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America's Suburban Centers

A Study of the Land Use—Transportation Link

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REPORT SUMMARY

Research Context and Purpose

Suburban traffic conditions have markedly worsened in recent years. This study postulates that the land use and physical design characteristics of suburban workplaces have directly contributed to the decline in suburban mobility by inducing most employees to drive alone to work. Specifically, it is hypothesized that the low density, single-use, and non-integrated character of many suburban office-commercial centers and corridors, combined with their tendency to provide plentiful, free parking, have compelled many workers to become dependent on their automobiles for accessing work and circulating within projects and these factors, combined with a sharp curtailment in new road construction and meagers levels of suburban transit services, have led to unprecedented levels of congestion. While vehicles generally circulate freely once inside sprawling suburban office compounds, the reliance of most workers on their own automobiles to access job sites has all too often clogged connecting freeways and arterials. The emergence of suburban workplaces with densities equivalent to those of small downtowns, rich mixtures of land uses, pedestrian-friendly environments, and nearby affordable housing, it is argued, could do at least as much to mitigate congestion over the long run as any mix of traffic management or roadway expansion programs, and perhaps far more.

Study Approach

To test these hypotheses, this study relied on land use and transportation data compiled for 57 of the largest Suburban Employment Centers, hereafter abbreviated SECs, in the nation. Data on the density, site design, employment, land use, and workforce travel characteristics of centers with at least one million square feet of office floorspace and 2,000 or more workers were collected for SECs in 26 of the nation's largest metropolitan areas.

A combination of statistical models and cases studies were relied upon in testing the underlying hypotheses of this research. In addition to the national-scale analysis, a disaggregate study of commute choices among suburban workers is also carried out based on a 1986 travel survey of workers in Pleasanton, California, one of the San Francisco Bay Area's fastest growing suburbs. The empirical phases of the study are further embellished by an overview of land use and mobility issues for SECs in the greater Seattle, Chicago, and Houston metropolitan areas, concentrating on such topics as jobs-housing imbalances, site design practices, and the provision of mixed-use, pedestrian-oriented work environments.

Types of SECs and their Characteristics

Because the surveyed SECs were found to be so diverse in terms of land use and employment composition, they were sorted into six fairly homogenous groups using the technique of cluster analysis. The six classes of SECs that were found were: 1) office parks; 2) office centers and concentrations; 3) large-scale mixed-use developments (MXDs); 4) moderate-size mixed-use developments (MXDs); 5) sub-cities; and 6) large-scale office growth corridors.

Based on the threshold values of scale, density, and other land use variables, the six classes of SECs are defined as follows. Office parks are generally master-planned developments under 1,000 acres in size, with exceedingly low floor area ratios and over 65 percent of total floorspace in office use. Office centers tend to be even larger in acreage and floorspace, denser, and architecturally less unified than office parks. Large-scale MXDs are over 2,000 acres in size and as their name implies, they support a wealth of activities (e.g., hotels, shops, theatres), with offices accounting for no more than two-thirds of all space. Moderate-size MXDs are fairly similar in make-up, however they tend to be more nodal in form than large MXDs, encompassing no more than 1,000 acres of land. Sub-cities are veritable downtowns in their own right, except they are relatively new and, of course, on the fringes of large metropolitan areas. Finally, large office growth corridors are expansive stretches of office, light-industrial and spot commercial development along major highway axes, with generally low densities and little coordination of designs among projects.

The 57 surveyed SECs were found to be split fairly evenly among these six classes, with large MXDs accounting for the largest number of cases -- 14, or nearly one-quarter of the sample. Geographically, these projects are spread throughout the U.S., with no one region showing a particular dominance in any one type of SEC.

Differences in Transportation Conditions Among SEC Groups

Through a comparison of differences in the characteristics of work trips among the six SEC classes, the following was found:

* The share of commute trips made in some manner other than driving alone (e.g., carpool, transit) increases as a SEC becomes denser and features a wide variety of land uses. Large-scale MXDs and sub-cities average the highest share of non-solo commuting. This was found to be the case even when the quality of transportation services and other contextual variables were controlled for.

* The incidence of ridesharing is the highest in settings with substantial commercial components, most notably sub-cities and MXDs. The availability of retail activities appears to induce a number of employees to carpool and vanpool to work.

* The share of work trips made by foot is the highest at MXDs, the SEC groups with the highest proportion of multi-family housing units within a three mile radius. This suggests that the availability of moderate-priced housing could be inducing some employees to reside nearby and walk to work.

* Sub-cities appear to have the least degree of peaking of commute trips. This is most likely due to the ability of highly varied land uses to shift commute trips to the shoulders of the peak and to encourage a more even temporal distribution of travel.

* SECs with the slowest average speeds for employee commutes and the most congested local streets and freeways are sub-cities and large-scale MXDs, the two groups with the highest employment densities.

Based on these findings, the three major site variables which appear to influence employee travel behavior and local traffic conditions around SECs the most are density, size, and land use mixtures. The SEC groups with the highest densities have the highest incidences of ridesharing and transit usage, but also the most congested local streets. The paradox of density in suburbia appears to be that in the near term, as long as most employees drive to work, local streets invariably become more congested as activities intensify; however over the long haul, density is necessary to build up a ridership base to sustain transit and ridesharing services. Additionally, ridesharing tends to be most prevalent in large-scale SECs, suggesting that a critical mass of employees is likely necessary for mounting successful vanpool and carpool programs in suburbia. Land use mixing also emerged as an important determinant of travel choice -- those SECs with the greatest variety of activities were found to average the highest shares of non-solo commutes, including walk trips. In tandem, then, density, size, and mixed-development appear to be necessary, though probably not sufficient, prerequisites if reasonably significant levels of ridesharing, transit usage, cycling, and foot travel are to be achieved in suburbia.

Effects of Land Use on Commuting Choices and Traffic Conditions

To specifically test the hypotheses postulated in this research, the direct influences of density, scale, land use mixtures, and jobs-housing balances on mode choice and local traffic conditions were tested. The following was found:

Density -- Employment densities were found to influence local traffic conditions more than any single factor. High density SECs average the slowest employee commutes and the worst levels of service on connecting freeways and arterials. Additionally, high densities are positively correlated with high shares of ridesharing, transit usage, and pedestrian travel. High density SECs also generally have relatively low levels of parking supply, a factor which also reduces the share of solo-commuters.

Size and Scale -- The size of SEC activities was found to influence both local traffic conditions and mode choice. SECs with expansive floorareas average the poorest levels of service on connecting freeways and arterials. Large developments also tend to experience greater peaking of employee arrivals and departures. Large-scale employers, on the other hand, are generally more successful in winning their workers over to carpools and vanpools. Buildings occupied by single-tenants, moreover, generally have relatively high shares of carpoolers and vanpoolers.

Jobs-Housing Balances -- SEC settings with a more even balance of jobs and housing tend to have less congestion on connecting roadways, possibly because conflicts between SEC-oriented trips and other through travel are reduced. Jobs-housing mismatches appear to be most common in areas with large shares of employees in clerical, sales, and other moderate-salary positions. Nearby housing in these settings also tends to be relatively expensive. On the whole, it appears that appreciable numbers of clerical and service-industry workers in many SEC settings are prevented from residing near their workplaces and end up driving to work alone as a consequence.

Overall, the hypotheses posited in this research appear to be borne out by the empirical findings. However, changes in site designs, land use mixtures, and densities, in and of themselves, will not bring about dramatic shifts in commuting behavior, at least not in the near term. In tandem with broad-based programs to manage traffic congestion, such as staggered work hour initiatives and new road construction, it is felt that the design of higher-density, more mixed-use suburban workplaces with nearby affordable housing could yield substantial mobility dividends in the long run.

Three Case Studies

Suburban land use and transportation issues in the greater Seattle, Chicago, and Houston areas are also highlighted in this study. These three cases provide a representative cross-section of suburban development and mobility issues currently being grappled with in the United States. The case study of Bellevue in the Seattle area suggests what can be achieved when suburban centers are transformed to places where people take priority over the automobile. Parking containment has been an integral part of Bellevue's concerted program to create a pedestrian-friendly downtown. Bellevue's system of density bonuses has also been instrumental at encouraging private sponsorship of pedestrian amenities, such as public squares and street-level retail functions. While many of Houston's suburban centers have densities that match Bellevue's, foot travel tends to be less frequent in these places mainly because the long spacing between buildings and abundance of surface parking invites car traffic.

Nonetheless, Houston's high suburban employment densities and mixed-use environs have enticed many workers to commute via vanpools and bus transit. Finally, the Chicago case emphasizes the importance of careful site planning and jobs-housing coordination in areas experiencing strip-like development of office parks, shopping malls, and freestanding buildings. Shortages of affordable housing near some of Chicago's suburban office corridors have displaced some workers, setting the stage for long-distance freeway commuting.

Overview of Research Findings

Both the national level analyses and the three case studies support the underlying hypotheses of this research. SECs with the smallest shares of work trips made by the private automobile are generally dense and varied in their land use make-up. Large-scale MXDs and sub-cities, such as Bellevue and Post Oak in Houston, were found to have particularly high shares of their workers commuting via carpools, vanpools, and buses. On-site and near-site retail services, like restaurants, shops, and banks, are especially important if suburban workers are to be lured out of their cars. Where such activities are absent, many workers find it necessary to drive in order to have a car handy for running midday errands, meeting a colleague for lunch, or cashing a check. Mixed-use environments also allow parking to be reduced through shared-parking arrangements (e.g., office workers use parking set aside for theater-goers in the evening). Reductions in surface parking, in turn, can shrink the dimensions of a project so as to make walking more attractive.

Many suburban office projects were found to be insensitive to the needs of pedestrians, cyclists, and transit users. Site layouts that segregate buildings and land parcels manytimes create prohibitively long walking distances. Most corridors of unrelated office projects have disconnected series of sidewalks surrounded by indistinguishable spaces. The combination of wide setbacks and separate access roads, moreover, discourage the entry of transit vehicles into these properties. Where foot travel and transit usage are relegated to a second-class status, to no surprise, solo-commuting predominates. While spacious site designs enable vehicles to circulate freely once they are inside an office compound, thoroughfares which serve these developments are all too often saturated by vehicles hauling a single occupant. Many office complexes with the best on-site circulation suffer the worst off-site congestion.

Two other sources of worsening suburban congestion have been the abundence of free parking and widening jobs-housing mismatches. The provision of of free, convenient parking zoned at more or less one space per employee is an open invitation for most suburban workers to drive to work. Those centers where parking is restricted and prices are charged consistently achieve the highest rates of vehicle-pooling and transit usage. The jobs-housing imbalance problem has been a significant source of the freeway congestion encountered upstream and downstream from major suburban job centers. Growing numbers of non-professional workers are being forced to live distances farther than they might otherwise because of the relatively high cost of housing near many suburban centers. In general, SECs with the most expensive nearby housing average the highest shares of moderate-salaried service-industry workers. The farther away these workers live, the greater the likelihood that suburban freeways will become congested since more miles are logged by more people on the same few beltloops and thoroughfares.

