METROPOLITAN STRUCTURE AND COMPLEX COMMUTING: A REGIONAL AND NATIONAL ANALYSIS

Dissertation for the Degree of Ph. D.
MICHIGAN STATE UNIVERSITY
PHILIP NEAL FULTON
1975

This is to certify that the

thesis entitled

METROPOLITAN STRUCTURE AND COMPLEX COMMUTING:

A REGIONAL AND NATIONAL ANALYSIS

presented by

Philip Neal Fulton

has been accepted towards fulfillment
of the requirements for

the Ph. D. degree in Sociology

James J. Zuiches
Major professor

Date July 7, 1975

O-7639

ABSTRACT

METROPOLITAN STRUCTURE AND COMPLEX COMMUTING:
A REGIONAL AND NATIONAL ANALYSIS

By

Philip Neal Fulton

This dissertation is concerned with the relationship between metropolitan structural characteristics and complex, non-centrally oriented journey-to-work patterns among U.S. SMSA's. Its basic thesis is that the degree of complex commuting, i.e., the proportion of journeys to work within the SMSA to destinations outside the central city, is dependent upon the extent of functional decentralization in the area. A causal model made up of nine metropolitan structural characteristics is proposed to explain the level of commuting complexity among 240 SMSA's as of 1970. The study uses published data from several Census sources plus commuting data not available in published form provided by the U.S. Bureau of the Census. A descriptive analysis of commuting patterns across SMSA's by geographic division is carried out, and the model of commuting complexity is tested first for all SMSA's and then for each division, using path analysis.

The descriptive analysis shows that of all workers commuting to jobs in U.S. metropolitan areas, about 43 percent commute to workplaces in the ring. Furthermore, three-quarters of these trips also have ring origins. Divisions where SMSA's are less developed and more centralized exhibited commuting complexity below the average for all SMSA's, while

divisions where SMSA's are more highly developed and decentralized evidenced comparatively greater commuting complexity. The model of commuting complexity provides evidence that among all SMSA's age, population size, central city density, contiguity to other SMSA's, and mass transit availability influence complexity indirectly through suburbanization of the labor force, decentralization of manufacturing and business, and urban development in the ring, the key indicators of functional decentralization. These factors in turn exert strong direct effects on complexity. Application of the model to SMSA's by geographic division reveals differences in the causal pattern between older, more heavily developed divisions and divisions with newer, less developed SMSA's.

In sum, the study supports the contention that complex movement systems arise out of the decentralization of functional units of the metropolitan area. Such diffuse commuting patterns are viewed to be a particularly difficult problem with which transportation planning must deal. The results indicate that the problem is most intense in older, larger metropolitan areas where transit modes to accomodate intersuburban movement appear to be needed. Newer, smaller SMSA's, often located in less metropolitan sections of the country evidence less complex commuting. It is suggested that these areas may benefit most from knowledge of the determinants and consequences of complex commuting in older SMSA's by planning for future development in conjuction with public transportation, rather than attempting to adapt transit technology to uncontrolled patterns of land use.

METROPOLITAN STRUCTURE AND COMPLEX COMMUTING: A REGIONAL AND NATIONAL ANALYSIS

By

Philip Neal Fulton

A DISSERTATION

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

DOCTOR OF PHILOSOPHY

Department of Sociology

1975

ACKNOWLEDGMENTS

I would like to express my sincere appreciation to a number of individuals who helped make this dissertation possible. Special thanks are given to Professor James Zuiches who encouraged my efforts from the study's inception as a paper in his human ecology seminar through its fruition in the present form. Our cooperative work resulted in the funding of the larger "Commuting Patterns in U.S. Metropolitan Areas" project, and his patient support, timely insights, and professional guidance throughout the course of the thesis research were fundamental to its completion. I also wish to express my appreciation to my major professor, Dr. J. Allan Beegle, for his critical examination of the thesis, but more importantly, for his unwavering interest and support during my graduate training, and for providing me with a constant example of genuine concern for the well-being of anyone passing through his office door. Professors Duane Gibson, William Kimball, and Harry Schwarzweller have contributed by their cordial encouragement as members of my guidance committee and by their critical examination of the thesis.

Gratitude is also extended to the National Institute of Child Health and Human Development for its funding of the larger project mentioned previously (grant number HD08947-01), of which this study is a part. Acknowledgment is similarly made to the assistance of the U.S. Bureau of the Census in providing unpublished data for analysis. Particular appreciation is expressed to Mr. Richard L. Forstall, Population Division, U.S. Bureau of the Census, for his interest and helpful counsel during the course of the research.

Kathy Beegle, John Burke, and Diane Seagreaves carried out the bulk of the coding and data transcription, and their efforts are sincerely appreciated.

The greatest debt which I owe is to my wife, Cheryl, who served as typist, editor, and commiserated in my frustrations at times when the study seemed to progress especially slowly. A simple thank you is grossly insufficient in return for her steadfast emotional support throughout my graduate work and during the thesis research. In many ways, I consider the achievement represented by this volume to be hers as well as my own.

TABLE OF CONTENTS

CHAPTER Page

TABLE OF CONTENTS--continued

CHAPTER Page

LIST OF TABLES

LIST OF TABLES--continued

TABLE Page

TABLE Page

LIST OF TABLES--continued

LIST OF FIGURES

CHAPTER I

THE RESEARCH PROBLEM

Introduction

Failure to anticipate and plan for the rapid expansion of suburban areas in the United States after World War II has resulted in the haphazard land-use patterns of urban sprawl and a deterioration of many amenities. In this regard the U.S. Commission on Population Growth and the American Future (1972:32) has indicated that "without proper efforts to plan where and how future urban growth should occur, . . . the problems of sprawl, congestion, inadequate open space, and environmental deterioration will grow on an ever-increasing scale."

Transportation technology, particularly the automobile and the extensive highway system, has contributed to the changes in the geographic scale at which we live and work. Urban business and industry has decentralized over the metropolitan region, and residences have dispersed into suburban areas in low-density patterns of single-family housing. These two processes of decentralization have not ordinarily been coordinated, and the length of work trips to peripheral workplaces as well as to the central city has been steadily increasing (Schnore, 1957a).

Students of urban phenomena have recently noted with concern the importance of changing patterns of metropolitan traffic flows. Hawley (1971:192) observes that the bulk of commuters during the first half of this century moved along radial routes converging in the central city. Since the arrival of the auto age, however, such movements have been increasingly replaced by lateral and circumferential flows with suburban residents commuting to suburban employment destinations. In their study of urban transportation problems, Meyer, Kain, and Wohl (1965:361-362) conclude:

> Another important postwar phenomenon is the increasing prevalence of cross-haul and reverse commuter trip patterns in urban areas to the point where non-CBD trips are now more than twice as numerous as those to and from the CBD. In the past, it was common to find a high concentration of urban travel demands along a few corridors originating in the CBD and radiating outward to residential neighborhoods.

Similarly, Mayer (1969:44) notes that, "In most cities the central business district is still the most important generator of trips, but an increasing proportion of the travel no longer originates, terminates, or passes through such areas; peripheral trips are of increasing significance."

Hoover and Vernon (1962), in their classic study of the New York metropolitan region, found that although there was a tendency to reduce commuting distance among workers, the commuter flow pattern included a great deal of cross-hauling. In a later interpretation of the study's findings, Vernon (1963:280) concluded that "the prime transportation 'problem' of the Region, so long thought of as that of bringing people to and from the central city, may well be matched by the development of many . . . bottlenecks, arising out of the diffuse cross-hauling and reverse commuting which the future will bring." Meyer (1964:89) also observes that, "Urban travel flows are assuming a pattern characterized more by a large number of relatively uniform, low-level, and criss-crossing trip densities than by very high concentrations in a few corridors emanating like spokes from the center of the city as was previously the case."

The complex journey-to-work patterns described above appear to pose a special problem for metropolitan areas in the future. Fewer people could utilize mass transit facilities which are typically best adopted for carrying large masses of people on high density routes (Bello, 1958; Mayer, 1969; Meyer, 1964). Intersuburban commuting is intimately dependent on the flexibility and convenience of the private automobile. Thus, it would seem that a thorough knowledge of the nature and implications of commuting patterns is crucial if we are to fully understand the structure of the metropolitan community and if thorough planning for future metropolitan growth is to become a reality. However, although the relationship between home and workplace location has been of great concern to students of the spatial organization of cities, no comprehensive study exists of complex, non-centrally oriented commuting patterns in U.S. metropolitan areas.

Historical Perspective

Sociologists working primarily in the tradition of human ecology have clearly recognized that the evolution of urban spatial patterns has been closely related to the changing forms and advances in internal

transportation (eg. Hawley, 1950; Hawley, 1971; McKenzie, 1927; McKenzie, 1933; Ogburn, 1946; Schnore, 1957b). The following discussion represents a synthesis of this perspective.

Historically, the great acceleration in population redistribution in urban centers came in the late 1800's when the ability of the electric street railway to move large volumes of people quickly and efficiently drew settlement outward from the central city in radiating bands along commuter routes. As circumferential street railways were built to intersect the radials, secondary business centers developed in a multinucleated pattern, creating suburban population clusters nearby. Decentralization of urban industry also began in the latter part of the nineteenth century as many firms moved to peripheral sites along steam railway lines. New industries located at the outskirts of urban centers, and each move or relocation was like a magnet for the gathering of workers' residences in close proximity.

The advent of the truck and automobile in the early part of the twentieth century, coupled with growing centrifugal forces in the interiors of large cities, began a period of extensive industrial deconcentration and population redistribution which is still prevalent today. By the 1920's, both jobs and people were dispersing at a rapid pace. The truck freed industry from the necessity of railroad access, and the automobile freed workers from the need to live within walking distance of their workplaces or commuter terminals. Construction of hard-surfaced roads around large and middle-sized cities allowed increased speed and efficiency of movement. As residential population was drawn toward suburban workplaces or neighborhoods in increasing densities, retail and service establishments followed, themselves providing further employment.

The extensive highway building program after World War II provided radial-circumferential patterns of metropolitan routes facilitating peripheral work trips as well as those from the ring into the central city. Interstitial and outlying suburban areas were increasingly developed for low-density single-family housing, and the flexibility offered by the automobile allowed the journey to work to vary in proportion to the worker's desire for accessibility or residential amenities.

The extensiveness of auto ownership today in all social strata and the increased availability of reasonably priced housing has made suburbs and satellite cities in the ring accessible to workers with moderate and sometimes lower incomes. Rising incomes have enabled many households to consume more residential space. Similarly, the search for space is a key factor in the locational pattern of manufacturing establishments. High costs of expanding inner-city sites, the need for horizontal plant layouts to accommodate modern production techniques, and traffic congestion and parking problems are among the reasons for the decentralization of manufacturing. Other important reasons are the availability of a varied and mobile labor force in suburban localities, suburbanization of consumers, highway access for truck transit, flight from taxes, and the spread of urban services and amenities (Chinitz, 1964:26; Dean, 1973; Hawley, 1971:167; Hoover, 1971:329-332; Hoover and Vernon, 1962:Chapter 2; Loewenstein, 1965:39-42). The increasingly decentralized pattern of residences and industry has been followed by consumer-oriented business firms that provide goods and services to both industrial and residential customers. The rapid growth of suburban shopping centers and the increased prevalence of wholesaling establishments outside central cities are evidence of this trend (Chinitz, 1964:26; Hawley, 1971:170-171; Manners, 1965:55-56).

Based on this discussion, my basic thesis is that commuting patterns may be best understood in relationship to the underlying ecological organization of the metropolitan community. Therefore, the purpose of this study is to (1) examine the nature and degree of complex commuting patterns across U.S. metropolitan areas, and (2) test the hypothesis that the extent of complex commuting is dependent upon the extent of functional decentralization in the area from which the commuting patterns arise.

Review of Literature and Theoretical Orientation

Data Sources for Commuting Research

Most commuting research has been based on data made available by the large number of elaborate home-interview origin and destination (O-D) studies carried out since World War II. Kain (1967:161) notes that by 1965 more than 200 of these studies had been completed since 1944. Although cities of all sizes were covered, the most notable were those in the larger metropolitan areas such as the Chicago Area Transportation Study (CATS), the Penn-Jersey Transportation Study in the Philadelphia area, the Detroit Metropolitan Area Traffic Study (DMATS), and the Pittsburgh Area Transportation Study (PATS). While early origin-destination studies were primarily intended for highway planning, more recent surveys have been increasingly concerned with providing data on characteristics of commuters and mode choice in addition to flow densities. Closely related to origin-destination studies are rapid transit feasibility studies which are generally focused on a narrower segment of urban travel, usually that to the central business district.

Social scientists have often criticized origin-destination studies because of their sampling methods (Kain, 1967:162), and because they typically cover only the largest cities or those with particularly severe traffic problems (Goldstein and Mayer, 1964a; Schnore, 1957b:178; Schnore, 1959:205). Most O-D studies are also specifically concerned with the direction, distance, cost, and volume of travel, and they have not attempted to relate commuting patterns to social and economic characteristics of the area being studied. Schnore (1960) has detailed the problems and possibilities of three major sources of commuting data for research. In addition to O-D studies he identifies management records, which may possess great advantages for studies of personal characteristics, and census data. Questions on the journey to work have been included in the decennial census since 1960, providing more or less universal coverage of dispersal from the dwelling area and conflux at the workplace for counties and central cities of Standard Metropolitan Statistical Areas (SMSA's).

Early Commuting Studies

Liepman's (1944) study of commuting patterns in London and other European cities may be viewed as an important benchmark study producing hypotheses for much subsequent research. She found that journeys to work tended to be concentrated in the direction of central workplaces or areas of conflux, while journeys back home were more widely scattered to suburban areas, resulting in deconcentration or dispersion. Further, this main trend was cut across by "multifarious cross-currents and counter currents of various volume" (Liepman, 1944:3). Cross-currents were most conspicous in areas where several industrial centers were within traveling distance in the same urban region, and counter-currents were evident where residents of central districts traveled out to peripheral workplaces.

Liepman determined that commuting patterns were a result of topographic and social and economic causes. Topographic causes were seen to be the spatial segregation of industrial, commercial, and residential areas due to unplanned development and urban sprawl. Social and economic causes included the need on the part of industries for a large and varied labor force supplied by an extensive labor catchment area, and the need on the part of the highly mobile work force for residential locations offering the flexibility of access to several alternative places of work and separation from the unpleasant environment of economic activity. She argued that if journeys to work were long and tedious the region had a poor structure, whereas if journeys to work were short the region was well formed. Her final recommendation was that commuting be shortened by a pattern of small towns arrayed about a central nucleus.

Much early American research focused on the implications of the "daytime" as opposed to the residential population of the central business district (CBD) (Breese, 1949; Foley, 1954; Sharp, 1955). Other early research by Carroll was premised on Zipf's (1947) "hypothesis of the minimum equation" which stated that man strives to minimize the distance involved in interaction. In a study of Massachusetts manufacturing workers Carroll (1949) found that the bulk of the workers lived close to work, and the proportion of workers diminished as distance from the plant increased. He also found that workers living the furthest away tended to move closer to work or find jobs closer to home. Based on pre-World War II traffic surveys and his research, Carroll (1952) concluded that the residential distribution of CBD employees was similar to that of the urban population, while off-center work places had worker residences more concentrated in the near vicinity. He did find some indication that the distance between home and workplace was increasing over time, but he argued that this was the result of irrational land-use patterns and inadequate transportation facilities which served as obstacles to people trying to live closer to their workplace.

Research Based on the Theories of Location Economics

The economic rationality of residential location evidenced in the work of Carroll is reflected in subsequent studies by regional economists. Journey-to-work costs are the most important explanatory variable found in most theoretical models of residential location (Alonso, 1960; Kain, 1962; Muth, 1961; Wingo, 1961). According to the economic theory of residential location, "households substitute journey-to-work expenditures for site expenditures. This substitution depends primarily on household preferences for low-density as opposed to high-density residential services" (Kain, 1962:137). Thus, workers with higher incomes should be able to trade off the cost of traveling longer distances to work for more living space in lower-density areas. Lower-status workers would then have to live closer to their workplaces in order to minimize the diseconomy of commuting. Several studies have, in fact, shown that travel time and distance travelled to work generally increase with income (Beyer, 1951; Hoover and Vernon, 1962:155-168; Kain, 1962:148-150; Lonsdale, 1966; Meyer, Kain, and Wohl, 1965:119-130; Thompson, 1956) and socioeconomic status (Adams and Mackesey, 1955; Duncan, 1956; Duncan, 1957; Duncan and Duncan, 1960; Goldstein and Mayer, 1964b; Wheeler, 1967; Wheeler, 1968a; Wheeler, 1969a). Similarly, studies have also found that longer journeys to work are related to residence in lower-density areas or single-family housing (Beyer, 1951; Hoover and Vernon, 1962:159; Kain, 1962; Mayer, Kain, and Wohl, 1965:126-129).

Despite the fact that they tend to make longer journeys to work, higher-income workers often reduce their travel time by substituting faster, more expensive travel modes for slower and cheaper ones (Kain, 1967:186). Studies by Bostick (1963:258), Bostick and Todd (1966:275), Lansing and Mueller (1964:69-95), and Meyer, Kain, and Wohl (1965:140) have reported greater use of faster and more expensive travel modes by higher-income workers and workers employed in higher-income occupations. Higher-income workers evidence greater automobile ownership and use (Duncan, 1957; Lapin, 1964:56-57; Meyer, Kain, and Wohl, 1965:132; Reeder, 1956), while lower-status workers evidence less auto ownership and greater use of mass transit (Duncan, 1957; Lapin, 1964:56; Meyer, Kain and Wohl, 1965:140-141).

Studies of the journey to work have also provided evidence of several other commuting differentials. Females have been found to typically commute shorter distances than males (Kain, 1962; Thompson, 1956; Wheeler, 1967; Wheeler, 1969a), and to be more likely to use public transportation (Kain, 1962; Kain, 1964b; Meyer, Kain, and Wohl, 1965:119-130; Reeder, 1956). Other research has shown that blacks tend to have longer journeys to work than whites because of the residential segregation of blacks and the increasing decentralization of employment opportunities (Duncan, 1956; Kain, 1962; Kain, 1964a; McKay, 1973; Wheeler, 1968b; Wheeler, 1969b). Finally, increased family size and particularly the presence of school-age children have been found to increase residential space consumption and lead to longer journeys to work (Kain, 1962:150-154; Lansing and Mueller, 1964:15-75; Meyer, Kain, and Wohl, 1965:141).

Similar to the studies generated by location economics, "trip generation" research is based on the locational pattern of residential and commercial land use (Mitchell and Rapkin, 1954). Such studies have attempted to develop "systematic quantitative relationships between urban travel and land use and their use in combination with land use forecasts in predicting future travel" (Kain, 1967:178). Trip generation refers to the number of trips per household or per employment unit. Exemplary studies here include Curran and Stegmaier (1958), Mertz and Hamner (1957), Oi and Shuldiner (1962), and Sharpe, Hansen, and Hamner (1958). Most trip generation studies for planning purposes have used origin-destination data. Loewenstein (1965), however, has suggested an alternative method using census data which he has applied with some success in an analysis of Philadelphia trip densities.

Studies of Commuting to Non-central Destinations

The studies discussed thus far have been oriented for the most part, to commuting to central city destinations. There has been, however, some research which has focused on the journey to work to peripheral or suburban locations. For example, McKay (1973) studied the extent of suburban job-holding by inner-city residents of six major U.S. cities. She found that men were more likely to travel to suburban jobs than women, blacks were more likely to do so than whites, and blue-collar workers were more likely to do so than white-collar workers. The largest proportion of inner-city residents worked outside their neighborhood but within the city limits. The proportion who commuted to suburban jobs ranged from one-tenth in Houston and New York to over one-third in Los Angeles. Meyer, Kain, and Wohl (1965:129) found that commuters from the central city to outlying workplaces typically lived in multiple unit housing and tended to be workers from childless households and households with two or more wage earners. In a study of the adjustment of workers to the relocation of inner-city industry along Route 128 outside Boston, Burtt (1968) found that workers who kept their jobs were older, had more seniority and higher incomes, and were typically married. Many changed residences to be near the new jobsite, but for those who did not their average commuting time rose from 22.7 minutes to 38.3 minutes and use of public transportation was impossible. Newman (1967) has observed that the decentralization of employment poses serious problems for reverse commuters from the central city since mass transit is typically developed to bring workers to the city efficiently.

Taaffe et al. (1963), in a study of commuting to off-center workplaces outside Chicago, showed that commuting patterns away from the central city and among suburban areas were important, and that central city commuting no longer dominated the traffic pattern. Similar to Carroll (1952), the researchers found that the residential pattern of peripheral workers was more clustered, while the pattern for CBD workers was more dispersed, resulting in a longer journey to work. This finding has been substantiated by several other studies (Duncan, 1956; Duncan, 1957; Gerard, 1958:126; Kain, 1962; Kain, 1964b; Meyer, Kain, and Wohl, 1965:122-123; Wheeler, 1967; Wolforth, 1965). Taaffe and his associates also found the private auto was the overwhelmingly dominant mode of transportation among suburban commuters since such trips had little recourse to public transit. They also found that higher-income groups showed the least evidence of clustering about their workplace, and that higher-income people were more likely to live in the suburbs regardless of where they worked.

When the researchers projected Chicago's metropolitan commuting patterns to 1980, however, they predicted that the most striking trend would be a spreading of peripheral workers into interstitial areas and a decreasing tendency to cluster, especially with the promise of further industrial decentralization. New manufacturing in outlying areas was seen to provide greater employment alternatives for workers living in the vicinity and in other parts of the metropolitan area. Furthermore, most of this "complex" commuting would be done by automobile, since radially-oriented mass transit could not accommodate such diverse flows.

A trend toward more complex, less central city-directed commuting has also been found in other research (eg. Meyer, Kain, and Wohl, 1965: 35-38; Silver, 1959:153). Foley (1952), Gorman and Hitchcock (1959), and Hansen (1961) have shown that larger metropolitan areas tend to evidence proportionately less commuting to the CBD than smaller areas. Foley suggests that this is because larger areas have more outlying subcenters, while cities in smaller metropolitan areas retain more key functions. Chavrid (1957) studied employment by place of work and place of residence in 11 large metropolitan areas using data from state employment security agencies. He observed that many workers who live in one subarea often commute to other subareas even though there are job opportunities closer to home. Goldstein and Mayer (1964a:481), in a study of Providence, Rhode Island, found that as many as 49 percent of the residents in immediate suburbs worked within the suburbs or in outlying areas of the state. Finally, a number of researchers have suggested that suburban residential patterns which contribute to non-centrally oriented commuting provide an important alternative to migration since such locational patterns greatly enhance the flexibility of labor force adaptation to changing job opportunities within a wide commuting radius (Adams and Mackesey, 1955:79-83; Goldstein and Mayer, 1964a:473; Goldstein and Mayer, 1964b:278-279; Hawley, 1950:337; Hawley, 1971:192; Schnore, 1954:339; Schnore, 1965:160).

Studies Challenging the Perspective of Location Economics

Studies by sociologists and planners have challenged and refuted the perspective of location economics and the "minimum distance" approach, given the diversity of the contemporary metropolitan community. Schnore (1954) has been particularly critical and, based on his own research, concludes that while the principle of minimum distance may account for the concentration of workers near worksites, it fails to account for the equally obvious scatter of workers' residences away from those sites. He maintains that antecedent factors may limit the basic desire to minimize distance. Workers may actually be inclined to maximize the journey to work, given the flexibility of time, money, or motivation for residential amenities (Schnore, 1954:337). Similarly, Lapin (1964:153) has observed that the principle of minimum distance operates in conflict with social needs, and that "as real income rises, the long work-trip formerly associated only with upper-middle income groups becomes more representative of the entire metropolitan population."

Recent studies seem to substantiate the contention of Lapin and Schnore. Using evidence from a 1968 national survey of housing preferences, Stegman (1969) found that the large majority of families that recently moved to the suburbs were more concerned with neighborhood quality than accessibility to the family head's place of work. In addition, on a time-distance basis, suburban families were found to have more accessible residential locations than core area residents in metropolitan areas with at least a million people. This finding is also supported by the research of Morgan (1967). Stegman found, however, that this conclusion was less applicable for medium-sized metropolitan areas, and was reversed in smaller areas of less than 100,000 population. He concluded that smaller areas were still very much centralized with respect to the location of various population-serving activities, while larger areas tended to be more decentralized (Stegman, 1969:28).

Catanese (1970, 1971) has observed that the minimum distance theory of home-work separation poses a paradox for planners who tend to encourage less commuting as a normative objective but foster land-use patterns which locate homes far from workplaces. In a longitudinal comparative study of Milwaukee and Philadelphia, he found that "workplaces appear to be following middle and high-income families to suburban areas, but the amount of inter-suburban commuting indicates that work and home places do not necessarily move to the same suburbs. . . . The indication is that homes and jobs may be decentralizing, but the data do not indicate that they are decentralizing together" (Catanese, 1970:455). When asked why they live where they do, the dominant response of respondents in the study was better neighborhoods and housing. Distance to work was only a minor concern. Thus, Catanese concluded, "Commuting patterns are more complex than the traditional theory of conflux and dispersion would indicate. Reverse commuting and intersuburban commuting represent major patterns and trends" (Catanese, 1971:337).

A study by Lansing and Mueller (1964) of the nature and forces affecting urban growth and urban transportation also offers some rather interesting insights into household decisions regarding choice of residential location and choice of commuting mode. Based on a sample of families living in U.S. metropolitan areas in 1963, the study found that the desire to move farther out from the city was associated with getting away from noise, traffic, and crowding, while the most important reasons for wanting to live closer to the center were access to shopping and other services. Proximity to work was not of major concern in either preference. When people who had moved during the last five years were asked how important closeness to the husband's place of work was in their location decision, over 40 percent said it was of no importance at all and another fourth said it was only somewhat important (Lansing and Mueller, 1964:38). Similarly, Fuguitt and Zuiches (1973), in a 1973 survey of residential preferences, found that those who preferred suburban locations were not concerned with jobs or wages, but cited less crime and danger, the quality of air and water, and a better environment for raising children as the most important reasons for their preferences.

Metropolitan Structure and Commuting Patterns

Commuting research utilizing the journey-to-work data for SMSA's available from the decennial census has been surprisingly limited, given the extensive information of that nature which is available. Sheldon and Hoermann (1964) undertook one of the first such studies, examining the relationship between metropolitan structure and commutation in 85 isolated SMSA's, i.e., areas not adjacent to other SMSA's and outside New England. They found that the pattern of commuting within the SMSA is primarily a function of the distribution of population and jobs between the central city and ring. In fact, these two factors were so highly correlated that the pattern of commuting could be predicted solely by the distribution of population between the ring and the central city. SMSA's with a large proportion of the population living and working in the central city tended to be smaller and had more recently attained SMSA status, while areas with high ring-to-city commuting rates were on the average older and larger.

Yu (1972), in one of the most comprehensive examinations of commuting to date, also attempted to relate variations in metropolitan characteristics to rates of suburban ring to central city commuting among 95 SMSA's with populations of 250,000 or more at the time of the 1960 Census. His most important findings were: (1) the larger the percent of the SMSA population residing in the central city, the greater was the rate of ring-to-city commuting among all trips, (2) the more concentrated manufacturing jobs were in the central city, the greater was ring-to-city commuting, and (3) the larger the SMSA in population size, the smaller was the rate of commuting into the central city. Yu concluded that this low rate among more populated SMSA's was due to the proliferation of subdominant centers or off-center workplaces in larger metropolitan areas, providing intervening opportunities for the suburbanized labor force. He suggested that his findings "indicate that the level and direction of the commutation between the central city and ring of large SMSA's are largely determined by the industrial and socioeconomic structure of the SMSA and the locational pattern of the manufacturing jobs between the city and ring" (Yu, 1972:85-86).

Theoretical Orientation

Human ecologists (eg. Hawley, 1950) have long recognized that the fundamental interdependence between functional community units such as residences, industry, or administrative functions is based on access to one another. Since each activity has certain requirements with regard to the quality and amount of space it occupies, the resultant spatial distribution of functional units makes it necessary to overcome the friction of distance to attain interdependence. Such spatial friction may be reduced in terms of time and energy costs through transportation and communication technology, thereby permitting a wider scatter of component activities and a territorial differentiation of functional units. Clusters of community activities--industry, business establishments, or residences--constitute territorial units which form the overall spatial pattern of the community. Between them dynamic equilibrium is achieved over a broad area of interdependence by virtue of movement and exchange (Schnore, 1959).

The human ecological theory of community organization may also be applied to the metropolitan area. Schnore (1959) has proposed that the key structural feature of the metropolitan community is its extremely high degree of interdependence reflected in an intricate territorial division of labor. He assumes that complex movement systems arise out of the decentralization of many constituent functional units of the total area. As underlying patterns of interdependence become more complex, the manifest patterns of movement become progressively less simple. It follows that, in contrast to simple in-out movement between the periphery and the center of a smaller city, the truly metropolitan area should have a high proportion of complex non-centrally oriented flows. According to Schnore, commuting in these areas "is not merely a matter of centripetal and centrifugal flows morning and evening, but a confusing and asymmetrical compound of variously oriented threads of traffic, overlaying the older (and perhaps rudimentary) center-oriented pattern" (Schnore, 1959:205). Thus, the general hypothesis obtains that the level of complexity in metropolitan commuting patterns is determined by the extent to which metropolitan functions are decentralized in a pattern of territorial interdependence.

Based on this ecological perspective, the metropolitan area may be analyzed meaningfully in terms of zones of conflux and dispersion (Liepman, 1944:3-4; Mitchell and Rapkin, 1954:24; Vance, 1960). The most important elements in this framework are places of work whereby the area derives its support. These places may be viewed as collection points or zones of conflux for the various commuting streams originating from residential areas or dependent zones of dispersion. Hence zones of conflux, zones of dispersion, and their connecting commuting patterns make up a dynamic model of metropolitan organization (Vance, 1960). The distribution of zones of conflux is the most valid reflection of the extent of spatial differentiation in the metropolitan area, for it is the zones of conflux which generate and determine the magnitude of commuting streams that link the territorial organization together. To the extent to which productive economic functions are decentralized, a myriad of complex commuting patterns may arise based on the orientation of residences to workplaces.

In addition, as the U.S. becomes increasingly metropolitan in character and due to the relative proximity of large cities in many parts of the country, many SMSA's come to form part of metropolitan clusters of two or more with common boundaries. The degree of interdependence that the key economic functions of contiguous areas develop or the effect of one on the spatial structure of another provides impetus for inter-metropolitan commuting. Such proximity offers a type of secondary employment potential for those workers in adjacent suburban fringes or those willing to commute relatively long distances into an adjoining area if the opportunities there are sufficiently attractive.

Given the existence of decentralized economic functions, whether they are located in satellite employing centers or large plants situated in open areas of the suburban ring to obtain more operating space, or the presence of nearby metropolitan areas, workers may: (1) commute relatively short distances if housing is available near the outlying workplace; (2) travel longer distances from high-income residential areas further removed from areas of economic activity; (3) commute longer distances from other suburban areas where the ratio of population to available jobs results in a labor surplus; (4) journey in from adjacent metropolitan areas or nonmetropolitan counties; or (5) they may commute out from central city residences. In addition, depending on the extent to which important economic functions have decentralized, large numbers of workers will continue to follow the tradition of commuting to central city workplaces either from city residences, ring residences, or to a lesser extent, from outside the SMSA.

In sum, the foregoing perusal of the literature and theoretical orientation suggests the increasing importance of complex, non-centrally oriented commuting patterns in U.S. metropolitan areas. However, no study to date has endeavored to deal specifically with this topic. Also, no previous study has made complete use of the comprehensive journey-to-work data for SMSA's which is available from census documents, and such studies have suffered the additional limitation of access only to published data on roughly half of all SMSA's. Therefore, in the next chapter, a study will be detailed which attempts to rectify this void in our knowledge of metropolitan commutation.

