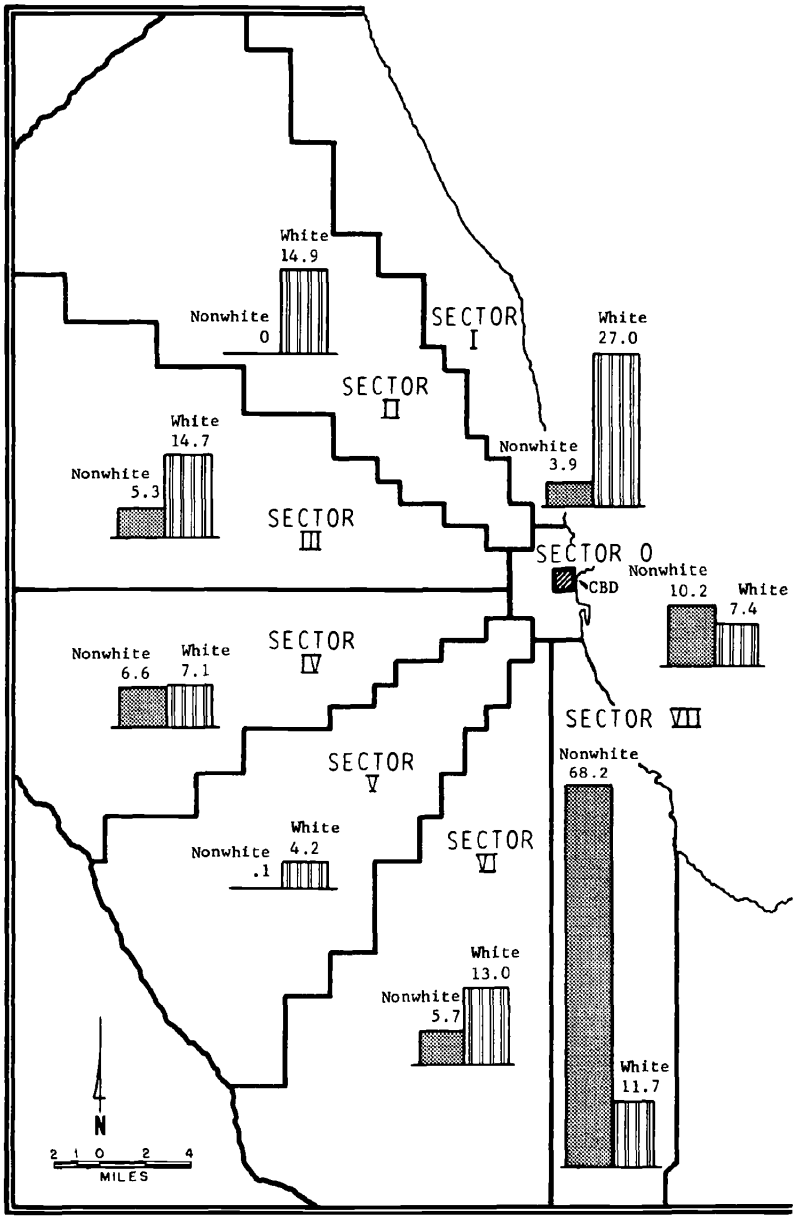
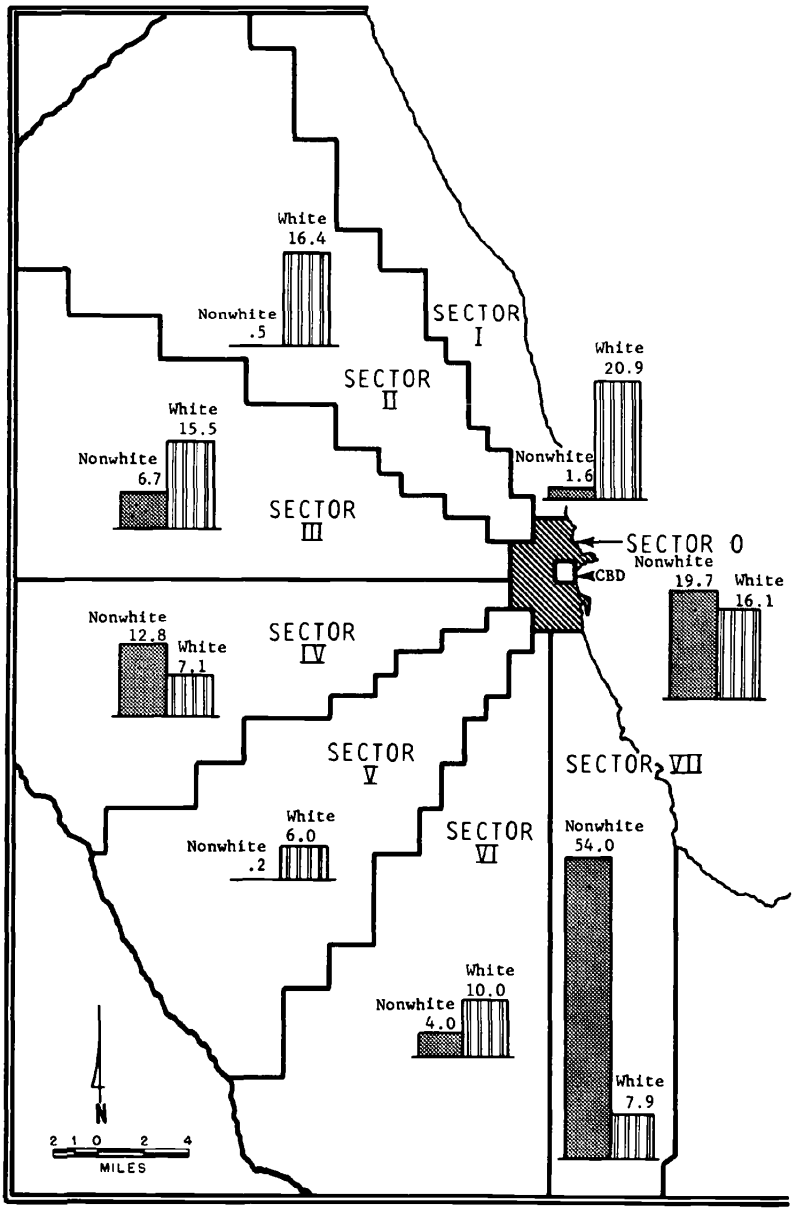