All of these influences, of course, do not operate independently of one another. Most suburban workplaces with low densities, for instance, also tend to have a single dominant use and bountiful free parking. Increasing densities while retaining a surfeit of parking will likely only worsen congestion as more workers descend upon the same work area each morning. Higher densities, alone, will normally heighten congestion around suburban workplaces in the near term. In tandem with market-rate parking fees and mixed-use development, however, densification is apt to make transit and ridesharing attractive enough so as to eventually bring about a net reduction in ambient levels of congestion.

Institutional, Regulatory, and Site Design Initiatives

A host of public and private sector initiatives could be introduced to more closely coordinate transportation and land use decisions around SECs. Two legislative reforms which would reduce fiscal competition among communities and promote balanced job and housing growth are tax-base sharing and fair-share housing requirements. Possible regulatory measures that could enhance suburban mobility by encouraging higher densities and more mixed-use development include performance zoning, inclusionary zoning, conditional use zoning, and incentive zoning. Transfer development credits and zoning swaps, moreover, could redistribute densities and uses so as to achieve more balanced growth. Other strategies for increasing density and reducing project scale include zero-lot line platting, lower right-of-way requirements, reduced parking space dimensions, and share-use parking arrangements in mixed-use developments.

A number of site planning principles should also be embraced when designing the suburban workplace of the future. Suburban office developments should have a well-defined, centralized core with people-oriented activities, such as restaurants and shops. Buildings, moreover, should be sited in close proximity to one another and setbacks should be restricted so as to shorten walking distances and invite pedestrian movements. To encourage transit patronage, roadways within SECs should be highly interconnected, avoiding branching access roads and cul-de-sacs which require buses to retrace their path on the way out. Terminals stops, bus connections points, and staging areas should also be designed so as to make transit, vanpooling, and carpooling as convenient and well protected from the elements as possible.

Initiatives that could help contain parking include: the switch from minimum parking floors to maximum parking ceilings; the design of parking structures to allow future alternative uses in the event parking demand diminishes; in-lieu of provisions which enable employers to substitute vanpools and other commuting alternatives for parking stalls; and ordinances which allow mixed-uses to share their respective parking facilities, thus modulating total parking supplies.

Finally, mixed-use developments and greater jobs-housing balance could be achieved in a number of ways, including the introduction of performance standards in zoning ordinances which hold developers accountable for the traffic impacts of their projects and which reward them for diversifying their developments. Tax-exempt municipal bonds could also be issued to finance affordable housing additions near suburban work centers. Additionally, linkage programs might be considered which require office developers to build some housing to meet the needs of their tenants' workers. The amount of commercial and office floorspace for which building permits are issued in any one year could also be indexed to how much housing was built the prior year. Such programs would bring about the kinds of balanced, moderate-density, mixed-use developments which would safeguard suburban mobility for years to come.

Preface

After completing a book several years ago, titled **Suburban Gridlock**, I became convinced that marked changes in how suburban workplaces are designed and built are absolutely essential if regional mobility is to be safeguarded in coming years. This initial research into suburban transportation issues suggested that the low-density, single-use character of most suburban work centers was a root cause of many of the congestion problems being faced in suburbia. While vehicles tend to circulate almost effortlessly once inside most suburban office parks and developments, roadways leading to them are all too often jammed because of the preponderance of automobiles with a single occupant in them. Thus, what we have witnessed during the 1980s is the construction of spacious, nicely landscaped suburban work settings that have had the unfortunate consequence of compelling most workers to commute alone, clogging up regional thoroughfares in the process.

To explore the extent to which this is true, I sought to carry out an empirical-based study of the relationship between the physical design characteristics of suburban workplaces and the commuting choices of their workforces. This work represents the results of that effort. The research would not have been possible without the generous contributions of a number of organizations and individuals. Foremost, my thanks goes to the Office of Budget and Policy of the Urban Mass Transportation Administration for their financial backing of this study. I am particularly indebted to Kenneth Bolton and Rob Martin for their inputs in both conceptualizing this study and revising earlier drafts. I also owe a debt of gratitude to the Rice Center for Urban Mobility Research for both administering the grant for this research and furnishing me with volumes of background materials that went into the analysis. Gary Brosch, Jon Martz, David Hitchcock, and Philip Loukisas of the Rice Center all provide valuable assistance during various phases of the research. I also thank Bob Dunphy of the Urban Institute for making numerous reports and data sources available to me at the outset of the study. Finally, numerous individuals associated with the case sites used in this study, including developers, business association staff, local planners, and private employers, provided data, reports, and other support materials which allowed this research to be conducted. All were generous with their time and shared their many insights on a host of suburban mobility and growth issues. Without their assistance and interest in the topic, this work could never have been completed.

Robert Cervero
April 1988

CHAPTER ONE

Introduction: Suburban Office Growth and Congestion

1.1 Study Purpose

Suburban traffic congestion has received considerable attention during the 1980s. A flurry of articles, reports, and media accounts have identified suburban congestion as one of the most pressing problems in the transportation field today and, most probably, one that will hold center stage in the transportation policy arena for years to come [Cervero, 1984, 1986B; Dunphy, 1985; Leinberger and Lockwood, 1986; Orski, 1986A, 1987]. To date, most research on the topic has focused on the economic and demographic forces that have given rise to worsening suburban traffic conditions as well as the most promising demand management and funding programs for preserving regional mobility.

The one area where there has been far less research and where a considerable knowledge gap remains is the relationship between suburban development patterns and mobility. More specifically, how the size, scale, density, and land use make-up of suburban office and commercial centers affect the travel choices of their tenants' employees as well as areawide traffic conditions remains unclear and, at best, is treated in the literature mainly through anecdotes. Since transportation is a derived demand (i.e., people travel in order to access activities occurring in different places), transportation scholars have long argued that coordinated land use planning offers the most effective and enduring basis for improving mobility over the long run. And since congestion is largely a problem associated with the peak-period, commute trip, the spatial proximity of residences and workplaces can have a particularly strong bearing on suburban travel patterns and traffic conditions. Accordingly, this study probes the relationship between development patterns, land uses, and travel conditions of suburban job centers, and based on its findings, recommends land use practices and policy initiatives that are most consonant with high levels of regional mobility.

Since suburban congestion has been most acute around large employment centers, this report concentrates mainly on the linkage between mobility and commercial-office development. This linkage is examined for major suburban office centers and corridors in America's largest metropolitan areas, with primary attention given to how the travel choices of workers and local traffic conditions are influenced by the following site characteristics: 1) employment densities; 2) site designs; 3) land use composition, particularly the level of mixed-use activities; 4) suburban levels of jobs-housing balance; 5) land lotting and ownership patterns; and 6) parking provisions. Only through a better understanding of how these factors, both singularly and collectively, shape the travel choices of suburban workers can meaningful land use measures be introduced to safeguard mobility and head off, what some forewarn, could be an impending suburban congestion crisis.

1.2 Hypotheses

The central proposition of this study is that congestion problems and declining mobility are inescapably linked to the emerging land use environment of suburban employment areas. Specifically, it is hypothesized that the low density, single-use, and non-integrated character of many suburban office-commercial centers and corridors, combined with their tendency to provide plentiful, free parking, have compelled many workers to become dependent on their automobiles for accessing work and circulating within projects and these factors, combined with a sharp curtailment in new road construction, have contributed to unprecedented levels of congestion. Many suburban work settings, it is argued, are designed principally for private automobile access and circulation and, consequently, are insensitive to the needs of pedestrians, cyclists, buses, and other commute options -- what some critics have called "transit hostile" environments. Severe jobs-housing imbalances in many outlying growth areas, moreover, are also thought to be a root cause of growing auto-dependency and, as a result, worsening congestion. The emergence of suburban workplaces with densities equivalent to those of small downtowns, rich mixtures of land uses, and near-site affordable housing, it is postulated, could do at least as much to mitigate congestion over the long run as any mix of traffic management or roadway expansion programs, and perhaps far more. The analyses which follow attempt to test the soundness of these propositions, relying on a balance of statistical investigations and case analyses. As a prelude, the next two sections of this introduction offer an overview on suburban growth and congestion issues in the U.S. and a chapter-by-chapter outline of the remainder of the report.

1.3 Suburban Growth and Congestion

<u>The Office Boom</u>

The migration of traffic jams to the suburbs has followed on the heels of what some have called America's "third wave" of suburbanization. The first wave involved the mass movement of middle-class and upper-income residents to the outskirts of cities throughout the 1900s in search of spacious living conditions and detached, single-family homes. The construction of inter-urban streetcar lines and modern motorways literally paved the way for this exodus [Warner, 1962; Adams, 1970]. The second wave of decentralization, which occurred primarily during the three decades following World War II and continues today, witnessed the migration of commercial and industrial activities to the outskirts, attracted to the vast reservior of potential consumers and workers living in the suburbs. The opening of massive indoor shopping malls and the emergence of commercial strips and industrial parks along axial motorways perhaps best characterized this transformation of America's suburbs from predominantly bedroom communities to more urban-like places.[1]

The third wave of suburban expansion -- the arrival of workers, particularly those in the office and high-technology sectors -- has brought many American suburbs full circle. With the addition of a day-time workforce population, many suburbs have become virtually indistinquishable from traditional urban centers, featuring a mosaic of places, from office towers and executive parks to fern bars and performing arts centers. No longer do Americans vacate suburbs each morning; today's suburbs have become primary destinations themselves. Unfortunately, suburbs have also suffered many of the ills that accompany maturation, most notably traffic congestion.

The pace of suburban employment growth has been phenomenal. In 1980, 57 percent of all office space in the U.S. was located in urban centers and 43 percent in the suburbs; by 1986, the situation was reverse -- 60 percent was in the suburbs, compared to 40 percent in cities [Pisarski, 1987; Office Network, 1987]. Attracted by cheaper land, closer proximity to regional airports, smart buildings laced with fiber optic cables and advanced telecommunications equipment, and country-like amenities, the overwhelming majority of the nation's high-technology firms today have chosen a suburban address [Urban Land Institute, 1986; 1987]. Many firms in the financial/insurance/ real estate (FIRE) sectors, one of the nation's fastest growing, have likewise opted for the suburbs, moving their back office and clerical workers to branch facilities that are hooked up to the main offices via telephone lines and satellites. Low land prices and the availability of pools of (primarily female) second wage-earners have been the primary lures attracting FIRE firms to the fringes [Dowall, 1987; Kroll, 1986; Urban Land Institute, 1986].