CHAPTER II

METHODOLOGY

This study investigates the nature of non-centrally oriented journey-to-work flows in U.S. metropolitan areas and examines the relationship between metropolitan structural characteristics and such complex commuting patterns. The present chapter describes the hypothesized relationships in a proposed model of commuting complexity, the unit of analysis, operationalization of the dependent and independent variables, data to be used to test the model, operational hypotheses in the model, and the method of analysis.

The Model of Commuting Complexity

The hypothesized model may be summarized as follows. Larger metropolitan areas are typically older with very dense central cities. Such places have historically been conducive to the development of more extensive mass transit facilities. Larger metropolitan areas are also frequently contiguous to smaller metropolitan areas in regional patterns of dominance.

Dense central cities, mass transit availability, and contiguity with other metropolitan areas function to encourage a larger portion of the metropolitan labor force to reside outside the central city.

Congested cities are typically less residentially desirable than more spacious suburban areas, mass transit allows relatively cheap and efficient access to central city destinations, and the presence of adjacent metropolitan areas provides additional employment alternatives which are most accessible from the ring.

As larger proportions of the metropolitan labor force reside outside of the central city, ring locations become more advantageous for manufacturing establishments seeking more spacious sites with an accessible labor market and for business or trade establishments requiring proximity to both industrial and individual consumers. Contiguity to other metropolitan areas also offers flexibility in ring location for manufacturing in terms of labor force and market area considerations and for business establishments in terms of a more diverse market area. As larger segments of the metropolitan labor force and greater proportions of the area's manufacturing and business establishments locate outside the central city, more extensive development of the ring into satellite urban places will ensue.

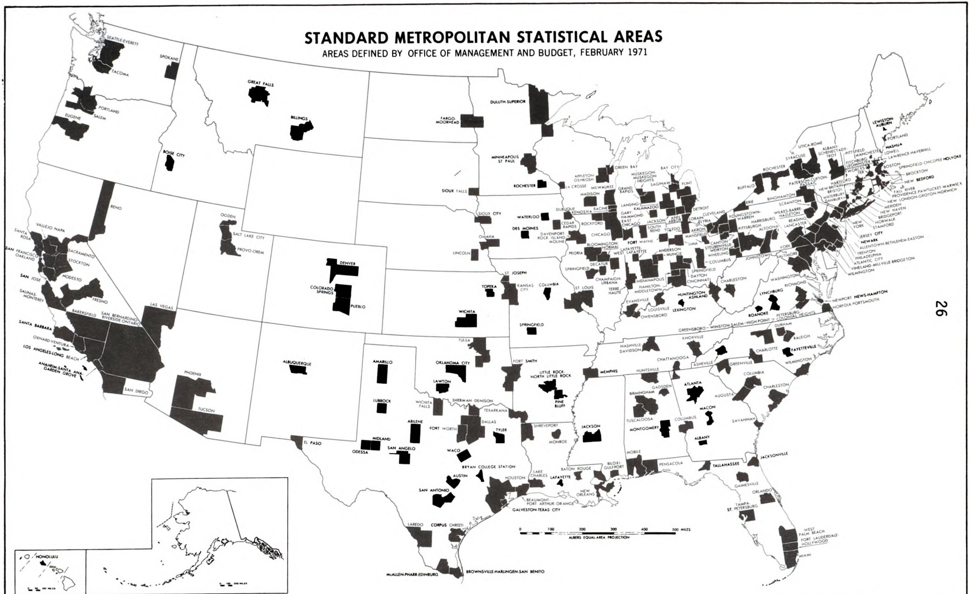
Finally, given the underlying relationships described above, the extent to which the metropolitan area's commuting patterns are complex, i.e., oriented toward ring destinations, will be dependent upon the proportion of the area's labor force, manufacturing establishments, and business establishments that reside or are located outside the central city and the extent of urban development in the ring. These are viewed to be the key indicators of functional decentralization.

Thus, age and population size are taken to be background or exoger variables which influence intermediate endogenous variables--central ci population density, contiguity to other metropolitan areas, mass transi availability, suburbanization of the metropolitan labor force, decentra zation of manufacturing establishments, decentralization of business establishments, and the extent of urban development in the ring. These intermediate variables are posited to influence commuting complexity, t final endogenous variable, directly and indirectly through their inter-relationships with each other. Metropolitan area age and size are expected to affect complexity through their influence on intermediate endogenous variables.

Unit of Analysis

The analysis is based on 240 of the 243 U.S. Standard Metropolitar Statistical Areas (SMSA's) defined as of 1970. Honolulu, Hawaii was eliminated since its location makes comparability with other areas rath difficult. Jacksonville, Florida and Meriden, Connecticut were also eliminated because they have no suburban ring. SMSA's with more than one central city are treated as if they had only one central city. Par of counties in New England SMSA's and independent cities that are not central cities in Virginia SMSA's and the Washington, D.C. metropolitar area are treated as county equivalents. Figure 1 presents a map show the distribution of SMSA's at the time of the 1970 Census.

SMSA's may be justifiably criticized as ecological units because they are made up of entire counties, only parts of which may be functio ally integrated with the area's central city. However, SMSA's are wel



SOCIAL AND ECONOMIC STATISTICS ADMINISTRATION — BUREAU OF THE CENSUS institutionalized statistically and politically. Hawley (1956b) notes that however arbitrary they may be, central city, ring, and SMSA boundaries have important implications for many organized activities. He maintains that the redistribution of population, the housing industry, and other urban activities are unquestionably influenced by the juxtaposition of political units. SMSA's are also planning entities, and they offer the obvious advantage of being the geographic unit for which most comprehensive commuting data are available.

The Dependent Variable

We may ascertain the existence of nine possible types of commuting streams which may reflect different aspects of decentralization of zones of conflux and dispersion:

A. Live in the central city and work:

1. central city (Central City-Central City)
2. ring (Central City-Ring)
3. outside the SMSA (Central City-Outside)

B. Live in the ring and work:

4. central city (Ring-Central City)
5. ring, same county (Intracounty Ring)
6. ring, different county (Intercounty Ring)
7. outside the SMSA (Ring-Outside)

C. Live Outside the SMSA and work:

8. ring (Outside-Ring)
9. central city (Outside-Central City)

The sum of all nine commuting streams represents the total commuting traffic for a particular SMSA. With respect to direction, we may discern that three streams are associated with centralized zones of conflux (Central City-Central City, Ring-Central City, Outside-Central City), four imply complexity and may be considered to be related to the extent of decentralization of activities in the area (Central City-Ring, Intra-county-Ring, Intercounty-Ring, Outside-Ring), and the remaining two (Central City-Outside and Ring-Outside) suggest complexity but are not necessarily related to the degree of decentralization within the metropolitan area. At this point, a brief discussion of these streams is in order.

1. Central City-Central City. Living and working in the central city is the ultimate in centralization. Both zones of dispersion and zones of conflux are concentrated. Within this category I also include living in one central city and working in another central city of the same multiple-centered SMSA.

2. Central City-Ring. Typically called "reverse commuting," central city-ring is associated with decentralized zones of conflux. However, in this case, the zone of dispersion remains the central city. This pattern may result when workers cannot afford suburban living, when they have neighborhood ties, or when central city residence is preferred for social or cultural reasons such as among young single people and some high income groups. Theoretically, the more extensive is the decentralization of employment opportunities, and especially industrial blue-collar jobs, the greater will be reverse commuting.

3. Central City-Outside. This commuting pattern often exists due to the presence of one or more contiguous SMSA's offering alternative opportunities. Nevertheless, I would expect such commuting to be relatively infrequent across all metropolitan areas.

4. Ring-Central City. This pattern typifies the metropolitan area with centralized functional units and thereby zones of conflux. To the extent that ring-to-city commuting occurs, job opportunities will be concentrated and predominant commuting will be made up of traditional centripetal-centrifugal flows morning and evening.

5. Intracounty Ring. Intracounty commuting results from decentralized zones of conflux and the settlement of workers in suburban zones of dispersion. Living and working within the same ring county suggests a relatively short trip to work, but in some larger counties such trips may be quite lengthy.

6. Intercounty Ring. Commuting from one ring county into another implies a long journey to work. However, it can also occur when a county line runs through a densely settled area. Nevertheless, this type of pattern may result when zones of conflux (job opportunities) and residential areas are located in different ring sectors, or when some workers select more exclusive residential areas away from the workplace even though lower quality housing may be available nearby. Intercounty commuting may also be encouraged by the settlement of population in suburban zones of dispersion in surplus numbers over and above the number of available jobs in the local vicinity. The ease and flexibility of the automobile and the typically extensive suburban highway system would

appear to make commuting of this nature increasingly possible.

7. Ring-Outside. Such commuting should be primarily oriented toward nearby metropolitan areas offering alternative opportunities. I would not expect a great deal of this type of movement into adjacent nonmetropolitan counties.

8. Outside-Ring. Decentralized zones of conflux may attract workers from outside the political boundaries of the metropolitan area, often either from contiguous SMSA's or surrounding nonmetropolitan counties. Commuting from outside to the ring implies the importance of decentralized zones of conflux as opposed to the attraction of the central city, in large part due to the closer proximity of ring workplaces.

9. Outside-Central City. In contrast to the outside-ring pattern, commuting into the central city from outside the metropolitan area suggests the importance of centralized zones of conflux, that is, the relative concentration of key productive activities. Such a pattern may be particularly prevalent into cities which are large regional centers.

I will be concerned in this research with the determinants of complex commuting related to the extent of functional decentralization <u>within</u> the metropolitan area. Thus, although they will be discussed briefly, the Central City-Outside and Ring-Outside commuting streams will not be included in the test of the model.

The dependent variable, <u>complexity of commuting patterns</u>, is operationalized by the Index of Commuting Complexity (CPLX):

$$\text{CPLX} = \frac{(\text{Intra R}) + (\text{Inter R}) + (\text{C-R}) + (\text{O-R})}{(\text{Intra R}) + (\text{Inter R}) + (\text{C-R}) + (\text{O-R}) + (\text{C-C}) + (\text{R-C}) + (\text{O-C})} \times 100$$

where Intra R = Intracounty Ring, Inter R = Intercounty Ring, C-R = Central City-Ring, O-R = Outside-Ring, C-C = Central City-Central City, R-C = Ring-Central City, and O-C = Outside-Central City. The Index of Commuting Complexity represents the proportion of commuting traffic to destinations within an SMSA which is oriented to ring destinations, regardless of origin. For instance, an index score of 40 would indicate that 40 percent of all commuting to workplaces within that particular metropolitan area concludes in the ring. Conversely, the score also indicates that 60 percent of commuting trips to workplaces within the SMSA conclude in the central city.

Independent Variables

The independent variables in the study include nine structural factors that are hypothesized to be related to the extent of metropolitan decentralization and to prevalent commuting patterns, and which make up the hypothesized model of commuting complexity. The variables are operationalized as follows:

SMSA Age, 1970 (AGESMSA). The number of census decades in which the central city or one central city in the case of multiple-centered areas has had a population of 50,000 or greater.

SMSA Population Size, 1970 (SMSAPOP). Actual population of the SMSA.

Central City Density, 1970 (CCDENS). Number of persons per square mile in the central city.

Contiguity to Other SMSA's, 1970 (CONTIGU). Number of metropolitan areas that share common boundaries with the SMSA in question.

Mass Transit Availability, 1970 (TRANSIT). Percent of central city workers using public transportation to get to work. This variable is taken to be an indicator of the overall extensiveness of mass transit facilities in the SMSA.

Labor Force Suburbanization, 1970 (PWORKLVR). Percent of the SMSA labor force that lives in the ring. The population of the ring may contain disproportionate numbers of persons not in the labor force, such as housewives, children, or people in institutions. Therefore, the proportion of workers living in the ring is a more meaningful variable with respect to commuting.

Manufacturing Decentralization, 1967 (PMFGESTR). Percent of SMSA manufacturing establishments located in the ring.

Business Decentralization, 1967 (PRWSESTR). Percent of SMSA retail, wholesale, and selected services establishments located in the ring. An alternative to this variable and the one above would be to use the percent of jobs in each economic sector that were located in the ring. However, since the number of commuters to ring destinations presumably reflect the number of jobs there, the two decentralization variables together could theoretically duplicate the dependent varialbe.

Settlement Pattern of the Ring, 1970 (PRNGURB). Percent of the population in the ring residing in urban territory, i.e., places of 2,500 or larger and nonplace portions of urbanized areas.

The suburbanization and decentralization variables measure the degree to which areas of conflux and dispersion are located outside the central city. Conceptualized in this way, they represent both actual deconcentration from the center plus relative decentralization, that is, the location of new residents, businesses, or industries initially in the ring.

Data and Data Sources

Data for metropolitan commuting flows, providing central city or cities, remainder of central county or counties, selected ring cities, and additional ring counties within the SMSA, plus outside the SMSA as origins and destinations, were obtained from the 1970 Census subject report on the journey to work (U.S. Bureau of the Census, 1973b). This report includes only those SMSA's with a population of 250,000 or more, however. Therefore, the U.S. Bureau of the Census has provided special unpublished data on commuting for areas under 250,000, comparable to the information in the subject report, to allow a comprehensive analysis. Numbers of commuters in each stream previously delineated were then ascertained for each SMSA, both for descriptive purposes and for calculation of index scores.

Data for metropolitan characteristics were obtained from the 1970 Census of Population (U.S. Bureau of the Census, 1971; 1972a, b, c), the 1970 Census of Population and Housing (U.S. Bureau of the Census, 1972d), the 1967 Census of Business (U.S. Bureau of the Census, 1969a, b, c), the 1967 Census of Manufactures (U.S. Bureau of the Census, 1970), and the County and City Data Book, 1972 (U.S. Bureau of the Census, 1973a). Information on each characteristic was collected for the total SMSA and for the central city, then calculated by subtraction for the ring. Percentage scores on the variables were then computed where necessary.

Operational Hypotheses of the Model

Figure 2 presents the hypothesized causal paths for the linear model. If the model is valid, I would expect age and population size to affect commuting complexity indirectly through their influence on central city density and mass transit availability. Density, in turn, should exert an indirect effect through transit. I would also expect size to have an indirect effect due to its influence on contiguity to other metropolitan areas.

Central city density, contiguity, and mass transit availability should affect commuting complexity because of their influence on the percentage of the labor force residing in the ring. However, I would expect the extensiveness of mass transit facilities to have a negative direct effect on complex commuting because it typically subsidizes flows to the central city. Contiguity also ought to have an indirect effect due to its influence on the location of manufacturing and business establishments outside the central city.

The proportion of the labor force residing in the ring should affect commuting complexity indirectly through its relationship with the location of manufacturing and business establishments outside the central city. I would also expect the distribution of the labor force to have a strong, positive direct effect on complexity after its influence

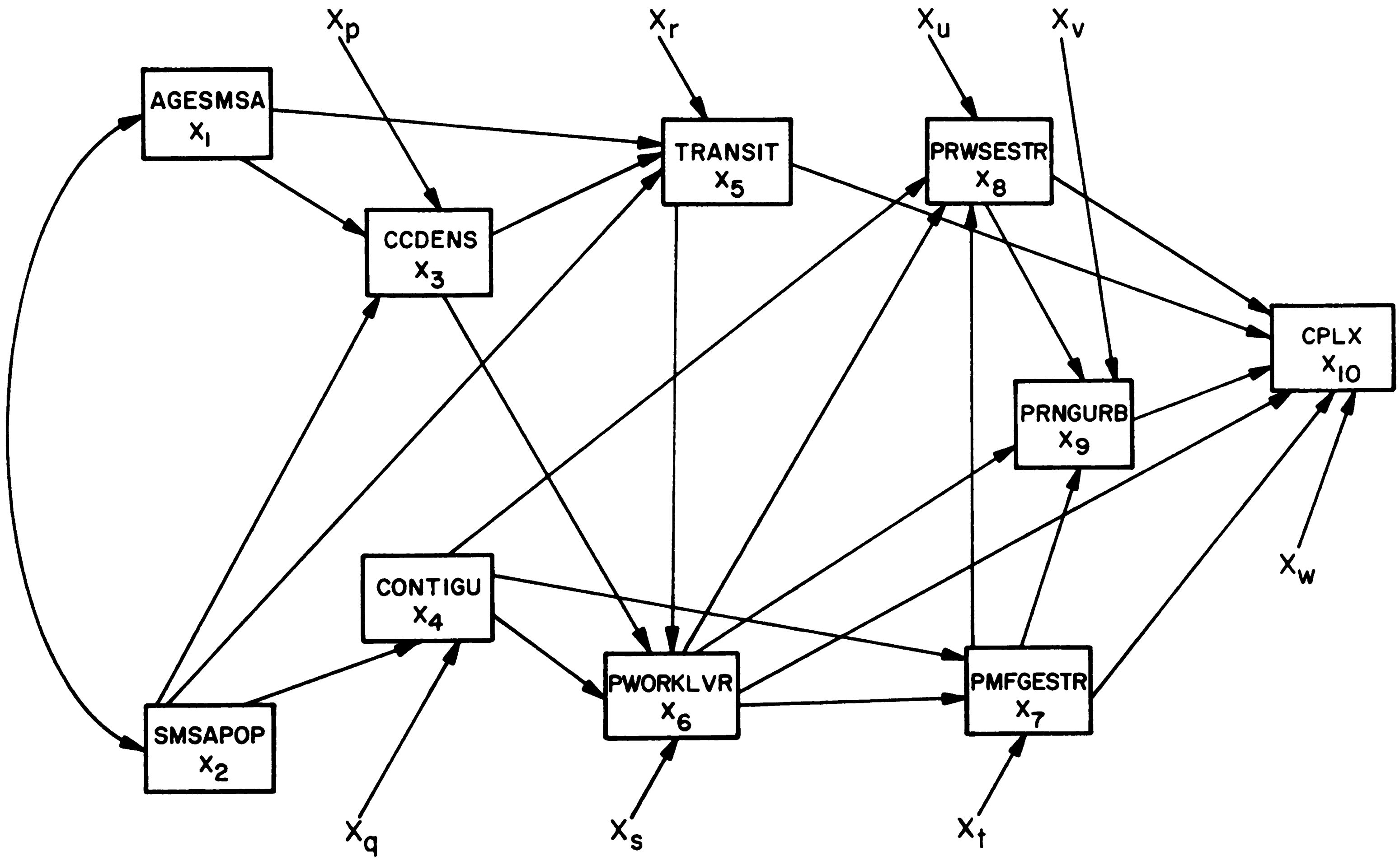


Figure 2. Hypothesized Causal Paths for a Model of Commuting Complexity in Metropolitan Areas

through intervening variables is removed. In addition, manufacturing in the ring should evidence an indirect effect due to its relationship with the proportion of business establishments also located there, and both manufacturing and business should have strong, positive direct effects on commuting complexity. The degree to which the labor force and manufacturing and business establishments are distributed towards the ring ought to have an indirect effect through the extent of urban development outside the central city. Finally, I would expect such development to have a positive direct effect on commuting complexity.

Method of Analysis

The model of commuting complexity will be tested using path analysis and multiple regression (for a discussion of path analytic techniques see Duncan, 1966; Heise, 1969; Land, 1969). In this analysis, I will utilize the method of decomposing effects in recursive models put forth by Alwin and Hauser (1975). A brief description of their approach is in order at this point.

The total association between two variables is given by their zero-order correlation. The total effect of one variable on another is the part of their total association that is neither due to their common causes or correlation among their causes (spurious relationship), nor to unanalyzed correlation. A total effect, then, represents the amount of change in a consequent variable that is induced by a given change in an antecedent variable, regardless of the mechanisms by which the change occurs. Indirect effects are those parts of a variable's total effect which are transmitted or mediated by variables specified as intervening between the cause and effect of interest in the model. They indicate the amount of a given effect which occurs because the manipulation of the antecedent variable of interest leads to changes in other variables which in turn change the consequent variable. The direct effect of one variable on another is that part of its total effect which is not transmitted through intervening variables, i.e., the effect that remains if intervening variables are held constant. Of course, the possibility exists that additional intervening variables not specified in the model may transmit part or all of this unmediated effect.

The method developed by Alwin and Hauser (1975:42-43) for ascertaining total, indirect, and direct effects is as follows. For a particular endogenous (dependent) variable in a model, successive regressions are performed beginning with only exogenous variables, then adding intervening variables in sequence from cause to effect in subsequent regressions until all variables preceding that endogenous variable in the causal chain have been taken into account. For example, in a hypothetical model if X5 was the dependent variable, X1 and X2 were exogenous, and X3 and X4 were intervening endogenous variables, we would first regress X5 on X1 and X2. In the next regression we would regress X5 on X1, X2, and X3, and in the final regression we would regress X5 on X1, X2, X3, and X4.

The total effect of a variable is its standardized partial regression coefficient (beta weight) in the first equation in which it appears as a regressor. Indirect components of its total effect are given by differences between its coefficients in two equations in the sequence where the mediating variable is that which appears as a regressor in one equation but not in the other. Finally, the direct effect of a variable is given by its coefficient in the last regression equation in the sequence.

Returning to the example above, in the first regression of X5 on X1 and X2, the coefficients for X1 and X2 would be their total effect on X5. In the second regression, X5 on X1, X2, and X3, the coefficient for X3 would be its total effect on X5 and the difference between the coefficients for X1 and X2 in the first equation and in the second would represent their indirect effects on X5 via X3. In the third and final regression in the sequence, X5 on X1, X2, X3, and X4, the coefficient for X4 is its total effect because it is the first equation in which it appears as a regressor and it is also its direct effect because the equation is the last in the sequence. The difference between the coefficients for X1, X2, and X3 in the second equation and in the third equation represents their indirect effects on X5 via the intervening variable X4.

A variable's total effect is thus the sum of its indirect and direct effects. Viewed in this way, we may take a direct or indirect effect as a percentage of the total effect to more easily observe its importance in respect to the total effect of the variable. However, Alwin and Hauser (1975:43) note that situations may occur in which direct and indirect effects counteract one another, i.e., suppressor or negative effects, so the total effect is less than the sum of the absolute effects, and some components may be larger than the total effect. They suggest that the direct and indirect effects be expressed as proportions of the sum of their absolute values in such a case.

Computation of the effect parameters for the model of commuting complexity will be done on the basis of the fully determined model which includes all possible causal paths from each variable to each subsequent variable in the causal order. Thus, the dependent variable CPLX (X10) is first regressed on the two exogenous variables AGESMSA (X1) and SMSAPOP (X2) together. Next, CPLX is regressed on AGESMSA, SMSAPOP, and CCDENS (X3). The series of regressions is then continued, each time adding a new endogenous intervening variable in the order specified by the model until, in the last regression, CPLX is regressed on all independent variables (X1 through X9) together. The total, indirect, and direct effects of the structural characteristics on commuting complexity are then calculated using the Alwin-Hauser method.

Strategy of Analysis

The analysis is concerned with the nature and determinants of complex commuting patterns across all SMSA's and for SMSA's by geographic region. In the regional analyses, SMSA's are classified with that geographic division which contains the majority of their population in cases where the SMSA lies on a divisional boundary.

Initially, a descriptive analysis of the nature of complex commuting patterns is undertaken. I examine the distribution of complexity index scores and the overall commuting patterns found in the 240 metropolitan areas under study, looking particularly at extreme cases. Then, I examine commuting across SMSA's and by geographic region from the standpoint of summary profiles. The first section of the analysis should thus provide a valuable overview of commuting in U.S. metropolitan areas.

In the second section of the analysis, the model of commuting complexity is first tested using the data for all 240 SMSA's. It is then applied to the SMSA's by geographic division to ascertain the particular importance of specific structural characteristics in each region. Such regional analyses are somewhat limited by small sample size, which results in a greater chance of random error and a lesser chance of obtaining statistically significant coefficients. Nevertheless, this strategy appears to offer more promise of obtaining useful information than using "dummy" variables for division, especially in the interpretation of indirect effects. My object is explanation not prediction.

Before proceeding on to the results of the analysis, however, it is useful to provide a brief overview of U.S. SMSA's.

An Overview of U.S. Standard Metropolitan Statistical Areas

This section presents an overview of the distribution of population and employment in SMSA's for the entire U.S. by geographic divisions. The information presented is based on data for the 230 SMSA's defined as of January, 1968, and used in the 1967 censuses of business and manufactures (U.S. Bureau of the Census, 1972e). Figure 3 presents a map of the geographic divisions.

General Trends

Table 1 indicates that in 1970, a larger proportion (54.3 percent) of the U.S. metropolitan population lived in rings than in central cities,

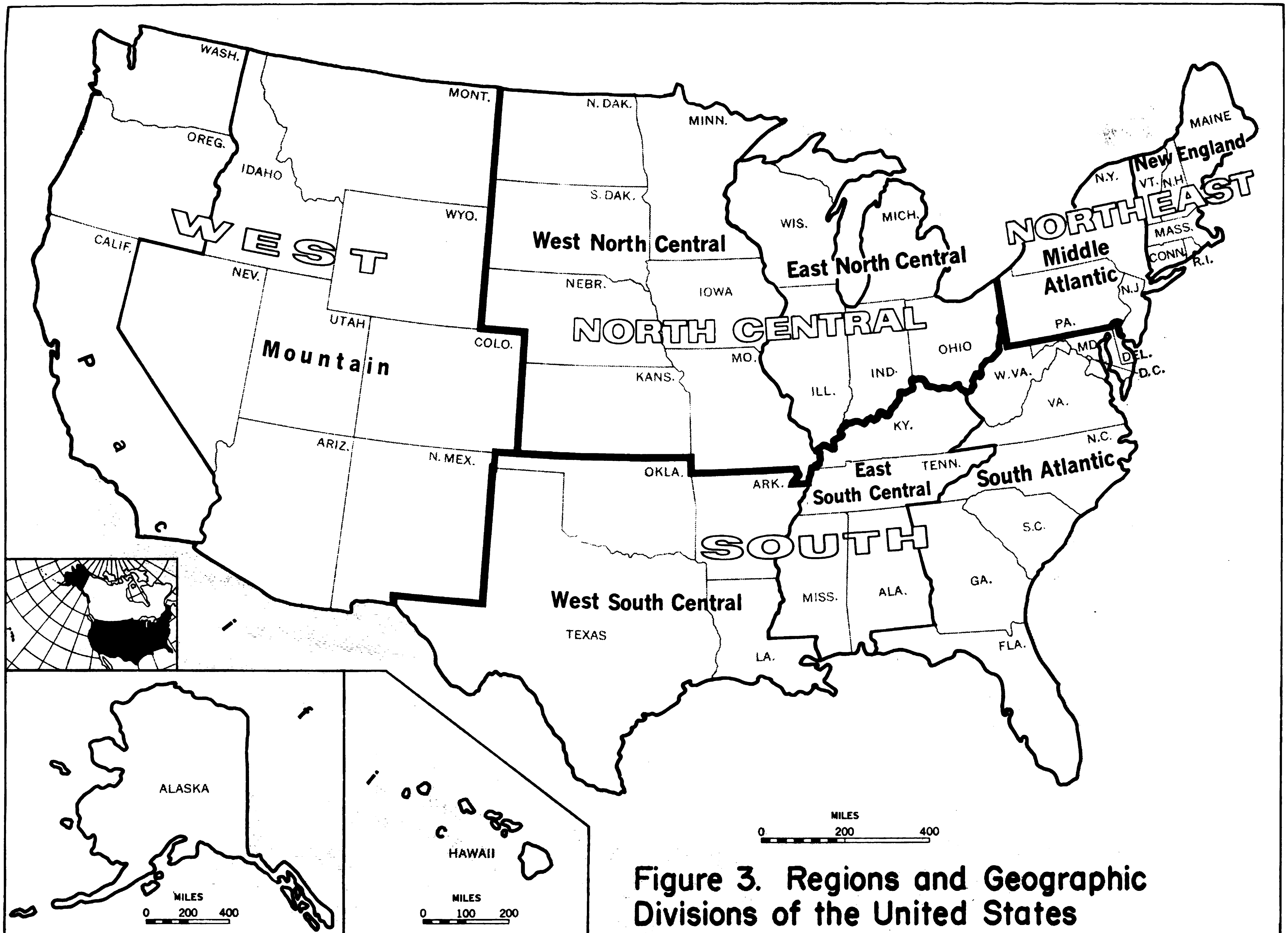


Figure 3. Regions and Geographic Divisions of the United States

Table 1. Population and Employment in SMSA's, Central Cities, and Rings in Millions.

	Population				Number of Employees															
					Manufacturing				Retail Trade				Wholesale Trade				Selected Services			
	1970		1960		1967		1958		1967		1958		1967		1958		1967		1958	
Area	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
SMSA's	137.8	100.0	118.4	100.0	14.3	100.0	12.2	100.0	7.0	100.0	5.6	100.0	3.0	100.0	2.3	100.0	3.2	100.0	2.4	100.0
Central Cities	63.0	45.7	59.9	50.6	7.8	54.5	7.3	59.9	4.1	58.7	3.8	67.9	2.0	67.1	1.8	77.9	2.2	69.7	1.8	76.3
Rings	74.8	54.3	58.5	49.4	6.5	45.5	4.9	40.1	2.9	41.3	1.8	32.1	1.0	32.9	0.5	22.1	1.0	30.3	0.6	23.7

Percentage Change Between Years*

	1960-1970	1958-1967	1958-1967	1958-1967	1958-1967
SMSA's	16.4	17.0	24.7	28.1	37.2
Central Cities	5.2	6.8	7.7	10.5	25.3
Rings	27.9	32.0	60.6	90.2	75.3

Source: U.S. Bureau of the Census (1972e:19)
*Not adjusted for annexation by central cities.

reversing the pattern that prevailed in 1960. During the decade ring growth surpassed overall SMSA growth (27.9 percent) while central city growth (5.2 percent) lagged behind.

Employment in all major economic sectors remained relatively centralized in 1967, although the central city's share decreased in each case. Ring employment was proportionately greatest in manufacturing and retail trade and least in wholesale trade and selected services. Viewed from the standpoint of percentage change, central cities actually grew slowly in all sectors, most notably in selected services, but rapid ring growth far overshadowed this increase. For SMSA's as a whole, all categories of trade grew faster than manufacturing.

Table 2 provides clear evidence that population and employment are not uniformly distributed across the nation. In 1970, the old industrial belt of the Middle Atlantic and East North Central divisions accounted for about 43 percent of all metropolitan population, and the South Atlantic and Pacific divisions together accounted for another 29 percent. Similar concentrations are evident in manufacturing and trade.

Although the older areas of the Northeast and East North Central division contain the largest concentrations of metropolitan population and employment, SMSA's in the South Atlantic and Pacific divisions showed higher growth rates in population from 1960 to 1970 and in manufacturing and trade from 1958 to 1967 (Table 3). Growth rates in New England, Middle Atlantic, East North Central, and West North Central SMSA's tended to lag behind the overall growth rate for all SMSA's. In contrast, metropolitan areas in the South Atlantic, East South Central, West South

Table 2. Percent Distribution of Population and Employment for SMSA's, by Geographic Divisions.

Geographic Divisions	Population		Employment: Manufacturing		Employment: Retail Trade		Employment: Selected Services	
	1970	1960	1967	1958	1967	1958	1967	1958
	(Percents)							
All SMSA's	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
New England	6.0	6.4	8.3	8.9	6.6	6.9	5.3	5.3
Middle Atlantic	22.2	23.9	25.8	29.1	21.5	23.5	24.4	26.6
East North Central	21.1	21.8	28.0	27.7	21.6	21.7	18.1	19.8
West North Central	5.9	6.1	6.2	6.0	6.5	6.7	5.5	5.8
South Atlantic	12.8	11.8	8.6	7.9	12.8	12.2	13.3	12.1
East South Central	3.7	3.9	3.4	3.1	3.6	3.6	3.4	3.3
West South Central	8.7	8.4	5.3	4.7	8.5	8.3	8.1	7.9
Mountain	3.4	3.0	1.5	1.3	3.3	2.9	4.5	3.5
Pacific	16.1	14.8	12.8	11.4	15.7	14.1	17.3	15.6

Source: U.S. Bureau of the Census (1972e:21)

Table 3. Percent Change in Population and Employment for SMSA's and Their Components, by Geographic Divisions.