Figure 7
Percentages of Chicago White and Nonwhite
Sector O Workers Residing in Each Sector, 1956



Despite the great differences in the nonwhite and white residence profiles shown in Figure 5, the full effect of segregation on nonwhite commuting patterns is still greater than suggested there. From Figure 4 it is apparent that the few Negro residences in the outlying areas of Chicago are distributed very unequally. A large majority of Chicago Negroes live in the dismal South Side. Discrimination's full effects on the commuting of Negro central business district workers may be seen more clearly in Figures 6 and 7, which show the residential distributions of workers of both races employed in Chicago's central business district and in Sector 0 surrounding it.

Segregation also affects the residential preferences of whites, many of whom have a dual motivation: to avoid living near nonwhites, and to reside in prestige areas. In Chicago, these preferences no doubt help explain the high proportions of whites employed in the central business district and Sector 0 who reside in Sectors 1 to 3 (especially in Sector 1, which includes Chicago's Gold Coast, Evanston, and other high-status areas), and the lower proportions residing in Sectors 4 to 7 (especially Sector 7, the predominantly Negro South Side).

IV. Residential Space Consumption and the Length of the Journey to Work

It was postulated above that workers who prefer to live in lower-density structures are able to economize the most on housing costs by commuting longer distances. If the postulate is true, the author would expect their journeys to work to be longer than those of other workers employed in the same workplaces. Similarly, since residential space is postulated to cost more for Chicago's than for Detroit's central business district workers, we would expect to find that Chicago's workers residing in each structure type consistently make longer work trips than those of their Detroit counterparts. Table 1 confirms this expectation; for both races, in fact, work trip length increases as the density of the structure type decreases. With city and structure type held constant, whites uniformly commute longer distances and spend more time commuting farther than do nonwhites.