While the suburban office boom has been most pronounced along the America's sunbelt crescent [Cervero, 1986B], the trend has been truly nationwide in scope, occurring even in older industrial areas. In greater Philadelphia and St. Louis, for instance, suburban employment grew by 8 and 17 percent respectively between 1982 and 1986, contrasted with a loss in central city jobs over the same period [Orski, 1986A; Urban Land Institute, 1987]. Office decentralization has also been swift in New England, the region of the country enjoying the healthiest economic growth over much of the 1980s. As shown in Figure 1.1, the suburbs' share of the total office market in the greater Boston area rocketed from 20 percent in 1979 to 60 percent in 1986, an average annual gain of over five percentage points.

The physical appearances and make-up of suburban employment areas are as diverse as the types of businesses and activities that are locating in them. Some of the larger, nodal developments have been varyingly referred to as suburban downtowns, urban centers, and megacomplexes -- clusters of office and commercial development that resemble the downtowns of many medium-sized cities in both scale and density [Leinberger and Lockwood, 1986; Orski, 1986A, 1987]. Notable examples are Tysons Corner in northern Virginia, Las Colinas west of Dallas, and South Coast Metro in Orange County, California. While traditional downtowns have evolved gradually, allowing a buildup of road improvements over time, these suburban downtowns have sprouted in as few as five years, often overloading the local infrastructure. All too frequently, these "instant downtowns" have produced "instant congestion".

At the other end of the workplace spectrum has been master-planned office parks, ranging from small business compounds to massive expanses of low-lying office buildings spread over 500 acres or more, such as Bishop Ranch east of San Francisco and Technology Park northeast of Atlanta. Many business parks resemble modern college campuses, designed to provide a premium, rural-like work environment for high-skilled, professional workers. Most are characterized by nicely groomed landscapes, glass-textured buildings with impressive atrium entrances, plentiful parking, and employment densities that are a fraction of those found downtown. While traffic often flows freely once inside these spaciously designed premises, the convergence of thousands of motorists driving to and from these parks has jammed connecting arterials and freeways in many instances.

Suburban job growth has also been less nodal and focussed, situated instead along suburban corridors -- generally loosely organized strips of freestanding office buildings and retail complexes, typically aligned along axial freeways and arterials. Most of the better-known corridors are host to some of the nation's most prestigious high-technology firms. Notable among these "silicon strips" are the "Princeton Zip Strip" in central New Jersey (Route 1), the Sunset Corridor west of Portland, Route 128 encircling Boston, and the Silicon Valley north of San Jose (Route 101) [Fulton, 1986B]. While the traffic impact of individual projects along these corridors tend to be modest, the cumulative effects of numerous unrelated projects have frequently clogged up areawide thoroughfares.

Still another form of suburban development that has gained recognition is megacounties -- massive, often amorphous, swaths of urban-like growth that has leaped over to once-tranquil counties ringing major urban centers, such as Gwinnett County northeast of Atlanta, DuPage County west of Chicago, and Oakland County north of Detroit. In the case of Oakland County, 40 percent of all of Michigan's job growth between 1982 and 1986 occurred there, spread fairly evenly throughout the county [Church, 1987]. This countywide version of

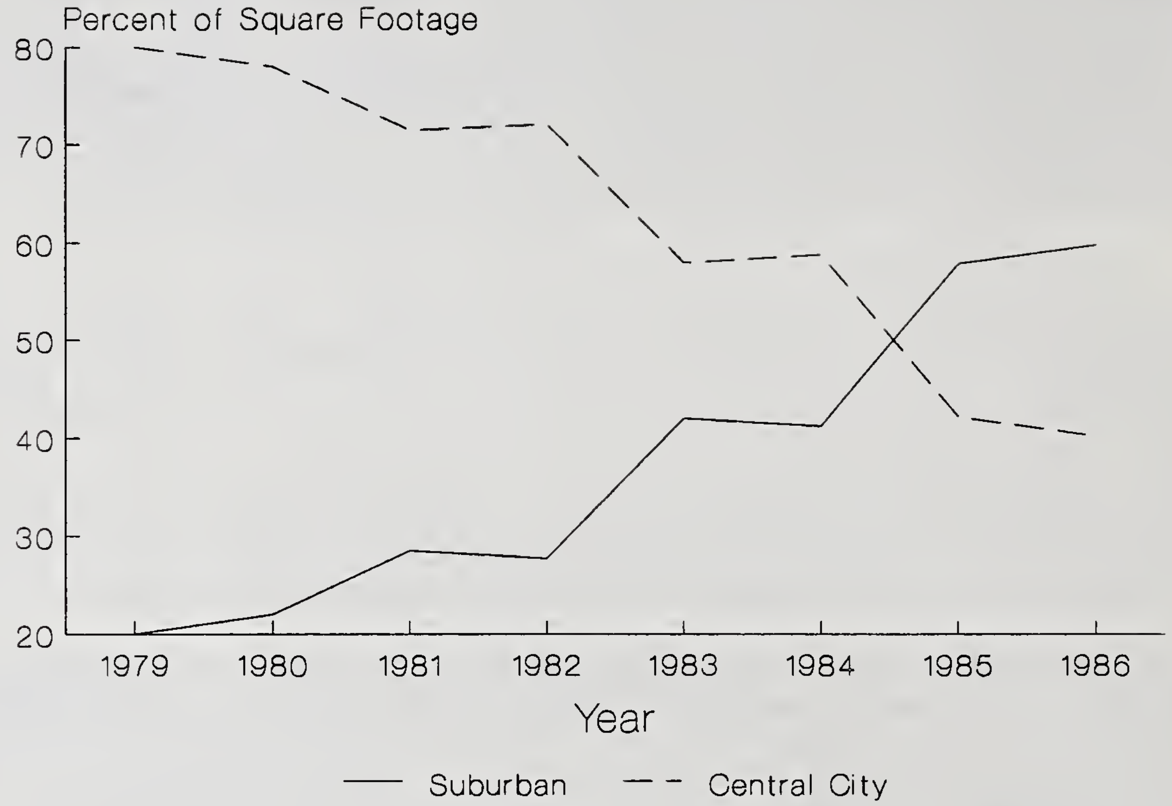


Figure 1.1 **Comparison of Office Growth in Boston Area Suburbs and Central City, 1979-1986.** Source: Robert Charles Lesser & Company [1987].

urbanization has often overwhelmed secondary roads that only five or ten years earlier functioned as leisurely farm-to-market roads.

The Traffic Boom

Job dispersal has had a profound affect on commuting patterns during the 1980s. No longer focussed on a single downtown, America's metropolises have far more complex patterns of travel than ten or fifteen years ago. For most urbanized regions, a pathwork of criss-cross and lateral movement streams has replaced radial commutes as the dominant pattern. National statistics confirm this. Between 1960 and 1980, the share of work trips which began and ended in the suburbs increased from 30 percent to nearly 42 percent within U.S. metropolitan areas larger than 250,000 population [Fulton, 1986A]. In greater Boston, Detroit, St. Louis, and Pittsburgh, nearly two-thirds of work trips today take place wholely within suburbs.

This trend does not square well with the nation's urban highway and transit networks, most of which are of a hub-and-spoke variety, designed to funnel commuters downtown. Those making lateral and cross-town journeys are all too often forced onto secondary arteries and ring roads that were never designed or oriented to serve large volumes of traffic. Circuitous trip-making and clotted arteries have resulted. This trend bodes unfavorably for mass transit as well since buses and trains are poor substitutes for the automobile when trips ends are dispersed. In 1980, only 1.6 percent of all suburb-to-suburb work trips were made via public transit [Fulton, 1986A].

Traffic is spreading out not only spatially, but temporally as well. Stop-and-go conditions can be found throughout the day in many areas. Dallas's North Central Expressway, Chicago's Dan Ryan Expressway, Los Angeles's Ventura Freeway, Washington's Beltway, and the Long Island Expressway are frequently as jammed during the noon hours as they are at 7:30 a.m. and 5:30 p.m. [Orski, 1986A].

Within limits, one should be reminded, traffic congestion is desirable -- a sign that a region is economically vibrant and has refrained from overinvesting in highways. And, of course, congestion is relative -- residents of Manhattan, Kansas City, and Boise perceive congestion quite differently. Recent public outcries and the rash of initiatives to halt growth, however, suggest that congestion in the 1980s has exceeded acceptable limits and may indeed be approaching the intolerable. From 1975 to 1985, the share of rush hour freeway traffic in urbanized areas that flowed under 35 m.p.h., what traffic engineers consider to be congested, increased from 41 percent to 56 percent [Lindley, 1987; U.S. Department of Transportation, 1985]. In over a dozen metropolitan areas across the country, public opinion polls indicate that traffic congestion is viewed as the number one urban problem. In the San Francisco Bay Area, residents have cited congestion as the worst public menace for five years straight, outdistancing its closest rival -- air pollution -- by more than two-to-one. Such widespread dissatisfaction reflects the fact that congestion now afflicts nearly all metropolitan commuters to some degree -- whether headed downtown, reverse-commuting, or traveling on a secondary, county road. While only a decade ago congestion was the scourge of downtown commuters, today it is pandemic, pervading the freeway networks of most American metropolises.

The mounting congestion crisis poses a grave threat to the high standard of mobility that Americans have long cherished and taken for granted as well as a threat to continued economic growth in many regions of the country. Infuriated by traffic's ever-increasing presence, more and more suburbanites are insisting that future commercial and office growth be regulated, be it through downzoning, moratoria on the issuance of building permits, or height restrictions placed on new buildings. In California, 47 growth control initiatives were placed before voters in 1986 alone, of which nearly two-thirds passed [Cervero, 1988]. Along Boston's Route 495, restrictive zoning by-laws in many towns have restrained housing construction and driven up prices. Because such measures tend to push growth elsewhere in the region, quite often farther out along the urban periphery, and because increases in traffic headed to surrounding communities frequently clog these places regardless, some argue that efforts to control growth at a municipal level are doomed for failure [Work, et al., 1987; Cervero, 1986B]. The battle to halt suburban growth will no doubt intensify in coming years, with traffic being the dominant issue around which battle lines are drawn.

1.4 Study Outline

In this study, both statistical and interpretative approaches are used in examining how the site and physical design characteristics of suburban workplaces influence travel behavior and local traffic conditions. Much of the empirical work is based on land use, employment, and travel data compiled for over fifty of the nation's largest suburban employment centers. This national-scale analysis is supplemented by a more disaggregate study of worker travel behavior for employment centers in Pleasanton, California, one of the fast growing suburbs in the San Francisco Bay Area. The empirical phase of the study, moreover, is complemented by several case studies, based on the results of site visits, interviews with developers and public officials, and literature reviews. Various policy issues and competing theories related to land use and transportation in suburbia are interwoven throughout the analysis.