Geographic Divisions	Population 1960-1970	Employment 1958-1967 Manufacturing	Retail Trade	Selected Services
		(Percents)		
All SMSA's	16.4	17.0	24.7	37.3
Central City	5.2	6.8	7.7	25.2
Ring	27.9	16.6	60.6	75.7
New England	10.6	9.5	18.5	38.6
Central City	- 2.1	- 4.5	- 0.8	23.2
Ring	20.5	26.6	44.8	70.9
Middle Atlantic	7.9	3.7	13.9	25.9
Central City	- 2.3	- 5.5	- 4.4	15.3
Ring	18.2	16.6	43.9	61.8
East North Central	12.6	18.5	23.9	25.8
Central City	.7	11.0	3.2	12.7
Ring	24.6	30.6	68.7	75.3
West North Central	13.4	20.4	21.4	30.5
Central City	- 0.4	5.1	3.4	19.7
Ring	28.5	42.9	69.3	78.9
South Atlantic	25.9	27.9	31.2	51.3
Central City	8.1	14.0	10.9	29.4
Ring	41.8	47.8	83.9	111.7
East South Central	11.4	26.1	25.1	38.2
Central City	10.3	21.7	16.8	39.2
Ring	12.8	37.1	62.6	32.2
West South Central	21.2	33.3	26.6	40.0
Central City	14.0	36.1	20.7	37.8
Ring	35.9	26.9	57.6	56.8
Mountain	34.4	44.1	40.6	74.9
Central City	22.8	49.7	26.0	63.7
Ring	51.5	36.6	95.7	56.4
Pacific	27.1	31.6	38.3	51.7
Central City	16.3	7.2	20.9	40.2
Ring	35.5	58.2	65.2	75.9

Source: U.S. Bureau of the Census (1972e:22)

Central, Mountain, and Pacific divisions registered higher growth rates, indicating the developmental "push" at work in the south and west. Also, central cities in the older, more intensively populated divisions lagged further behind their SMSA's than did cities in other divisions. New England and Middle Atlantic central cities actually showed declines in population from 1960 to 1970 and in manufacturing and retail employment from 1958 to 1967. Central cities in the West North Central division also lost population and gained only slightly in employment.

Geographic Divisions

One of the oldest divisions, New England is heavily industrialized and densely populated. Most of the division's metropolitan population and industrial employment is located in Massachusetts, Rhode Island, and Connecticut. The 10.6 percent increase in New England SMSA's between 1960 and 1970 was the second lowest of all divisions, reducing slightly their share of the national metropolitan population. Central cities actually declined while ring population increased 20.5 percent. SMSA manufacturing employment increased 9.5 percent between 1958 and 1967, the second lowest increase of any division. Most of this increase occurred in the ring while central cities declined. The division's 18.5 percent increase in SMSA retail employment was again the second lowest among all divisions. Rings showed a large increase (44.8 percent) while central cities declined (-0.8 percent). In respect to services, the New England SMSA's increase in employment was the second highest of any division with the rings again showing particularly high growth.

Along with the East North Central division, the Middle Atlantic dominates the nation's metropolitan population and industrial employment, accounting for 22.1 percent of the total U.S. population in SMSA's in 1970. However, the SMSA growth rate for the division was only 7.9 percent from 1960 to 1970, the lowest for any division and significantly below the 16.4 percent rate for all SMSA's. Ring population increased slightly but central cities declined (-2.3 percent). The 3.7 percent increase in manufacturing employment between 1958 and 1967 was the lowest for any division. Rings increased slightly (16.6 percent), but central cities suffered a decline. Retail employment in the division also increased at the slowest rate for any division, with rings attaining a large 43.9 percent increase while central cities were again declining. The Middle Atlantic SMSA's evidenced the second lowest increase in selected services employment although ring areas registered a marked gain of 61.8 percent.

The East North Central division is the second most industrialized area in the United States. Its population increased 10.7 percent from 1960 to 1970 as opposed to 16.4 percent for all SMSA's. Rings grew 24.6 percent but central cities increased only 0.7 percent. Manufacturing employment in the division's SMSA's increased at about the national metropolitan average, but rings increased faster in that economic sector (30.6 percent) than did central cities (11.0 percent). By 1967, the East North Central share of SMSA manufacturing employment had risen to 28.1 percent versus a 21.1 percent share of the U.S. metropolitan population in 1970. Retail trade employment in the division's SMSA's increased 23.9 percent, close to the 24.7 percent national average. Rings accounted for most of the growth, increasing 68.7 percent in retail employment, while central cities increased 3.2 percent. The East North Central division's 25.8 percent increase in selected services employment was the lowest increase for any division. Central cities increased 12.7 percent, but rings showed a marked increase of 75.3 percent.

Third smallest division in SMSA population in 1970 with only the East South Central and Mountain divisions smaller, the West North Central division includes the major farm states of North Dakota, South Dakota, Nebraska, Kansas, and Iowa as well as Minnesota and Missouri. SMSA population increase in the division was below the national average with rings growing 28.5 percent, but central cities growing less than one percent. Growth patterns in manufacturing and retail employment closely followed the population pattern. Central cities increased 5.1 percent and rings 42.9 percent in manufacturing employment, giving SMSA's in the division an overall gain of 20.4 percent. Retail employment showed a similar increase of 21.4 percent, but this was the third smallest increase among divisions. Central cities evidenced an average 3.4 percent increase in retail employment while rings grew 69.3 percent in the same economic sector. Employment increase in services in West North Central SMSA's was also the third lowest among divisions at 30.5 percent. Rings increased 78.9 percent as opposed to a 19.7 percent gain for central cities.

The diverse South Atlantic division is made up of states which have been less industrialized for a long period of time--Virginia, North Carolina, South Carolina, Georgia, and Florida--but which have made distinct recent gains. Maryland and Delaware differ from other states in the division, reflecting their place as part of the highly industrialized eastern corridor. The District of Columbia is, of course, the seat of a major portion of the federal administrative structure, while West Virginia is an area of heavy mining.

SMSA population increase in the division between 1960 and 1970 (25.9 percent) was exceeded only by the Mountain and Pacific divisions. Central cities grew 8.1 percent and rings increased an average of 41.8 percent. This growth improved the division's share of the national metropolitan population from 11.8 percent in 1960 to 12.8 percent in 1970. Manufacturing employment growth in the South Atlantic SMSA's reached 27.9 percent during the 1958-1967 period, fourth highest among divisions. Central cities averaged a 14 percent gain, while rings increased 47.8 percent. Retail and services employment also increased substantially in the division. The SMSA's 31.2 percent average increase in retail employment was exceeded only by the Mountain and Pacific divisions. Central cities accounted for a 10.9 percent increase while rings gained a very high 83.9 percent. Similarly, the South Atlantic SMSA's 51.3 percent average increase in selected services employment was second only to the Mountain division. Central cities increased 29.4 percent and rings increased a phenomenal 111.7 percent in service employment.

The East South Central division is the second smallest in metropolitan population with only the Mountain division below it. SMSA population in the division increased 11.4 percent in the division between

1960 and 1970, somewhat less than the national average. Manufacturing employment increased 26.1 percent in the division's SMSA's (21.7 percent in central cities and 37.1 percent in rings), maintaining their small 3.4 percent national share. Retail employment increased slightly more than the national average (25.1 percent) with central cities growing 16.8 percent and rings a substantial 62.6 percent. Services employment also increased at a rate just above the average for all SMSA's (38.2 percent). The East South Central division was one of two where central city employment in selected services grew faster than ring employment (39.2 percent versus 32.2 percent).

The 21.2 percent SMSA population increase from 1960 to 1970 in the West South Central division was largely due to the rapid growth experienced in Texas metropolitan areas. Central cities grew 14 percent and rings gained 35.9 percent. The division's 33.3 percent increase in manufacturing employment, which was twice the national SMSA average and second highest among divisions, increased the West South Central share from 4.7 percent to 5.3 percent in this sector. Retail employment increased at a rate just above the national average (26.6 percent) with central cities gaining 20.7 percent and rings 57.6 percent. Employment in services increased 40 percent in West South Central SMSA's versus 37.3 percent for all metropolitan areas. Central cities increased a substantial 37.8 percent and rings grew 56.8 percent.

Although it is one of the smaller divisions in terms of metropolitan population, the Mountain division covers a large geographic area containing eight states that are relatively scarcely populated. The SMSA population increase in the division (34.4 percent) between 1960 and 1970 was more than double the rate for all SMSA's and the highest of any geographic division. Nevertheless, the Mountain division's share of U.S. metropolitan population remains small at 3.4 percent. Central cities increased 22.8 percent and rings grew 51.5 percent. In addition to population growth the division has been undergoing rapid industrialization.

Manufacturing employment in the division's SMSA's increased 44.1 percent, more than double the average rate for all SMSA's and the highest for any division. Central cities manufacturing employment rose 49.7 percent, the most for any division, and rings increased 36.6 percent. SMSA retail employment increased 40.6 percent, more than any other division, with central cities gaining 26 percent and rings gaining 95.7 percent, the largest increase in retailing employment for rings in any division. Selected services employment also increased more than in other divisions, the rate of 74.9 percent being almost twice the rate for all U.S. metropolitan areas. Central cities rose 63.7 percent and rings increased 96.4 percent in service employment, the most of any division.

The Pacific division, one of the fastest growing areas of the country, is dominated by California which has 16 of the division's 22 SMSA's (excluding Honolulu). Population growth in the Pacific metropolitan areas reached 27.1 percent between 1960 and 1970, second only to the Mountain division. Its 16.1 percent share of the national metropolitan population makes the division the third largest behind the Middle

Atlantic and East North Central states. Central cities grew 16.3 percent in the Pacific division over the last decade while rings increased 35.5 percent.

Growth in manufacturing employment in the Pacific division between 1958 and 1967 (31.6 percent) was exceeded only by the West South Central and Mountain SMSA's. Central city increase was relatively small at 7.2 percent, but rings in Pacific SMSA's rose 58.2 percent. Most of this increase was due to the rapid industrialization of California. The division's growth in retail and services employment was also comparatively high. Retail employment in Pacific metropolitan areas increased 38.3 percent, second only to the Mountain division. Central cities increased 20.9 percent, while rings grew 65.2 percent. Similarly, employment in selected services in Pacific SMSA's, 51.7 percent, was also second only to the Mountain division. Central cities attained a large growth rate of 40.2 percent, and rings rose even more significantly in service employment with 75.9 percent.

What emerges from these brief profiles is a general picture of metropolitan areas in the older, more industrialized, heavily developed divisions growing slowly in both population and employment with most of the growth accounted for by ring areas. Central city importance is actually declining in New England and the Middle Atlantic states. In contrast, newer SMSA's in the South and West are developing more rapidly, showing associated population and employment growth. Ring growth in these divisions is also more extensive than in central cities, but central city residence and employment is still very important here, especially in the East and West South Central and Mountain SMSA's.

Perhaps one reason for the contemporary development in the South and West, aside from the historical primacy of the Northeastern and North Central industrial belts, is the diversified economies in those divisions. As Table 4 shows, the New England, Middle Atlantic, East North Central, and even the West North Central divisions are heavily manufacturing-oriented. Contrastingly, the SMSA's in the southern and western divisions depict a more even distribution of manufacturing and trade. It is not surprising, then, that these divisions are the fastest growing areas for manufacturing employment.

Table 4. Percentage Distribution of SMSA Employment in Economic Sectors by Geographic Division, 1967.

Geographic	Percent in Each Sector			
Division	Manufacturing	Retail Trade	Wholesale Trade	Selected Services
All SMSA's	51.9	25.6	10.8	11.7
New England	59.5	23.3	8.6	8.6
Middle Atlantic	54.8	22.5	11.0	11.7
East North Central	59.7	22.5	9.0	8.8
West North Central	50.6	26.5	12.4	10.5
South Atlantic	42.3	30.9	12.0	14.8
East South Central	49.2	27.3	12.1	11.4
West South Central	40.5	31.7	13.9	13.9
Mountain	32.2	34.1	12.5	21.2
Pacific	46.7	28.2	11.2	13.9

Source: U.S. Bureau of the Census (1972e:20)

CHAPTER III

DESCRIPTIVE FINDINGS

This chapter presents a descriptive analysis of metropolitan structural characteristics and commuting complexity. The first section will examine the pattern of structural characteristics found in the independent variables over all SMSA's and for SMSA's by geographic region. The next section will examine the commuting patterns found in the 240 metropolitan areas under study while looking particularly at extreme cases. The third section will deal with an analysis of commuting across SMSA's and by divisions from the standpoint of general, summary profiles.

Structural Characteristics of Metropolitan Areas

Before looking specifically at commuting, it should be valuable to briefly examine the pattern of metropolitan structural characteristics evident in the independent variables. Such a perusal will allow a comparison with the geographic division profiles presented previously, as well as provide insight into the nature of metropolitan areas in different parts of the country.

Table 5 presents unweighted mean scores on each of the nine independent variables for all SMSA's by geographic region and division. I will focus my comments primarily on the divisional level.

Table 5. Unweighted Means of Independent Variables, All SMSA's by Geographic Region and Division.

Geographic Unit	AGESMSA (X1)	SMSAPOP (X2)	CCDENS (X3)	CONTIGU (X4)	TRANSIT (X5)	PWORKLVR (X6)	PMFGESTR (X7)	PRWSESTR (X8)	PRNGURB (X9)
All SMSA's	4.5	575,853	4,384.9	1.1	7.9	47.3	38.9	38.2	55.9
Northeast Region	6.7	781,440	6,854.0	2.0	13.7	54.7	46.5	48.7	62.9
New England	5.2	339,372	4,515.4	1.8	9.1	43.2	36.3	38.8	62.9
Middle Atlantic	8.2	1,223,509	9,192.6	2.2	18.2	66.2	55.9	57.4	63.0
North Central Region	4.9	563,361	4,360.0	1.0	6.5	46.0	35.8	37.4	49.9
E. North Central	4.8	612,232	4,758.1	1.4	6.6	51.3	40.1	41.1	52.8
W. North Central	5.0	439,897	3,354.2	.1	6.1	32.6	25.2	28.3	42.4
South	3.6	398,206	3,238.2	.5	7.4	42.2	34.3	31.6	50.4
South Atlantic	4.1	481,633	3,954.9	.5	10.5	55.1	44.6	40.6	56.4
E. South Central	4.1	349,736	3,006.9	.3	6.3	40.5	32.4	29.7	45.2
W. South Central	2.9	334,974	2,617.9	.5	4.6	29.9	24.6	23.5	46.7
West	2.9	742,880	3,773.4	1.7	4.1	51.5	45.2	41.6	70.4
Mountain	2.3	336,725	3,237.0	.7	2.5	36.1	30.1	26.9	64.9
Pacific	3.3	1,001,342	4,114.7	2.3	5.2	61.4	54.1	51.0	74.0

Metropolitan Area Age (AGESMSA). The mean age of the 240 U.S. SMSA's in the study is 4.5 decades, suggesting that on the average, central cities reached a population of 50,000 or greater by 1920 or 1930. Variation across geographic divisions depicts the historical movement of population and subsequent urban development in the U.S. with the oldest SMSA's in the Northeast and age gradually declining as we move to the North Central region, the South, and finally the West. Middle Atlantic SMSA's are the oldest, attaining metropolitan status, on the average, before 1900. New England central cities generally reached 50,000 in population by 1920, as did the cities in the East and West North Central divisions. Metropolitan areas in the South and West are typically "younger" than the average age of all SMSA's. SMSA's in the South Atlantic and East South Central divisions reached metropolitan status by about 1930, while West South Central cities generally reached that point by 1940, as did cities in the Pacific division. Mountain central cities did not, on the average, become metropolitan until around 1950.

Population Size (SMSAPOP). U.S. metropolitan areas had attained an average population of almost 576,000 by 1970. Middle Atlantic SMSA's tend to be the largest as a group since the division contains New York, Philadelphia, Pittsburgh, Newark, Paterson-Clifton-Passaic, and Buffalo, all of which are well over one million. As we have seen above, the Middle Atlantic metropolitan areas are also the oldest. Although Pacific SMSA's are generally much "younger," their size is second only to the Middle Atlantic division with an average population of just over a million people. The industrial East North Central division also has SMSA's typically larger than the average for all areas.

The least populated SMSA's are found in the East and West South Central divisions, the Mountain division, and in New England even though the latter is among the oldest areas of metropolitan development.

Central City Population Density (CCDENS). The average population density for metropolitan central cities was nearly 4,400 people per square mile in 1970. Divisions where SMSA's are older and larger tend to have denser central cities. The Middle Atlantic division which has the oldest and largest SMSA's also has the densest urban centers with an average of 9,192.6 persons per square mile. New England and the East North Central SMSA's also have average densities above that for all SMSA's. Less populated and younger areas tend to have less dense central cities, ranging from about 4,000 people per square mile in the Pacific division to about 2,600 per square mile in West South Central SMSA's, well below the national SMSA average.

Contiguity of Other SMSA's (CONTIGU). On the average, U.S. SMSA's tend to be contiguous to one other metropolitan area. Variation among divisions ranges from 2.3 in the Pacific division and 2.2 in the Middle Atlantic to almost no contiguity among West North Central and East South Central SMSA's, and very little in the South Atlantic, West South Central, and Mountain divisions.

Percent of Central City Resident Workers Using Public Transportation to Get to Work (TRANSIT). A mean proportion of 7.9 percent of central city resident workers use public transportation in their daily trip to work. The Middle Atlantic SMSA's, again the oldest and typically largest, show the heaviest transit use among geographic areas. South Atlantic and New England areas are also over the average percent for all SMSA's. Lowest public transit use is evidenced among Mountain, West South Central, and Pacific SMSA's, three divisions with younger metropolitan areas and less dense central cities.

Percent of SMSA Resident Workers Living in the Ring (PWORKLVR). For all SMSA's, the mean percent of SMSA workers living in the ring is 47.3 percent. However, we must remember that this is an unweighted average of percentage scores, and not the absolute distribution of workers between central cities and rings. Therefore, the unweighted mean scores on this variable offer only a rough indication of absolute distribution in the divisions and should be viewed accordingly. In general, New England, Middle Atlantic, Pacific, South Atlantic, and East North Central SMSA's tend to have higher percentages of their resident workers living in the ring, while West South Central, West North Central, Mountain, and East South Central SMSA's tend to have a much smaller proportion of worker suburbanization.

Percent of SMSA Manufacturing Establishments Located in the Ring (PMFGESTR). Middle Atlantic and Pacific SMSA's have, on the average, a larger proportion of manufacturing establishments located in their rings. South Atlantic and East North Central SMSA's also exhibit a higher average percentage of manufacturing decentralization than the figure for all SMSA's. New England manufacturing establishments tend to be slightly more central city-oriented, while such establishments are quite centralized in the East and West South Central, West North Central, and Mountain divisions.

Percent of SMSA Retail, Wholesale, and Service Establishments Located in the Ring (PRWESTER). The distribution pattern of metropolitan trade establishments follows very closely the location of manufacturing. Here again, Middle Atlantic and Pacific SMSA's show a larger percentage of trade establishments located in their rings. While being basically centralized in terms of trade establishments, SMSA's of the East North Central and South Atlantic divisions do evidence a greater extent of decentralization than the average for all areas. New England falls just about on the mean, while trade establishments tend to be very centralized in the East and West South Central, West North Central, and Mountain divisions.

Percent of the Ring Population Residing in Urban Territory (PRNGURB). The ring population in the Pacific, Middle Atlantic, New England, South Atlantic, and Mountain divisions tends to be more urban than the overall average for all SMSA's. East North Central SMSA's also appear to have a large proportion of ring residents in urban places. East and West South Central, as well as West North Central metropolitan areas exhibit predominantly rural rings.

Summary. To sum up, we can make several general observations from the independent variables. First, older SMSA's tend to be larger, denser, and located in the Northeastern and North Central areas of the country. The exception to this pattern is the Pacific metropolitan areas, represented mainly by California, which are very large but younger and not particularly dense. Second, older, denser areas generally have more mass transit usage. This is not surprising since transit requires high-volume use to function economically. Also, older cities developed during the pre-auto period when mass transit was built to serve central business districts. Post-auto SMSA's, i.e., those which developed primarily after 1920, grew in an era of highway development and widespread automobile ownership, allowing an initially more diffuse development pattern.

Third, the fact that divisions with low-density central cities also tend to have small SMSA's (except the Pacific) implies that central cities in these areas have room to expand within their own boundaries and remain functionally viable. In contrast, the observation that Middle Atlantic and East North Central SMSA's are large with dense central cities, plus the fact that New England metropolitan areas are small but also have very dense centers, suggests that in those divisions central cities are crowded, forcing development into the rings. The more recent period of major growth among the SMSA's of the South and West allows less congested cities and less urbanized rings.

Finally, in viewing the crucial variables which deal with suburbanization of the labor force, decentralization of manufacturing and trade establishments, and the settlement pattern of rings, we can arrive at some initial expectations in regard to how commuting patterns may differ across regions. Re-asserting my general thesis, divisions with SMSA's that are more decentralized in terms of these structural characteristics should evidence greater commuting complexity. Hence, I would expect SMSA's in the Pacific and Middle Atlantic divisions to have especially high complexity index scores, as well as those in the East North Central and South Atlantic divisions. The New England division should also show a fairly high level of commuting complexity despite the greater than average centralization of its economic establishments. SMSA's in this division show extensive ring development, and the importance of contiguous areas. On the other hand, SMSA's in the West North Central, East and West South Central, and Mountain divisions exhibit a typically centralized pattern of key characteristics, suggesting central city functional viability. I would expect these divisions to have low levels of commuting complexity among their metropolitan areas.

Commuting Complexity of Metropolitan Areas

This section examines the complexity of commuting patterns found in the 240 metropolitan areas under study, looking particularly at extreme cases.

Table 6 presents the commuting complexity index scores for the 240 SMSA's as of 1970. Figure 4 shows the distribution of index scores about the mean score of 36.22. The standard deviation is 17.15. The distribution is somewhat bimodal with the small negative kurtosis indicating that the values are slightly less peaked in the middle than a perfectly normal distribution. A low positive skewness implies that there are a few more cases to the right of the mean score than to the left.

Instead of discussing the entire list of 240 complexity index scores individually it is more useful to look at those metropolitan areas which scored highest and lowest. By way of a preliminary comment, it is necessary to briefly consider some of the phenomena which may

Table 6. Commuting Complexity Index Scores for 240 Standard Metropolitan Statistical Areas, 1970.

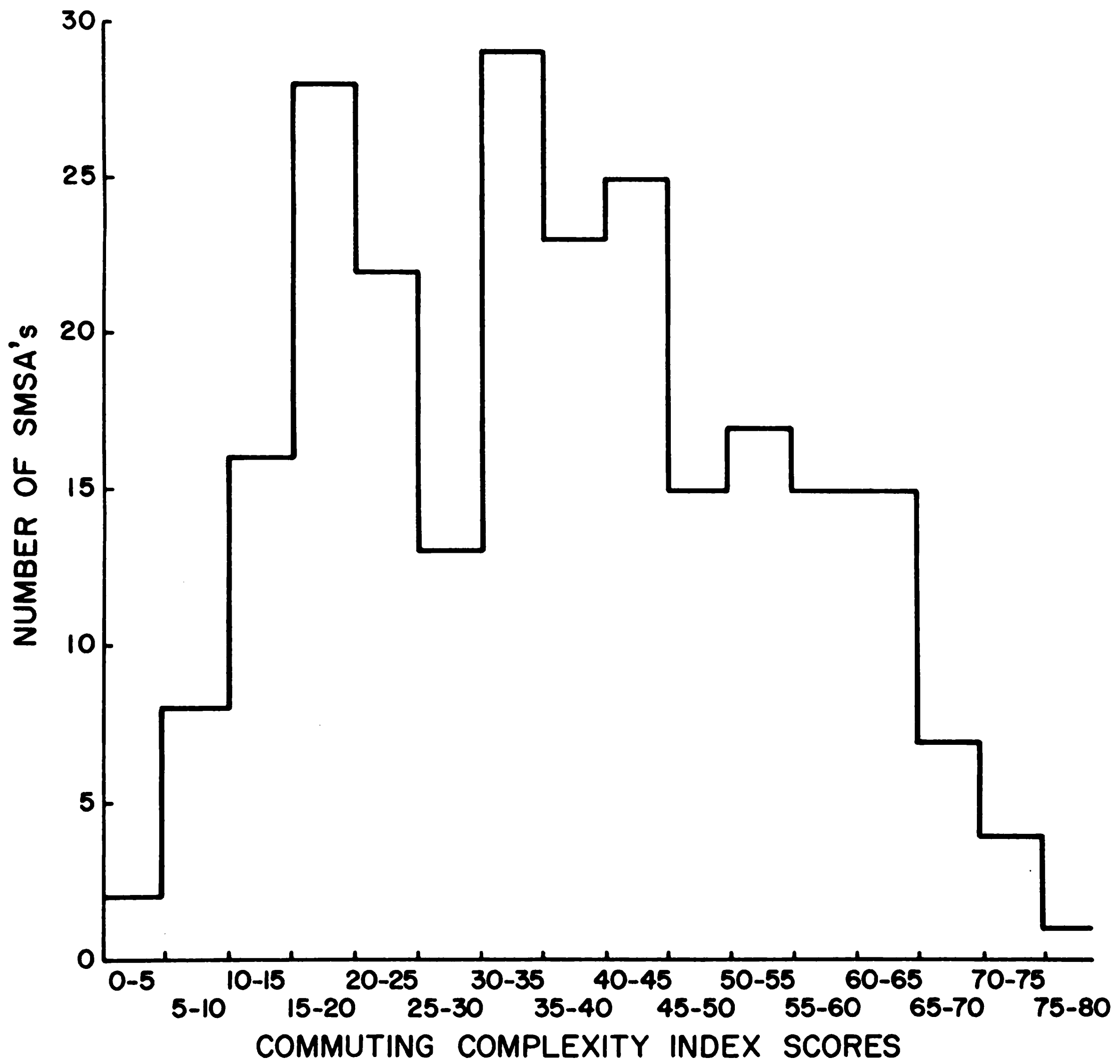
SMSA	Index Score	SMSA	Index Score
Abilene, TX	19.41	Charlotte, NC	22.58
Akron, OH	46.53	Chattanooga, TN-GA	27.94
Albany, GA	15.06	Chicago, IL	46.60
Albany-Schenectady-Troy, NY	41.69	Cincinnati, OH-KY-IN	51.19
Albuquerque, NM	15.85	Cleveland, OH	46.66
Allentown-Bethlehem-Easton, PA-NJ	42.52	Colorado Springs, CO	39.43
Altoona, PA	41.98	Columbia, MO	10.95
Amarillo, TX	11.52	Columbia, SC	50.87
Anaheim-Santa Ana-Garden Grove, CA	60.74	Columbus, GA-AL	45.80
Anderson, IN	21.16	Columbus, OH	30.34
Ann Arbor, MI	51.20	Corpus Christi, TX	30.46
Appleton-Oshkosh, WI	54.51	Dallas, TX	30.34
Asheville, NC	43.07	Danbury, CT	17.78
Atlanta, GA	45.78	Davenport-Rock Island-Moline, IA-IL	42.58
Atlantic City, NJ	58.51	Dayton, OH	48.34
Augusta, GA-SC	67.46	Decatur, IL	12.87
Austin, TX	10.61	Denver, CO	40.11
Bakersfield, CA	63.72	Des Moines, IA	16.72
Baltimore, MD	50.46	Detroit, MI	60.96
Baton Rouge, LA	18.59	Dubuque, IA	24.13
Bay City, MI	32.71	Duluth-Superior, MN-WI	39.33
Beaumont-Port Arthur-Orange, TX	25.56	Durham, NC	34.58
Billings, MT	20.89	El Paso, TX	18.20
Biloxi-Gulfport, MS	9.19	Erie, PA	44.13
Binghamton, NY-PA	65.68	Eugene, OR	35.44
Birmingham, AL	39.61	Evansville, IN-KY	28.83
Bloomington-Normal, IL	20.70	Fall River, MA-RI	15.02
Boise City, ID	19.37	Fargo-Moorhead, ND-MN	21.47
Boston, MA	63.35	Fayetteville, NC	70.19
Bridgeport, CT	48.57	Fitchburg-Leominster, MA	11.16
Bristol, CT	12.77	Flint, MI	36.54
Brockton, MA	44.31	Fort Lauderdale-Hollywood, FL	42.70
Brownsville-Harlingen-San Benito, TX	19.57	Fort Smith, AR-OK	37.05
Bryan-College Station, TX	47.72	Fort Wayne, IN	24.16
Buffalo, NY	55.77	Fort Worth, TX	41.14
Canton, OH	55.05	Fresno, CA	45.11
Cedar Rapids, IA	14.51	Gadsden, AL	19.05
Champaign-Urbana, IL	33.75	Gainesville, FL	16.63
Charleston, SC	58.37	Galveston-Texas City, TX	21.82
Charleston, WV	43.58	Gary-Hammond-East Chicago, IN	30.92
		Grand Rapids, MI	51.84
		Great Falls, MT	31.48

Table 6. Continued

SMSA	Index Score	SMSA	Index Score
Green Bay, WI	30.25	Manchester, NH	9.96
Greensboro-Winston-Salem-High Point, NC	24.90	Mansfield, OH	38.71
Greenville, SC	56.12	McAllen-Pharr-Edinburg, TX	50.01
Hamilton-Middletown, OH	27.28	Memphis, TN-AR	17.86
Harrisburg, PA	66.43	Miami, FL	59.31
Hartford, CT	61.34	Midland, TX	6.78
Houston, TX	25.33	Milwaukee, WI	43.75
Huntington-Ashland, WV-KY-OH	31.75	Minneapolis-St. Paul, MN	41.45
Huntsville, AL	38.92	Mobile, AL	31.73
Indianapolis, IN	30.68	Modesto, CA	47.87
Jackson, MI	41.34	Monroe, LA	30.68
Jackson, MS	21.75	Montgomery, AL	15.82
Jersey City, NJ	64.10	Muncie, IN	19.32
Johnstown, PA	58.79	Muskegon-Muskegon Heights, MI	33.12
Kalamazoo, MI	34.28	Nashua, NH	4.90
Kansas City, MO-KS	44.40	Nashville-Davidson, TN	11.03
Kenosha, WI	15.23	New Bedford, MA	16.87
Knoxville, TN	35.96	New Britain, CT	45.53
La Crosse, WI	16.25	New Haven, CT	44.13
Lafayette, LA	19.65	New London-Groton-Norwich, CT	60.52
Lafayette-West Lafayette, IN	13.71	New Orleans, LA	33.07
Lake Charles, LA	32.88	New York, NY	24.22
Lancaster, PA	67.57	Newark, NJ	73.86
Lansing, MI	43.69	Newport News-Hampton, VA	6.49
Laredo, TX	15.21	Norfolk-Portsmouth, VA	22.74
Las Vegas, NV	55.06	Norwalk, CT	31.32
Lawrence-Haverhill, MA-NH	48.36	Odessa, TX	16.16
Lawton, OK	69.93	Ogden, UT	28.49
Lewiston-Auburn, ME	4.67	Oklahoma City, OK	23.76
Lexington, KY	20.66	Omaha, NE-IA	28.63
Lima, OH	57.13	Orlando, FL	57.76
Lincoln, NE	5.90	Owensboro, KY	21.86
Little Rock-North Little Rock, AR	17.11	Oxnard-Ventura, CA	61.39
Lorain-Elyria, OH	34.30	Paterson-Clifton-Passaic, NJ	76.17
Los Angeles-Long Beach, CA	50.44	Pensacola, FL	62.58
Louisville, KY-IN	38.88	Peoria, IL	55.01
Lowell, MA	36.03	Petersburg-Colonial Heights, VA	58.30
Lubbock, TX	13.52	Philadelphia, PA-NJ	51.48
Lynchburg, VA	36.42	Phoenix, AZ	33.66
Macon, GA	43.03	Pine Bluff, AR	18.63
Madison, WI	23.25	Pittsburgh, PA	63.64

Table 6. Continued

SMSA	Index Score	SMSA	Index Score
Pittsfield, MA	18.47	Stamford, CT	40.88
Portland, ME	37.34	Steubenville-Weirton, OH-WV	46.67
Portland, OR-WA	43.28	Stockton, CA	51.00
Providence-Pawtucket-Warwick, RI-MA	48.94	Syracuse, NY	51.00
Provo-Orem, UT	35.13	Tacoma, WA	54.84
Pueblo, CO	13.35	Tallahassee, FL	10.81
Racine, WI	30.87	Tampa-St. Petersburg, FL	38.76
Raleigh, NC	25.32	Terre Haute, IN	36.25
Reading, PA	54.95	Texarkana, TX-AR	36.65
Reno, NV	23.56	Toledo, OH-MI	33.29
Richmond, VA	28.21	Topeka, KS	15.11
Roanoke, VA	34.51	Trenton, NJ	51.70
Rochester, MN	9.99	Tucson, AZ	18.24
Rochester, NY	42.19	Tulsa, OK	20.36
Rockford, IL	32.94	Tuscaloosa, AL	31.51
Sacramento, CA	42.63	Tyler, TX	27.20
Saginaw, MI	39.50	Utica-Rome, NY	42.94
St. Joseph, MO	10.73	Vallejo-Napa, CA	63.73
St. Louis, MO-IL	58.30	Vineland-Millville-Bridgeton, NJ	13.81
Salem, OR	37.46	Waco, TX	18.96
Salinas-Monterey, CA	60.97	Washington, DC-MD-VA	54.52
Salt Lake City, UT	42.27	Waterbury, CT	39.03
San Angelo, TX	8.00	Waterloo, IA	29.07
San Antonio, TX	18.80	West Palm Beach, FL	72.38
San Bernardino-Riverside-Ontario, CA	65.97	Wheeling, WV-OH	59.45
San Diego, CA	33.33	Wichita, KS	30.08
San Francisco-Oakland, CA	51.18	Wichita Falls, TX	15.16
San Jose, CA	65.29	Wilkes-Barre--Hazelton, PA	60.50
Santa Barbara, CA	63.40	Wilmington, DE-NJ-MD	62.19
Santa Rosa, CA	55.06	Wilmington, NC	37.84
Savannah, GA	21.29	Worcester, MA	29.65
Scranton, PA	45.57	York, PA	70.75
Seattle-Everett, WA	36.00	Youngstown-Warren, OH	50.25
Sherman-Denison, TX	30.57		
Shreveport, LA	29.49		
Sioux City, IA-NE	21.22		
Sioux Falls, SD	14.97		
South Bend, IN	41.91		
Spokane, WA	30.95		
Springfield, IL	23.60		
Springfield, MO	7.10		
Springfield, OH	25.70		
Springfield-Chicopee-Holyoke, MA-CT	38.38		



MEAN SCORE = 36.22 STD. DEVIATION = 17.15 KURTOSIS = -.885 SKEWNESS = .195

Figure 4. Distribution of Commuting Complexity Index Scores
240 SMSA's, 1970

influence the magnitude of index scores. I have hypothesized that functional decentralization in metropolitan areas results in patterns of commuting markedly different than the simple suburb-city exchange. However, in addition to decentralization other factors may potentially enter into the picture. While it may not be feasible to separate their effects from those of decentralizing forces, these factors are worthy of note.[1]

Several types of occurrences have to do with the problem of where metropolitan area boundaries are placed. In the first instance, some suburban sections of an SMSA's ring may actually be more fitting if they were considered as part of a larger, all encompassing metropolitan entity. This is particularly the case in the New York Consolidated Area where Newark, Jersey City, and Paterson-Clifton-Passaic are more or less large industrialized suburbs of New York. SMSA boundaries run through the New York Urbanized Area. Hence commuting movement in the ring may be a result of the ecological pattern of the smaller area or it may be a part of the larger pattern of interaction over the entire consolidated region.