The simple consumer-choice model underlying the analysis also predicts—if the two cities' central business district workers do not have significantly different incomes and space preferences—that Detroit's workers will consume more than Chicago's, and whites more than nonwhites. Table 2 lists the relevant percentages for various structure types, revealing—among other things—that the percentage of Chicago

TABLE 1

QUARTILE DISTANCE AND TIME OF TRAVEL FOR CENTRAL BUSINESS DISTRICT COMMUTERS, BY RACE AND RESIDENCE STRUCTURE TYPE

Quartile and Residence Structure Type	AIRLINE DISTANCE (miles)				ELAPSED TIME (hours)			
	White		Negro		White		Negro	
	Chi.	Det.	Chi.	Det.	Chi.	Det.	Chi.	Det.
1st quartile								
One-family	7.7	5.0	4.0	1.8	6.4	4.5	5.1	3.3
Two-family	4.3	3.1	3.3	1.2	4.8	4.0	4.2	3.0
Multiple	3.5	1.7	3.2	0.3	4.2	2.9	3.9	2.3
2nd quartile								
One-family	10.5	7.1	7.1	3.2	8.3	6.2	7.3	4.5
Two-family	6.0	4.5	5.4	2.4	6.6	4.9	5.8	4.4
Multiple	5.7	3.1	4.5	1.6	5.5	4.4	4.8	3.8
3rd quartile								
One-family	15.3	9.4	9.4	4.1	9.9	7.9	8.9	6.1
Two-family	7.8	6.0	7.4	3.5	8.2	7.1	7.5	5.9
Multiple	7.6	4.5	6.0	2.9	7.2	5.6	6.4	4.9

TABLE 2

PERCENTAGES OF CHICAGO AND DETROIT WHITE AND NEGRO CENTRAL BUSINESS DISTRICT WORKERS RESIDING IN VARIOUS STRUCTURE TYPES

Structure Type	White		Negro	
	Chicago	Detroit	Chicago	Detroit
One-family	36.5	58.4	9.2	30.2
Two-family	15.0	18.2	9.5	30.0
Multiple	41.4	17.4	73.0	28.7
Other	7.1	6.0	8.3	11.1
Total	100.0	100.0	100.0	100.0

whites residing in multiple units is more than twice that of Detroit whites. From this fact the author concludes that the higher price (minimum-cost combination of commuting costs and location rents) Chicago workers must pay for residential space discourages them from consuming more of it.

Part of the racial difference in residential space consumption in both Chicago and Detroit is possibly due to differences in incomes and preferences; however, the author concludes that much of it is due to the higher costs of residential space and restricted choices in the market for real property.

V. Substitution of Time and Money Expenditures in Commuting

Trade-offs between housing and travel costs are not the only alternatives available to urban households attempting to maximize their real incomes. Journey-to-work travel costs have two components: dollar costs and time costs. Commuters to the central business district may choose among fairly numerous transportation means in Detroit, and even more in Chicago, with widely varying time and money costs. The relative costs among the means partly depend on distance traveled and on the household's choice of residential density. The choice, as discussed previously, strongly affects the amount a worker can save in housing costs by commuting longer distances. The numerous transportation means can also be used in combination to provide still more alternative time and money costs.

If we consider only out-of-pocket costs, and if parking is free, the dollar costs of a railroad commuter and of a lone automobile commuter to the Chicago central business district are very similar; parking charges and car pooling, however, greatly affect the out-of-pocket costs of automobile commuting. These costs, for a single car commuter paying $1.00 a day for parking, exceed rail-commuting costs by about $0.80 a day, assuming no collection or distribution charges for the railroad commuter. If these costs are shared by two persons, auto commuting costs 20 per cent less for a trip to and from a residence area twenty miles from the Loop.