The report is divided into seven remaining chapters. The second chapter describes the research methodology and data sources in more detail and sets forth definitions for a number of terms applied throughout the analysis. In the third chapter, the land use, site development, employment, and transportation characteristic of 57 of the largest suburban employment centers in the United States are summarized. This chapter also reviews the literature and cites empirical findings on the land use and development characteristics of suburban work centers. Various policy topics on land use and mobility are also discussed.

The forth and fifth chapters of the report are devoted to classifying these employment centers into one of six homogenous groups based on clustering techniques and examining variations in site, land use, employment, and transportation characteristics among these groups. Chapter Four reviews past work on metropolitan growth, presents the results of a cluster analysis, and describes several employment centers within each classification group. Threshold ranges on the size, density, site, and land use features of each group are also presented. Chapter Five follows this with a detailed analysis of the degree to which site, employment, and travel characteristics vary among the groups, based on both statistical tests and a variety of charts and figures.

The report's sixth chapter subjects the hypotheses presented in section 1.2 to statistical tests. Specifically, the influences of various site, land use, and density characteristics on mode choice, average speeds, level of service, and other mobility indices are examined and empirically tested. Overall policy inferences are drawn from these test results.

The seventh chapter embellishes the empirical phase of the study by presenting an overview of land use, development, and mobility issues for suburban employment centers in the Chicago, Houston, and Seattle areas. Such topics as jobs-housing imbalances, site design practices, and growth management are covered.

The concluding chapter presents policy options for designing future suburban employment centers with mobility concerns in mind. Examples of higher density, mixed-use projects that seem to be offering mobility payoffs are highlighted. Institutional and legislative remedies that might be introduced for synchronizing job and residential growth in suburban areas are also discussed.

Notes

1. For a fuller discussion of this process, see: Masotti and Hadden [1973] and Hartshorn and Muller [1986].

CHAPTER TWO

Probing the Suburban Land Use - Transportation Link: Definitions and Research Methodology

2.1 Defining Terms

The proliferation of terms used to describe concentrations of suburban employment and activities has given rise to a rather loose set of jargon, found in the press and research literature alike. This section defines key terms used throughout this report. It is followed by a discussion of the methodologies and data sources used in carrying out the empirical phases of this research.

Suburban

The distinction between what is "suburban" and what is "urban" has blurred in recent years. In many cases, political boundaries are used to distinquish suburbs from central cities, even though activities on both sides of the boundary may be virtually identical. Some employment centers are on the metropolitan fringes and have distinct suburban characters, while others are in more mature, inner-tier areas. Perimeter Center (a mid-rise office complex and regional shopping center north of Atlanta) is an example of the former while Bethesda's cluster of offices around its Washington Metro station represents more of the latter. Still other clusters function more as satellites, straddled between two or more central cities. The Research Triangle, for instance, lies approximately 15 miles west of Raleigh, North Carolina and operates more as a satellite employment center than as a suburb of the Raleigh-Durham-Chapel Hill metropolitan area. Perhaps the common feature all of these centers share is that they are "Non-Central Business District", or "Non-CBD", locales. Partly for convenience, the term "suburban" is used in this report. It is used loosely, however, and is meant to suggest the location of any land activity outside of a regional CBD, generally at least five or more radial miles away.[1]

Centers versus Corridors

Another distinguishing characteristic of suburban agglomerations is whether they are nodal clusters of development (i.e., centers), or linear strips (i.e., corridors) [Baerwald, 1982]. Clusters, or centers, tend to be more well-defined, focussed concentrations of development, often with relatively high densities and a mixture of land uses. They are generally surrounded by a traditional pattern of low-density, homogenously zoned development, such as tract residential housing. Corridors, on the other hand, can generally be thought of as a series of pod-like developments that straddle one or more major thoroughfares, akin to a string of pearls, and that function independently of one another. Some concentrations are more or less hybrids of the two. Where possible, this report will refer to suburban developments as either centers[2] or corridors.

Employment Centers

The phrase that has gained currency for describing a large-scale, mixed-use concentration of urban or suburban development is "activity center". To be considered a major activity center in the greater Washington, D.C. area, Christopher Leinberger of the firm Robert Charles Lesser & Company used the following five-prong criteria:

* The area must have at least 5 million square feet of development;

* The area must have at least 600,000 square feet of retail space;

* The area must have more people commuting into it than out of it each morning;

* The area must have more jobs than housing; and

* The area must be perceived by the public as "having it all" -- being an end destination for mixed use: entertainment, shopping, and jobs.

Based on these criteria, Leinberger identified thirteen suburban activity centers in the greater Washington, D.C. area, with Tysons Corner, Rockville/Gaithersburg, Rosslyn/Ballston, and Crystal City forming the largest ones [Garreau, 1987].

In the analysis of major growth centers in the Houston area, the Rice Center [1987, p. I-1] also adopted the phrase "activity center", which is defined as "major employment concentrations located outside of the Central Business District". Twenty-two activity centers were identified based on employment, density, land uses, and other factors. Centers ranged in size from 1 to 15 million square feet of building space, 900 to 7,500 acres of land aea, and 60,000 to 100,000 residents. Outside of downtown, the three largest activity centers in the Houston area were Post Oak (purported to be the nation's largest non-CBD center), Greenway Plaza, and the West Houston Energy Corridor.

A study by the Atlanta Regional Commission [1985, p. 5] defined activity centers as "areas with more than 7,500 jobs in contiguous census blocks that have an identifiable relationship". This simpler definition resulted in seventeen activity centers (including downtown) being identified in the Atlanta region, ranging in size from 1,011 acres (CBD) to 48,536 acres (Fulton Industrial District) and in employment from 7,920 (South Lake Mall) to 94,135 (CBD).

While these and other studies have adopted the "activity center" naming convention, in this study the term "employment center" is used in order to convey the idea of a massing of workers. While most major centers support retail and other uses, it is their employment base, and more specifically office jobs, that are their dominant feature and that contributes most directly to peak-period traffic problems. Since congestion occurs principally in rush hours and is thus connected with the journey-to-work trip, using the term "employment" rather than "activity" in qualifying these centers seems preferrable. As defined by the Institute of Transportation Engineers [1976], "activity centers" can also include regional shopping centers, university campuses, medical centers, airports, major recreation centers, and sports stadia. Travel to many of these centers generally occurs outside of traditional peak periods, even though roads leading to them are quite often congested. To use the more generic term "activity center", then, would encompass a wide range of places outside of CBDs and obfuscate the purpose of this study -- to focus on mobility and land use relationships in areas of massive suburban employment growth.

In light of the above, the phrase "Suburban Employment Center", abbreviated SEC, is used throughout the remainder of this report. As noted above, distinctions should also be made between centers and corridors. Thus, the SEC abbreviation is used to represent both "suburban employment centers" and "suburban employment corridors".

The minimum thresholds used in selecting SEC case sites are described in the next section and Chapters Three and Four. All of the SECs examined in this study had at least 2,000 employees and one million square feet of office floorspace, which under this definition, would have included most of the "activity centers" selected for Washington, D.C., Houston, and Atlanta in the above-cited studies.

Land Use

Land use generally refers to "how land is put to use" -- that is, whether it is employed for residential, commercial, industrial, open space, or some other purpose [Chapin and Kaiser, 1979]. Virtually all travel is inextricably tied to land use. With the exception of Sunday excursions and perhaps teenage joy-riding, few motorized trips occur for the simple pleasure of driving. Rather, people make trips to access places in order to satisfy personal and social objectives, be it earning wages, visiting a doctor, or attending a sports event. How these places are developed and designed -- their densities, mixture of uses, site layout, parking provisions, and so on -- sets the stage for virtually all commuting behavior.

In this report, the term "land use" is employed fairly liberally. It refers to all aspects of the built environment of a SEC -- its density, composition of activities, scale, layout, and physical design. Thus, under this broader definition, the "land use-transportation link" is meant to convey how various site features, including density and design, influence mobility, not just the composition of land activities.

2.2 Methodology

Since many of the nation's SECs are relatively new, some having evolved only within the past ten years, land use and transportation data on them tend to be fairly sparse. Because most of the hypotheses tested in this study relied upon empirical data, a national data base of selected land use, employment, and transportation variables was built. In all, 57 SEC case sites were sampled. This and other data sources used in this study, along with the general research design, are described below.

Case Selection and Data Sources

Because suburban traffic congestion is most acute around the largest SECs in the country, the sample frame for this study was SECs: 1) of at least 1 million square feet of office floorspace; 2) with 2,000 or more workers; and 3) located at least 5 radial miles away from the regional CBD. Through an initial review of the literature and various publications available from the Urban Land Institute [1984; 1987], the Office Network [1987], and other primary sources, it was found that most SECs meeting these minimum thresholds were from Metropolitan Statistical Areas (MSAs) with 1980 populations exceeding one million, which numbered 39 in all. Because of the national prominence of some SECs, such as the Research Triangle in central North Carolina, as well as the availability of nearly complete data for these places, case sites from several smaller MSAs were also included. Thus, the sampling frame consisted of potential SECs in the 39 largest MSAs in the country plus several others from smaller MSAs that were known to have reasonably complete data.

The major factor constraining the choice of case sites was the availability of data on the travel characteristics of an SECs workforce. In most cases, only 1980 journey-to-work census data were available for the tract or tracts most closely corresponding to an SEC. Data on land use and employment characteristics of SECs, however, were usually more recent, generally available for the 1985-1987 time frame. Because many SECs were only in their embroyonic stage of growth in 1980, and in order to ensure data were longitudinally consistent, cases were generally eliminated from consideration if only 1980 journey-to-work data were available. In several instances, regional transportation planning agencies had updated 1980 travel data to 1985 or later, enabling these cases to be included in the analysis.

One notable difficulty that was faced was defining the geographic boundary of each SEC. In some cases, such as for master-planned developments, new-towns, business parks, and planned urban developments (PUDs), boundaries were clear, corresponding to the property lines of the project. In other instances, in particular large-scale corridors, boundaries were not easily delineated. In these cases, the boundaries defined by local or regional planning authorities (often as a specific study area) and local business associations[3] were generally adopted. In general, the SEC boundaries corresponding to the territories for which relevant data were most readily available were used in this study.

The actual instruments and sources used to compile relevant data included a questionnaire, land use and transportation inventories maintained by both local agencies and by national associations, various published and unpublished documents and reports, and primary data collected locally through site visits and field surveys. Where not available from questionnaire responses, land use and employment data (e.g., floorspace, housing units, employment densities, and work force composition) were obtained from inventories and publications provided by the Urban Land Institute[4], the Rice Center[5], the Office Network[6], local and national real estate firms, private developers, corridor and business associations, chambers of commerce, city and county planning agencies, and metropolitan planning organizations (MPOs). Land use data were also compiled from a number of monthly real estate publications, such as National Real Estate Investor (City Review section), Real Estate Forum, and Real Estate News (available for four different regions of the country).