A second type of boundary problem has to do with overbounding, i.e., because of its large areal size, an SMSA ring may include areas which are not really suburban to that SMSA's central city, but more functionally integrated with another urban center. This occurs because entire counties are included within the SMSA with which they are <u>most</u>

---

[1]The following discussion has benefited from the comments of Richard L. Forstall, Population Division, U.S. Bureau of the Census.

functionally integrated, a procedure which allows for partial linkage with other places. Such partial linkages result, conversely, in another problem similar to the one just described, that of underbounding. A high incidence of in-commuting from outside the SMSA suggests that all territory functionally integrated with the metropolitan area is not included in the SMSA. Hence, we may have the case where a section of ring in one SMSA is more closely linked with another nearby metropolitan area, resulting in out-commuting from one ring and in-commuting to another, oblivious to SMSA boundaries. Underbounding is also evident when large numbers of commuters come into an SMSA from sections of non-metropolitan territory not included within the SMSA boundary. The solution to this problem would be for SMSA's to have irregular boundaries like urbanized areas. However, Standard Metropolitan Statistical Areas are well-institutionalized statistically and politically, and thus must be dealt with in the best way possible. Another important consideration is that most useful commuting data is available for SMSA's and their components.

A final occurrence which must be taken into account is the location of large military installations within metropolitan areas. The presence of these installations in the ring can inflate the prominence of ring-oriented commuting even though it may be from one part of a military base to another. Also, the commuters may not be permanent residents of the area.

Effects of the problems just described cannot easily be controlled for. They are simply imperfections in the SMSA as a purely ecological unit. Nevertheless, as stated previously, there is no better way to deal comprehensively with the determinants and implications of commuting patterns in large urban centers.

Table 7 presents the 25 SMSA's that achieved the highest and lowest scores on the commuting complexity index. Looking first at the maximums, as expected a large majority of the SMSA's in this group are located in the heavily developed, industrialized Middle Atlantic division and in California (Pacific division) where we have observed metropolitan areas to be especially functionally decentralized. In fact, of the 25 most complex SMSA's, 16 are located in these parts of the country. The rest are primarily from the South Atlantic division and New England. It is also interesting to observe that many of the SMSA's in the group are particularly large with ten being over 500,000 in population.

Paterson-Clifton-Passaic, New Jersey achieved the highest index score with 76.17 percent of all commuters to workplaces within the SMSA working in the ring. Its neighbor, Newark, New Jersey, also achieved a very high score at 73.86. Like most SMSA's in the Middle Atlantic division, we can attribute a good bit of this complexity to dense, urbanized ring development. However, in the case of these SMSA's plus Jersey City as noted previously, their scores are affected by their location in the New York Consolidated Area. Substantial amounts of ring movement are related to the larger metropolitan entity. Complexity in the other Middle Atlantic SMSA's in the group--York, Lancaster, Harrisburg, and Pittsburgh, Pennsylvania as well as Binghamton, New York-Pennsylvania--would appear more closely related to the historically small areal size of Northeastern central cities, their heavily industrialized

Table 7. Twenty-Five SMSA's Scoring Highest and Lowest on the Commuting Complexity Index, 1970.

25 Highest Scoring Areas			25 Lowest Scoring Areas		
	SMSA	Index Score		SMSA	Index Score
1.	Paterson-Clifton-Passaic, NJ	76.17	1.	Lewiston-Auburn, ME	4.67
2.	Newark, NJ	73.86	2.	Nashua, NH	4.90
3.	West Palm Beach, FL	72.38	3.	Lincoln, NB	5.90
4.	York, PA	70.75	4.	Newport News-Hampton, VA	6.49
5.	Fayetteville, NC	70.19	5.	Midland, TX	6.78
6.	Lawton, OK	69.93	6.	Springfield, MO	7.10
7.	Lancaster, PA	67.57	7.	San Angelo, TX	8.00
8.	Augusta, GA-SC	67.46	8.	Biloxi-Gulfport, MS	9.19
9.	Harrisburg, PA	66.43	9.	Manchester, NH	9.96
10.	San Bernardino-Riverside-Ontario, CA	65.97	10.	Rochester, MN	9.99
11.	Binghamton, NY-PA	65.68	11.	Austin, TX	10.61
12.	San Jose, CA	65.29	12.	St. Joseph, MO	10.73
13.	Jersey City, NJ	64.10	13.	Tallahassee, FL	10.81
14.	Vallejo-Napa, CA	63.73	14.	Columbia, MO	10.95
15.	Bakersfield, CA	63.72	15.	Nashville-Davidson, TN	11.03
16.	Pittsburgh, PA	63.64	16.	Fitchburg-Leominster, MA	11.16
17.	Santa Barbara, CA	63.40	17.	Amarillo, TX	11.52
18.	Boston, MA	63.35	18.	Bristol, CT	12.77
19.	Pensacola, FL	62.58	19.	Decatur, IL	12.87
20.	Wilmington, DE-NJ-MD	62.19	20.	Pueblo, CO	13.35
21.	Oxnard-Ventura, CA	61.39	21.	Lubbock, TX	13.52
22.	Hartford, CT	61.34	22.	Lafayette-W. Lafayette, IN	13.71
23.	Salinas-Monterey, CA	60.97	23.	Vineland-Millville-Bridgeton, NJ	13.81
24.	Detroit, MI	60.96	24.	Cedar Rapids, IA	14.51
25.	Anaheim-Santa Ana-Garden Grove, CA	60.74	25.	Sioux Falls, SD	14.97

character, and the resultant decentralization of metropolitan functions into ring areas. Also, where ring counties are particularly large in these SMSA's the problem of overbounding may have additional importance.

Many of the Pacific SMSA's in the high-complexity group are affected by forces similar to those working in the New York region. California SMSA's are typically young, decentralized, auto-oriented places with significant ring development. However, rings in the San Bernardino-Riverside-Ontario, Oxnard-Ventura, and Anaheim-Santa Ana-Garden Grove metropolitan areas more or less overlap with territory suburban to the larger Los Angeles-Long Beach SMSA. San Jose and Vallejo-Napa have a similar relationship with the San Francisco-Oakland SMSA. In addition, large ring counties in the San Bernardino-Riverside-Ontario, Bakersfield, Santa Barbara, and Salinas-Monterey SMSA's add the effects of overbounding. Vallejo-Napa, Santa Barbara, and Salinas-Monterey also have large military installations located in their rings.

The New England SMSA's of Boston, Massachusetts and Hartford, Connecticut as well as Detroit, Michigan (East North Central) and Wilmington, Delaware-New Jersey-Maryland (South Atlantic) follow a fairly straightforward pattern of functional decentralization without noticeable bounding difficulties. This may presumably be attributed to their heavily developed character and the fact that their central cities are comparatively old. Other South Atlantic SMSA's in the group seem to have attained a high level of complexity for rather specific reasons.

West Palm Beach, Florida is a resort area in which services have traditionally been very decentralized. Pensacola, Florida appears to have a central city which is areally somewhat small, allowing for more substantial ring growth. Augusta, Georgia-South Carolina exhibits some concentration of manufacturing in the ring, but its ring also contains the Fort Gordon military base. Similarly, Fort Bragg is the primary center of employment in Fayetteville, North Carolina's ring, and Lawton, Oklahoma, the only SMSA from the West North Central division in the 25 more complex areas, has the Fort Sill military installation just outside the central city.

SMSA's that scored the lowest on the commuting complexity index seem to require less extensive explanation. We may immediately note that metropolitan areas in this group are typically small New England areas or, as expected, tend to be located in the West North Central or West South Central divisions, divisions which we previously observed to be quite centralized in terms of population, employment, and economic functions. Eighteen of the 25 least complex SMSA's have populations of under 150,000, ten of which are under 100,000.

SMSA's in the mid-section of the country tend to have areally large, low-density central cities and underdeveloped rings including much rural or open country. Such areas are also less industrialized than the North Central or Northeastern metropolitan areas. The small New England SMSA's have very little ring territory due to the system of towns there which are much smaller in area than normal counties. Also, many of the SMSA's in the less complex group are one-county areas with especially dominant central cities. Newport News-Hampton, Virginia's low score seems to result from its relative centralization plus expansive city limits, a characteristic similar to Nashville-Davidson, Tennessee, a large SMSA whose central city is actually an entire county through annexation.

Table 8 presents extremes of out-commuting and in-commuting, providing some first-hand evidence of bounding problems as well as additional information. We can first observe that most of the SMSA's on both lists are from the more metropolitan New England states of Connecticut and Massachusetts, or are part of the New York Consolidated Area. The presence of the New England SMSA's is indicative of sections of one SMSA's ring being more functionally integrated with a contiguous SMSA, resulting in heavy in- and out-commuting. In fact, in each New England metropolitan area where 20 percent or more of the workers commute in, 20 percent or more of the workers living in the SMSA commute out.

In respect to the SMSA's contiguous to New York--Jersey City, Newark, and Paterson-Clifton-Passaic, New Jersey--the same phenomenon seems to be occurring except that these areas are more realistically large industrial components of the larger New York region. Thus, their rings may contain activity which is functionally integrated with their central cities while containing substantial activity--both residential and productive--which is more integrated with the whole consolidated area.

The remaining metropolitan areas in Table 8 imply other kinds of linkages. Part of the Ann Arbor, Michigan urbanized area extends into the Detroit SMSA, presumably accounting for much of the in-commuting taking place. Lexington, Kentucky is not contiguous to any other SMSA, suggesting that it may pull a considerable number of workers from surrounding non-metropolitan counties. Ogden, Utah, Kenosha, Wisconsin,

Table 8. SMSA's with High Rates of In-Commuting and Out-Commuting, 1970.

SMSA's Where 20 Percent or More Workers Commute In		SMSA's Where 20 Percent or More Resident Workers Commute Out	
SMSA	Percent	SMSA	Percent
Jersey City, NJ	33.73	Brockton, MA	42.77
Norwalk, CT	33.47	Lowell, MA	41.29
Stamford, CT	27.95	Bristol, CT	40.73
Nashua, NH	27.62	Norwalk, CT	38.03
Ann Arbor, MI	27.48	Jersey City, NJ	35.93
New Britain, CT	27.31	New Britain, CT	34.91
Trenton, NJ	27.18	Stamford, CT	29.51
Brockton, MA	25.06	Paterson-Clifton-Passaic, NJ	29.14
Bristol, CT	23.52	Danbury, CT	28.81
Newark, NJ	22.35	Ogden, UT	26.32
Danbury, CT	22.30	Fall River, MA-RI	25.78
Lexington, KY	20.57	Kenosha, WI	25.78
		Anaheim-Santa Ana-Garden Grove, CA	25.52
		Springfield, OH	25.18
		Bay City, MI	22.75
		Fitchburg-Leominster, MA	22.59
		Hamilton-Middletown, OH	21.96
		Lawrence-Haverhill, MA	21.87
		Waterbury, CT	21.62
		Nashua, NH	20.67

Anaheim-Santa Ana-Garden Grove, California, Springfield, Ohio, and Bay City, Michigan, areas which evidence high levels of commuter loss, are examples of SMSA's which function as large suburbs for other areas in addition to being metropolitan entities in and of themselves.

In summary, this preliminary look at complexity scores for SMSA's on an individual basis, as well as in- and out-commuting, provides initial evidence that complex commuting patterns are related to functional decentralization in metropolitan areas. SMSA's that evidence the most complexity tend to be larger and located in sections of the country where metropolitan development began very early in our history around older, major urban centers, or where more recent extensive urbanization occurred in a typically decentralized pattern. Conversely, SMSA's that show the least commuting complexity tend to be relatively smaller, more uniformly younger, and located in sections of the nation where urbanization has occurred later, cities are less industrialized, and where urban centers have tended to retain their functional viability and rings remain less developed. With this background, we will next look at the summary data for all SMSA's by geographic region and division.

Metropolitan Commuting Patterns: National and Regional Profiles

This section deals with an analysis of commuting patterns across SMSA's and by geographic region and division. Its purpose is to relate findings observed in the complexity index scores to underlying patterns and flows of movement which contribute to the complexity level.

Table 9 presents the summary commuting complexity index scores for all U.S. metropolitan areas by geographic region and division. The scores are weighted means computed on the basis of all non-central SMSA commuters in the particular geographic unit, rather than an unweighted average of index scores for individual SMSA's.

The index score of 42.93 means that over all SMSA's, 42.93 percent of commuters to within-SMSA destinations travel to ring workplaces or zones of conflux, while 57.07 percent commute to central cities. This 14.14 percent advantage indicates the continuing superiority of the central city as the primary area of employment across U.S. metropolitan areas.

Viewing this pattern by region, there is noticeable geographic variation. Regional index scores range from 47.26 for the West to 36.50 for the South. The Northeast, North Central, and West regions show positive differences from the U.S. average, while the South shows a negative difference. However, looking further within the regions, it becomes apparent that they are far from homogeneous in commuting complexity.

The New England division shows more complexity relative to the entire country than does the Middle Atlantic, but the Northeast regional score is weighted by the larger number of commuters in Middle Atlantic SMSA's. Similarly, in the North Central region, the West North Central division is actually 3.74 percentage points below the national average, but the regional score attains a positive difference through the East North Central division whose SMSA's attract over three times more workers. In the South the South Atlantic division's large positive difference serves to temper the effect of the East and West South Central divisions

Table 9. Weighted Mean Commuting Complexity Index Scores For All SMSA's by Geographic Region and Division, 1970.

Geographic Unit	No. of SMSA's	No. of Workers Working in SMSA's	Complexity Score	Difference From U.S. Score
All SMSA's	240	49,464,280	42.93	--
Northeast Region	50	13,787,512	45.74	+ 2.81
New England Div.	25	3,122,731	48.95	+ 6.02
Middle Atlantic Div.	25	10,664,781	44.80	+ 1.87
North Central Region	67	13,561,308	43.11	+ 0.18
E. North Central Div.	48	10,394,973	44.31	+ 1.38
W. North Central Div.	19	3,166,335	39.19	- 3.74
South Region	87	12,743,748	36.50	- 6.43
S. Atlantic Div.	36	6,541,694	45.79	+ 2.86
E. South Central Div.	15	1,917,075	27.53	-15.40
W. South Central Div.	36	4,284,979	26.33	-16.60
West Region	36	9,371,712	47.26	+ 4.33
Mountain Div.	14	1,674,067	34.31	- 8.62
Pacific Div.	22	7,697,645	50.08	+ 7.15

whose index scores are considerably below the average for all SMSA's. The South Atlantic division appears to be distinctly more similar to the Middle Atlantic than to its southern counterparts. Finally, in the West the strong positive increase over the national average exhibited by the Pacific division is reduced at the regional level by the larger negative difference on the part of the Mountain division. However, the fact that Pacific division SMSA's attract over four times as many commuters as do SMSA's in the Mountain States allows the West to attain the highest complexity score of any region with 47.26 percent of SMSA commuters journeying to non-central workplaces.

Overall, the Pacific States, highly influenced by the large size and more spacious pattern of California metropolitan areas, exhibit the highest level of complex metropolitan commuting with more than half of all within-SMSA workers going to ring jobsites. Other large scores are prominent in New England, and the heavily industrialized Middle Atlantic and East North Central divisions, as well as in the large and diverse South Atlantic division. Lower scores are evidenced by the SMSA's of the less industrialized, central city-oriented West North Central division, East and West South Central divisions, and the Mountain states. These results are in line with my expectations of geographic variation due to differences in metropolitan characteristics. However, the especially high index score of the New England division is somewhat surprising. The reason for this outcome should become more apparent when we look at divisions individually.

Table 10 presents the distribution of the SMSA resident labor force aged 16 and over who reported their place of work in 1970 (4,662,936 or 8.77 percent of all SMSA resident workers did not report their place of work) by place of work within or outside their SMSA of residence. Looking first at the marginals for all SMSA's, although a majority (54.7 percent) of SMSA resident workers live in the ring, central cities are the predominant workplaces of such workers with 14.5 percent more workers employed in central cities than in rings. Over all SMSA's, 5.6 percent of the resident workers commute outside their SMSA of residence, and it is important to note that many of these workers become in-commuters for adjoining or nearby SMSA's.

Continuing within the U.S. panel, central city residents tend to work within the city and ring residents tend to work within the ring. However, city residents are more likely to do so than are ring residents (81.1 percent versus 60.2 percent). This pattern is amplified by the fact that 32.5 percent of ring-resident workers commute to central city workplaces, while only 15.3 percent of central city residents reverse commute to ring employment, further emphasizing the continued importance of central city job opportunities but also as a consequence of the greater ease of commuting into the city as opposed to commuting out. Mass transit tends to serve central points of conflux, and central city residents are less likely to own automobiles. Also, the table indicates that ring residents are more likely to commute outside the SMSA than are central city residents. This is not surprising, given the factors noted above which tend to limit reverse commuting and the simple

Table 10. Place of Residence by Place of Work, 1970, for All SMSA's by Geographic Region and Division (Number of SMSA's in Geographic Unit in Parentheses).

Geographic Unit and Place of Residence	N	% Down	Place of Work (Percent Across) Central City	Ring	Outside	Total
All SMSA's (240)						
Central City	21,976,717	45.3	81.1	15.3	3.6	100.0
Ring	26,509,486	54.7	32.5	60.2	7.3	100.0
SMSA	48,486,203	100.0	54.5	39.8	5.7	100.0
Northeast Region (50)						
Central City	5,859,905	43.2	83.9	11.1	5.0	100.0
Ring	7,697,741	56.8	25.4	63.9	10.7	100.0
SMSA	13,557,646	100.0	50.6	41.1	8.3	100.0
New England Div. (25)						
Central City	1,204,258	38.9	73.0	14.9	12.1	100.0
Ring	1,889,209	61.1	28.2	57.4	14.4	100.0
SMSA	3,093,467	100.0	45.6	40.9	13.5	100.0
Middle Atlantic Div. (25)						
Central City	4,655,647	44.5	86.7	10.1	3.2	100.0
Ring	5,808,532	55.5	24.5	66.0	9.5	100.0
SMSA	10,464,179	100.0	52.1	41.1	6.8	100.0
North Central Region (67)						
Central City	5,977,653	45.2	79.6	17.8	2.6	100.0
Ring	7,257,732	54.8	34.9	60.0	5.1	100.0
SMSA	13,235,385	100.0	55.1	40.9	4.0	100.0
E. North Central Div. (48)						
Central City	4,532,624	44.5	78.2	19.1	2.7	100.0
Ring	5,645,285	55.5	34.1	60.0	5.9	100.0
SMSA	10,177,909	100.0	53.7	41.8	4.5	100.0
W. North Central Div. (19)						
Central City	1,445,029	47.3	84.0	13.8	2.2	100.0
Ring	1,612,447	52.7	37.7	59.9	2.4	100.0
SMSA	3,057,476	100.0	59.6	38.1	2.3	100.0
South Region (87)						
Central City	6,165,279	50.0	83.0	13.9	3.1	100.0
Ring	6,162,182	50.0	39.4	54.8	5.8	100.0
SMSA	12,327,461	100.0	61.3	34.3	4.4	100.0
South Atlantic Div. (36)						
Central City	2,429,694	38.4	77.9	18.6	3.5	100.0
Ring	3,891,167	61.6	36.0	58.3	5.7	100.0
SMSA	6,320,861	100.0	52.1	43.1	4.8	100.0
E. South Central Div. (36)						
Central City	1,059,078	58.5	86.1	10.8	3.1	100.0
Ring	750,612	41.5	46.7	48.0	5.3	100.0
SMSA	1,809,690	100.0	69.7	26.3	4.0	100.0
W. South Central Div. (36)						
Central City	2,676,507	63.8	86.5	10.8	2.7	100.0
Ring	1,520,403	36.2	44.8	49.0	6.2	100.0
SMSA	4,196,910	100.0	71.4	24.7	3.9	100.0
West Region (36)						
Central City	3,973,880	42.4	76.2	20.0	3.8	100.0
Ring	5,391,831	57.6	31.6	61.2	7.2	100.0
SMSA	9,365,711	100.0	50.5	43.7	5.8	100.0
Mountain Div. (14)						
Central City	919,763	55.0	81.5	15.5	3.0	100.0
Ring	753,636	45.0	42.2	53.4	4.4	100.0
SMSA	1,673,399	100.0	63.8	32.6	3.6	100.0
Pacific Div. (22)						
Central City	3,054,117	39.7	74.7	21.3	4.0	100.0
Ring	4,638,195	60.3	29.9	62.5	7.6	100.0
SMSA	7,692,312	100.0	47.7	46.1	6.2	100.0

observation that ring residents are closer to outside job opportunities than are urban workers.

Viewing next the marginals in the panels for each region, we may first note that in all regions except the South where residence appears to be evenly distributed, a larger proportion of workers live in rings than in central cities. This proportion ranges from 54.8 percent in the North Central region to a high of 57.6 percent in the West. The place of work data indicate that in all regions, the central city is the predominant place of employment for SMSA resident workers with more than half of such workers employed in central city jobs in each region. The importance of urban jobsites varies from 61.3 percent for SMSA resident workers in the South to 50.5 percent for workers in the West. Regional differences in the proportion of SMSA resident workers working in the ring follow the same regional ordering as do the complexity index scores with the West highest (43.7 percent) followed by the Northeast, North Central, and South regions, the latter with only 34.3 percent of all SMSA resident workers working in the ring. Since the complexity scores are based on all commuters to non-central SMSA workplaces, this finding suggests that in-commuters simply tend to accentuate the pattern already determined by commuters within the metropolitan area. Finally, ring-resident workers are more likely to commute out of their SMSA than are central city-resident commuters in all regions. The more extreme rate of this phenomenon in the Northeast region may, as I have already suggested, be attributed to the closely settled, uniformly urban character of Connecticut and Massachusetts SMSA's and consistent overbounding.

Workers cross metropolitan area boundaries as a matter of course in their daily movements.

Moving within the regional panels, we observe that in all regions there is a strong tendency for city resident workers to work in the city and for ring resident workers to work in the ring. Central city residents are also more likely to work in the city than are ring residents likely to work in the ring in all regions. As with the entire U.S., each region evidences greater ring-to-city movement than city-to-ring or reverse movement. The detail of these patterns becomes more specific as we move to consideration of divisions within regions. I will follow the same strategy as done previously, looking first at marginals and then at variations within the panels.

The differentiation between divisions in terms of residential distribution shows some interesting differences within regions. The East and West North Central divisions offer the most intra-regional consistency with 55.5 and 52.7 percent of SMSA resident workers residing in the ring respectively. The difference may presumably be attributed to the extensive development of the more industrial eastern part of the region as compared to the typically agricultural rings of SMSA's further west.

The divisions of the Northeast also seem relatively consistent, though the extent of ring residence is of a larger magnitude. The New England division is highly ring-oriented with over 60 percent of its resident workers living in such areas. This appears to be one reason the division attained a high complexity score. Surprisingly enough, however, looking at the divisions in the South we find that the South Atlantic division appears to be slightly more suburbanized than New England with 61.6 percent of all SMSA resident workers living in rings. The distinct difference between the South Atlantic and East and West South Central divisions also becomes readily apparent if we observe that while the South Atlantic has the highest percentage of population in the ring, the East and West South Central divisions have the lowest with 41.5 and 36.2 percent respectively. Such a distribution of workers further indicates the importance of central cities as places of residence in those divisions.

Similarly, the divisions of the West also show a marked discrepancy of residential patterns. Whereas Mountain division SMSA's evidence a central city orientation with only 45 percent of resident workers living in the ring, SMSA's in the Pacific division show a significant reversal of this pattern with over 60 percent of SMSA resident workers residing in rings.

Looking next at the marginals for place of work across divisions, the initial realization must be that central cities tend to be the predominant place of work in all divisions but to varying degrees. It may be useful here to view the distribution of workplaces in terms of city-ring differences. Table 11 shows the inverse relationship between the extent to which job opportunities are concentrated in central cities and the commuting complexity score which measures the relative importance of ring workplaces. We may again note the city-oriented pattern of the West North Central, Mountain, and East and West South Central divisions.

Table 11. Relationship Between Difference Score for Central City Versus Ring Employment and Commuting Complexity Index, Geographic Divisions, 1970.

Division	Percent Central City Employment Greater Than Ring	Commuting Complexity Index Score
Pacific	1.5	50.08
New England	4.7	48.95
South Atlantic	9.0	45.79
Middle Atlantic	11.0	44.80
East North Central	11.9	44.31
West North Central	21.3	39.19
Mountain	31.2	34.31
East South Central	43.4	27.53
West South Central	46.7	26.33

Returning to Table 10, the data within the division panels further elaborates this tendency.

First, in all divisions, the strong tendency is for central city residents to work in the city and for ring residents to work in the ring. The city-city pattern is most prevalent in the low-complexity West North Central, East and West South Central, and Mountain divisions and somewhat surprisingly in the Middle Atlantic division which has a high commuting complexity index score. However, Middle Atlantic SMSA's also have the highest proportion of ring resident workers who work in the ring (66 percent) of any division and the lowest proportion of workers in this residence category who commute into the central city (24.5 percent).

Because of the difficulty in dealing with the internal patterns within the nine divisional panels, it is useful to extract some of the key information for closer scrutiny. Therefore, Table 12 ranks the divisions by complexity score for comparison with select commuting indicators from Table 10. Divisions with higher mean complexity scores appear to have somewhat lower proportions of SMSA resident workers living and working in the central city and a somewhat higher proportion of workers living and working in the ring. These patterns are by no means distinct, however. There does appear to be a more marked tendency for divisions with high mean complexity scores to have a smaller percentage of ring resident commuters who journey to work into the central city than occurs in SMSA's in divisions with lower mean complexity scores, implying the retentive power of ring workplaces. There is also some

Table 12. Commuting Complexity Index Scores and Selected Commuting Indicators From Table 10, Geographic Divisions, 1970.

Division	Commuting Complexity Score	% Central City Resident Workers Working in Central City	% Ring Resident Workers Working in Ring	% Ring Resident Workers Commuting to Central City	% Central City Resident Workers Commuting to Ring
Pacific	50.08	74.7	62.5	29.9	21.3
New England	48.95	73.0	57.4	28.2	14.9
South Atlantic	45.79	77.9	58.3	36.0	18.6
Middle Atlantic	44.80	86.7	66.0	24.5	10.1
East North Central	44.31	78.2	60.0	34.1	19.1
West North Central	39.19	84.0	59.9	37.7	13.8
Mountain	34.31	81.5	53.4	42.2	15.5
East South Central	27.53	86.1	48.0	46.7	10.8
West South Central	26.33	86.5	49.0	44.8	10.8

tendency for divisions with higher mean complexity to evidence a larger proportion of reverse (central city-to-ring) commuting than divisions with lower complexity, but again the pattern is not distinct.

Observing the divisional patterns of commuting out of the SMSA of residence shown in Table 10, we again find that ring resident workers are more likely to commute out than are city residents. Such out-commuting is most prevalent in New England, as previously observed, and in the Pacific division where contiguity to other SMSA's and bounding problems are the crucial factors. In fact, it appears that the extremely high rate of commuting across SMSA boundaries in New England contributes greatly to its unexpectedly high complexity score. More than 12 percent of workers residing in New England central cities commute outside the SMSA, as opposed to only 3.6 percent across all SMSA's. The large majority of this movement is into other contiguous metropolitan areas and presumably to ring workplaces.

Table 13 helps elaborate the incidence of in-commuting into SMSA's by geographic division. Viewing New England, the data further confirm the importance of inter-metropolitan movement. Keeping in mind the extreme rate of contiguity in the division, we may observe that New England SMSA's have far and away the most extensive in-commuting of any division, both to central cities and rings. However, it is the fact that over 17 percent of all New England ring workers commute in from outside that is most worthy of note. This is almost twice the rate of rings in all SMSA's.

Table 13. Percent of SMSA Workers Living Outside Their SMSA of Work, For All SMSA's by Geographic Division, 1970.