The level of transportation service, the amount of inconvenience and delay, and the portal-to-portal time of commuting by alternative travel means largely depend on the density of the worker's residence and workplace. Chicago's central business district has a combination of an unusually high level of transit service and high parking charges,

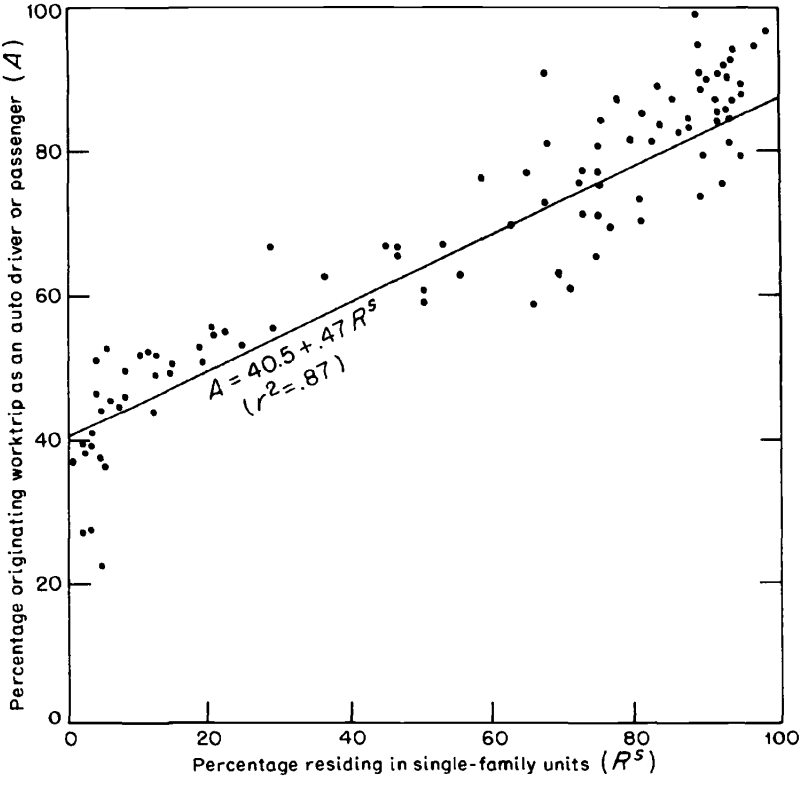
TABLE 3

PERCENTAGES OF DETROIT WHITE WORKERS USING PUBLIC TRANSIT, BY WORKPLACE RING AND RESIDENCE TYPE

Workplace Ring (higher to lower workplace density)	Residence Type (higher to lower residential density)		
	Multiple	Two-Family	One-Family
1	60.7	58.7	50.6
2	28.5	28.6	19.5
3	29.4	23.1	18.9
4	27.3	23.1	14.1
5	17.8	11.1	8.4
6	5.8	4.1	3.5

both stemming from its very high workplace density. The result is a high rate of public transit use: 80 per cent of the central business district's workers arrive there by some form of transit. The lower rate in Detroit—53 per cent—is attributable to lower parking charges, lower levels of public transit services, and lower average residential density. Both high workplace and high residential densities usually mean more frequent transit service with wider coverage. Thus, there is a high probability that a worker employed at a very high-density workplace, such as the CBD, and residing in a very high-density residential area, will find it cheaper to use public transit than to travel by car. The probability is much lower for a worker employed at the same workplace but residing in a lower-density area, and it is nearly zero for a worker having both a very low-density workplace and a low-density residence. Table 3, which lists the percentage of Detroit workers using public transit, by workplace ring and structure type of residence, illustrates just this relationship. Reading the table from top to bottom, we find a decrease in the average workplace density and thus in the level of transit service at workplaces; and reading from left to right, we find a decrease also in the average residential density and thus the average level of transit service. The transit-use figures shown in Table 3 are just those that would be predicted if the probability of public transit use were expressed as the joint probability of use at the workplace and at the residence, where the independent probabilities are positively related to workplace and residence densities. The scatter diagram, Figure 8, illustrates the relationship between automobile use at the origin of the work trip (either by driver or rider) and the percentage of workers residing in single-family dwelling units, for all white Chicago workers. From the figure, it is clear that those

Figure 8
Percentage of Automobile Commuters in
Each of Chicago's Residence Areas,
by Percentage of Area's Single-Family Dwelling Units



residence areas having fewer single-family units and thus lower residential densities tend to have lower rapid-transit use at the origin of work trips.