Data on the travel characteristics of SEC workers were obtained from reports and summaries provided by developers, business and property-owner associations, and local transportation planning agencies. Information on traffic volumes, average travel speeds, and levels of service for major arterials and freeways serving SECs were obtained from local traffic engineering departments. And most of the data collected on regional travel characteristics were obtained from various publications by the U.S. Bureau of Census [1982] and the Federal Highway Administration [Briggs, et al., 1986; Klinger and Kusmyak, 1986; and Rodriquez, et al., 1985].

Survey Instrument

For supplementing the data mentioned above, two different questionnaires were designed, pre-tested, and administered. Appendix I shows the questionnaire sent to "centers", in general well-defined, master-planned projects for which preliminary investigations revealed fairly extensive data were available. Another form, a more abbreviated version of the former, went to "concentrations", in general clusters of several independent projects and defined corridors.[7]

After candidate sites within each metropolitan area were identified, a reconnaissance investigation was conducted to determine which agencies and individuals were best suited for responding to the questionnaire. Individuals were queried over the telephone to find out the general availability of relevant data and to assess their willingness to participate in the study. In most instances, three or more individuals filled out a questionnaire for each SEC, providing information only for those questions for which reliable data were available. A typical case was a developer providing responses to questions on land use and employee travel characteristics of his or her project, staff of a business association furnishing information on density and square footage of a corridor, and local transportation planners completing the survey for those questions regarding areawide traffic conditions. By obtaining multiple responses from different informants, it was possible to cross-check many responses for internal consistency.[8]

The questionnaire shown in Appendix I elicited the following basic information:

* Scale and Locational Characteristics -- total acreage, square footage, miles to CBD;

* Employment Characteristics -- current employment, work force composition;

* Density and Design Characteristics -- floor area ratios (FAR)[9], average building heights and lot sizes, and project design philosophy;

* Land Use Characteristics -- composition of land uses, number of on-site housing units and retail centers, and mean single-family home purchase price within a three mile radius of the development;

* Land Ownership Characteristics -- number of property owners and percent of land owned by companies and firms;

* Workforce Travel Characteristics -- mean travel time, modal splits, and time distributions of travel;

* Site and Areawide Transportation Facilities, Services, and Conditions -- level of service of principal freeway serving the SEC, parking spaces per employee, and number of company-sponsored vanpools operating.

Questionnaires were sent out in mid-August, 1987 and returned by mid-October, 1987. Informants were asked to furnish information as of mid-1987 or for whatever time period the latest data were availability. While some responses were for different years, in the vast majority of cases responses were for either 1986 or 1987, and in no case was there more than a three year difference in the period of responses.

Data Base Cases

In all, questionnaires were mailed to informants from 88 different SECs which met the minimum size and locational threshold requirements and for which preliminary inquiries suggested fairly complete data might be available (most notably, the existence of recent employee travel data). Call-backs were made to clarify questions and increase the response rate. In all, at least one questionnaire was returned for 79 of the candidate sites, for an initial response rate of almost 90 percent. However, reasonably complete, reliable data were obtained from 57 of the SECs, for a final response rate of 65 percent. In general, the lack of sufficient data on the travel characteristics of an SEC's workforce resulted in the elimination of most of the 31 omitted candidate sites.

Table 2.1 lists the SECs that comprised the national data base used in this study and Figures 2.1 through 2.18 show the geographic locations of these sites, both nationally and within metropolitan areas. The 57 sites are spread among 21 different states and 26 metropolitan areas. The geographic diversity of these sites is evident in Figure 2.1. From a sampling standpoint, such variety is important since commuter attitudes and behavior (e.g.,

Table 2.1

Listing of Case Sites by State, Metropolitan Area, and Jurisdiction

State	Metropolitan Area	Jurisdiction[1]	SEC Case Site	Map Figure
Arizona	Phoenix	Phoenix	Central Avenue Corridor	--
			Camelback Corridor	--
California	Los Angeles-Orange County	Los Angeles	Warner Center	Figure 2.2
		Santa Ana	South Coast Metro	Figure 2.2
	San Francisco-Oakland-San Jose	San Ramon	Bishop Ranch	Figure 2.3
		San Jose	Santa Clara Golden Triangle	Figure 2.3
		Pleasanton	Hacienda Business Park	Figure 2.3
		Walnut Creek	Central Walnut Creek	Figure 2.3
Colorado	Denver	Denver	Denver Technological Center	Figure 2.4
			Greenwood Plaza	Figure 2.4
			Inverness Business Park	Figure 2.4
Connecticut	New York	Stamford	Central Stamford	Figure 2.5
Florida	Miami-Ft. Lauderdale-Palm Beach	Boca Raton	Avida's Park of Commerce (APOC)	Figure 2.6
		Ft. Lauderdale	Central Ft. Lauderdale	Figure 2.6
			Cyprus Creek	Figure 2.6
			Plantation	Figure 2.6
	Orlando	Orlando	Maitland Center	--
Georgia	Atlanta	Gwinnett Cty.	Gwinnett Place	Figure 2.7
		DeKalb Cty.	North Lake	Figure 2.7
		DeKalb Cty.	Perimeter Center	Figure 2.7
		Gwinnett Cty.	Technology Park	Figure 2.7
Illinois	Chicago	Naperville	Naperville/I-88 Tollway	Figure 2.8
		Oak Brook	Oak Brook/I-88 Tollway	Figure 2.8
		Schaumburg	Schaumburg Village	Figure 2.8
Kansas	Kansas City	Overland Park	College Blvd. Corridor	--
			Corporate Woods	--
Maryland	Baltimore	Anne Ar. Cty.	BWI area	Figure 2.9
		Baltimore	Central Towson	Figure 2.9
			Hunt Valley	Figure 2.9
	Washington, D.C.	Montgomery Cty.	Rocksprings Park	Figure 2.10

Note:
1. City or county in which the SEC is located.

Table 2.1 (continued)

Listing of Case Sites by State, Metropolitan Area, and Jurisdiction

State	Metropolitan Area	Jurisdiction[1]	SEC Case Site	Map Figure
Massa-chusetts	Boston	Lexington	New England Executive Park	Figure 2.11
		Middlesex Cty.	Route 9 Corridor	Figure 2.11
			Route 128 Corridor	Figure 2.11
			Route 495 Corridor	Figure 2.11
Michigan	Detroit	Dearborn	Fairlane Town Center	Figure 2.12
Minnesota	Minneapolis-St. Paul	St. Paul	3M Center	Figure 2.13
			Edina/I-494 Corridor	Figure 2.13
New Jersey	New York-Newark	Bergen Cty.	The Meadowlands	Figure 2.5
	Trenton-Princeton	Mercer Cty.	Route 1 "Zip Strip"	Figure 2.14
New York	New York-Newark	Garden City	E. Garden City/Rte. 25	Figure 2.5
		Farmingdale	E. Farmingdale/Rte. 110	Figure 2.5
North Carolina	Raleigh-Durham	Durham Cty.	Research Triangle Park	--
Ohio	Cleveland	Cuyahoga Cty.	Chagrin Blvd. Corridor	Figure 2.15
			I-77/Rockside Corridor	Figure 2.15
Oregon	Portland	Portland	I-5 Corridor	--
Pennsyl-vania	Philadelphia	Chester Cty.	Chesterbrook Center	Figure 2.14
Texas	Austin	Austin	3M Center - Austin	--
	Dallas	Dallas	North Dallas Parkway	Figure 2.16
	Houston	Harris Cty.	The Woodlands	Figure 2.17
		Houston	City Post Oak (Uptown)	Figure 2.17
			Greenway Plaza	Figure 2.17
			N. Houston North Belt	Figure 2.17
			West Houston Energy Corridor	Figure 2.17
Virginia	Washington, D.C.	Fairfax Cty.	Tysons Corner	Figure 2.10
Washington	Seattle	Bellevue	Central Bellevue	Figure 2.18
			Bell-Red Corridor	Figure 2.18

Note:
1. City or county in which the SEC is located.