Geographic Unit	Place of Work		
	SMSA	Central City	Ring
		(Percents)	
All SMSA's	7.5	6.3	9.0
New England	14.3	11.5	17.3
Middle Atlantic	8.5	7.3	9.9
East North Central	6.5	5.4	7.7
West North Central	5.7	5.4	6.1
South Atlantic	8.1	7.2	9.1
East South Central	9.4	9.2	9.9
West South Central	5.9	5.0	8.3
Mountain	3.7	3.0	5.0
Pacific	6.3	4.6	7.9

Looking across divisions, rings uniformly attract a higher proportion of workers than do central cities. Over all SMSA's, rings attract 9 percent of their workers from outside the SMSA while central cities attract 6.3 percent. It is interesting to observe that the East South Central division metropolitan areas, where SMSA's tend to be independent of contiguous areas, attract more than the average amount of in-commuting especially to their central cities. This finding reaffirms the importance of cities in that area of the South, in this case evidencing non-metropolitan-to-central city commuting.

The final concern of this section is the contribution of each type of non-centrally oriented commuting to the complexity level. Table 14 presents the relative importance of each constituent commuting stream for all SMSA's by geographic division. Seventy-five percent of the non-central journeys to work are trips from ring origins to ring destinations. The remainder is made up of 15.9 percent reverse or city-to-ring trips, and 9 percent from outside the SMSA.

Reverse commuting ranges from a low of 9.8 percent in Middle Atlantic SMSA's to a high of 25.7 percent in the West South Central division. It is interesting to note that reverse commuting is more important in the low complexity, centralized metropolitan areas of the West North Central, East and West South Central, and Mountain divisions. Apparently, the labor force in these SMSA's is more centralized than potential sources of employment. Also, the fact that they are divisions where SMSA's are "younger" and less congested suggests that auto ownership is very common in the central cities and reverse journeys to work

Table 14. Individual Commuting Flows As a Percent of Total Non-Central Commuters, All SMSA's by Geographic Division, 1970.

Geographic Unit	Commuting Flow: Central City to Ring	Within the Ring	Outside to Ring	Total
	(Percents)			
All SMSA's	15.9	75.1	9.0	100.0
New England	11.8	70.9	17.3	100.0
Middle Atlantic	9.8	80.3	9.9	100.0
East North Central	18.8	73.5	7.7	100.0
West North Central	16.1	77.8	6.1	100.0
South Atlantic	15.1	75.8	9.1	100.0
East South Central	21.8	68.3	9.9	100.0
West South Central	25.7	66.0	8.3	100.0
Mountain	24.9	70.1	5.0	100.0
Pacific	16.9	75.2	7.9	100.0

are easier to make. SMSA's in the Middle Atlantic division are older and more congested with higher mass transit use.

Intra-ring commuting varies from 80.3 percent of the non-central trips in the Middle Atlantic SMSA's to a low of 66 percent in SMSA's of the West South Central division. The pattern in the Middle Atlantic division suggests that the low city-to-ring rate there may be additionally attributed to the large proportion of ring residents saturating the job market. Low intra-ring rates in the centralized East and West South Central SMSA's imply the importance of ring-to-city commuting.

Finally, in observing the incidence of commuting into SMSA's from outside, the significance of this stream for the complexity of New England metropolitan areas is again readily apparent. Over 17 percent of the non-central commuting in that division crosses the metropolitan boundary compared to only 9 percent for all SMSA's. Much of this influx is undoubtedly out-commuting from other metropolitan areas.

Summary

This chapter has provided a descriptive analysis of metropolitan structural characteristics and commuting complexity based on 240 U.S. Standard Metropolitan Statistical Areas. In the first section I examined the pattern of structural characteristics found over all SMSA's and for SMSA's by geographic region. I found that older SMSA's tend to be larger, denser, and located in the Northeastern and North Central regions of the country. Pacific SMSA's also tended to be very large but were found to be much younger and not as dense. Older cities also evidenced greater mass transit use. Low density central cities tended to be found in SMSA's with smaller populations implying that the cities were still able to grow within their own boundaries and retain their functional viability.

Finally, based on the unweighted mean scores for the variables measuring suburbanization of the labor force, decentralization of manufacturing and trade establishments, and the settlement pattern of the ring, I predicted that SMSA's in the Pacific, Middle Atlantic, East North Central, and South Atlantic geographic divisions would tend to have high scores on the commuting complexity index due to the generally decentralized pattern of their functional units. I also predicted that New England SMSA's would exhibit a high level of complexity due to their extensive ring development. In contrast, SMSA's in the West North Central, East and West South Central, and Mountain divisions, SMSA's which evidenced a typically centralized pattern of functional units, were expected to show a relatively low level of commuting complexity.

The next section examined the distribution of scores on the commuting complexity index achieved by the metropolitan areas under study. The analysis provided initial evidence that complex commuting patterns are related to the extent of functional decentralization in metropolitan areas. SMSA's exhibiting the highest proportion of non-central commuting tended to be large and located in the Middle Atlantic and Pacific divisions, areas of heavy metropolitan development showing substantial decentralization. Metropolitan areas among those with the very lowest complexity scores were significantly smaller in population size, younger, and tended to be located in the West North Central and West South Central geographic divisions. These are sections of the nation with less urbanization and industrialization where central cities still retain a strong functional importance over their rings.

The final section provided a more in-depth analysis of commuting patterns across SMSA's and by geographic region and division to ascertain the types of underlying movement which contribute to the complexity levels. I found that as expected, SMSA's in geographic divisions exhibiting greater functional decentralization also tended to have more complex commuting patterns. The Pacific, New England, Middle Atlantic, South Atlantic, and East North Central divisions achieved high SMSA commuting complexity scores, while SMSA's in the West North Central, East and West South Central, and Mountain divisions achieved lower scores.

Furthermore, I found that people who live in the central city tend to work there, while people who live in the ring tend to work in the ring. However, when central city boundaries are crossed, ring residents are much more likely to commute to the city than are city residents likely to commute to the ring. Over all SMSA's, the majority of workers live in the ring, but the majority of metropolitan jobs are located in the central cities. The East and West South Central and Mountain divisions are the only divisions where a larger proportion of the metropolitan labor force lives in central cities than in rings. Yet, central city workplaces attract a larger percentage of these workers than do ring workplaces in every geographic division, but to varying degrees.

Divisions with higher mean SMSA complexity scores tended to have a lower proportion of workers living and working in central cities and a somewhat higher proportion of workers living and working in the ring. There was also a tendency for divisions with higher SMSA scores to have a smaller percentage of ring resident commuters who work in the central city and a higher proportion of central city resident workers who reverse commute to ring workplaces. New England SMSA's were found to have extreme amounts of in- and out-commuting which was attributed in large part to the contiguity of many SMSA's and the fact that overbounding often results in suburban sections of one area being more closely functionally related to another area close by.

Finally, I found that three quarters of all complex commuting begins and ends in the ring. Another 16 percent is reverse commuting and 9 percent comes from outside the SMSA.

This chapter, then, has broadly developed the substantive nature of metropolitan commuting. With this background, in the next chapter I will test the causal model hypothesized in Chapter II for all U.S. metropolitan areas and then apply it to the SMSA's by geographic division to observe variations in specific areas of the country.

CHAPTER IV

MULTIVARIATE ANALYSIS

In this chapter I test the model of commuting complexity hypothesized in Chapter II for all U.S. metropolitan areas. The model is then applied to SMSA's by geographic division to assess regional differences. Before presenting the results of the analysis, it is advantageous to review the nature of the relationships predicted earlier.

My general thesis is that the degree of commuting complexity in metropolitan areas is dependent upon several structural characteristics which determine the extent of functional decentralization in the area from which the commuting patterns arise. Age and population size are taken to be background or exogenous variables which influence intermediate endogenous variables--central city population density, contiguity to other metropolitan areas, mass transit availability, suburbanization of the metropolitan labor force, decentralization of manufacturing establishments, decentralization of retail, wholesale, and selected services (business or trade) establishments, and the extent of urban development in the ring. These intermediate variables are posited to influence commuting complexity, the final endogenous variable, directly and indirectly through their interrelationships with each other.

Metropolitan area age and size are expected to affect complexity through their influence on intermediate endogenous variables.

The hypothesized model may be summarized as follows. Larger metropolitan areas are typically older with very dense central cities. Such places have historically been conducive to the development of more extensive mass transit facilities. Larger metropolitan areas are also frequently contiguous to smaller metropolitan areas in regional patterns of dominance.

Dense central cities, mass transit availability, and contiguity with other metropolitan areas function to encourage a larger portion of the metropolitan labor force to reside outside the central city. Congested cities are typically less residentially desirable than more spacious suburban areas, mass transit allows relatively cheap and efficient access to central city destinations, and the presence of adjacent metropolitan areas provides additional employment alternatives which are most accessible from the ring.

As larger proportions of the metropolitan labor force reside outside of the central city, ring locations become more advantageous for manufacturing establishments seeking more spacious sites with an accessible labor market and for business establishments requiring proximity to both industrial and individual consumers. Contiguity to other metropolitan areas also offers flexibility in ring location for manufacturing in terms of labor force and market area considerations and for business establishments in terms of a more diverse market area. As larger segments of the metropolitan labor force and greater proportions of the area's manufacturing and business establishments locate outside the central city, more extensive development of the ring into sattelite urban places will ensue.

Finally, given the underlying relationships described above, the extent to which the metropolitan area's commuting patterns are complex, i.e., oriented toward ring destinations, will be dependent upon the proportion of the area's labor force, manufacturing establishments, and business establishments that reside or are located outside the central city and the extent of urban development in the ring. These are viewed to be the key indicators of functional decentralization.

Thus, if the model is valid, I would expect age and population size to affect commuting complexity indirectly through their influence on central city density and mass transit availability. Density, in turn, should exert an indirect effect through transit. I would also expect size to have an indirect effect due to its influence on contiguity to other metropolitan areas.

Central city density, contiguity, and mass transit availability should affect commuting complexity because of their influence on the percentage of the labor force residing in the ring. However, I would expect the extensiveness of mass transit facilities to have a negative direct effect on complex commuting because it tends to subsidize ring-to-city flows. Contiguity also ought to have an indirect effect due to its influence on the location of manufacturing and business establishments outside the central city.

The proportion of the labor force residing in the ring should affect commuting complexity indirectly through its relationship with the location of manufacturing and business establishments outside the central city. I would also expect the distribution of the labor force to have a strong positive direct effect on complexity after its influence through intervening variables is removed. In addition, manufacturing in the ring should evidence an indirect effect due to its effect on the proportion of business establishments also located there, and both manufacturing and business should have a positive direct effect on commuting complexity. The degree to which the labor force and manufacturing and business establishments are distributed towards the ring ought to have an indirect effect through the extent of urban development outside the central city. Finally, I would expect such development to have a positive direct effect on commuting complexity.

Test of the Model for All Metropolitan Areas

Table 15 presents the zero order correlation matrix for all variables in the study. Table 16 presents the direct and indirect effects of each structural characteristic on commuting complexity, while Table 17 shows the proportion of each variable's total effect that is direct or indirect.

The results shown in the tables are largely consistent with my expectations. About 33 percent of the total effect of age is transmitted via central city density, nearly 11 percent is transmitted via mass transit availability, and another 11 percent is transmitted via labor force suburbanization. Thus, of the effect of age on commuting

Table 15. Correlation Matrix, Means, and Standard Deviations of Variables in the Model for All SMSA's.

	AGESMSA	SMSAPOP	CCDENS	CONTIGU	TRANSIT	PWORKLVR	PMFGESTR	PRWSESTR	PRNGURB	CPLX
AGESMSA	1.000	.553	.638	.313	.731	.310	.148	.318	.512	.271
SMSAPOP		1.000	.680	.428	.682	.169	.102	.204	.445	.207
CCDENS			1.000	.507	.803	.405	.329	.428	.448	.414
CONTIGU				1.000	.360	.446	.462	.524	.413	.471
TRANSIT					1.000	.357	.272	.361	.467	.346
PWORKLVR						1.000	.856	.931	.476	.850
PMFGESTR							1.000	.884	.357	.818
PRWSESTR								1.000	.502	.881
PRNGURB									1.000	.536
CPLX										1.000
Mean	4.50	575,853	4,384.94	1.13	7.94	47.26	38.89	38.22	55.89	36.22
Std.Dev.	3.63	1,126,041	3,184.65	1.24	8.47	18.94	17.47	16.78	24.02	17.15

Table 16. Interpretation of Effects in a Model of Commuting Complexity for 240 U.S. Metropolitan Areas, 1970.

Independent Variables	Total Effect	Indirect Effect Via							Direct Effect
		X3	X4	X5	X6	X7	X8	X9	
AGESMSA(X1)	.226	.185	-.020	.060	.063	-.068	.043	.045	-.082
SMSAPOP(X2)	.082	.231	.062	.035	-.261	-.024	.007	.039	-.007
CCDENS(X3)	.489	--	.160	.092	.171	.001	.010	-.020	.075
CONTIGU(X4)	.376	--	--	-.015	.299	.048	.048	.017	-.021
TRANSIT(X5)	.181	--	--	--	.170	.041	-.030	.007	-.007
PWORKLVR(X6)	.795	--	--	--	--	.276	.329	.027	.163
PMFGESTR(X7)	.335	--	--	--	--	--	.182	-.034	.187*
PRWSESTR(X8)	.553	--	--	--	--	--	--	.065	.488**
PRNGURB(X9)	.170	--	--	--	--	--	--	--	.170**

*Coefficient is twice its standard error.
**Coefficient is three-times its standard error.
R^2=.807

Table 17. Percentage Interpretation of Effects in a Model of Commuting Complexity for 240 U.S. Metropolitan Areas, 1970.

Independent Variables	Sum of Absolute Values of Effects	% of Absolute Summed Effect Via Intervening Variables							% of Absolute Effect Direct
		X3	X4	X5	X6	X7	X8	X9	
AGESMSA(X1)	.566	32.69	3.53	10.60	11.13	12.01	7.60	7.95	14.49
SMSAPOP(X2)	.666	34.68	9.31	5.26	39.19	3.60	1.05	5.86	1.05
CCDENS(X3)	.529	--	30.25	17.39	32.33	.19	1.89	3.78	14.18
CONTIGU(X4)	.448	--	--	3.35	66.74	10.71	10.71	3.79	4.69
TRANSIT(X5)	.255	--	--	--	66.67	16.08	11.76	2.75	2.75
PWORKLVR(X6)	.795	--	--	--	--	34.72	41.38	3.40	20.50
PMFGESTR(X7)	.403	--	--	--	--	--	45.16	8.44	46.40
PRWSESTR(X8)	.553	--	--	--	--	--	--	11.75	88.25
PRNGURB(X9)	.170	--	--	--	--	--	--	--	100.00

complexity, a third is due to denser central cities in older metropolitan areas and smaller portions are due to the tendency for older SMSA's to have more extensive mass transit facilities and a greater degree of labor force suburbanization.

Almost 35 percent of the total effect of population size is also transmitted via central city density, but the indirect effect of size through mass transit availability is minimal. Similarly, size evidences a very small indirect effect through contiguity. Hence, a third of the effect of size is due to the fact that larger SMSA's tend to have denser central cities, but across all SMSA's, sheer population size does not influence commuting complexity due to greater transit availability or by fostering contiguous metropolitan areas.

As anticipated 32 percent of the total effect of central city density is transmitted via labor force suburbanization and another 17 percent is transmitted via mass transit availability. However 30 percent of the total effect is also transmitted via contiguity and 14 percent is unmediated by other variables in the model. This indicates that of the effect of central city density on commuting complexity, about a third is due to the greater labor force suburbanization encouraged by congested cities, and 17 percent results from the tendency of such places to have more extensive mass transit facilities in the area. Rather unexpectedly, almost a third of the effect of urban density is due to contiguity to other SMSA's, implying that metropolitan areas with denser central cities have a tendency to be contiguous to other areas which increases the likelihood of complex movement. The positive direct effect suggests that all other things being equal, SMSA's with denser central cities have a higher level of commuting complexity.

Sixty-seven percent of the total effect of contiguity, as expected, is transmitted via labor force suburbanization, while much smaller portions are transmitted via manufacturing and business decentralization. Thus, of the effect of contiguity, over two-thirds is due to greater labor force suburbanization when contiguous metropolitan areas are present. However, there is only a slight tendency for contiguous SMSA's to encourage greater segments of an area's manufacturing and business establishments to locate outside the central city. In accordance with the hypothesized pattern, almost 67 percent of the total effect of mass transit availability is transmitted via labor force suburbanization, and another 16 percent is transmitted via manufacturing decentralization. This indicates that two-thirds of the effect of mass transit availability on commuting complexity is due to the fact that more extensive transit facilities are conducive to greater labor force suburbanization; there is an additional tendency for manufacturing to be more decentralized in SMSA's where public transportation is most readily available. Contrary to expectations, the independent effect of transit on complexity is negative but virtually zero.

Nearly 80 percent of the total effect of labor force suburbanization is indirect. Thirty-five percent is transmitted via manufacturing decentralization, 41 percent is transmitted via business decentralization, and about 21 percent is unmediated by other variables in the model. Only a negligible portion is transmitted via the extent to which the ring population is urban. Thus, of the effect of labor force suburbanization on commuting complexity, about a third is due to a larger proportion of metropolitan manufacturing establishments being located outside the central city where the work force is more suburbanized, 41 percent is due to the same relationship between labor force distribution and the location of business establishments, and 21 percent is due to the fact that where workers have a greater tendency to reside in the ring, commuting patterns are generally more complex.

About 45 percent of the total effect of manufacturing decentralization is transmitted via the decentralization of business establishments, and 46 percent is accounted for by a significant direct effect. Manufacturing has no indirect effect via the extent to which the ring population is urban. Hence, of the effect of decentralized manufacturing on commuting complexity, about half is due to the influence that industry located outside the central city has on the increased presence of businesses there as well, and the other half is simply due to the fact that as manufacturing becomes more decentralized, commuting patterns become more complex.

Decentralization of business transmits about 12 percent of its total effect via urban development in the ring, while most (88 percent) of its influence is accounted for independently. The majority of the effect of business decentralization, then, is due to the causal relationship between retail, wholesale, and service establishments located in the ring and the degree of ring-oriented commuting, and a small portion results from the fact that a larger proportion of business establishments located outside the central city tends to encourage the growth of urban communities there. The extent to which the ring population is settled in urban places has a small but significant, positive effect on commuting complexity, suggesting that as the ring becomes more urban, complex commuting increases.

Summing up, across all SMSA's the model provides evidence that the historical period of a metropolitan area's growth affects commuting complexity because older SMSA's often contain denser central cities and exhibit a tendency toward more extensive mass transit availability and a more suburbanized labor force. Population size also influences complexity because larger SMSA's tend to have denser central cities. More congested central cities are related to greater labor force suburbanization and more extensive mass transit facilities. SMSA's with such cities also have a tendency to be contiguous to other metropolitan areas and evidence a higher level of commuting complexity independent of other factors. The presence of contiguous metropolitan areas encourages larger portions of the labor force to reside in the ring and, to a much lesser extent, encourages manufacturing and business to locate there as well. The degree of mass transit availability is similarly related to a greater degree of labor force suburbanization, and it is also somewhat associated with manufacturing located in the ring.

As the labor force becomes more suburbanized across all SMSA's, manufacturing and business becomes more decentralized. The distribution of manufacturing establishments also influences the location of businesses. Greater proportions of retail, wholesale, and service establishments outside the central city tend to encourage the development of urban communities. Finally, as the SMSA labor force becomes more residentially suburban, as the location pattern of the area's manufacturing and business establishments become more decentralized, and as larger percentages of the ring population are settled in urban places, metropolitan commuting patterns become more complex. The coefficient of determination is 0.807, indicating that the variables in the model account for about 81 percent of the variance in commuting complexity across all SMSA's.

It must be understood, however, that I have used nine of many possible structural factors which may be important determinants of commuting patterns in metropolitan communities. In applying the model to metropolitan areas by geographic division, the additional constraint of small numbers of cases becomes apparent, allowing a greater margin for error in estimating the coefficients for interpretation. Nevertheless, such an analysis is much less confusing than assigning "dummy" variables for geographic regions (since there are nine divisions) and should provide valuable information given the constraints just noted. Therefore, subsequent sections of the chapter present the results of applying the model to SMSA's by geographic division. My strategy will be to ascertain what factors or patterns of structural relationships seem to be most important in determining the level of commuting complexity among metropolitan areas in a particular division based on the hypothesized model.

Application of the Model to New England Metropolitan Areas

New England SMSA's tend to be older with dense central cities, but smaller than the average population for all metropolitan areas. They are typically contiguous to two other SMSA's. Public transit availability is somewhat higher than the average for all areas. The labor force in New England SMSA's tends to be quite suburbanized, moreso than manufacturing or business establishments. Almost two-thirds of the population in the ring typically resides in urban places. The zero-order correlation matrix for New England SMSA's may be found in Appendix A. Table 18 presents the direct and indirect effects of each structural variable on commuting complexity, while Table 19 shows the proportion of each variable's effect that is indirect or direct.

The New England model presents a problem in that the proportion of the labor force residing in the ring is highly correlated with the proportion of businesses located in the ring (0.943), and both variables are highly correlated with commuting complexity (0.940 for the former and 0.938 for the later). Given this condition of co-linearity, the variable measuring the proportion of SMSA business establishments located in the ring was not entered into the regression equation because it was temporally preceded by the labor force variable in the model. With the distribution of workers taken into account, the business establishments variable provided little additional explanation of complexity. I will, nevertheless, attempt to interpret the information provided by the model despite its limitations.

Table 18. Interpretation of Effects in a Model of Commuting Complexity for New England Metropolitan Areas, 1970.

Independent Variables	Total Effect	Indirect Effect Via							Direct Effect
		X3	X4	X5	X6	X7	X8	X9	
AGESMSA(X1)	.307	.210	-.009	-.053	.405	-.034	*	.003	-.215
SMSAPOP(X2)	.369	.206	-.003	.306	-.224	-.007	*	.004	.087
CCDENS(X3)	.433	--	.074	.306	.146	-.004	*	.023	-.112
CONTIGU(X4)	.104	--	--	-.043	-.016	.030	*	.023	.110
TRANSIT(X5)	.566	--	--	--	.629	.019	*	-.020	-.062
PWORKLVR(X6)	1.105	--	--	--	--	.111	*	.021	.973
PMFGESTR(X7)	.125	--	--	--	--	--	*	-.006	.131
PRWSESTR(X8)	*	*	*	*	*	*	*	*	*
PRNGURB(X9)	.051	--	--	--	--	--	--	--	.051

*Variable X8 was not entered into the regression equation. See text for explanation.
R^2=.935

Table 19. Percentage Interpretation of Effects in a Model of Commuting Complexity for New England Metropolitan Areas, 1970.

Independent Variables	Sum of Absolute Values of Effects	% of Absolute Summed Effect Via Intervening Variables							% of Absolute Effect Direct
		X3	X4	X5	X6	X7	X8	X9	
AGESMSA(X1)	.929	22.60	.97	5.71	43.60	3.66	*	.32	23.14
SMSAPOP(X2)	.837	24.61	.36	36.56	26.76	.84	*	.48	10.39
CCDENS(X3)	.665	--	11.13	46.02	21.95	.60	*	3.46	16.84
CONTIGU(X4)	.222	--	--	19.37	7.21	13.51	*	10.36	49.55
TRANSIT(X5)	.730	--	--	--	86.16	2.60	*	2.74	8.49
PWORKLVR(X6)	1.105	--	--	--	--	10.05	*	1.90	88.05
PMFGESTR(X7)	.137	--	--	--	--	--	*	4.38	95.62
PRWSESTR(X8)	*	*	*	*	*	*	*	*	*
PRNGURB(X9)	.051	--	--	--	--	--	--	--	100.00

*Variable X8 was not entered into the regression equation. See text for explanation.

Among New England SMSA's, about 23 percent of the total effect of age is transmitted via central city density, and 44 percent is transmitted via labor force suburbanization. Twenty-five percent of the total effect of population size is transmitted via central city density, while 37 percent is transmitted via mass transit availability. Thus, of the effect of age on commuting complexity, nearly a quarter is due to the tendency of older SMSA's to have denser central cities, but another 44 percent is due to the fact that the labor force is generally more suburbanized in older metropolitan areas. Of the effect of size on complexity, a quarter is due to the tendency of larger SMSA's to have denser central cities and about a third is due to typically more extensive mass transit facilities in larger areas.

About 46 percent of the total effect of central city density is transmitted via mass transit availability, 22 percent is transmitted via labor force suburbanization, and another 11 percent is transmitted via contiguity. Almost 50 percent of the total effect of contiguity is unmediated by other variables and about ten percent is transmitted via urban settlement in the ring. Over 86 percent of the total effect of mass transit availability is transmitted via labor force suburbanization. Thus, of the effect of central city density on commuting complexity, nearly half is due to more extensive mass transit facilities in SMSA's with congested cities, 22 percent is due to the positive influence of such cities on the degree of labor force suburbanization, and a small portion is due to the tendency of SMSA's with denser central cities to be contiguous to other metropolitan areas. Of the effect of contiguity on complexity, about half is independent of intervening variables, suggesting that contiguous metropolitan areas are important contributors of in-commuters to ring destinations among New England SMSA's. There is also a slight tendency for contiguity to be associated with greater urban settlement in the ring. Finally, of the effect of mass transit availability on complexity, nearly all of it results from greater labor force suburbanization in SMSA's where public transportation is more extensive.

Only about ten percent of the total effect of labor force suburbanization is transmitted via manufacturing decentralization, while about 86 percent represents a large, independent effect. Nearly all of the total effect of manufacturing's moderate effect is direct, but urban settlement in the ring evidences only a small influence. The large direct effect of labor force suburbanization and the fact that its total effect is greater than one are indicative of the variable's co-linearity with business decentralization. This is undoubtedly a function of small sample size, but it does provide evidence that where the labor force is more suburbanized, business tends to be more decentralized and both result in complex commuting. The extent of manufacturing decentralization also appears to be related to the extent of commuting complexity more or less independent of work force distribution. The coefficient of determination is 0.935, indicating that the variables in the model account for about 94 percent of the variance in commuting complexity among New England metropolitan areas.

Application of the Model to Middle Atlantic Metropolitan Areas

Metropolitan areas in the Middle Atlantic division tend to be the oldest, largest, and have the densest central cities of all divisions. They are, on the average, contiguous to two other areas, and they exhibit the highest rate of mass transit availability of any group. A greater percentage of workers in these SMSA's generally live in the ring, a location pattern similar to that exhibited by manufacturing and business establishments in the division. Almost two-thirds of the population in Middle Atlantic rings typically reside in urban places.

The zero-order correlation matrix for Middle Atlantic SMSA's may be found in Appendix A. Table 20 presents the direct and indirect effects of each structural variable on commuting complexity, and Table 21 shows the proportion of each variable's effect that is indirect or direct.

About 31 percent of the effect of age is transmitted via central city density, 24 percent is transmitted via labor force suburbanization, and 13 percent is transmitted via urban settlement in the ring. Just over 22 percent of the total effect of population size is also transmitted via central city density. Thus, of the effect of age on commuting complexity, nearly a third is due to the presence of denser central cities in older SMSA's, and smaller portions are due to greater labor force suburbanization and more extensive urban settlement in the ring in such areas.

Nearly 42 percent of the total effect of central city density is transmitted via labor force suburbanization, another 11 percent is

Table 20. Interpretation of Effects in a Model of Commuting Complexity for Middle Atlantic Metropolitan Areas, 1970.

Independent Variables	Total Effect	Indirect Effect Via X3	X4	X5	X6	X7	X8	X9	Direct Effect
AGESMSA(X1)	.468	.306	-.054	.005	.236	-.052	.049	.133	-.155
SMSAPOP(X2)	-.645	.404	.105	.003	-.820	-.172	.065	-.121	-.109
CCDENS(X3)	.815	--	.087	.007	.340	.020	.055	.079	.227
CONTIGU(X4)	.272	--	--	.002	.168	.039	-.018	-.016	.097
TRANSIT(X5)	.015	--	--	--	-.039	.129	-.104	.128	-.099
PWORKLVR(X6)	.812	--	--	--	--	.252	.218	-.045	.387*
PMFGESTR(X7)	.354	--	--	--	--	--	.183	-.021	.192
PRWSESTR(X8)	.385	--	--	--	--	--	--	.108	.277
PRNGURB(X9)	.274	--	--	--	--	--	--	--	.274*

*Coefficient is twice its standard error.
R^2=.955

Table 21. Percentage Interpretation of Effects in a Model of Commuting Complexity for Middle Atlantic Metropolitan Areas, 1970.

Independent Variables	Sum of Absolute Values of Effects	% of Absolute Summed Effect Via Intervening Variables							% of Absolute Effect Direct
		X3	X4	X5	X6	X7	X8	X9	
AGESMSA(X1)	.990	30.91	5.45	.51	23.84	5.25	4.95	13.43	15.66
SMSAPOP(X2)	1.799	22.46	5.84	.17	45.58	9.56	3.61	6.73	6.06
CCDENS(X3)	.815	--	10.67	.86	41.72	2.45	6.75	9.69	27.85
CONTIGU(X4)	.340	--	--	.59	49.41	11.47	5.29	4.71	28.53
TRANSIT(X5)	.499	--	--	--	7.82	25.85	20.84	25.65	19.84
PWORKLVR(X6)	.902	--	--	--	--	27.94	24.17	4.99	42.90
PMFGESTR(X7)	.396	--	--	--	--	--	46.21	5.30	48.48
PRWSESTR(X8)	.385	--	--	--	--	--	--	28.05	71.95
PRNGURB(X9)	.274	--	--	--	--	--	--	--	100.00

transmitted via contiguity, and 28 percent is unmediated by other variables in the model. Over 49 percent of the total effect of contiguity is transmitted via labor force suburbanization, 11 percent is transmitted via manufacturing decentralization, and 28 percent is direct. About 26 percent of the total effect of mass transit availability is transmitted via manufacturing decentralization, another 26 percent is transmitted via urban settlement in the ring, and 20 percent is negative and direct.

Hence, of the effect of central city density, the largest portion is explained by the tendency for denser cities to encourage greater labor force suburbanization, and smaller portions are due to contiguous areas near SMSA's with denser cities and the general tendency for SMSA's with denser central cities to exhibit more complex commuting patterns. Of the effect of contiguity on complexity, half is due to more extensive labor force suburbanization encouraged by contiguous areas, a small portion is explained by this same tendency for manufacturing decentralization, and about 28 percent is due to contiguous SMSA's supplying in-commuters to ring destinations. Finally, of the effect of mass transit availability, a quarter is due to the tendency for manufacturing decentralization to be greater where mass transit is more extensive, and another quarter is due to the fact that such areas have more urban settlement in their rings. The negative direct effect of mass transit availability suggests that if all other things are equal, public transportation tends to encourage commuting to central city destinations in Middle Atlantic SMSA's.

Almost 28 percent of the total effect of labor force suburbanization is transmitted via manufacturing decentralization, 24 percent is transmitted via business decentralization, and 43 percent is unmediated by other variables in the model. Over 46 percent of the total effect of manufacturing decentralization is also transmitted via business decentralization, and 48 percent is direct. Twenty-eight percent of the total effect of business decentralization is transmitted via urban settlement in the ring, and 72 percent is independent of intervening variables. Lastly, the extent of urban development in the ring evidences a large, positive effect on commuting complexity.

Therefore, of the effect of labor force suburbanization on commuting complexity, about a quarter is due to the attraction of manufacturing establishments to the ring by the resident work force there, another quarter is explained by the similar attraction of business establishments to locations outside the central city, and almost half is due to the strong, direct relationship between the degree of worker suburbanization and the extent to which commuting patterns are complex. Similarly, of the effect of manufacturing decentralization on commuting complexity, about half is explained by the attraction of business establishments to ring locations by manufacturing also located there, and the other half is due to the direct relationship of manufacturing decentralization to more complex commuting. A portion of the effect of business decentralization on complexity is due to the relationship between business establishments in the ring and the growth of urban communities there, but the bulk of the effect is due to the contribution of greater decentralization of retail, wholesale, and service establishments to greater complexity. Finally, urban development in the ring is an important determinant of ring-oriented commuting across Middle Atlantic SMSA's. The coefficient of determination is 0.955, indicating that the variables in the model explain about 96 percent of the variance in commuting complexity evidenced among Middle Atlantic metropolitan areas.