Even among those CBD workers in Chicago who reside in low-density structures, the vast majority are discouraged from commuting by automobile all the way to work, because of the high employment density and high parking charges in the CBD, and the high levels of service and abundant capacity provided by rapid transit and commuter railroads. Typically, those residing in single-family units combine the use of private automobiles, either as drivers or passengers, with commuter railroad or—slightly less often—rapid transit. Table 4

TABLE 4

PERCENTAGE OF CHICAGO CENTRAL BUSINESS DISTRICT WORKERS RESIDING IN VARIOUS STRUCTURE TYPES, BY TRAVEL MODE COMBINATIONS

Travel Mode at Origin	Travel Mode at Destination	Type of Residence				
		One-Family	Two-Family	Multiple	Other	Total
Automobile Driver	Car driver	40.0	13.9	40.2	5.9	100.0
Driver	Railroad	81.9	8.1	8.8	1.2	100.0
Driver	Rapid transit	56.3	22.0	21.7	0	100.0
Driver	Bus	63.6	7.4	27.1	1.9	100.0
Passenger	Car pass.	28.3	13.4	50.9	7.4	100.0
Passenger	Railroad	85.4	6.9	5.5	2.2	100.0
Passenger	Rapid transit	60.6	13.5	25.2	0.7	100.0
Passenger	Bus	77.7	9.5	12.8	0	100.0
Railroad	Railroad	47.4	9.7	38.4	4.5	100.0
Railroad	Rapid transit	76.0	6.0	18.0	0	100.0
Railroad	Bus	57.5	1.9	29.0	11.6	100.0
Rapid transit	Rapid transit	11.4	13.3	67.6	7.7	100.0
Rapid transit	Bus	12.4	30.9	43.7	13.0	100.0
Bus	Railroad	54.7	20.5	20.2	4.6	100.0
Bus	Rapid transit	31.9	25.3	40.8	2.0	100.0
Bus	Bus	17.4	16.2	51.1	15.3	100.0
All modes		36.5	14.8	41.1	7.6	100.0

illustrates the relationship for Chicago between choice of mode combinations and the decision to reside at various densities, as measured by structure type. For example, 85 per cent of those who are combined car passengers and railroad commuters, and 82 per cent of those who are combined car drivers and rail commuters reside in single-family units; only 6 and 9 per cent of those groups, respectively, reside in multiple units. As pointed out previously, the dollar-cost and time-cost properties of these combination modes result in the highest-cost and highest average speed of all of the combination modes shown in Table 4.

The lowest money-cost, lowest speed-mode combination included in Table 4 is undoubtedly the combination of the local bus at residence and the local bus at workplace; only 17 per cent of those using that combination reside in single-family structures, while 51 per cent reside in multiple units, and 15 per cent in other dwelling units (which usually have the highest densities of all).

The interpretation offered here for the differences in the rates of use of the combinations listed in Table 4 is that they are the result of the cost-minimization, utility-maximization calculus described previously.

The large housing-cost savings per mile traveled for those residing at the lowest densities encourages them to travel long distances. As the distance traveled increases, the time savings obtainable from using modal combinations with higher speed encourages long-distance commuters to spend more money to reduce travel time. In addition, as residential density decreases, the time costs of using various travel modes from residence—railroad and rapid transit in particular and, to a lesser extent, bus—increase rapidly, usually making the private car the most economical way of originating the trip.

The situation is somewhat different for a great many people who choose to commute entirely by local bus. Their decision to reside at high density causes their potential housing-cost savings by commuting longer distances to be small and to dictate minimal transportation expenditures in both time and money. Since terminal time makes up a very large proportion of total time spent on short trips by all modes, the travel-time savings obtainable from the faster, more costly travel combinations are often too small to justify the larger dollar expenditures. Moreover, many small-space consumers employed in the Chicago central business district can use the relatively high-speed rapid-transit mode for the entire trip and walk to residences and workplaces located near the rapid transit stations; of those using rapid transit for the entire trip, the percentage residing in multiple units is higher than that for any other travel model combination—68 per cent.