Figure 2.1 Location of 57 Case Sites in the United States

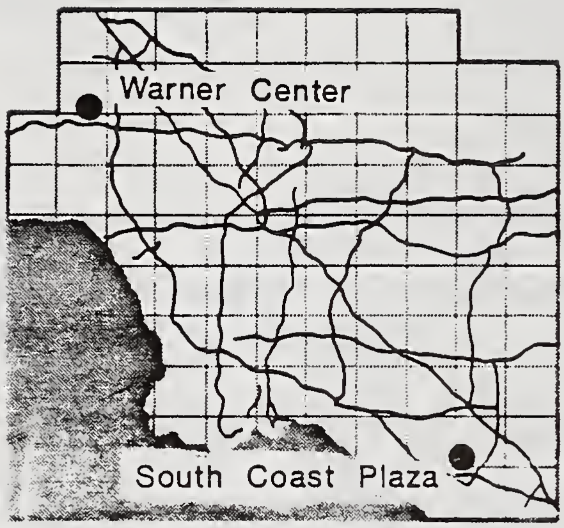


Figure 2.2 Los Angeles-Orange County Cases

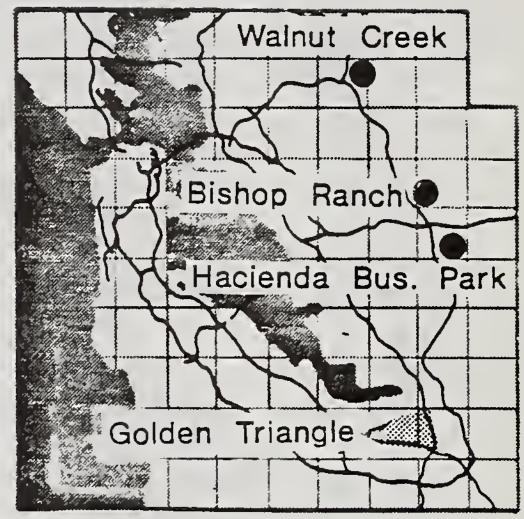


Figure 2.3 San Francisco-San Jose Cases

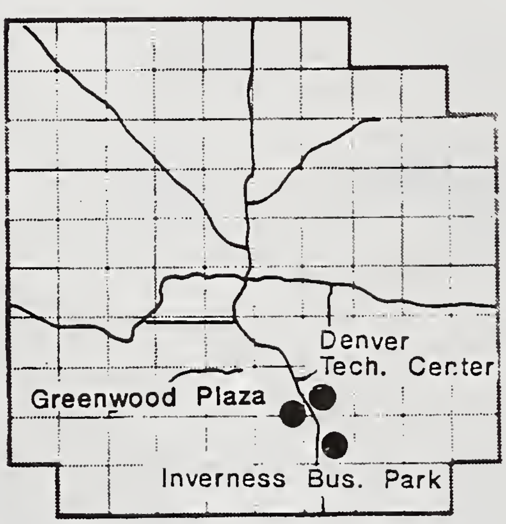


Figure 2.4 Denver Cases

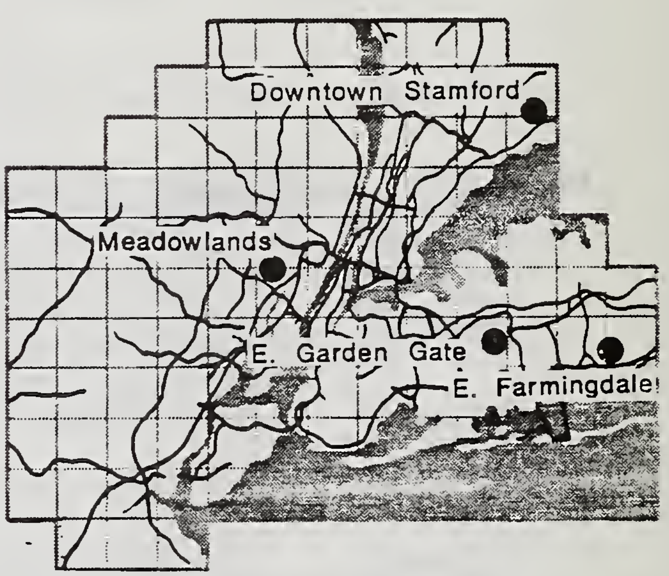


Figure 2.5 New York-New Jersey-Connecticut Cases

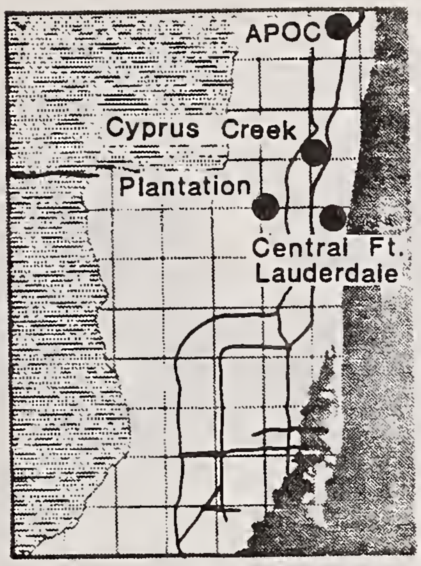


Figure 2.6 Miami-Ft. Lauderdale-Palm Beach Cases

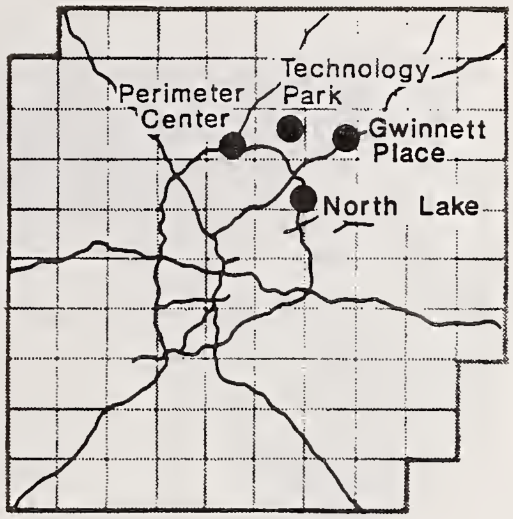


Figure 2.7 Atlanta Cases

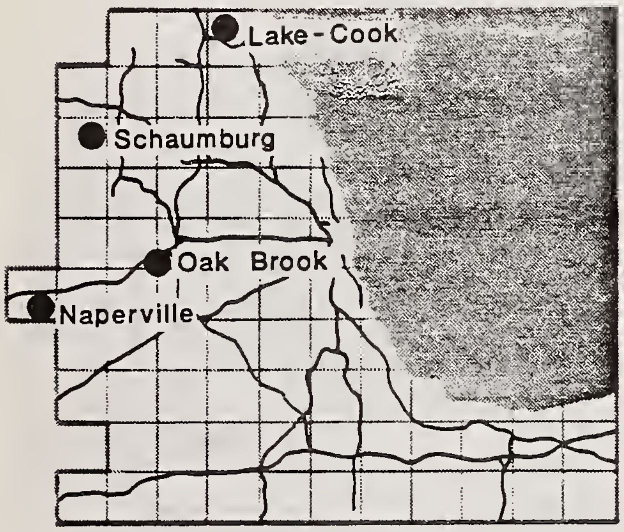


Figure 2.8 Chicago Cases

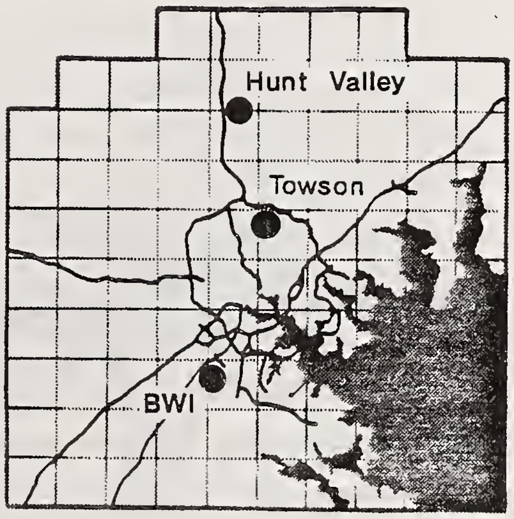


Figure 2.9 Baltimore Cases

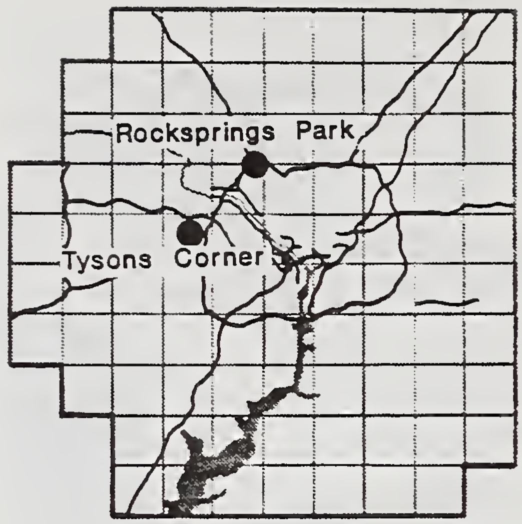


Figure 2.10 Washington, D.C. Cases

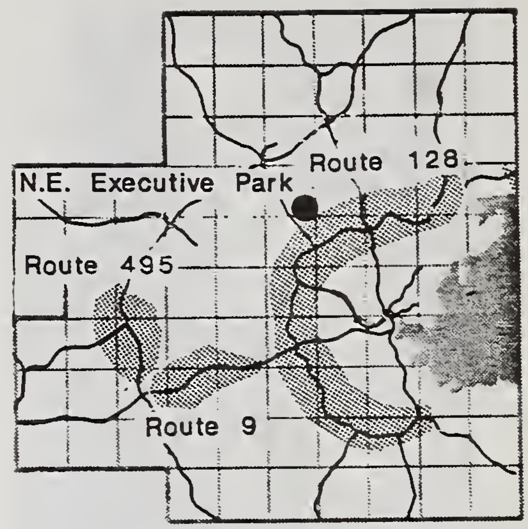


Figure 2.11 Boston Cases

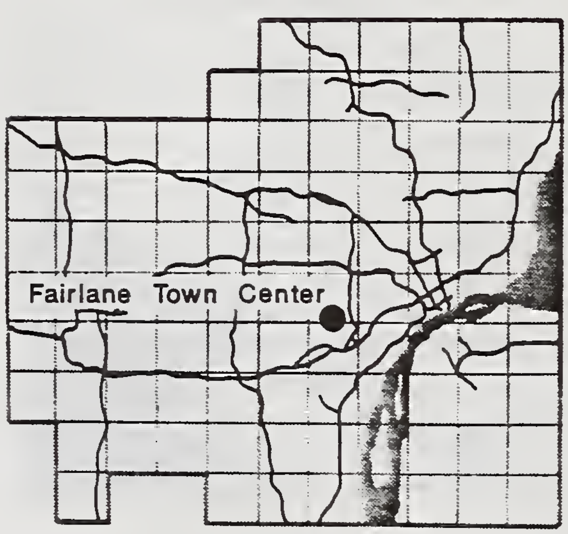


Figure 2.12 Detroit Case

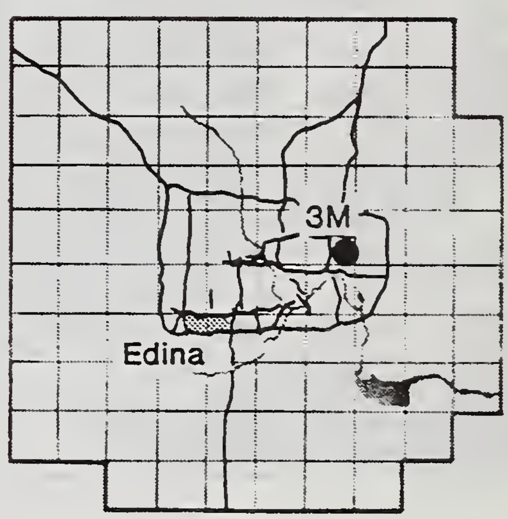


Figure 2.13 Minneapolis-
St. Paul Cases

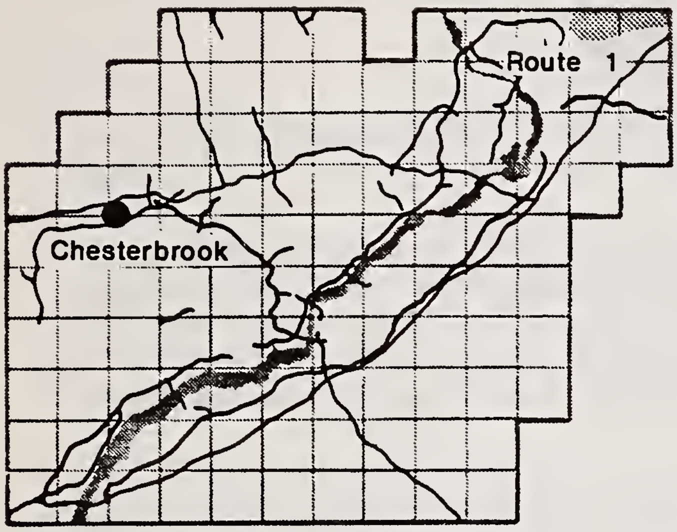


Figure 2.14 Philadelphia Cases

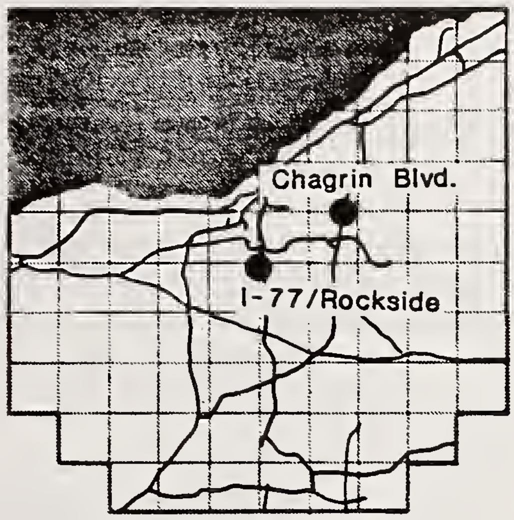


Figure 2.15 Cleveland Cases

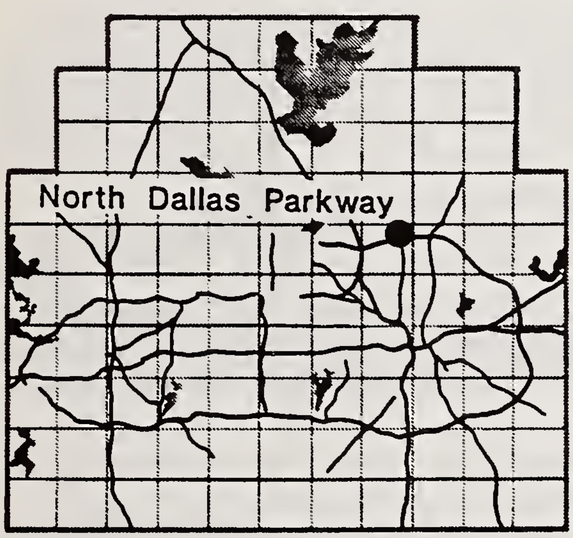


Figure 2.16 Dallas Cases

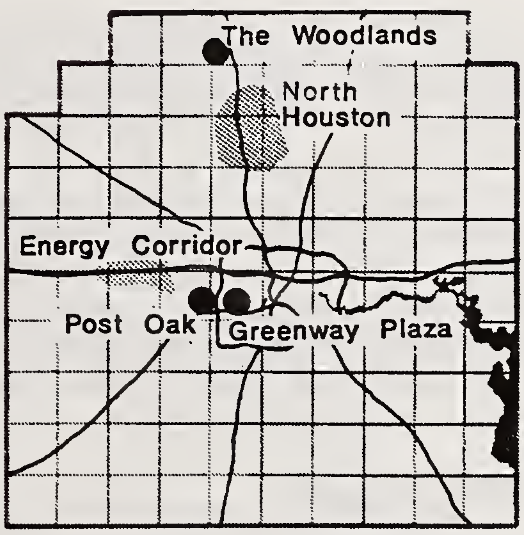


Figure 2.17 Houston Cases

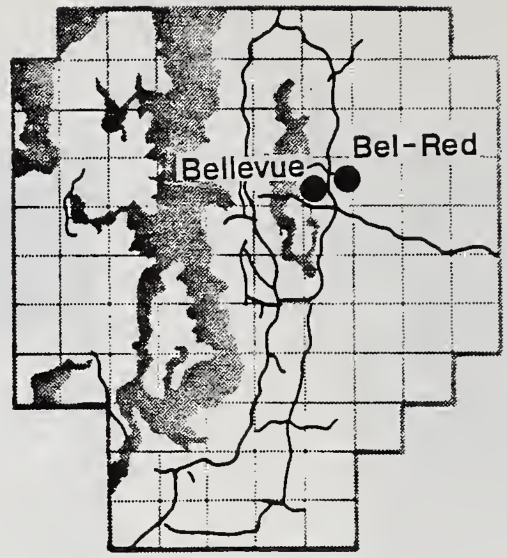


Figure 2.18 Seattle Cases

driver aggressiveness, tolerance for delay, perceptions of public transit) are not uniform across the country or within regions. Figures 2.2 through 2.18 show that selected SECs lie varying distances from regional CBDs as well, representing older, inner-tier suburban sites as well as newer, peripheral settings.

It should be noted that SECs from many older industrial cities, such as Buffalo and Pittsburgh, are not represented in this analysis. In general, these cities have not experienced massive-scale suburban employment growth, in large part because their transition from a "smokestack" to a service-based, postindustrial economy has been relatively slow [Hartshorn and Muller, 1986, p. 124]. There are some exceptions, however, such as Detroit, a metropolis with a strong tradition of suburban business centers, owing largely to the early suburbanization of automobile assembly plants. In this study, Detroit is represented by the Fairlane Town Center, a massive office-retail complex being developed by Ford Motor Land Development Corporation. Additionally, some newer metropolises with fairly diversified economies that meet the one million population threshold, such as Columbus and San Diego, are not represented among the SEC cases either. In these instances, none of the candidate sites had sufficient data to allow inclusion.

Research Methods

A combination of simple statistical tabulations, hypothesis tests, and causal models are developed and presented in the next four chapters in probing the relationship between the site and development characteristics of SECs and the travel choices and mobility levels of their workforces. In addition to the more aggregate-level national-scale analysis, a disaggregate study of commute choices among suburban workers is carried out based on a 1986 travel survey of workers in Pleasanton, California, one of the San Francisco Bay Area's fastest growing suburbs. A variety of statistical techniques, including factor analysis, cluster analysis,

analysis of variance (ANOVA), regression analysis, and logit analysis are employed in exploring patterns in these two data sets and in carrying out specific hypothesis tests. These empirical evaluations are supplemented by more qualitative assessments based on literature reviews, site visits, and interviews. Together, it is felt that empirical and interpretative techniques offer a balanced perspective into the transportation-land use link among America's SECs.

Notes

1. See Cervero [1986B, pp. 17-18] for further discussions on locational dimensions of suburban growth.

2. Some observers make a further distinction between centers and clusters. Centers generally connote a well-defined, master-planned project, sometimes under single ownership. By comparison, clusters are sometimes thought of as amalgamations of independent projects -- a nodal version of strip development, of sorts. In this report, the two terms are used interchangably and are meant to connote a concentrated form of suburban growth.

3. Corridor and business associations, such as the West Houston Association and Warner Center Association in Los Angeles, have been formed by property-owners and major businesses in the largest SECs to take positions on public policy matters, to deal with common concerns such as traffic congestion, and to promote the collective interests of participants. These associations typically maintain the most recent land use, employment, and transportation data available for specific SECs. For more discussion on associations, see Orski [1986B].