Application of the Model to East North Central Metropolitan Areas

East North Central metropolitan areas tend to be slightly older, larger, and contain denser central cities than the average for all SMSA's. They are typically contiguous to at least one other metropolitan area, and mass transit availability is somewhat less than for all areas. On the average, a greater percentage of the labor force lives in the ring, but the locational pattern for manufacturing and trade establishments tends to emphasize the central city. SMSA's in the division typically have more than half of the ring population residing in urban places.

The zero-order correlation matrix for East North Central SMSA's may be found in Appendix A. Table 22 presents the direct and indirect effects of each structural variable on commuting complexity, and Table 23 shows the proportion of each variable's effect that is indirect or direct.

The total effect of age is exerted in a rather fragmented pattern among East North Central SMSA's. About 17 percent is transmitted via labor force suburbanization, 16 percent is transmitted via business decentralization, 24 percent is transmitted via urban settlement in the

Table 22. Interpretation of Effects in a Model of Commuting Complexity for East North Central Metropolitan Areas, 1970.

Independent Variables	Total Effect	Indirect Effect Via							Direct Effect
		X3	X4	X5	X6	X7	X8	X9	
AGESMSA(X1)	.227	.002	.021	.011	.050	-.032	.048	.071	.056
SMSAPOP(X2)	.226	.117	-.001	.054	-.203	.178	-.028	.023	.086
CCDENS(X3)	.143	--	.135	.004	.074	-.216	-.040	.000	.186
CONTIGU(X4)	.291	--	--	-.005	.296	.088	.012	-.005	-.095
TRANSIT(X5)	.072	--	--	--	.127	-.012	.075	.086	-.204
PWORKLVR(X6)	.782	--	--	--	--	.416	.102	.059	.205
PMFGESTR(X7)	.543	--	--	--	--	--	.209	-.003	.337*
PRWSESTR(X8)	.345	--	--	--	--	--	--	.017	.328*
PRNGURB(X9)	.242	--	--	--	--	--	--	--	.242*

*Coefficient is twice its standard error.
R^2=.885

Table 23. Percentage Interpretation of Effects in a Model of Commuting Complexity for East North Central Metropolitan Areas, 1970.

Independent Variables	Sum of Absolute Values of Effects	% of Absolute Summed Effect Via Intervening Variables							% of Absolute Effect Direct
		X3	X4	X5	X6	X7	X8	X9	
AGESMSA(X1)	.291	.69	7.22	3.78	17.18	11.00	16.49	24.40	19.24
SMSAPOP(X2)	.690	16.96	.14	7.83	29.42	25.80	4.06	3.33	12.46
CCDENS(X3)	.655	--	20.61	.61	11.30	32.98	6.11	0.00	28.40
CONTIGU(X4)	.501	--	--	1.00	59.08	17.56	2.40	1.00	18.96
TRANSIT(X5)	.504	--	--	--	25.20	2.38	14.88	17.06	40.48
PWORKLVR(X6)	.782	--	--	--	--	53.20	13.04	7.54	26.21
PMFGESTR(X7)	.549	--	--	--	--	--	38.07	.55	61.38
PRWSESTR(X8)	.345	--	--	--	--	--	--	4.93	95.07
PRNGURB(X9)	.242	--	--	--	--	--	--	--	100.00

ring, and 19 percent is unmediated by other variables in the model. Thus, the effect of age on commuting complexity is due to the tendency of older SMSA's to have a more suburbanized labor force, more decentralized business establishments, and more urban settlement in the ring; and all other things being equal, older SMSA's simply tend to have more complex commuting patterns in the East North Central Division. About 26 percent of the total effect of size is transmitted via manufacturing decentralization, 17 percent is transmitted via central city density, and 12 percent is direct. Of the effect of population size on commuting complexity, then, a quarter is due to a tendency for larger SMSA's to have more decentralized manufacturing, while smaller portions are due to denser central cities in larger areas and the fact that larger SMSA's in the East North Central division tend to have more complex commuting patterns, all other things being equal.

Almost 21 percent of the total effect of central city density is transmitted via contiguity, 11 percent is transmitted via labor force suburbanization, and 28 percent is unmediated by other variables in the model. Fifty-nine percent of the total effect of contiguity is transmitted via labor force suburbanization, and another 18 percent is transmitted via manufacturing decentralization. About 25 percent of the effect of mass transit availability is transmitted via labor force suburbanization, 15 percent is transmitted via the decentralization of business establishments, and 17 percent is transmitted via urban settlement in the ring. Over 40 percent of the effect of mass transit is direct and negative.

Hence, of the effect of central city density on commuting complexity, only a small portion is due to greater worker suburbanization where central cities are more dense. Nearly a quarter of the effect is due to the tendency of SMSA's with denser cities to be contiguous to other metropolitan areas, and slightly more than a quarter is explained by the fact that as central city density increases, commuting complexity also generally increases among SMSA's in the division. Of the effect of contiguity on commuting complexity, more than half is explained by greater labor force suburbanization where contiguous SMSA's are present, and a smaller portion is due to the encouragement of manufacturing decentralization by such adjacent areas. Of the effect of mass transit availability on complexity, a quarter is the result of labor force suburbanization when transit facilities are more extensive, and smaller portions are due to greater business decentralization and urban development in the ring where mass transit is readily available. However, the large, negative, independent effect of mass transit availability on complexity indicates that the overriding influence of such facilities among East North Central SMSA's is to subsidize commuter movement to central city destinations.

Over 53 percent of the total effect of labor force suburbanization is transmitted via manufacturing decentralization, only 13 percent is transmitted via business decentralization, and 26 percent is direct. About 38 percent of the total effect of manufacturing decentralization is transmitted via business decentralization and 61 percent, representing a large positive effect, is direct. Nearly all of the large positive effect of business decentralization is direct, and the extent of urban development in the ring also has a significant influence on commuting complexity. Thus, of the effect of labor force suburbanization on commuting complexity, over half is due to the relationship between worker suburbanization and manufacturing decentralization, while only a minimal portion is explained by business establishments being more decentralized where the labor force is more residentially suburban. A quarter of the effect is explained by the general tendency of SMSA's with more suburbanized work forces to have more complex commuting.

Of the effect of manufacturing decentralization on complexity, over a third is due to the influence of manufacturing located outside the central city on the location pattern of business establishments, and nearly two-thirds is a direct result of the tendency of SMSA's with more decentralized manufacturing to have more complex commuting. Similarly, the large direct effects of business decentralization and urban settlement in the ring provide evidence that as larger proportions of metropolitan businesses locate outside the central city and as the ring becomes more urban, complex commuting patterns also become more prevalent. The coefficient of determination is 0.885, indicating that the variables in the model account for about 89 percent of the variance in commuting complexity among East North Central metropolitan areas.

Application of the Model to West North Central Metropolitan Areas

SMSA's in the West North Central division tend to be older than the SMSA average but are somewhat smaller in population size with less dense central cities. They also tend to be independent of other areas. Transportation availability is less among West North Central SMSA's than for all metropolitan areas. The proportion of the labor force, manufacturing establishments, or businesses located in the ring is typically much smaller than the overall SMSA average, and rings in the division are generally rural with less than half of the ring population in urban places.

The zero-order correlation matrix for West North Central SMSA's may be found in Appendix A. Table 24 presents the direct and indirect effects of each structural variable on commuting complexity, and Table 25 shows the proportion of each variable's effect that is indirect or direct.

Across West North Central SMSA's, age has no large, positive indirect effects on commuting complexity. However, 28 percent of its total effect is positive and direct. Over 45 percent of the total effect of population size is transmitted via labor force suburbanization and 13 percent is transmitted via mass transit availability. Thus, of the effect of age on commuting complexity, a quarter is due to the tendency in the division for older SMSA's to have more complex commuting patterns, and of the effect of size on complexity, almost half is due to greater labor force decentralization in larger SMSA's and a

Table 24. Interpretation of Effects in a Model of Commuting Complexity for West North Central Metropolitan Areas, 1970.

Independent Variables	Total Effect	Indirect Effect Via							Direct Effect
		X3	X4	X5	X6	X7	X8	X9	
AGESMSA(X1)	.096	.062	-.035	.074	-.271	-.053	.026	.067	.226
SMSAPOP(X2)	.758	-.224	-.034	.242	.852	-.304	.098	.017	.111
CCDENS(X3)	-.227	--	.058	.057	-.398	-.082	.022	.002	.114
CONTIGU(X4)	-.097	--	--	.002	-.045	-.029	-.008	-.013	-.004
TRANSIT(X5)	.367	--	--	--	.397	.236	-.146	-.059	-.061
PWORKLVR(X6)	.837	--	--	--	--	.529	.346	.110	-.148
PMFGESTR(X7)	.460	--	--	--	--	--	.259	.013	.188
PRWSESTR(X8)	.586	--	--	--	--	--	--	-.050	.636
PRNGURB(X9)	.099	--	--	--	--	--	--	--	.099

R^2=.929

Table 25. Percentage Interpretation of Effects in a Model of Commuting Complexity for West North Central Metropolitan Areas, 1970.

Independent Variables	Sum of Absolute Values of Effects	% of Absolute Summed Effect Via Intervening Variables							% of Absolute Effect Direct
		X3	X4	X5	X6	X7	X8	X9	
AGESMSA(X1)	.814	7.62	4.30	9.09	33.29	6.51	3.19	8.23	27.76
SMSAPOP(X2)	1.882	11.90	1.81	12.86	45.27	16.15	5.21	.90	5.90
CCDENS(X3)	.733	--	7.91	7.78	54.30	11.19	3.00	.27	15.55
CONTIGU(X4)	.101	--	--	1.98	44.55	28.71	7.92	12.87	3.96
TRANSIT(X5)	.899	--	--	--	44.16	26.25	16.24	6.56	6.79
PWORKLVR(X6)	1.133	--	--	--	--	46.69	30.54	9.71	13.06
PMFGESTR(X7)	.460	--	--	--	--	--	56.30	2.83	40.87
PRWSESTR(X8)	.686	--	--	--	--	--	--	7.29	92.71
PRNGURB(X9)	.099	--	--	--	--	--	--	--	100.00

small portion is due to more extensive mass transit facilities in such areas.

Central city density also evidences no large, positive indirect effects on commuting complexity. However, nearly 16 percent of its total effect is unmediated by other variables. Contiguity does not contribute to complexity either directly or indirectly. Over 44 percent of the total effect of mass transit availability is transmitted via labor force suburbanization, and 26 percent is transmitted via manufacturing decentralization. The direct effect of mass transit is negative, but negligible. Hence, of the effect of central city density on complexity, a small portion is due to the tendency of SMSA's in the division with denser central cities to have more complex commuting patterns. Contiguity has no discernible influence on commuting among West North Central metropolitan areas. Of the effect of mass transit availability, nearly half is due to more extensive labor force suburbanization where transit facilities are most readily available, and another quarter is due to greater manufacturing decentralization in such areas. In general, mass transit does not tend to decrease complex commuting independent of other factors.

Nearly 47 percent of the total effect of labor force suburbanization is transmitted via manufacturing decentralization, and 30 percent is transmitted via business decentralization. Labor force suburbanization does not exert a positive direct effect on complexity in this division. About 56 percent of the effect of manufacturing decentralization is transmitted via business decentralization and 41 percent is unmediated by other variables. Business decentralization evidences a large direct effect, but the direct effect of urban settlement in the ring is very small.

Therefore, of the effect of labor force suburbanization on commuting complexity, about half is due to the positive relationship between worker suburbanization and manufacturing decentralization and nearly a third is due to the same association with the decentralization of business establishments. More than half of the effect of manufacturing decentralization on complexity is also due to its relationship to business decentralization and about 40 percent is due to the general tendency of SMSA's with more extensive manufacturing decentralization to have more complex commuting patterns. Finally, to the extent that business establishments are decentralized, commuting is more complex. The coefficient of determination is 0.929, indicating that the variables in the model account for about 93 percent of the variance in commuting complexity among West North Central metropolitan areas.

Application of the Model to South Atlantic Metropolitan Areas

South Atlantic SMSA's are generally somewhat younger than the average for all divisions, slightly smaller in population size, and contain central cities that are much less dense than the mean for all areas. They tend to be independent of contiguous areas and exhibit the second highest rate of transit availability of any division. In general, a larger proportion of workers in these areas live in the ring than the central city, but manufacturing and business establishments remain somewhat more centralized. More than half of the ring population typically resides in urban places.

The zero-order correlation matrix for South Atlantic SMSA's may be found in Appendix A. Table 26 presents the direct and indirect effects of each structural variable on commuting complexity, while Table 27 shows the proportion of each variable's effect that is indirect or direct.

Across SMSA's in the division, about 19 percent of the total effect of age is transmitted via central city density, and another 14 percent is transmitted via mass transit availability. Thirty-three percent of the total effect of population size is also transmitted via central city density, and 19 percent is transmitted via business decentralization. Thus, of the effect of age on complexity, portions are due to the tendency for older SMSA's to have denser central cities and more extensive mass transit facilities. Of the effect of size on complexity, a third is due to denser central cities in larger SMSA's and a lesser part is explained by a tendency toward greater business decentralization in such places.

Only about 11 percent of the total effect of central city density is transmitted via labor force suburbanization. Another 12 percent is transmitted via urban settlement in the ring, but over 60 percent is transmitted via contiguity. Seventy percent of the total effect of contiguity is transmitted via labor force suburbanization, and 22 percent is transmitted via the decentralization of business establishments. Nearly 65 percent of the total effect of mass transit availability is

Table 26. Interpretation of Effects in a Model of Commuting Complexity for South Atlantic Metropolitan Areas, 1970.

Independent Variables	Total Effect	Indirect Effect Via							Direct Effect
		X3	X4	X5	X6	X7	X8	X9	
AGESMSA(X1)	-.030	.095	.028	.071	-.169	-.071	-.015	.042	-.011
SMSAPOP(X2)	.214	.381	-.233	.040	-.073	.008	.216	.041	-.166
CCDENS(X3)	.513	--	.379	.022	.071	.026	-.052	.073	-.006
CONTIGU(X4)	.398	--	--	-.003	.333	.001	.102	-.002	-.033
TRANSIT(X5)	.137	--	--	--	.278	-.010	-.069	-.067	.005
PWORKLVR(X6)	.830	--	--	--	--	.215	.502	.030	.083
PMFGESTR(X7)	.233	--	--	--	--	--	.307	-.055	-.019
PRWSESTR(X8)	.877	--	--	--	--	--	--	.118	.759
PRNGURB(X9)	.238	--	--	--	--	--	--	--	.238

R^2=.805

Table 27. Percentage Interpretation of Effects in a Model of Commuting Complexity for South Atlantic Metropolitan Areas, 1970.

Independent Variables	Sum of Absolute Values of Effects	% of Absolute Summed Effect Via Intervening Variables							% of Absolute Effect Direct
		X3	X4	X5	X6	X7	X8	X9	
AGESMSA(X1)	.502	18.92	5.58	14.14	33.67	14.14	2.99	8.37	2.19
SMSAPOP(X2)	1.158	32.90	20.12	3.45	6.30	.69	18.65	3.54	14.34
CCDENS(X3)	.629	--	60.25	3.50	11.29	4.13	8.27	11.61	.95
CONTIGU(X4)	.474	--	--	.63	70.25	.21	21.52	.42	6.96
TRANSIT(X5)	.429	--	--	--	64.80	2.33	16.08	15.62	1.17
PWORKLVR(X6)	.830	--	--	--	--	25.90	60.48	3.61	10.00
PMFGESTR(X7)	.381	--	--	--	--	--	80.58	14.44	4.99
PRWSESTR(X8)	.877	--	--	--	--	--	--	13.45	86.55
PRNGURB(X9)	.238	--	--	--	--	--	--	--	100.00

transmitted via labor force suburbanization, and transit has no direct effect on complexity.

Hence, of the effect of central city density on complexity, well over half is due to the fact that SMSA's with denser central cities are generally contiguous to other areas, while small portions are explained by greater labor force decentralization and urban development in the ring where central cities are more congested. Almost three-quarters of the effect of contiguity on commuting complexity is due to the encouragement of labor force suburbanization where adjacent SMSA's are present, and nearly a quarter is explained by the same influence on business distribution. Finally, the majority of the effect of mass transit availability on complexity is due to transit's support of worker suburbanization. Mass transit does not tend to decrease the level of complexity, independently of other factors, among South Atlantic SMSA's.

Only 26 percent of the total effect of labor force suburbanization is transmitted via manufacturing decentralization. Over 60 percent is transmitted via business decentralization, and the direct effect of suburbanization is very small. Almost 81 percent of the total effect of manufacturing decentralization is transmitted via business decentralization, and manufacturing has little direct effect. About 13 percent of the total effect of business decentralization is transmitted via urban settlement in the ring, and 87 percent is represented by a very large direct effect. Urban settlement in the ring also evidences a strong independent influence.

All of the influence of labor force suburbanization which is supportive of complex commuting is indirect. Of the effect of suburbanization, only a quarter is due to the relationship between workers residing outside the central city and manufacturing locating there also. Well over half is due to the tendency for SMSA's with more suburbanized labor forces to evidence more decentralized patterns of business location. Similarly, nearly all of the effect of manufacturing decentralization on complexity is due to the direct relationship between the extent of manufacturing in the ring and the proportion of business establishments also found there. Of the effect of business decentralization, the majority is explained by the fact that a greater degree of decentralization among retail, wholesale, and service establishments leads to a greater degree of commuting complexity. A small part is also due to the tendency for rings containing a larger proportion of businesses to evidence more urban settlement. As the extent of urban settlement increases, commuting to ring destinations increases. The coefficient of determination is 0.805, indicating that the variables in the model account for about 81 percent of the variance in commuting complexity among South Atlantic SMSA's.

Application of the Model to East South Central Metropolitan Areas

East South Central SMSA's are somewhat younger than the average, substantially smaller in population size, and typically contain central cities which are much less dense. They tend to be independent of contiguous areas and evidence a low level of mass transit availability.

Over all SMSA's in the division, a larger proportion of the labor force generally lives in the central city, and manufacturing and business are also typically centralized. Ring settlement patterns exhibit a low level of urban residence.

The zero-order correlation matrix for East South Central SMSA's may be found in Appendix A. Table 28 presents the direct and indirect effects of each structural variable on commuting complexity, while Table 29 shows the proportion of each variable's effect that is indirect or direct.

Among East South Central SMSA's, age has no substantial indirect or direct supportive influence on commuting complexity. About 17 percent of the total effect of size is transmitted via business decentralization, and 43 percent is represented by a large direct effect. Thus, of the effect of size on commuting complexity, nearly half is due to the general tendency in the division for larger SMSA's to evidence more complex commuting patterns regardless of intervening factors. Another portion is due to the greater extent of business decentralization in larger SMSA's.

Although central city density evidences no positive indirect effect on complexity of any consequence, 43 percent of its effect is unmediated by other variables. Almost 55 percent of the total effect of contiguity is transmitted via labor force suburbanization, and 18 percent is transmitted via manufacturing decentralization. Forty-two percent of the total effect of mass transit availability is also transmitted via labor force suburbanization, but another 47 percent is negative and direct.

Table 28. Interpretation of Effects in a Model of Commuting Complexity for East South Central Metropolitan Areas, 1970.

Independent Variables	Total Effect	Indirect Effect Via							Direct Effect
		X3	X4	X5	X6	X7	X8	X9	
AGESMSA(X1)	-.412	-.006	-.213	-.077	.019	.056	-.033	.050	-.208
SMSAPOP(X2)	.707	.009	.162	-.054	-.370	-.084	.308	-.049	.785
CCDENS(X3)	.016	--	.054	-.033	-.046	-.078	-.151	-.018	.288
CONTIGU(X4)	.352	--	--	.028	.307	.102	-.045	.019	-.059
TRANSIT(X5)	-.161	--	--	--	.518	.020	-.037	-.075	-.587
PWORKLVR(X6)	.782	--	--	--	--	.101	.611	-.014	.084
PMFGESTR(X7)	.212	--	--	--	--	--	.147	-.004	.069
PRWSESTR(X8)	.754	--	--	--	--	--	--	-.016	.770
PRNGURB(X9)	-.131	--	--	--	--	--	--	--	-.131

R^2=.814

Table 29. Percentage Interpretation of Effects in a Model of Commuting Complexity for East South Central Metropolitan Areas, 1970.

Independent Variables	Sum of Absolute Values of Effects	% of Absolute Summed Effect Via Intervening Variables							% of Absolute Effect Direct
		X3	X4	X5	X6	X7	X8	X9	
AGESMSA(X1)	.662	.91	32.18	11.63	2.87	8.46	4.98	7.55	31.42
SMSAPOP(X2)	1.821	.49	8.90	2.97	20.32	4.61	16.91	2.69	43.11
CCDENS(X3)	.668	--	8.08	4.94	6.89	11.68	22.60	2.69	43.11
CONTIGU(X4)	.560	--	--	5.00	54.82	18.21	8.04	3.39	10.54
TRANSIT(X5)	1.237	--	--	--	41.88	1.62	2.99	6.06	47.45
PWORKLVR(X6)	.810	--	--	--	--	12.47	75.43	1.73	10.37
PMFGESTR(X7)	.220	--	--	--	--	--	66.82	1.82	31.36
PRWSESTR(X8)	.786	--	--	--	--	--	--	2.04	97.96
PRNGURB(X9)	.131	--	--	--	--	--	--	--	100.00

Of the effect of central city density on commuting complexity, then, 43 percent is due to the fact that SMSA's in the division with denser central cities tend to have more complex commuting. More than half of the effect of contiguity results from the influence of adjacent SMSA's on labor force suburbanization even though contiguity is not prevalent in this division. A smaller part is due to the same influence on manufacturing decentralization. A large portion of the effect of mass transit availability on commuting complexity is due to more extensive worker suburbanization where transit facilities are more extensive. However, about half of the total effect is negative and direct, indicating that where public transportation is available among East South Central SMSA's, it generally encourages commuting to central city destinations.

Slightly over 12 percent of the total effect of labor force suburbanization is transmitted via manufacturing decentralization, 75 percent is transmitted via business decentralization, and ten percent is direct. Sixty-seven percent of the total effect of manufacturing decentralization is transmitted via business decentralization, and 31 percent is the result of a small direct effect. Business decentralization evidences a large direct effect, while urban settlement in the ring is not related to complexity. Thus, of the effect of labor force suburbanization only a small portion is explained by its influence on manufacturing decentralization, while three-quarters of the effect is due to its influence on business decentralization and very little is unmediated. About two-thirds of the effect of manufacturing

decentralization is due to its influence on business decentralization, and another third is directly explained by the positive relationship between manufacturing decentralization and commuting complexity. Finally, the extent of business decentralization is very strongly associated with the extent to which commuting patterns are ring-oriented in the division. The coefficient of determination is 0.814, indicating that the variables in the model account for about 81 percent of the variance in commuting complexity among East South Central SMSA's.

Application of the Model to West South Central Metropolitan Areas

West South Central SMSA's are generally quite "young" compared to all areas, much smaller in average population size, and their central cities are substantially less dense than the average for all areas. They tend to be independent of contiguous areas and evidence a low level of mass transit availability. A larger proportion of the labor force here usually resides in the central city, and the pattern of manufacturing and business distribution is very centralized. Less than half of the ring population resides in urban places in most areas.

The zero-order correlation matrix for West South Central SMSA's may be found in Appendix A. Table 30 presents the direct and indirect effects of each structural variable on commuting complexity, and Table 31 shows the proportion of each variable's effect that is indirect or direct.

Among West South Central SMSA's 26 percent of the total effect of age is transmitted via mass transit availability, and 12 percent is

Table 30. Interpretation of Effects in a Model of Commuting Complexity for West South Central Metropolitan Areas, 1970.

Independent Variables	Total Effect	Indirect Effect Via							Direct Effect
		X3	X4	X5	X6	X7	X8	X9	
AGESMSA(X1)	- .267	-.005	.001	.352	-.106	-.007	.036	.164	- .702
SMSAPOP(X2)	.257	.000	-.003	-.063	.066	-.004	.323	.013	- .075
CCDENS(X3)	- .013	--	.000	.269	-.083	.001	- .265	-.004	.069
CONTIGU(X4)	- .003	--	--	.034	.097	.003	- .215	.008	.070
TRANSIT(X5)	.556	--	--	--	.179	.008	- .085	-.023	.477
PWORKLVR(X6)	.396	--	--	--	--	.012	1.097	.052	- .765
PMFGESTR(X7)	.019	--	--	--	--	--	.524	-.053	- .452
PRWSESTR(X8)	1.584	--	--	--	--	--	--	.065	1.519
PRNGURB(X9)	.241	--	--	--	--	--	--	--	.241

R^2=.517

Table 31. Percentage Interpretation of Effects in a Model of Commuting Complexity for West South Central Metropolitan Areas, 1970.

Independent Variables	Sum of Absolute Values of Effects	% of Absolute Summed Effect Via Intervening Variables							% of Absolute Effect Direct
		X3	X4	X5	X6	X7	X8	X9	
AGESMSA(X1)	1.373	.36	.07	25.64	7.72	.51	2.62	11.94	51.13
SMSAPOP(X2)	.547	0.00	.55	11.52	12.07	.73	59.05	2.38	13.71
CCDENS(X3)	.691	--	0.00	38.93	12.01	.14	38.35	.58	9.99
CONTIGU(X4)	.427	--	--	7.96	22.72	.70	50.35	1.87	16.39
TRANSIT(X5)	.772	--	--	--	23.19	1.04	11.01	2.98	61.79
PWORKLVR(X6)	1.926	--	--	--	--	.62	56.96	2.70	39.72
PMFGESTR(X7)	1.029	--	--	--	--	--	50.92	5.15	43.93
PRWSESTR(X8)	1.584	--	--	--	--	--	--	4.10	95.90
PRNGURB(X9)	.241	--	--	--	--	--	--	--	100.00

transmitted via urban settlement in the ring. Fifty-nine percent of the total effect of size is transmitted via the decentralization of business. Thus, of the effect of age on commuting complexity, about a quarter is due to the presence of more extensive mass transit facilities in older SMSA's and a lesser portion is explained by the tendency of such areas to contain more urban settlement in their rings.

Nearly 39 percent of the total effect of central city density is transmitted via mass transit availability. About 23 percent of the total effect of contiguity is transmitted via labor force decentralization, and another 16 percent is unmediated by other variables. Slightly over 23 percent of the total effect of mass transit availability is transmitted via labor force suburbanization, and nearly 62 percent is represented by a large direct effect. Hence, of the effect of central city density on commuting complexity, over a third is due to the greater availability of mass transit facilities in SMSA's with more congested cities. Of the effect of contiguity on complexity, nearly a quarter is explained by the influence of adjacent metropolitan areas on more extensive labor force suburbanization, and a smaller part is due to the contribution of in-commuters from contiguous areas where such areas are present. Although the West South Central division evidences comparatively low mass transit availability, nearly a quarter of its influence is due to greater labor force suburbanization where facilities are more extensive, and 62 percent is explained by the tendency of areas with more extensive public transportation to have more complex commuting despite intervening factors.

Almost 57 percent of the total effect of labor force suburbanization is transmitted via business decentralization, but suburbanization has no indirect effect via manufacturing decentralization nor does it have a positive direct effect on complexity. Similarly, 51 percent of the total effect of manufacturing decentralization is transmitted via business decentralization, but manufacturing also evidences no positive, independent effect on complexity. The distribution of business establishments, however, exhibits a very large direct effect on commuting patterns, and urban settlement in the ring shows a positive influence as well. Therefore, of the effect of labor force suburbanization on commuting complexity, more than half is due to its direct relationship to business decentralization, and of the effect of manufacturing decentralization, about half is also due to its association with the distribution of business establishments. The greater the extent to which businesses are decentralized and the ring population is settled in urban places, commuting patterns will tend to be more complex.

It is appropriate to note here that the unusually large direct effect of business decentralization is likely the result of the small sample size and would be reduced if more SMSA's were available in the division. Although the coefficient is greater than unity, its explanatory power is counteracted by the large, negative direct effects of other variables. The result is that the coefficient of determination is 0.517, indicating that the variables in the model account for about 52 percent of the variance in commuting complexity among West South Central SMSA's.

Application of the Model to Mountain Metropolitan Areas

Mountain SMSA's are, on the average, the newest of any division, very small compared to the average population size for all areas, and their central cities are significantly less dense. SMSA's here tend to be independent of contiguous areas and exhibit the lowest level of mass transit availability of any division. The working population as well as manufacturing and business establishments are generally quite centralized. Surprisingly, however, over half of the ring population among these SMSA's typically lives in urban places.

The zero-order correlation matrix for Mountain SMSA's may be found in Appendix A. Table 32 presents the direct and indirect effects of each structural variable on commuting complexity, while Table 33 shows the proportion of each variable's effect that is indirect or direct.

Across Mountain SMSA's, 17 percent of the total effect of age is transmitted via mass transit availability, and 22 percent is transmitted via urban settlement in the ring. About 12 percent of the total effect of size is transmitted via central city density, 17 percent is transmitted via mass transit availability, 24 percent is transmitted via business decentralization, and 16 percent is unmediated by other variables. Thus, of the effect of size on commuting complexity, small portions are due to greater transit availability in older SMSA's and more urban settlement in the rings of such areas. Of the effect of population size on complexity, about a quarter is due to more decentralized business establishments in larger SMSA's, and smaller parts are

Table 32. Interpretation of Effects in a Model of Commuting Complexity for Mountain Metropolitan Areas, 1970.

Independent Variables	Total Effect	Indirect Effect Via							Direct Effect
		X3	X4	X5	X6	X7	X8	X9	
AGESMSA(X1)	- .054	-.333	.177	.544	.084	.078	-.117	.671	-1.158
SMSAPOP(X2)	.408	.123	-.086	.167	.013	-.061	.242	-.147	.157
CCDENS(X3)	- .464	--	-.152	-.033	-.217	-.058	-.006	-.949	.951
CONTIGU(X4)	.160	--	--	-.060	.149	-.123	-.004	-.685	.883
TRANSIT(X5)	.812	--	--	--	.443	-.033	-.147	.373	.176
PWORKLVR(X6)	.677	--	--	--	--	.156	.529	.308	- .316
PMFGESTR(X7)	.218	--	--	--	--	--	.144	-.479	.553
PRWSESTR(X8)	.657	--	--	--	--	--	--	.567	.090
PRNGURB(X9)	1.168	--	--	--	--	--	--	--	1.168

R^2=.949

Table 33. Percentage Interpretation of Effects in a Model of Commuting Complexity for Mountain Metropolitan Areas, 1970.

Independent Variables	Sum of Absolute Values of Effects	% of Absolute Summed Effect Via Intervening Variables							% of Absolute Effect Direct
		X3	X4	X5	X6	X7	X8	X9	
AGESMSA(X1)	3.162	10.53	5.60	17.20	2.66	2.47	3.70	21.22	36.62
SMSAPOP(X2)	.996	12.35	8.63	16.77	1.31	6.12	24.30	14.76	15.76
CCDENS(X3)	2.366	--	6.42	1.39	9.17	2.45	.25	40.11	40.19
CONTIGU(X4)	1.904	--	--	3.15	7.83	6.46	.21	35.98	46.38
TRANSIT(X5)	1.172	--	--	--	37.80	2.82	12.54	31.83	15.02
PWORKLVR(X6)	1.309	--	--	--	--	11.92	40.41	23.53	24.14
PMFGESTR(X7)	1.176	--	--	--	--	--	12.24	40.73	47.02
PRWSESTR(X8)	.657	--	--	--	--	--	--	86.30	13.70
PRNGURB(X9)	1.168	--	--	--	--	--	--	--	100.00

explained by the tendency for larger areas to have denser central cities and greater mass transit availability. There is also a tendency for larger SMSA's to have more complex commuting patterns regardless of intervening factors.