The relatively small percentage of whole-trip automobile commuters, both drivers and riders, residing in single-family units (40 and 28 per cent, respectively) suggests the interpretation that a majority of automobile commuters to the Chicago central business district use their cars for work-associated purposes.[11]

The importance of cars and buses in trips from residence to the higher-volume grade-separated facilities is to be seen in Table 5, which gives the percentages of Chicago central business district workers residing within the cordon area and using each mode at their residences, and the percentages arriving in the central business district by each travel mode. (Detroit data do not permit comparable tabulations, since only the primary mode used was coded.) Table 5 shows that 20 per cent of the work trips to the Chicago central business district originate as car-driver trips, 12 per cent as car-rider trips, and 39 per cent as bus trips, while only 12.4 per cent of the arrivals represent

[11] This interpretation is supported by the finding that a disproportionate number of both car drivers and car passengers to Chicago's central business district and Sector 0 gave "sales" as their occupation.

TABLE 5

PERCENTAGE OF CHICAGO CENTRAL BUSINESS DISTRICT WORKERS USING EACH MODE AT THEIR RESIDENCES AND WORKPLACES

Travel Mode	At Origin	At Destination
Car driver	19.9	12.3
Car rider	11.6	9.3
Railroad	13.1	22.1
Rapid transit	13.7	33.5
Bus	39.2	25.0
Taxi	--	0.3
Walk	1.3	1.3

car-driver trips, 4 per cent car-rider trips, and 25 per cent bus trips. Commuter railroad, by way of contrast, accounts for 22 per cent of destinations but only 13 per cent of origins; and rapid transit accounts for only 14 per cent of trip origins but over 33 per cent of trip destinations. Table 6 shows that the majority of commuter railroad trips combined with another mode are serviced at the origin by auto; of the 22 per cent of work trips arriving in the Loop by commuter railroad, 9 per cent originate by car, about equally divided between driver and passenger trips. Car trips are only about half as important as feeders for the rapid-transit lines: of the 34 per cent of destinations accounted for by rapid transit, only about 4.1 per cent begin by car. Buses are the important collector for the rapid transit system: almost one-half the 75,000 rapid-transit trips terminating in the central business district originate by bus, while only slightly more than one-third of the 75,000 arrivals originate on the rapid-transit line.

A comparison of Tables 5 and 6 illustrates the combined effect of lower parking fees and slightly poorer transit service on modes of

TABLE 6

PERCENTAGE OF CHICAGO WORKERS EMPLOYED IN SECTOR 0 USING EACH MODE AT THEIR RESIDENCES AND WORKPLACES

Travel Mode	At Origin	At Destination
Car driver	36.8	34.3
Car rider	10.9	8.5
Railroad	4.2	6.4
Rapid transit	6.9	8.6
Bus	33.9	34.0
Walk	6.6	6.6
Work at home	1.0	1.0

TABLE 7

PERCENTAGE OF CHICAGO WORKERS USING EACH COMBINATION OF ORIGIN AND DESTINATION MODES, BY WORKPLACE LOCATION AND RESIDENCE TYPE

Origin Mode	Destination Mode	One-Family	Two-Family	Multiple	All Residence Types
	A. CENTRAL BUSINESS DISTRICT				
Automobile					
Driver	Car driver	13.5	11.6	12.1	12.3
Driver	Railroad	10.5	2.5	0.9	4.4
Driver	Rapid transit	3.7	3.4	1.2	2.3
Driver	Bus	1.2	0.3	0.5	0.7
Passenger	Car passenger	3.4	3.4	5.1	4.2
Passenger	Railroad	11.6	2.2	0.6	4.6
Passenger	Rapid transit	3.2	1.7	1.0	1.8
Passenger	Bus	1.8	0.5	0.3	0.8
Railroad	Railroad	16.3	8.2	10.7	12.0
Railroad	Rapid transit	0.9	0.2	0.2	0.4
Railroad	Bus	1.2	0.1	0.5	0.7
Rapid transit	Rapid transit	4.2	12.0	20.7	13.2
Rapid transit	Bus	0.1	0.6	0.7	0.5
Bus	Railroad	1.8	1.7	0.5	1.1
Bus	Rapid transit	14.1	26.7	15.4	15.8
Bus	Bus	11.0	24.1	27.7	22.3
Other	Other	1.5	.8	1.9	2.9
All modes		100.0	100.0	100.0	100.0
	B. SECTOR 0				
Automobile					
Driver	Car driver	42.8	36.9	33.0	34.2
Driver	Railroad	4.4	0.6	0.2	1.4
Driver	Rapid transit	1.1	0.5	0.2	0.5
Driver	Bus	1.8	0.1	0.1	0.5
Passenger	Car passenger	7.4	9.2	3.4	8.2
Passenger	Railroad	3.9	0.6	0.2	1.2
Passenger	Rapid transit	0.8	0.2	0.2	0.4
Passenger	Bus	2.3	0.5	0.6	1.0
Railroad	Railroad	6.5	3.0	2.5	3.4
Railroad	Rapid transit	0.4	--	0.1	0.1
Railroad	Bus	1.2	0.4	0.4	0.6
Rapid transit	Rapid transit	1.8	3.6	5.1	3.9
Rapid transit	Bus	1.0	1.5	4.1	2.6
Bus	Railroad	0.9	0.2	0.2	0
Bus	Rapid transit	5.0	5.9	4.2	3.6
Bus	Bus	16.2	32.3	35.8	29.3
Other	Other	2.5	4.5	9.7	9.1
All modes		100.0	100.0	100.0	100.0