4. In addition to such publications as Development Trends and Market Profiles, data were obtained from the Project Reference File series, the Metropolitan Today series, the Land Use Digest series, the Urban Land publication, the Office Development Handbook, and several technical memoranda and data listings made available by ULI, generally for the periods 1980 through 1987.

5. Information was obtained from a number of Rice Center publications from the past ten years, including various case study reports (e.g., Houston's Major Activity Centers and Worker Travel Behavior [1987], the Research Brief series, the Private Sector Briefs series, and other documents made available by the Rice Center.

6. The primary sources used were the National Office Market Report and monthly office inventory publications.

7. The original versions of both questionnaires were pre-tested and eventually redesigned to improve the wording and clarity of questions and to remove possible biases stemming from question phrasing and sequencing.

8. Cross-checking between responses and empirical data compiled from primary sources was also carried out. Questionnaires with two or more discrepancies were eliminated from consideration. In some cases, respondents furnished best "guestimates". In these instances, estimates were only used if they could be corroborated from other sources or informants.

9. Floor Area Ratio (FAR) represents the ratio of gross floorspace of all buildings divided by the total land area of the development. A ratio of one could represent either a one-story building that covers the full perimeter of a property (i.e., zero side, front, and back lot setbacks) or a four-story building covering only one-quarter of a lot.

CHAPTER THREE

Land Use, Employment, and Transportation Characteristics of SECs

3.1 Characterizing SECs in the United States

This chapter introduces various suburban land use and transportation topics discussed throughout this report and presents summaries of the land use, employment, and transportation characteristics of the 57 SECs case sites from across the United States. Summary statistics are interwoven into the more general discussion of land use planning principles for SECs. Particular attention is given to the topics of site design, mixed-use development, and jobs-housing balancing.

In the following sections, land use is expressed in terms of: 1) size and scale; 2) composition of land uses; 3) land and employment densities; 4) housing, retail, and other tenant-support provisions; 5) site organization; 6) lotting practices; 7) land ownership; and 8) SEC evolution. Employment is examined in terms of: 1) current and future workforce size; and 2) labor force composition. Finally, transportation and mobility are summarized with respect to: 1) travel characteristics of workers for home-work trip, including travel times, speeds, and modes of commuting; 2) available transportation facilities and services, both within and near SECs, including roadway capacity, transit operations, van and ridesharing services, and parking provisions; and 3) level of service on nearby road facilities. Through a literature review, the characteristics of the case SECs are compared with empirical findings of other researchers.

3.2 Scale, Locational, and Employment Characteristics of SECs

These factors -- scale, location, and employment composition -- provide a general context for describing SECs: how big they are, where they're situated, and what goes on in them.

Table 3.1 presents summary statistics on the size, location, and employment characteristics of the SECs studied in this report. On average, SECs cover an expansive territory, with a mean land size of 27,162 acres (42.4 square miles). This average, however, is skewed by the inclusion of some very large corridors. Acreage varies from as small as 82 to as large as 440,000 (Route 128 corridor outside of Boston). The standard deviation is also three times the size of the mean value, offering further evidence of the extreme variation in the size of SECs.[1] Excluding seven large corridors with acreage exceeding 20,000 (Routes 9, 128, and 495 in Boston; Route 1 in central New Jersey; Golden Triangle in Santa Clara County; Portland's I-5 corridor; and N. Houston Beltloop corridor), the mean acreage is much smaller -- 3,068 (nearly five square miles), although the degree of variation still remains high. Still, these SECs examined in this study encompass a much larger territory than those studied previously. A 1970 study by the Urban Land Institute of suburban business parks found an average size of 70 acres [McKeever, 1970], whereas a more recent analysis of suburban office parks by the author examined centers averaging 270 acres [Cervero, 1986B]. As discussed in the fifth chapter, the SECs comprising campus-style, business parks in this study compare favorably in size to those parks examined in the analysis several years previously.