Over 40 percent of the total effect of central city density is direct, and it has no positive indirect effects. Similarly, 46 percent of the total effect of contiguity is unmediated by other variables. Almost 38 percent of the total effect of mass transit availability is transmitted via labor force suburbanization, 32 percent is transmitted via urban settlement in the ring, and 15 percent is direct. These relationships suggest that SMSA's with denser central cities or SMSA's that are contiguous to other metropolitan areas have more complex commuting patterns in the Mountain division despite any intervening factors. Contiguity apparently provides in-commuters from adjacent areas. Although SMSA's in this division generally have limited mass transit facilities, where transit is available slightly over a third of its effect on complexity is due to greater labor force suburbanization and another third is due to more urban settlement in the ring in such areas. There is also a small direct relationship between mass transit availability and commuting complexity independent of other factors.

Only about 12 percent of the total effect of labor force suburbanization is transmitted via manufacturing decentralization, 40 percent is transmitted via business decentralization, and 24 percent is transmitted via urban settlement in the ring. Similarly, only 12 percent of the total effect of manufacturing decentralization is transmitted via business establishment distribution, but 47 percent is represented by a large direct effect. Over 86 percent of the total effect of business decentralization is transmitted via urban settlement in the ring, and about 14 percent is unmediated by other variables. Finally, the extent of urban settlement in the ring has an extremely large direct effect on commuting complexity among Mountain SMSA's.

Hence, of the effect of labor force suburbanization on commuting complexity, 40 percent is due to the relationship between worker distribution and the distribution of business establishments, another quarter is due to greater urban settlement in the ring where the labor force is proportionately more suburban, and a lesser part is explained by the direct relationship between work force suburbanization and manufacturing decentralization. A small portion of the effect of manufacturing establishments on complexity is due to their association with business location, but nearly half is due to the fact that SMSA's with more decentralized manufacturing have more complex commuting patterns regardless of intervening factors. Of the effect of business establishment distribution on complexity, most is due to more extensive urban settlement in the ring where metropolitan businesses are located in a more decentralized pattern. A lesser portion is explained by the tendency for areas with more decentralized business establishments to have greater commuting complexity, all other things being equal. The strong influence of urban settlement in the ring implies that to the extent that complex commuting occurs in the Mountain division, it is almost exclusively oriented toward urban communities outside the central city.

The unusually large direct effect of urban settlement in the ring is likely the result of the small sample size and would be reduced if more SMSA's were available in the division. Despite the fact that the coefficient is greater than unity, much of its explanatory power is counteracted by the large, negative direct effect of age. Furthermore, the independent effect of age is misleading. Upon closer examination we may observe that although its coefficient is substantial, its net (total) effect is near zero. Nevertheless, the coefficient of determination is 0.949, indicating that the variables in the model account for about 95 percent of the variance in commuting complexity among Mountain SMSA's.

Application of the Model to Pacific Metropolitan Areas

Although SMSA's in the Pacific division are second only to those in the Middle Atlantic in average population size, they are among the youngest of all metropolitan areas. Despite their large size, the central cities in these SMSA's are generally less dense than the average for all areas. They also evidence less overall transit availability than the average. Pacific SMSA's exhibit the greatest tendency toward contiguity of any division. The location pattern of workers and establishments for SMSA's in the division tends to be decentralized with the percentage of workers living in the ring averaging well over 50 percent. Manufacturing and trade establishments show a lesser pattern of ring location than does the working population. Rings in the region show a high degree of development with nearly three-fourths of the population residing in urban places.

The zero-order correlation matrix for Pacific SMSA's may be found in Appendix A. Table 34 presents the direct and indirect effects of each structural variable on commuting complexity, while Table 35 shows the proportion of each variable's total effect that is indirect or direct.

Age and size are not particularly important determinants of commuting complexity among Pacific metropolitan areas. Almost 11 percent of the total effect of age is transmitted via urban settlement in the ring, while nearly 41 percent of the total effect of population size is transmitted via contiguity. Thus, of the effect of age, its small influence is due to the tendency for older areas to have more urban settlement in their rings. Of the effect of size, a large portion is due to the typical pattern of contiguous areas clustered around larger SMSA's.

Slightly over 18 percent of the total effect of central city density is transmitted via contiguity, 15 percent is transmitted via urban settlement in the ring, and 32 percent is unmediated by other variables in the model. About 11 percent of the total effect of contiguity is transmitted via labor force suburbanization, 19 percent is transmitted via urban settlement in the ring, and 52 percent is direct. Just over 13 percent of the total effect of mass transit availability is transmitted via labor force suburbanization, 19 percent is transmitted via business decentralization, and 49 percent is negative and direct.

Hence, of the effect of central city density on commuting complexity, about a third is due to the tendency for SMSA's with denser central cities to have more complex commuting patterns despite intervening

Table 34. Interpretation of Effects in a Model of Commuting Complexity for Pacific Metropolitan Areas, 1970.

Independent Variables	Total Effect	Indirect Effect Via							Direct Effect
		X3	X4	X5	X6	X7	X8	X9	
AGESMSA(X1)	-.558	.061	-.151	-.186	-.173	.103	-.104	.118	-.226
SMSAPOP(X2)	.308	.059	.309	.064	-.016	-.042	.030	.069	-.165
CCDENS(X3)	.178	--	.106	-.117	-.024	-.010	-.052	.086	.189
CONTIGU(X4)	.630	--	--	-.021	.110	-.045	-.106	.188	.504
TRANSIT(X5)	-.254	--	--	--	.109	.019	.151	-.136	-.397
PWORKLVR(X6)	.201	--	--	--	--	-.029	-.167	-.103	.500
PMFGESTR(X7)	-.166	--	--	--	--	--	-.092	-.175	.101
PRWSESTR(X8)	-.304	--	--	--	--	--	--	.176	-.480
PRNGURB(X9)	.400	--	--	--	--	--	--	--	.400

R^2=.630

Table 35. Percentage Interpretation of Effects in a Model of Commuting Complexity for Pacific Metropolitan Areas, 1970.

Independent Variables	Sum of Absolute Values of Effects	% of Absolute Summed Effect Via Intervening Variables							% of Absolute Effect Direct
		X3	X4	X5	X6	X7	X8	X9	
AGESMSA(X1)	1.122	5.44	13.46	16.58	15.42	9.18	9.27	10.52	20.14
SMSAPOP(X2)	.754	7.82	40.98	8.49	2.12	5.57	3.98	9.15	21.88
CCDENS(X3)	.584	--	18.15	20.03	4.11	1.71	8.90	14.73	32.36
CONTIGU(X4)	.974	--	--	2.16	11.29	4.62	10.88	19.30	51.75
TRANSIT(X5)	.812	--	--	--	13.42	2.34	18.60	16.75	48.89
PWORKLVR(X6)	.799	--	--	--	--	3.63	20.90	12.89	62.58
PMFGESTR(X7)	.368	--	--	--	--	--	25.00	47.55	27.45
PRWSESTR(X8)	.656	--	--	--	--	--	--	26.83	73.17
PRNGURB(X9)	.400	--	--	--	--	--	--	--	100.00

factors. Lesser portions may be explained by greater labor force suburbanization where central cities are more congested and the fact that such areas are often contiguous to other SMSA's. The contribution of contiguity to complexity is partially due to proportionately greater ring residence among workers and more extensive urban settlement outside the central city where adjacent SMSA's are present. However, the large direct effect of contiguity implies that the primary influence of contiguous areas is to add in-commuters to complex commuting streams. Small portions of the effect of mass transit availability on complexity are due to greater labor force suburbanization and business decentralization where transit facilities are more extensive. But the large, negative direct effect of mass transit suggests that its independent influence in the Pacific division is to support commuting to central city destinations.

Labor force suburbanization evidences no positive indirect effects on commuting complexity, but 63 percent of its total effect is direct. Similarly, manufacturing decentralization has no positive indirect effects, but 27 percent of its total effect is also direct. The distribution of business establishments transmits 27 percent of its total effect via urban settlement in the ring, but its direct effect is not supportive of complex commuting. The extent of urban settlement in the ring evidences a strong independent effect. These relationships indicate that as labor force suburbanization and manufacturing decentralization increase, commuting patterns become more ring-oriented. Furthermore, larger proportions of business establishments located outside the central city are conducive to greater urban development there, and as the extent of urban settlement in the ring increases, commuting complexity increases. The coefficient of determination is 0.608, indicating that the variables in the model account for about 61 percent of the variance in commuting complexity among Pacific SMSA's.

Summary

This chapter presented a multivariate analysis of the determinants of complex commuting patterns across all metropolitan areas and by geographic division using the model proposed in Chapter II. The first section presented the results of testing the model for all metropolitan areas.

I found that across SMSA's, age affects commuting complexity because older areas often contain denser central cities and exhibit a tendency toward greater mass transit availability and a more suburbanized labor force. Further, I found that population size also influences complexity because larger SMSA's tend to have denser central cities. Congested central cities were related to greater labor force suburbanization and more extensive mass transit facilities. SMSA's with such cities also had a tendency to be contiguous to other metropolitan areas and evidenced a higher level of commuting complexity independent of other factors. The presence of contiguous metropolitan areas encouraged larger portions of the labor force to reside in the ring and, to a much lesser extent, encouraged manufacturing and business to locate there as well. The degree of mass transit availability was found to be similarly related to a greater degree of labor force suburbanization, and it was also somewhat associated with manufacturing located in the ring.

I found that as the labor force becomes more suburbanized, manufacturing and businesses tended to become more decentralized. The distribution of manufacturing establishments also influenced the location of businesses. Greater proportions of retail, wholesale, and service establishments outside the central city tended to be related to the development of urban communities. As the SMSA labor force became more residentially suburban, as the location pattern of manufacturing and business establishments became more decentralized, and as larger percentages of the ring population were settled in urban places, metropolitan commuting patterns generally became more complex.

In the subsequent sections of the chapter, I presented results of applying the causal model to metropolitan areas by division to ascertain regional differences in the importance of structural factors which determine commuting complexity. I will limit this summary discussion to indirect or direct effects, noted in parentheses, which were found to be at least 15 percent of a variable's total effect.

SMSA Age

Age was found to have an important indirect effect on complexity due to central city density in the New England (23 percent), Middle Atlantic (31 percent), and South Atlantic (19 percent) divisions. New England and Middle Atlantic SMSA's are generally much older than the average for all areas and evidence especially dense central cities, presumably a result of the historical period of their development.

Many cities in the Northeast were the earliest industrial centers with initially heavy concentrations of industry and workers located in the urban core. Despite later decentralization, these areas have continued to evidence very dense central cities. Such congestion is related to greater labor force suburbanization in the Middle Atlantic division and mass transit availability and labor force suburbanization in New England, factors that lead directly to more complex commuting.

While average SMSA age and central city density are slightly lower than the average for all areas in the South Atlantic division, the division is particularly diverse, containing several older areas such as Washington, D.C., Baltimore, and Wilmington, Delaware which are actually part of the heavily populated eastern corridor. This fact undoubtedly influences the indirect effect of age through urban density. South Atlantic SMSA's with denser central cities tend to be more contiguous to other metropolitan areas, and contiguity has a very strong influence on labor force suburbanization and business decentralization.

The West South Central division and the Mountain division, two regions with the lowest overall rate of mass transit availability, evidence important indirect effects on complexity of age via mass transit facilities (26 percent and 17 percent respectively). This seemingly incongruous result suggests that although public transportation facilities are not extensive across all SMSA's of these divisions, they are more prevalent in the older metropolitan areas where they are related to greater labor force suburbanization. Also, as will be shown later, these divisions are the only ones in which the independent influence of mass transit availability is significantly supportive of more complex commuting patterns.

Age was found to have an important indirect effect on complexity due to greater labor force suburbanization in the New England (44 percent), Middle Atlantic (24 percent), and East North Central (17 percent) divisions. The fact that SMSA's in these divisions are generally very old, contain denser central cities, and are typically heavily developed industrial areas again suggests an evolution from congested central cities, subsequent suburbanization of the labor force, and later ring development independent of the central city. Each division evidences high rates of urban settlement outside the central city and decentralization of manufacturing and business. In fact, the East North Central division also exhibits significant indirect effects of age via business decentralization (16 percent) and urban settlement in the ring (24 percent). Despite being among the youngest areas as a group, Mountain SMSA's have an important indirect effect of age on complexity due to urban settlement in the ring (21 percent). Thus, in this division older areas tend to have sattelite communities outside their central cities which are especially related to the amount of ring-oriented commuting.

Age also evidences a direct effect on commuting complexity among East North Central (19 percent) and West North Central (28 percent) SMSA's, indicating that regardless of intervening factors, older areas tend to have somewhat greater functional decentralization and therefore more complex commuting patterns in these divisions. Thus, these findings provide evidence that while age is an important factor contributing to commuting complexity among SMSA's in older, more heavily developed areas, it also has important effects on commuting patterns in divisions showing less overall complexity, but where older SMSA's exhibit patterns of functional decentralization due to their historical period of development similar to those of the more typically metropolitan divisions in the industrialized Northeastern and North Central sections of the country.

SMSA Population Size

Metropolitan area population size was found to influence complexity due to dense central cities among SMSA's in divisions where age was also a prominent factor. Size had an important indirect effect via urban density in the New England (25 percent), Middle Atlantic (22 percent), East North Central (17 percent), and South Atlantic (33 percent) divisions. These are regions where larger SMSA's are typically older with very dense central cities and high rates of labor force suburbanization. Size was found to have an important indirect effect on commuting complexity due to larger areas evidencing greater contiguity with other SMSA's only in the Pacific division. This is a result of the high interchange of commuters between the San Francisco-Oakland and Los Angeles-Long Beach SMSA's and the clusters of smaller metropolitan areas surrounding them, the smaller areas typically providing larger numbers of in-commuters to complex flows.

Population size had a significant effect on complexity due to greater mass transit availability among New England (37 percent) and Mountain (17 percent) SMSA's. Both of these divisions evidence relatively small average SMSA populations compared to the average for all areas, but both also contain very large and very small metropolitan areas. However, New England SMSA's show one of the highest rates of mass transit availability and Mountain SMSA's the lowest. It appears, then, that where mass transit availability is supportive of more complex commuting, it is generally in the larger SMSA's of these divisions. Size evidenced an especially important indirect effect on complexity due to greater labor force suburbanization in larger areas only in the West North Central division (45 percent). This may be a result of the presence of larger SMSA's like St. Louis, Kansas City, and Minneapolis-St. Paul in a group of comparatively small metropolitan areas. Population size evidenced an important effect on complexity due to greater manufacturing decentralization only in the East North Central division (26 percent), where SMSA employment in manufacturing is proportionately highest of any division.

Size had a significant influence on commuting complexity via greater decentralization of business establishments in larger areas in several regions, including the South Atlantic (19 percent), the East South Central (17 percent), the West South Central (59 percent), and the Mountain (24 percent) divisions. SMSA's in these regions are generally smaller in average population and more diversified areas with more than half of their employment in retail trade, wholesale trade, and selected services. Finally, larger population size was found to be directly related to greater commuting complexity among East South Central (43 percent) and Mountain (16 percent) SMSA's regardless of intervening factors. Metropolitan areas in these divisions are typically younger and smaller than the average for all areas, and sheer size is associated with the degree of functional decentralization and resultant complex movement. Hence, we may observe that population size contributes to commuting complexity not only in divisions where average SMSA size is very large, but also among larger metropolitan areas in regions where average size is smaller and overall complexity is comparatively low.

Central City Density

Central city density was found to have a significant influence on commuting complexity due to greater mass transit availability in areas with denser cities in the New England (46 percent) and West South Central (39 percent) divisions. As noted before, New England SMSA's tend to have very dense cities, but West South Central SMSA's do not. Also, New England metropolitan areas evidence a high overall rate of mass transit availability while West South Central areas evidence a comparatively low rate. The fact that age also showed an indirect effect through mass transit availability in the West South Central division indicates that transit facilities are more extensive in older, denser areas there. Mass transit availability generally affects complexity through its relationship with greater labor force suburbanization in both divisions. New England and Middle Atlantic SMSA's had important indirect effects of central city density on complexity due to greater labor force suburbanization in areas where central cities were more congested (22 percent and 42 percent respectively). Thus, in these divisions we see the total pattern of heavy, overall development as evidenced previously by the effect of age and size on density and of age and size on labor force distribution among the same SMSA's. Only SMSA's of the Pacific division had a noteworthy indirect effect of central city density on complexity due to extensive urban settlement in the ring (15 percent) when the urban center was more congested.

Finally, there was a tendency among SMSA's in several regions--both high and low complexity divisions--for places with denser central cities to have more complex commuting over and above any intervening factors. This phenomenon was prevalent in the Middle Atlantic (28 percent), East North Central (28 percent), West North Central (15 percent), East South Central (43 percent), Mountain (40 percent), and Pacific (32 percent) divisions.

Contiguity

The presence of contiguous metropolitan areas was found to have an important effect on commuting complexity due to their influence on greater labor force suburbanization in several divisions, including the Middle Atlantic (49 percent), East North Central (59 percent), East South Central (55 percent), West South Central (23 percent), and the South Atlantic (70 percent). These divisions represent cases of both high and low overall contiguity, providing evidence that across all regions, there is a tendency for adjacent areas to encourage greater worker residence in the ring. Similarly, contiguity had an important indirect effect on commuting complexity due to greater manufacturing decentralization in the high complexity East North Central division (18 percent) and the low complexity East South Central division

(18 percent). Both of these regions have heavy concentrations of manufacturing relative to their total metropolitan employment by sector, with the East South Central division showing the highest percentage of manufacturing employment of any low-complexity group and the East North Central division showing the highest percentage of manufacturing employment of any high-complexity group. Only the diversified South Atlantic division had a significant indirect effect on complexity due to the influence of contiguity on business decentralization (22 percent).

Several divisions evidenced important direct effects on complexity due to contiguity, including the New England (50 percent), Pacific (52 percent), Middle Atlantic (28 percent), West South Central (62 percent), and Mountain (46 percent) divisions. This finding indicates that among these metropolitan areas, contiguous SMSA's are contributing in-commuters into complex commuting flows. We have previously observed that New England, Pacific, and Middle Atlantic SMSA's have a distinct tendency to be adjacent to about two other areas, but Mountain and West South Central SMSA's evidence considerably less overall contiguity. Nevertheless, when contiguous areas are present in these divisions, they apparently contribute large numbers of in-commuters which add to the level of commuting complexity in the receiving SMSA.

Mass Transit Availability

Mass transit availability had an important indirect effect on commuting complexity due to its relationship with labor force suburbanization in the New England (86 percent), East North Central (25 percent), West North Central (44 percent), South Atlantic (65 percent), East South Central (42 percent), West South Central (23 percent), and Mountain (38 percent) divisions. Since these represent divisions evidencing both high and low overall transit availability, it appears that across all divisions, where mass transit facilities are more extensive, the labor force will be more suburbanized. The findings also indicated that in the Middle Atlantic and West North Central divisions, where mass transit availability was greater, manufacturing tended to be more decentralized (26 percent of the total effect of mass transit in each case). Similarly, in the East North Central and Pacific divisions, more extensive transit facilities were related to greater decentralization of businesses (15 percent and 19 percent of the total effect of transit respectively).

In the Middle Atlantic, East North Central, and Mountain divisions, mass transit availability had an important indirect effect on complexity due to its relationship with urban settlement in the ring (26 percent, 17 percent, and 32 percent respectively). Hence, in these divisions where urban communities outside the central city are important destinations for complex commuting flows, mass transit appears to expedite the process where it is most available. Finally, in six of the nine geographic divisions mass transit had a negative direct effect on commuting complexity of various magnitudes, ranging from 49 percent of the total effect of mass transit availability in the Pacific division, 47 percent in the East South Central, 40 percent in the East North Central, and 20 percent in the Middle Atlantic, to less than ten percent in the New England and West North Central divisions. Thus, regardless of intervening factors such as labor force suburbanization, the independent influence of more extensive public transportation among SMSA's in these divisions was to decrease the extent of complex commuting and to support movement to central city destinations. The direct effect of transit in the South Atlantic division was virtually zero, while in the West South Central and Mountain divisions it was distinctly positive (62 percent and 15 percent of the total effect of mass transit respectively) and thus conducive to commuting to ring destinations.

Labor Force Suburbanization

Labor force suburbanization transmitted somewhat larger proportions of its total effect on commuting complexity due to its influence on manufacturing decentralization in divisions where manufacturing employment was predominant. For instance, in the Middle Atlantic division 28 percent of the total effect of labor force suburbanization on commuting complexity was due to its relationship with manufacturing decentralization, while 24 percent was due to its relationship with the decentralization of business establishments. Similarly, in the East North Central division 53 percent of the effect of labor force suburbanization on complexity was due to its relationship with manufacturing decentralization, but less than 15 percent was due to its relationship with the decentralization of business. Among West North Central SMSA's, 47 percent of the effect of labor force suburbanization was due to the decentralization of industry, and 30 percent was due to the decentralization of business.

The opposite pattern of that above was found in divisions where retail trade, wholesaling, and selected services were the dominant sector of employment. For example, in the South Atlantic division, 26 percent of the total effect of labor force suburbanization was due to its relationship with manufacturing decentralization, but 60 percent was due to its relationship with the decentralization of business establishments. Although they evidenced little indirect effect on complexity due to the influence of labor force distribution on manufacturing, SMSA's in the diversified East South Central, West South Central, and Mountain divisions showed large proportions of the total effect of labor force suburbanization due to its influence on the decentralization of business (75 percent, 57 percent, and 40 percent respectively).

Only in the Mountain division where urban settlement in the ring was found to be particularly important to commuting complexity, did labor force distribution have a strong indirect effect on complexity through such development (24 percent of its total effect). Finally, labor force suburbanization was found to independently effect commuting complexity in all divisions whose overall complexity score was higher than the average score for all SMSA's, except the South Atlantic. These divisions included the Pacific with a direct effect of 0.500, the Middle Atlantic with a direct effect of 0.387, the East North Central with 0.205, and New England with 0.973. Of course, New England's large effect may in part be attributed to the co-linearity of labor force suburbanization and business decentralization. Nonetheless, the size of the coefficient suggests that suburbanization has a strong influence.

Manufacturing Decentralization

Manufacturing decentralization had an important indirect effect on commuting complexity due to its relationship with the decentralization of businesses establishments in six of the nine divisions. Larger portions of manufacturing's total effect were transmitted through business decentralization among SMSA's in the South Atlantic (81 percent), East South Central (67 percent), West North Central (56 percent), and the West South Central (51 percent) divisions, divisions whose metropolitan economies are generally quite diversified. Lesser portions were transmitted via business in the Middle Atlantic (46 percent) and East North Central (38 percent) divisions where manufacturing employment tends to be the largest economic sector. Manufacturing decentralization did not evidence an indirect effect supportive of commuting complexity via urban settlement in the ring in any division, suggesting that industry as such is not necessarily conducive to the formation of communities outside the central city.

Manufacturing decentralization exhibited a strong direct effect on commuting complexity, independent of intervening factors, in six of the nine divisions, and in all of the five most complex regions with the exception of the diverse South Atlantic division. The coefficients were somewhat smaller than the direct effects of labor force suburbanization, but they did, nevertheless, represent large proportions of the total effect of manufacturing in each case. Divisions showing such independent effects included New England (0.131), the Middle Atlantic (0.192), the

East North Central (0.337), the West North Central (0.188), the Mountain (0.553), and the Pacific (0.101) divisions.

Business Decentralization

Decentralization of business establishments had an important indirect effect on commuting complexity due to its influence on urban settlement in the ring in the heavily developed Middle Atlantic division (28 percent), the typically decentralized Pacific division (27 percent), and in the Mountain division (86 percent) where urban communities in the ring appear to be especially necessary as destinations for complex commuting flows. Business decentralization evidenced a strong direct effect on complexity in all divisions except the Mountain and Pacific. SMSA's in more industrial divisions had somewhat lower coefficients, for example, the Middle Atlantic with a direct effect of 0.277 and the East North Central with 0.328, while SMSA's in more diversified divisions had comparatively higher coefficients, for example, the West North Central with 0.636, the South Atlantic with 0.759, the East South Central with 0.770, and the West South Central with 1.519. It will be recalled that no coefficient for business decentralization was calculated for New England SMSA's due to the variable's co-linearity with labor force suburbanization. However, the size of the direct effect of labor force distribution again implies that the decentralization of business establishments also has an important influence on complexity in that division as well.

Settlement Pattern of the Ring

The extent of urban settlement in the ring was found to have a strong effect on commuting complexity in six of the nine divisions. Four of the divisions evidenced comparatively high overall complexity scores. They were the Middle Atlantic division with a direct effect from urban development in the ring of 0.274, the East North Central division with 0.242, the South Atlantic with 0.238, and the Pacific with a coefficient of 0.400. The other two divisions had relatively low overall complexity, but in them, spacious rings apparently dictated the special importance of urban communities as destinations for complex commuting when it occurred. They were the West South Central division with a coefficient of 0.241 and the Mountain division with the unusually high coefficient of 1.168.

CHAPTER V

CONCLUSION

Overview of the Findings

The results of this study offer several basic generalizations pertaining to the nature and determinants of complex commuting patterns in U.S. metropolitan areas. First, of all workers commuting to jobs in U.S. SMSA's, about 43 percent commute to workplaces in the ring. Thus, 57 percent travel to central city jobsites, affirming the continued importance of the city across all SMSA's despite marked trends toward decentralization. Of those workers commuting to rings, 75 percent come from ring origins, 16 percent reverse commute from the central city, and nine percent originate outside the SMSA.

The distribution of Index of Commuting Complexity scores, i.e., the percent of all workers working in the SMSA who commute to ring jobsites, is somewhat bimodal, with large groupings at the 15-20 range and at the 30-35 range. Sixteen of the 25 SMSA's with the highest index scores are located in the older, heavily developed, industrialized Middle Atlantic division and in California (Pacific division) where metropolitan areas have grown in an especially decentralized pattern. The rest are primarily in New England and the South Atlantic division. Ten of

these high-complexity areas are over 500,000 in population. Contrastingly, the 25 SMSA's with the lowest index scores tend to be small New England metropolitan areas or located in the West North Central and West South Central divisions, parts of the country where SMSA's evidence centralization of population and economic functions. Eighteen of the 25 smallest areas have populations under 150,000, and ten of those are less than 100,000. The highest complexity score, 76.17, was attained by Paterson-Clifton-Passaic, New Jersey, and the lowest complexity score, 4.67, was achieved by Lewiston-Auburn, Maine.

SMSA's with both high percentages (20 percent or more) of their workforce commuting in from outside and more than 20 percent of their resident workers commuting out tend to be located in New England or the New York Consolidated Area. Other SMSA's with high out-commuting are typically contiguous to larger metropolitan areas. Each of the New England SMSA's that evidence high in-commuting also evidence high out-commuting.

Metropolitan areas in the highly decentralized Pacific division are the most complex as a group with more than half of SMSA workers commuting to ring destinations. Other divisions with overall SMSA commuting complexity above the average for all areas (42.9) are the heavily developed and industrialized New England, Middle Atlantic, and East North Central divisions and the economically diverse South Atlantic division. SMSA's in the less developed West North Central, Mountain, East South Central, and West South Central divisions are comparatively less complex in contrast to all SMSA's.

A larger proportion of workers across all metropolitan areas live in the ring than the central city, but a larger proportion work in the central city than in the ring. Less than six percent of the workers living in SMSA's commute outside their SMSA of residence. Central city residents show a strong tendency to work in the city, while workers living in the ring generally work within that ring but to a lesser extent than the city-city pattern. About a third of all workers living in the ring work in the central city, but only about one-sixth of workers living in central cities reverse commute to ring employment. Ring residents are more likely to commute outside the SMSA than are central city residents. In-commuters tend to accentuate the pattern of complexity already established within the SMSA.

More than half of the SMSA resident labor force lives in the ring in all divisions except the typically centralized East and West South Central and Mountain divisions. In contrast, the majority of the resident labor force work in the central city in every division except the high-complexity Pacific and New England SMSA's. Central city residents tend to work in the central city and ring residents tend to work in the ring in all divisions. The central city-central city commuting pattern is most prevalent in the low-complexity West North Central, East South Central, West South Central, and Mountain divisions. Divisions where SMSA's evidence higher overall complexity tend to have lower rates of central city-central city commuting, a higher incidence of ring-ring flows, lower rates of ring-central city trips, and more reverse commuting. Ring residents are most likely to commute outside their SMSA in all divisions, the highest rates occurring in the New England and Pacific divisions. New England exhibits far and away the greatest in-commuting, both to cities and rings. Rings attract a larger proportion of in-commuters than do central cities in all divisions.

Across all SMSA's older metropolitan areas tend to evidence greater commuting complexity because their typically denser central cities and more extensive mass transit facilities are associated with greater labor force suburbanization, a crucial determinant of commuting complexity. Older SMSA's also have a tendency toward greater worker suburbanization independent of other factors, suggesting a heavier regional pattern of settlement in such areas due to their longer history of metropolitan development. Larger SMSA's also evidence greater commuting complexity because they tend to have denser central cities which are related to greater mass transit availability and labor force suburbanization.

SMSA's with denser central cities also tend to be contiguous to other metropolitan areas, and contiguity appears to encourage greater worker suburbanization. Regardless of age or size, where mass transit is most extensive, the labor force tends to be more suburbanized and manufacturing is somewhat decentralized. The degree of labor force suburbanization is strongly associated with the extent of manufacturing and business decentralization. The distribution of industry is also related to the location of businesses. Larger proportions of retail, wholesale, and service establishments outside the central city are related to the development of urban communities there. Where the SMSA labor force is more residentially suburban, where the location pattern of manufacturing and business establishments is more decentralized, and where a large proportion of the ring population is settled in urban communities, metropolitan commuting patterns are generally more complex.

The effect of age on complexity due to intervening factors contributing to functional decentralization is most evident among SMSA's in older more developed divisions with higher overall complexity scores. Only in the Pacific division, where SMSA's are younger and where they grew in an initially decentralized fashion, is age not a factor supportive of more complex commuting. In New England and the Middle Atlantic division older SMSA's have denser central cities and greater labor force suburbanization, and density too influences suburbanization. Older SMSA's in the East North Central division evidence greater labor force suburbanization, decentralization of business establishments, greater urban settlement in the ring, and age even has a small direct effect on complexity. Among South Atlantic SMSA's, older areas exhibit denser central cities, and SMSA's with more congested centers are more likely to have contiguous areas nearby. Contiguity then encourages greater labor force suburbanization. Although age evidences some indirect influence on complexity in other divisions, it does not follow the pattern indicative of mature metropolitan development, i.e., denser cities and functional decentralization.

Similarly, the effect of population size on complexity due to intervening factors which contribute to functional decentralization is also most prominent among SMSA's in older more developed divisions with higher overall complexity scores. This is not surprising since age is highly correlated with size in every division. Larger SMSA's in New England and the Middle Atlantic division evidence denser central cities which are related to greater worker suburbanization. In the East North Central division, larger areas also evidence denser cities and greater manufacturing decentralization. Finally, among South Atlantic SMSA's, larger SMSA's again have denser central cities which are related to contiguity with other areas and subsequently labor force suburbanization.

Size evidences indirect effects on complexity in lower-complexity divisions, but again it does not follow the pattern of mature metropolitan development. This may be due to the fact that SMSA's in lower-complexity divisions tend to be younger with less dense central cities, implying that much of any decentralization which exists was not deconcentration from the urban center but initial location in the ring. The high-complexity Pacific division evidences a strong direct effect of size on complexity with no indirect effect via density or suburbanization, suggesting that larger SMSA's became functionally decentralized there without the sake of initial concentration and subsequent decentralization.

We have seen that central city density is typically an intervening factor between age and size and commuting complexity among SMSA's in older, more developed divisions, where metropolitan areas tend to be quite large and overall complexity is quite high. It appears that density is also important in low-complexity divisions, specifically the West North Central, East South Central, and Mountain divisions, where a large portion of the total influence of central city density on commuting complexity is direct. Thus, among SMSA's in these divisions, where complexity is greater central cities are more dense. Metropolitan areas in the complex Pacific division also follow this same pattern.