travel used by workers employed in Chicago's Sector 0. While only about 17 per cent of the central business district workers reach their workplaces by car, either as drivers or riders, more than twice that percentage (43 per cent) of Sector 0's workers do so. Similarly, while 22 per cent of the CBD's commuters arrive by commuter railroad, only a little more than 6 per cent of Sector 0's commuters do, of whom nearly one-half start the trip as car drivers or riders; and only 8.6 per cent arrive by rapid transit as opposed to nearly 34 per cent of Loop employees. The bus is by far the most important transit vehicle for Sector 0 workers: 34 per cent of the worktrip arrivals in Sector 0 are by bus, and 33 per cent of originations; 29 per cent of those workers ride the bus all the way between home and work.

The percentage distribution for the structure types given in Table 7 suggest how the use rate of each travel-mode combination is affected by workers' choices of residential density, differences in the level of service provided by various modes, and differences in the level of parking charges between the CBD and Sector 0. Perhaps the features most sharply exhibited in Table 7 are: (1) the much greater use of private automobiles by Sector 0 than by CBD workers; (2) the much greater use of commuter railroads in combination with other travel means by CBD workers residing in single-family units than by any other group employed in either CBD or Sector 0; and (3) the minimal use of either rapid transit or commuter railroad by Sector 0 workers. The greater distance of a majority of the workplaces in Sector 0 from railroad and rapid transit stations than in the CBD, and the lower parking costs in Sector 0 apparently lead workers who do not live conveniently near a railroad or rapid transit station or who place a

TABLE 8

PERCENTAGE OF CHICAGO WHITES AND NEGROES USING VARIOUS MODES OF TRAVEL TO TWO DESTINATIONS

	DESTINATION			
	Sector 0		CBD	
Travel Mode	Whites	Negroes	Whites	Negroes
Car driver	36.5	24.8	12.4	10.8
Car rider	8.3	9.0	4.1	6.9
Railroad	7.7	.6	23.9	4.6
Rapid transit	9.4	5.4	33.2	36.5
Bus	29.6	52.2	23.9	39.3
Walk	6.5	7.1	1.2	
Other	1.7	0.8	1.2	2.0

high value on their travel time to commute by car rather than by railroad or rapid transit. Nearly 43 per cent of Sector 0 workers who reside in single-family units drive private cars between home and work, and over 7 per cent commute the entire distance as car passengers.

Table 8 illustrates the greater use of public transit vehicles, especially buses, by Negroes employed in the CBD and Sector 0. Nearly 45 per cent of Sector 0 whites commute by car, compared with about 34 per cent of Negroes. Whites also use the longer-distance, higher-speed transit modes much more than Negroes do: nearly 8 per cent of Sector 0 and 24 per cent of CBD whites arrive by commuter railroad, as opposed to less than 1 per cent of Sector 0 and less than 5 per cent of CBD Negroes.

VI. Summary and Conclusions

The findings of this study have considerable bearing on a problem currently being debated: how to provide access to central urban workplaces for high- and middle-income commuters. The work reported here does not pretend to solve the problem, but some systematic information is presented that should help clarify it.

For example, the paper illustrates the great impact of racial discrimination on the travel behavior and residential location decisions of both whites and nonwhites. Discrimination is a central difficulty. It must be dealt with if we are to solve this aspect of the urban transportation problem, whether it be through renewal of central residential areas or by provision of high-speed rapid transit facilities.

The insights recorded which bear upon the determinants of residential location decisions and the choices among transportation means should also be useful in the evaluation of alternative urban transportation policies. Of particular significance are the data contributing to understanding of the extreme specialization of the high-speed rail facilities serving the Chicago central business district. Advocates of the rail-transit proposals noted in Section I tend to advance them as a cure-all for the transportation ills of urban communities. The findings presented here suggest that they are, instead, specific remedies for a small part of the over-all problem, and that their benefits are restricted to a narrow segment of the urban population.

The paper has a more important objective, however: the development and testing of a fairly simple but nonetheless powerful economic model that will be useful in explaining and predicting the travel and residential behavior of the urban population. The questions considered in this

paper have received little economic analysis heretofore; people who have been most closely identified with these problems have tended to discount the usefulness of economic theory and analysis in solving them.

The consumer-choice model described here emphasizes several kinds of economic calculations assumed to be made by urban workers in deciding on the mode or combination of transportation modes used for the journey to work, the distance commuted, the time spent commuting, and the amount of residential space consumed (or the residential density at which they reside). The model presents these choices as being determined by the minimization of household's urban locational costs, which are the sum of housing costs incurred to reside near work and of work-associated travel costs. The model explicitly considers several kinds of cost trade-offs available to urban households in maximizing their real income. The first is a trade-off between higher housing costs and higher transportation costs. Workers employed at high-density workplaces can save on housing costs by commuting longer distances—but thus increasing transportation costs. The amount they can save on housing costs depends on both the level and rate at which housing costs per residential-space unit decrease with distance from their workplaces and on the number of space units they consume.

The second important set of trade-offs embraces the substitution possibilities between travel-time and money-cost expenditures for the journey to work. The various modes or combinations of modes have different money-cost and speed characteristics, and the differences provide another opportunity to urban households for utility maximization. Moreover, these characteristics both affect and are affected by workers' decisions about residential density.

The model also deals explicitly with the effect of racial discrimination on the operation of the housing market and on the decisions of white and nonwhite households about their travel and residential behavior. Housing-market discrimination is treated as a constraint on nonwhite behavior, which also systematically affects the preferences of whites among alternative residential locations.

Finally, hypotheses suggested by this model are tested empirically using data on work travel obtained from the Chicago and Detroit transportation studies. Over all, the empirical tests are consistent with the simple economic model used in the analysis. Although incomplete, the model and its empirical testing suggest the likelihood that economic analysis of this type can greatly increase our understanding of the problems and thus promote the sounder urban transportation planning we so urgently need.

COMMENT

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Kain has made a useful start in exploring the structure of private preference for residential space and transportation cost, and the trade-offs between them. Such an exploration is certainly necessary to the investigation of various optima under different combinations of public policies of investment, operation, control, and incentives. The reaction of private decision-makers will surely influence the magnitudes of the payoffs of these public decisions. Housing market analysis by and large appears to neglect transportation factors, and transportation analysis has certainly neglected the influence of transportation on the housing market. Kain clearly demonstrates that this neglect is unpardonable, inasmuch as residential locators trade off freely between space and transportation costs. It is, however, not captious to suggest that serious analysis of these problems requires more accurate quantification than Kain has given us at this stage. Such a quantification should also take into account the interaction (or cross-elasticities) between a larger number of variables which may be subject to change over time as the metropolitan area changes. This consideration of the interaction of variables implies a more scrupulous separation of influences, which I feel Kain neglected in his treatment of race and location. There is no question that the urban Negro population of Chicago is seriously disadvantaged, but Kain does not tackle the question of the extent to which this disadvantage is occasioned by income and occupational factors alone, independent of segregation in housing. It is my own guess that housing segregation *per se* plays a minor role, while cultural deprivation and job discrimination are far more important in the phenomena which Kain displays. Important policy decisions depend on an elucidation of this point.