The presence of contiguous metropolitan areas and their relationship to greater labor force suburbanization influences commuting complexity in divisions where contiguity is common and in divisions where it is not. Among New England, Pacific, Middle Atlantic, West South Central, and Mountain SMSA's, contiguous areas especially tend to contribute in-commuters into complex flows. Mass transit availability influences commuting complexity because of its relationship with labor force suburbanization in several regions, but its independent effect in six of the nine divisions is to reduce the extent of complex flows.

The relationship between greater labor force suburbanization and greater manufacturing decentralization tends to be more important to commuting complexity in divisions where manufacturing employment is predominant in metropolitan areas. Contrastingly, the relationship between labor force suburbanization and more extensive decentralization of business establishments is more prevalent among SMSA's in divisions where retail trade, wholesaling, and selected services are the dominant sector of employment. More extensive labor force suburbanization is generally related to more complex commuting patterns in divisions whose overall complexity score is above the average for all SMSA's.

The relationship between decentralization of manufacturing establishments and decentralization of business is more important to commuting complexity in divisions with diversified metropolitan economies.

Manufacturing decentralization has a strong direct influence on complex commuting in all of the most complex divisions with the exception of the diverse South Atlantic. The decentralization of business establishments similarly influences complexity in all of the most complex regions except the Pacific. The independent effect of business decentralization on complex commuting patterns is somewhat greater in more diversified divisions and somewhat less in divisions with more industrial SMSA's. The extent of urban settlement in the ring is important to commuting complexity in each high-complexity division, with the exception of New England where heavy in-commuting tends to have a strong influence.

Thus, in sum the study's results provide support for the contention that complex movement systems arise out of the decentralization of functional units of the metropolitan area. As underlying patterns of interdependence between zones of conflux and zones of dispersion become more complex, the manifest patterns of movement become progressively less simple. Commuting streams link the territorial organization together in a dynamic pattern of metropolitan structure.

Policy Implications

Although my findings show that complex commuting does not yet represent the majority of journey-to-work trips in metropolitan areas, the superiority of ring as opposed to central city growth in population and all economic sectors shown in the tables of Chapter I suggests that this may in fact be a reality in the future. Furthermore, my results indicate that three-quarters of the complex movement is from one ring destination to another, presumably in criss-crossing, non-radial flows. Hence, it appears that the current study offers implications for both future metropolitan development and transportation planning despite the fact that it has the limitation of being a cross-sectional view of commuting at one point in time.

Transportation technology has allowed the "sprawl" condition which leads to complex commuting. Now, the uncoordinated locational pattern of residences, workplaces, and commercial areas is the problem with which transit planning must cope. We have seen, however, that the problem is most intense in older, larger metropolitan areas, especially in the older and/or more heavily developed regions of the country. Such large urban assemblages represent intricate legal and physical realities not easily amenable to change. Therefore, the only solution may be the design of transit modes to accommodate inter- and intrasuburban movement to help stem the personal and social costs of heavy automobile use on increasingly longer commuting trips. Because complex commuting is so individualistic, i.e., oriented to decentralized workplaces from dispersed points of origin, the only solution may be the development of more energy-efficient private vehicles.

Newer, smaller metropolitan areas, often in less developed, less metropolitan sections of the country evidence less complex commuting. These regions, such as the East South Central, West South Central, and Mountain divisions are regions where metropolitan growth is now rapidly occurring, but where central cities are generally holding their own as locations for economic and residential activity and thus as commuting

zones of conflux. Therefore, it appears that these metropolitan areas may benefit most from the knowledge of determinants and consequences of complex commuting in older SMSA's. Preparation for future metropolitan growth which includes planned industrial districts in outlying areas, the location of residential areas for maximum transit access, and resultant public transportation built on the basis of sound land-use planning seem imperative. Future highway construction in metropolitan areas, and especially in newer, developing SMSA's, invites further dispersal and longer trips.

A final issue which arises in considering complex commuting is the future of "reverse" journeys to work, i.e., commuting from the city to the ring. There is evidence that as blue-collar industrial employment takes on a more decentralized pattern of location, white-collar administrative functions are becoming more centralized. Thus, the poor and minorities which tend to be more heavily concentrated in central cities are increasingly separated from potential jobs. Their plight is further complicated by the fact that such groups have low rates of automobile ownership and the fact that much public transportation is intended to carry commuters to central locations during peak hours, not the reverse. Future metropolitan planning must deal with this problem in addition to that of inter-ring movement.

The present study was based on data reflecting the state of metropolitan structural characteristics and the journey to work at a time previous to the current energy problem. Therefore, future commuting patterns may be significantly affected by such factors as residential

location decisions which shorten travel time and the availability of fuel. Additionally, land-use legislation and taxation of externalities caused by heavy auto use may also be important determinants of the location of productive units which generate commuting flows.

Needed Research

Origin and destination data have provided a wealth of information on commuting patterns for description and secondary analysis. With the advent of journey-to-work questions in the decennial census as of 1960, comprehensive data on the intensity of flows and characteristics of commuters within those flows has been made available for larger areal units within metropolitan areas. Studies of the relationship between structural characteristics of SMSA's and observed commuting patterns are, however, rather scarce. This is an important direction for future research. In addition to cross-sectional studies testing alternative explanatory variables, longitudinal investigations could be undertaken to study changes in commuting patterns over time as they are related to changes in metropolitan characteristics. We also know little about the nature and importance of intermetropolitan commuting and journeys to work from non-metropolitan to metropolitan areas.

Another promising direction for research would be a comprehensive survey across many metropolitan areas of origins and destinations of commuting at the census tract level. Such research could provide a better indication of the precise flows which make up the overall complex pattern, as well as data on commuter preferences for different transit modes.

In sum, future urban commuting research should be carried on at the macro and micro levels, using all available data sources, to gain a holistic view of the determinants and consequences of the journey to work to help us better understand the structure of the metropolitan community and to make informed planning decisions.

APPENDIX A

ZERO-ORDER CORRELATION MATRICES FOR GEOGRAPHIC DIVISIONS

APPENDIX A

Table 36. Correlation Matrix, Means, and Standard Deviations of Variables in the Model for New England SMSA's.

	AGESMSA	SMSAPOP	CCDENS	CONTIGU	TRANSIT	PWORKLVR	PMFGESTR	PRWSESTR	PRNGURB	CPLX
AGESMSA	1.000	.556	.751	.423	.583	.678	.469	.480	.631	.513
SMSAPOP		1.000	.747	.448	.859	.582	.530	.599	.485	.540
CCDENS			1.000	.617	.829	.718	.640	.687	.725	.627
CONTIGU				1.000	.462	.394	.504	.596	.713	.445
TRANSIT					1.000	.711	.667	.686	.500	.650
PWORKLVR						1.000	.856	.943	.616	.940
PMFGESTR							1.000	.874	.554	.879
PRWSESTR								1.000	.745	.938
PRNGURB									1.000	.596
CPLX										1.000
Mean	5.24	339,372	4,515.40	1.76	9.10	43.23	36.26	38.76	62.85	33.17
Std.Dev.	3.92	542,570	3,118.84	1.27	8.22	18.92	18.85	16.24	19.69	18.06

APPENDIX A

Table 37. Correlation Matrix, Means, and Standard Deviations of Variables in the Model for Middle Atlantic SMSA's.

	AGESMSA	SMSAPOP	CCDENS	CONTIGU	TRANSIT	PWORKLVR	PMFGESTR	PRWSESTR	PRNGURB	CPLX
AGESMSA	1.000	.733	.739	.322	.791	-.112	-.214	-.035	.744	-.004
SMSAPOP		1.000	.771	.489	.789	-.411	-.497	-.332	.450	-.302
CCDENS			1.000	.472	.843	-.088	-.128	.009	.699	.126
CONTIGU				1.000	.501	-.020	.024	.009	.257	.121
TRANSIT					1.000	-.158	-.141	-.095	.714	.013
PWORKLVR						1.000	.861	.923	.163	.909
PMFGESTR							1.000	.870	.137	.879
PRWSESTR								1.000	.263	.927
PRNGURB									1.000	.384
CPLX										1.000
Mean	8.24	1,223,509	9,192.60	2.24	18.20	66.19	55.94	57.37	63.04	53.36
Std.Dev.	3.69	2,381,263	5,413.54	1.56	14.14	15.33	15.90	15.78	23.38	14.84

APPENDIX A

Table 38. Correlation Matrix, Means, and Standard Deviations of Variables in the Model for East North Central SMSA's.

	AGESMSA	SMSAPOP	CCDENS	CONTIGU	TRANSIT	PWORKLVR	PMFGESTR	PRWSESTR	PRNGURB	CPLX
AGESMSA	1.000	.568	.482	.295	.592	.168	.100	.289	.611	.356
SMSAPOP		1.000	.834	.424	.864	.154	.131	.233	.611	.355
CCDENS			1.000	.495	.728	.213	.075	.171	.530	.342
CONTIGU				1.000	.323	.385	.376	.398	.338	.401
TRANSIT					1.000	.165	.116	.279	.661	.332
PWORKLVR						1.000	.783	.806	.405	.823
PMFGESTR							1.000	.870	.315	.830
PRWSESTR								1.000	.453	.869
PRNGURB									1.000	.598
CPLX										1.000
Mean	4.79	612,232	4,758.14	1.42	6.59	51.33	40.07	41.13	52.84	36.37
Std.Dev.	3.38	1,158,600	2,363.18	.96	6.59	11.80	14.25	11.45	19.46	12.52

APPENDIX A

Table 39. Correlation Matrix, Means, and Standard Deviations of Variables in the Model for West North Central SMSA's.

	AGESMSA	SMSAPOP	CCDENS	CONTIGU	TRANSIT	PWORKLVR	PMFGESTR	PRWSESTR	PRNGURB	CPLX
AGESMSA	1.000	.700	.416	.359	.731	.518	.296	.426	.726	.627
SMSAPOP		1.000	.796	.125	.926	.845	.555	.740	.730	.825
CCDENS			1.000	-.170	.765	.572	.307	.475	.437	.569
CONTIGU				1.000	.133	.102	.028	.056	.147	.103
TRANSIT					1.000	.810	.602	.709	.676	.805
PWORKLVR						1.000	.838	.943	.756	.911
PMFGESTR							1.000	.903	.547	.819
PRWSESTR								1.000	.657	.921
PRNGURB									1.000	.761
CPLX										1.000
Mean	5.00	439,897	3,354.21	.11	6.13	32.59	25.16	28.33	42.35	23.37
Std.Dev.	3.43	647,681	2,151.61	.32	5.36	16.58	12.88	14.48	28.78	14.30

APPENDIX A

Table 40. Correlation Matrix, Means, and Standard Deviations of Variables in the Model for South Atlantic SMSA's.

	AGESMSA	SMSAPOP	CCDENS	CONTIGU	TRANSIT	PWORKLVR	PMFGESTR	PRWSESTR	PRNGURB	CPLX
AGESMSA	1.000	.674	.688	.324	.836	.206	-.052	.179	.396	.115
SMSAPOP		1.000	.870	.282	.795	.229	.103	.319	.499	.194
CCDENS			1.000	.482	.784	.325	.198	.392	.547	.281
CONTIGU				1.000	.314	.457	.376	.520	.387	.433
TRANSIT					1.000	.288	.082	.285	.404	.184
PWORKLVR						1.000	.893	.948	.483	.845
PMFGESTR							1.000	.912	.379	.808
PRWSESTR								1.000	.529	.874
PRNGURB									1.000	.572
CPLX										1.000
Mean	4.08	481,633	3,954.86	.53	10.53	55.09	44.61	40.57	56.40	42.00
Std.Dev.	3.47	583,865	2,427.26	.77	7.42	18.06	14.89	15.72	25.15	17.68

APPENDIX A

Table 41. Correlation Matrix, Means, and Standard Deviations of Variables in the Model for East South Central SMSA's.

	AGESMSA	SMSAPOP	CCDENS	CONTIGU	TRANSIT	PWORKLVR	PMFGESTR	PRWSESTR	PRNGURB	CPLX
AGESMSA	1.000	.905	.152	-.169	.844	.080	-.114	.308	.529	.228
SMSAPOP		1.000	.245	-.054	.829	.063	-.165	.302	.585	.334
CCDENS			1.000	.174	.331	.117	-.255	-.088	.336	.125
CONTIGU				1.000	-.237	.247	.486	.198	-.141	.349
TRANSIT					1.000	.179	-.162	.315	.695	.153
PWORKLVR						1.000	.564	.896	.315	.719
PMFGESTR							1.000	.619	-.045	.487
PRWSESTR								1.000	.376	.791
PRNGURB									1.000	.228
CPLX										1.000
Mean	4.13	349,736	3,006.93	.27	6.31	40.54	32.44	29.69	45.15	25.45
Std.Dev.	3.27	255,345	1,530.67	.46	4.04	13.79	12.82	9.60	20.72	10.24

APPENDIX A

Table 42. Correlation Matrix, Means, and Standard Deviations of Variables in the Model for West South Central SMSA's.

	AGESMSA	SMSAPOP	CCDENS	CONTIGU	TRANSIT	PWORKLVR	PMFGESTR	PRWSESTR	PRNGURB	CPLX
AGESMSA	1.000	.705	.439	.039	.767	.113	-.095	.094	.707	-.086
SMSAPOP		1.000	.333	.422	.518	.246	-.010	.247	.612	.069
CCDENS			1.000	-.006	.723	.052	.177	-.033	.192	-.043
CONTIGU				1.000	.034	.322	.302	.274	.156	.096
TRANSIT					1.000	.188	.214	.146	.474	.047
PWORKLVR						1.000	.724	.922	.382	.420
PMFGESTR							1.000	.746	.055	.344
PRWSESTR								1.000	.373	.569
PRNGURB									1.000	.198
CPLX										1.000
Mean	2.86	334,974	2,617.92	.50	4.63	29.94	24.62	23.50	46.70	25.28
Std.Dev.	2.77	426,980	1,080.78	.66	5.30	14.58	12.48	12.04	25.94	12.84

APPENDIX A

Table 43. Correlation Matrix, Means, and Standard Deviations of Variables in the Model for Mountain SMSA's.

	AGESMSA	SMSAPOP	CCDENS	CONTIGU	TRANSIT	PWORKLVR	PMFGESTR	PRWSESTR	PRNGURB	CPLX
AGESMSA	1.000	.742	.519	.212	.785	.533	.156	.377	.446	.249
SMSAPOP		1.000	.265	.029	.689	.484	.141	.500	.601	.369
CCDENS			1.000	-.517	.399	-.104	.002	-.174	-.229	-.244
CONTIGU				1.000	.095	.475	-.032	.326	.278	.354
TRANSIT					1.000	.658	.248	.471	.604	.515
PWORKLVR						1.000	.431	.835	.752	.772
PMFGESTR							1.000	.537	.132	.478
PRWSESTR								1.000	.738	.833
PRNGURB									1.000	.782
CPLX										1.000
Mean	2.29	336,725	3,237.00	.71	2.51	36.05	30.11	26.93	64.87	29.78
Std.Dev.	2.46	352,000	959.34	.61	2.15	14.81	8.33	12.29	21.00	11.98

APPENDIX A

Table 44. Correlation Matrix, Means, and Standard Deviations of Variables in the Model for Pacific SMSA's.

	AGESMSA	SMSAPOP	CCDENS	CONTIGU	TRANSIT	PWORKLVR	PMFGESTR	PRWSESTR	PRNGURB	CPLX
AGESMSA	1.000	.602	.545	.148	.845	-.437	-.565	-.405	.480	-.372
SMSAPOP		1.000	.540	.438	.475	-.167	-.050	.007	.579	-.027
CCDENS			1.000	.303	.750	-.061	-.151	-.043	.420	-.025
CONTIGU				1.000	.221	.468	.368	.664	.591	.556
TRANSIT					1.000	-.193	-.443	-.291	.372	-.266
PWORKLVR						1.000	.551	.831	-.016	.577
PMFGESTR							1.000	.739	-.137	.435
PRWSESTR								1.000	.188	.617
PRNGURB									1.000	.313
CPLX										1.000
Mean	3.32	1,001,342	4,114.68	2.32	5.18	61.35	54.13	50.98	73.96	50.90
Std.Dev.	3.18	1,514,279	1,911.41	1.49	6.57	8.62	11.74	9.87	16.59	11.50

BIBLIOGRAPHY

Adams, Leonard P., and Mackesey, Thomas W. Commuting Patterns of Industrial Workers. Ithaca, New York: Cornell University, Housing Research Center, 1955.

Alonso, William. "A Theory of the Urban Land Market," Papers and Proceedings of the Regional Science Association, 6 (1960), 149-157.

Alwin, Duane F., and Hauser, Robert M. "The Decomposition of Effects in Path Analysis," American Sociological Review, 40 (February, 1975), 37-47.

Bello, Francis. "The City and the Car," in the Editors of Fortune (eds.), The Exploding Metropolis. Garden City, New York: Doubleday, 1958, 53-80.

Beyer, Glenn H. Housing and Journey to Work: The Patterns of Rural Families in Monroe County. Ithaca, New York: New York Agricultural Experiment Station, Cornell University, 1951.

Bogue, Donald J., and Harris, Dorothy L. Comparative Population and Urban Research Via Multiple Regression and Covariance Analysis. Oxford, Ohio and Chicago: Scripps Foundation for Research in Population Problems, Miami University, and Population Research and Training Center, University of Chicago, 1954.

Bostick, Thurley A. "The Automobile in American Daily Life," Public Roads, 32 (December, 1963), 241-255.

Bostick, Thurley A., and Todd, Thomas R. "Travel Habits in Cities of 100,000 or More," Public Roads, 33 (February, 1966), 274-276.

Breese, Gerald W. The Daytime Population of the Central Business District of Chicago. Chicago: University of Chicago Press, 1949.

Burtt, Everett J. "Workers Adapt to Plant Relocation in Suburbia," Monthly Labor Review, 91 (April, 1968), 1-5.

Carroll, John D., Jr. "Some Aspects of Home-Work Relationships of Industrial Workers," Land Economics, 25 (November, 1949), 414-422.

Carroll, John D., Jr. "The Relation of Homes to Work Places and the Spatial Pattern of Cities," Social Forces, 30 (March, 1952), 271-282.

Catanese, Anthony J. "Commuting Behavior Patterns of Families," Traffic Quarterly, 24 (July, 1970), 439-457.

Catanese, Anthony J. "Home and Workplace Separation in Four Urban Regions," Journal of the American Institute of Planners, 37 (September, 1971), 331-337.

Chavrid, Vladimir D. "Employment and Residence in Major Metropolitan Areas," Monthly Labor Review, 80 (August, 1957), 932-937.

Chinitz, Benjamin. "City and Suburb," in Benjamin Chinitz (ed.), City and Suburb: The Economics of Metropolitan Growth. Englewood Cliffs, New Jersey: Prentice-Hall, 1964, 3-50.

Curran, Frank B., and Stegmaier, Joseph T. "Travel Patterns in 50 Cities," Public Roads, 30 (December, 1958), 105-121.

Dean, Robert D. The Suburbanization of Industry in the U.S.: An Overview. Oak Ridge, Tennessee: Southern Regional Demographic Group, June, 1973.

Duncan, Beverly. "Factors in Work-Residence Separation: Wage and Salary Workers, Chicago, 1951," American Sociological Review, 21 (February, 1956), 48-56.

Duncan, Beverly. "Intra-Urban Population Movement," in Paul K. Hatt and Albert J. Reiss, Jr. (eds.), Cities and Society. Glencoe: Free Press, 1957, 297-309.

Duncan, Beverly, and Duncan, Otis Dudley. "The Measurement of Intra-City Locational and Residential Patterns," Journal of Regional Science, 2 (Fall, 1960), 37-54.

Duncan, Otis Dudley. "Path Analysis: Sociological Examples," American Journal of Sociology, 72 (July, 1966), 1-16.

Foley, Donald L. "The Daily Movement of Population Into Central Business Districts," American Sociological Review, 17 (October, 1952), 538-543.

Foley, Donald L. "Urban Day-Time Population: A Field for Demographic-Ecological Analysis," Social Forces, 32 (May, 1954), 323-330.

Forstall, Richard L. "Commuting Characteristics of Large American Cities," in International City Managers' Association Yearbook. Chicago: International City Managers' Association, 1965, 98-111.

Fuguitt, Glen V., and Zuiches, James J. "Residential Preferences and Population Distribution: Results of a National Survey," Paper presented at the Annual Meeting of the Rural Sociological Society, College Park, Maryland, August 24, 1973.

Gerard, Roy. "Commuting and the Labor Market Area," Journal of Regional Science, (Summer, 1958), 124-130.

Goldstein, Sidney, and Mayer, Kurt. "Migration and the Journey to Work," Social Forces, 42 (May, 1964), 472-481.

Goldstein, Sidney, and Mayer, Kurt. "Migration and Social Status Differentials in the Journey to Work," Rural Sociology, 29 (September, 1964), 278-287.

Gorman, David A., and Hitchcock, Stedman. "Characteristics of Traffic Entering and Leaving the Central Business District," Public Roads, 30 (August, 1959), 213-220.

Hansen, Walter G. "Traffic Approaching Cities," Public Roads, 31 (April, 1961), 155-158.

Hawley, Amos H. Human Ecology. New York: Ronald Press, 1950.

Hawley, Amos H. The Changing Shape of Metropolitan America: Deconcentration Since 1920. Glencoe: The Free Press, 1956.

Hawley, Amos H. "A Further Note on Suburbanization," Land Economics, 32 (February, 1956), 87-89.

Hawley, Amos H. Urban Society: An Ecological Perspective. New York: The Ronald Press, 1971.

Heise, David R. "Problems in Path Analysis and Causal Inference," in Edgar F. Borgatta (ed.), Sociological Methodology, 1969. San Francisco: Jossey-Bass, Inc., 1969, 38-73.

Hoover, Edgar M. An Introduction to Regional Economics. New York: Alfred A. Knopf, 1971.

Hoover, Edgar, and Vernon, Raymond. Anatomy of a Metropolis. Garden City, New York: Anchor Books, 1962.

Kain, John F. "The Journey to Work as a Determinant of Residential Location," Papers and Proceedings of the Regional Science Association, 9 (1962), 137-160.

Kain, John F. "The Effect of the Ghetto on the Distribution and Level of Nonwhite Employment in Urban Areas," Proceedings of the Social Statistics Section, American Statistical Association. Washington, D.C.: American Statistical Association, 1964, 260-269.

Kain, John F. "A Contribution to the Urban Transportation Debate: An Econometric Model of Urban Residential and Travel Behavior," Review of Economics and Statistics, 46 (February, 1964) 55-64.

Kain, John F. "Urban Travel Behavior," in Leo F. Schnore (ed.), Social Science and the City. New York: Praeger, 1967, 161-192.

Land, Kenneth C. "Principles of Path Analysis," in Edgar F. Borgatta (ed.), Sociological Methodology, 1969. San Francisco: Jossey-Bass, Inc., 1969, 3-37.

Lansing, John B., and Mueller, Eva. Residential Location and Urban Mobility. Ann Arbor, Michigan: Survey Research Center, University of Michigan, 1964.

Lapin, Howard S. Structuring the Journey to Work. Philadelphia: University of Pennsylvania Press, 1964.

Liepman, Kate. The Journey to Work. London: Kegan Paul, Trench, Trubner & Co., 1944.

Loewenstein, Louis K. The Location of Residences and Work Places in Urban Areas. New York: Scarecrow Press, 1965.

Lonsdale, Richard E. "Two North Carolina Commuting Patterns," Economic Geography, 42 (April, 1966), 114-138.

Manners, G. "Urban Expansion in the United States," Urban Studies, 2 (May, 1965), 51-66.

Mayer, Harold M. The Spatial Expression of Urban Growth. Washington, D.C.: Association of American Geographers, Commission on College Geography, Resource Paper No. 7, 1969.

McKay, Roberta V. "Commuting Patterns of Inner-City Residents," Monthly Labor Review, 96 (November, 1973), 43-48.

McKenzie, Roderick D. "Spatial Distance and Community Organization Pattern," Social Forces, 5 (June, 1927), 623-627.

McKenzie, Roderick D. The Metropolitan Community. New York: The McGraw-Hill Book Co., 1933.

Mertz, William L., and Hamner, Lamelle B. "A Study of Factors Related to Urban Travel," Public Roads, 29 (April, 1957), 170-174.

Meyer, John R. "Knocking Down the Straw Men," in Benjamin Chinitz (ed.), City and Suburb: The Economics of Metropolitan Growth. Englewood Cliffs, New Jersey: Prentice-Hall, 1964, 85-93.

Meyer, John R., Kain, John F., and Wohl, Martin. The Urban Transportation Problem. Cambridge, Massachusetts: Harvard University Press, 1965.

Mitchell, Robert B., and Rapkin, Chester. Urban Traffic, A Function of Land Use. New York: Columbia University Press, 1954.

Morgan, James N. "A Note on the Time Spent on the Journey to Work," Demography, 4 (1967), 360-362.

Muth, Richard F. "The Spatial Structure of the Housing Market," Proceedings of the Regional Science Association, 7 (1961) 207-220.

Newman, Dorothy K. "The Decentralization of Jobs," Monthly Labor Review, 90 (May, 1967), 7-13.

Ogburn, William F. "Inventions of Local Transportation and the Patterns of Cities," Social Forces, 24 (May, 1946), 373-379.

Oi, Walter Y., and Shuldiner, Paul W. An Analysis of Urban Travel Demands. Evanston: Northwestern University Press, 1962.

Reeder, Leo G. "Social Differentials in Mode of Travel, Time, and Cost in the Journey to Work," American Sociological Review, 21 (February, 1956), 56-63.

Scaff, Alvin H. "The Effect of Commuting on Participation in Community Organizations," American Sociological Review, 17 (April, 1952), 215-220.

Schenker, Eric, and Wilson, John. "The Use of Public Mass Transportation in the Major Metropolitan Areas of the United States," Land Economics, 43 (August, 1967), 361-367.

Schmandt, Henry J., and Stephens, G. Ross. "Public Transportation and the Worker," Traffic Quarterly, 17 (October, 1963), 573-583.

Schnore, Leo F. "The Separation of Home from Work: A Problem for Human Ecology," Social Forces, 32 (May, 1954), 336-343.

Schnore, Leo F. "The Journey to Work in 1975," in Donald J. Bogue (ed.), Applications of Demography: The Population Situation in the U.S. in 1975. Oxford, Ohio and Chicago: Scripps Foundation for Research in Population Problems, and Population Research and Training Center, University of Chicago, 1957, 73-75.

Schnore, Leo F. "Metropolitan Growth and Decentralization," American Journal of Sociology, 63 (September, 1957), 171-180.

Schnore, Leo F. "The Timing of Metropolitan Decentralization: A Contribution to the Debate," Journal of the American Institute of Planners, 25 (November, 1959), 200-206.

Schnore, Leo F. "Three Sources of Data on Commuting: Problems and Possibilities," Journal of the American Statistical Association, 55 (March, 1960), 8-22.

Schnore, Leo F. "The Use of Public Transportation in Urban Areas," Traffic Quarterly, 16 (October, 1962), 488-498.

Schnore, Leo F. The Urban Scene. New York: The Free Press, 1965.

Sharp, Harry P. "The Non-Residential Population of the Central Business District," Land Economics, 31 (November, 1955) 378-381.

Sharpe, Gordon B., Hansen, Walter C., and Hamner, Lamelle B. "Factors Affecting Trip Generation of Residential Land Uses," Public Roads, 30 (October, 1958), 88-99.

Sheldon, Henry D., and Hoermann, Siegfried A. "Metropolitan Structure and Commutation," Demography, 1 (1964), 186-193.

Silver, Jacob. "Trends in Travel to the Central Business District by Residents of the Washington, D.C. Metropolitan Area, 1948 and 1955," Public Roads, 30 (April, 1959), 153-176.

Stegman, Michael A. "Accessibility Models and Residential Location," Journal of the American Institute of Planners, 35 (January, 1969), 22-29.

Taaffe, Edward J., Gardner, Barry J., and Yates, Maurice H. The Peripheral Journey to Work. Evanston, Illinois: Northwestern University Press, 1963.

Thompson, James H. "Commuting Patterns of Manufacturing Employees," Industrial and Labor Relations Review, 10 (October, 1956), 70-80.

U.S. Bureau of the Census. Census of Business, 1967. Retail Trade-Area Statistics (BC67-RA). Washington, D.C.: U.S. Government Printing Office, 1969.

U.S. Bureau of the Census. Census of Business, 1967. Selected Services-Area Statistics (BC67-SA). Washington, D.C.: U.S. Government Printing Office, 1969.

U.S. Bureau of the Census. Census of Business, 1967. Wholesale Trade-Area Statistics (BC67-WA). Washington, D.C.: U.S. Government Printing Office, 1969.

U.S. Bureau of the Census. Census of Manufactures, 1967. Area Studies (MC67-3). Washington, D.C.: U.S. Government Printing Office, 1970.

U.S. Bureau of the Census. U.S. Census of Population, 1970. Number of Inhabitants (PC(1)-A Series). Washington, D.C.: U.S. Government Printing Office, 1971.

U.S. Bureau of the Census. U.S. Census of Population, 1970. General Population Characteristics (PC(1)-B Series). Washington, D.C.: U.S. Government Printing Office, 1972.

U.S. Bureau of the Census. U.S. Census of Population, 1970. General Social and Economic Characteristics (PC(1)-C Series). Washington, D.C.: U.S. Government Printing Office, 1972.

U.S. Bureau of the Census. U.S. Census of Population, 1970. Detailed Characteristics (PC(1)-D Series). Washington, D.C.: U.S. Government Printing Office, 1972.

U.S. Bureau of the Census. U.S. Census of Population and Housing, 1970. Census Tracts (PHC(1) Series). Washington, D.C.: U.S. Government Printing Office, 1972.

U.S. Bureau of the Census. "Employment and Population Changes--SMSA's and Central Cities," Special Economic Reports, Series ES20 (72)-1, U.S. Government Printing Office, 1972.

U.S. Bureau of the Census. County and City Data Book, 1972. Washington, D.C.: U.S. Government Printing Office, 1973.

U.S. Bureau of the Census. U.S. Census of Population, 1970. Subject Reports-Journey to Work (PC(2)-6D). Washington, D.C.: U.S. Government Printing Office, 1973.

U.S. Commission on Population Growth and the American Future. Population and the American Future. U.S. Government Printing Office, 1972.

Vance, James E. "Labor-Shed Employment Field and Dynamics Analysis in Urban Geography," Economic Geography, 36 (July, 1960), 189-220.

Vernon, Raymond. Metropolis 1985. Garden City, New York: Anchor Books, 1963.

Wheeler, James O. "Occupational Status and Work-Trips: A Minimum Distance Approach," Social Forces, 45 (June, 1967), 508-515.

Wheeler, James O. "Residential Location by Occupational Status," Urban Studies, 5 (February, 1968), 24-32.

Wheeler, James O. "Work-Trip Length and the Ghetto," Land Economics, 4 (February, 1968), 107-112.

Wheeler, James O. "Some Effects of Occupational Status on Work Trips," Journal of Regional Science, 9 (1969), 69-77.

Wheeler, James O. "Transportation Problems in Negro Ghettos," Sociology and Social Research, 53 (January, 1969), 171-179.

Wingo, Lowdon, Jr. Transportation and Urban Land. Washington, D.C.: Resources for the Future, Inc., 1961.

Wolforth, John R. Residential Location and the Place of Work. Vancouver, British Columbia: Tantalus Research, Ltd., 1965.

Wolforth, John R. "The Journey to Work," in Larry S. Bourne (ed.), Internal Structure of the City. New York: Oxford University Press, 1971, 240-247.

Yu, Eui-Young. "Correlates of Commutation Between Central Cities and Rings of SMSA's," Social Forces, 51 (September, 1972), 74-86.

Zipf, George K. "The Hypothesis of the 'Minimum Equation' as a Unifying Social Principle," American Sociological Review, 12 (1947), 627-650.