From the table, the case sites appear to be fairly built-up as well, with the amount of office, commercial, and industrial floorspace (exclusive of the seven large corridors) averaging

Table 3.1

Size, Locational, and Workforce Characteristics of 57 Large SECs in the United States, as of 1987

	Mean	Std. Dev.	Min.	Max.	No. Cases
SIZE AND SCALE					
Total land acreage (All Cases)	27,162	88,916	82	440,000	57
(Excluding Large[1] Corridors)	3,068	4,791	82	25,100	50
Square footage of floorspace in office, commercial, and industrial uses (millions) (All Cases)	10.35	13.07	1.00	85.00	57
(Excluding Large Corridors)	8.10	8.04	1.00	31.28	50
LOCATION					
Radial miles to regional CBD	18.0	9.9	5	36	57
EMPLOYMENT					
Size of workforce (thousands) (All Cases)	46.1	97.0	2.0	480.5	57
(Excluding Large Corridors)	19.3	17.3	2.0	67.7	50
Percent of workforce in management, professional, technical, and administrative occupations	47.2	17.6	2.0	70.0	57
SEC EXPANSION					
Expected Year of Build-out (Non-corridors only)	1999	--	1988	2026	20

Note:
1. Large corridors are SECs of over 40,000 acres.

8.1 million square feet. Floorspace varied from one million to 31.28 million (New Jersey's Meadowlands) square feet.

SECs also tend to be far removed from regional CBDs. The mean distance is 18 miles, with a high of 36 miles (East Farmingdale/110, whose approximate center is 36 miles from mid-town Manhattan). On average, the SECs examined in this study are much farther from their region's CBD than were the 120 large-scale office parks examined in the earlier study (which averaged a mean distance of 10.7 miles) [Cervero, 1986B]. The inclusion of a number of large suburban employment clusters, agglomerations, and corridors on the peripheries of metropolises and large connurbations (such as New York-Newark) resulted in a ratcheting of the mean mileage statistic.

Table 3.1 further reveals that the SECs generally have extremely large employment bases, averaging 46,100 full-time workers, inclusive of all cases. Ignoring the seven large corridors, however, the average SEC labor force is 19,300 full-time workers. The table indicates there is tremendous variation in the size of employment bases as well.

The average occupational breakdown of SEC employees, shown in Figure 3.1, reveals the dominance of white-collar workers. The largest group is clerical staffs, comprising 22 percent of the workforce. This share closely matches the national average, which was 19 percent in 1982 and no doubt has risen since then [Dowall, 1987]. The next highest occupational group is technical workers (e.g., engineers, programmers, researchers), followed by a fairly even split of administrative (e.g., finance officers, billing agents, etc.), managerial, and manufacturing staffs. In all, nearly one-half of employees are in professional/administrative positions (Table 3.1) and over 70 percent work in desk jobs that involve some form of information-processing. This large share reflects the assignment of many mid-management, clerical, and back-office business functions to the suburbs over the past decade [Dowall, 1987; Urban Land Institute, 1986]. These findings are consistent with those from a recent study of SECs in the greater Houston area which found that suburban centers tend to have even larger shares of white collar workers and a higher proportion of professional-administrative staffs than CBDs [Rice Center, 1987].

Finally, Table 3.1 reveals the general time schedule planned for completing SECs. The "typical" SEC in the survey, excluding large corridors and non-master-planned centers, is projected to reach build-out in 1999. At build-out, these centers are expected to have, on average, 13.2 million square feet of office-commercial-industrial space and 21,000 full-time employees. Based on the ratio of current to expected future floorspace, on average, the surveyed SECs are approximately 57 percent built out.

3.2 Density, Site Design, and Property Ownership Characteristics

Density and Design

The densities of land uses have been shown to be one of the most important determinants of travel behavior, perhaps influencing the modes people opt for as much as any single factor [Pushkarev and Zupan, 1977]. Over the past decade, the design emphasis of many suburban office projects has been on creating a spacious, comfortable, and aesthetically pleasing working environment [Cervero, 1986B]. Many projects aim to attract prestigious corporate tenants, offering first floor atriums and courtyard space, high ceilings, and various design treatments, such as sculptures and fountains. Such add-ons usually increase the amount of floorspace per worker. "Smart buildings" designed for high-tech and information-processing tenants also tend to enlarge the floor and ceiling area in order to accommodate cables, computers, and satellite dishes as well as to ensure proper ventilation. One study of the

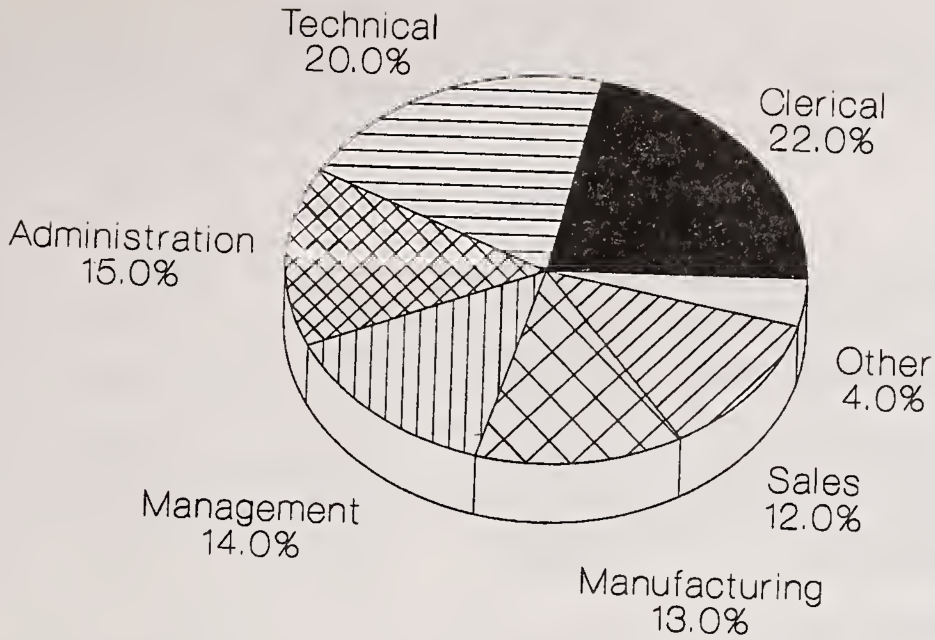


Figure 3.1 Distribution of Job Classifications in SECs

Route 73/38/70 corridor in central New Jersey found atriums and other common space add-ons comprised 7 percent of gross leasable space [Louis Berger & Associates, 1986].

This tendency to expand building space per worker has often been coupled with design initiatives that vastly increase land area per worker as well, such as lavish and spacious landscaping and the provision of bountiful parking. Many campus-style office parks feature low-rise buildings that hug the landscape, surrounded by a sea of parking, jogging trails, and nicely contoured open spaces. At the usual standard of four parking spaces per 1,000 square feet of building space, with each stall measuring approximately 325 square feet in size, 1,300 square feet of asphalt is paved for every 1,000 square feet of office space [O'Mara and Casazza, 1982; Leinburger and Lockwood, 1986]. Thus, more land is typically used for the unproductive purpose of housing cars than for the productive purpose of housing office workers. From a mobility standpoint, buildings are usually separated so far apart and the overall scale of the project is so spread out that the automobile becomes the only viable means of circulating within an SEC. What this means, of course, is that many workers are almost compelled to drive to work in order to have a vehicle available to circulate on-site.

Table 3.2 summarizes some of the density features of the SEC case sites examined in this study. The average floor area ratio (FAR) is nearly one, quite high by suburban standards. The 1985 study of 120 U.S. office parks [Cervero, 1986B], for instance, found an average FAR of 0.29, while a recent study by Gruen Gruen + Associates [1986] of nine office developments in suburban Philadelphia and San Francisco found an average of 0.30. In this present study, FARs were found to vary tremendously, from a low of 0.09 (Research Triangle Park) to a high of 6.00 (downtown Bellevue).

The table also reveals the average maximum FAR allowed by local zoning ordinances governing SECs. The mean is 2.34, skewed somewhat by the disproportionate share of higher

Table 3.2

Density, Lotting, and Land Ownership Characteristics of SECs

	Mean	Std. Dev.	Min.	Max.	No. Cases
DENSITY					
Floor Area Ratio (FAR)[1]	0.98	1.10	0.09	6.00	55
Maximum Allowable FAR[1]	2.34	3.68	0.25	15.00	35
Employees/Acre[2]	19.9	25.5	0.25	134.5	50
Square Footage of Land/Employee[2]	11,200	25,158	324	94,500	50
Square Footage of Floorspace/Employee[2]	492	398	164	2,150	50
Coverage Ratio[3]	0.31	0.20	0.10	0.90	52
Number of stories of:					
Highest Building	15.7	11.0	3	64	57
Lowest Building	1.3	1.1	1	8	57
"Modal" Building[4]	4.1	3.9	1	22	57
BUILDING LINES AND LOTTING					
Acreage of:					
Smallest Lot	1.3	1.9	1.0	9.0	44
Largest Lot	71.4	110.7	1.0	509.0	44
"Modal" Lot[4]	8.4	12.2	1.0	57.0	44
"Modal" lineal footage from:[4]					
Side of Building to Property Line	49.2	53.5	0	300.0	48
Front of Building to Property Line	64.4	57.0	0	300.0	48
PROPERTY OWNERSHIP					
Number of Property Owners[2]	112	204	1	900	41
Proportion of Land Owned by Developers[2]	.66	.24	0	1.0	41

Notes:
1. FAR = Building Square Footage/Lot Size. Maximum FAR is what current zoning allows.
2. Exclusive of seven large corridor cases. See section 3.2.
3. Proportion of land covered by buildings -- footprint of buildings to total land area.
4. Modal represents most frequently occurring case. This reflects the "typical" building.

density clusters among the 35 cases (due to missing observations). On average, these 35 SECs are being built at 48 percent of allowable density.[2] In some cases this "underdevelopment" is due to the relative infant stage of growth of the SEC and the lack of market demand, while in other cases growth control pressures have forced developers to settle for lower densities during the negotiation of site plans.

From Table 3.2, the average amount of land area per worker for the case SECs is also exceptionally high -- 11,200. This far exceeds the average ratio found in the 1985 study of 120 office parks, which was 1,410 square feet of land per employee [Cervero, 1986B]. In that 18 of the case sites in the current study have ratios below 1,000, it is clear that tremendous variation exists in land-to-employee intensity levels among the SECs. In some cases, bloated figures are due to the preponderance of retail and residential land uses within an SEC, resulting in a relatively low denominator. In other cases the high figure can be attributed to the existence of vast expanses of open space within the SEC boundaries. If data were available on net usable land area for only office and industrial uses, the mean ratio would be much lower.

Within buildings themselves, SEC employees working in the case sites appear to enjoy considerable elbow room. The fifth row of Table 3.2 indicates the average amount of gross floorspace per worker is nearly 500 square feet. This figure generally falls in the range found by other researchers. The 1985 study of low-density office parks found an average of 380 gross square feet of floor area per worker [Cervero, 1986B]. In their study of business parks, Gruen Gruen + Associates [1986] found an average of 347, 485, and 724 square feet per worker for office, research and development (R&D), and industrial-services land uses, respectively. A prior study by Gruen Gruen + Associates [1985] found slightly lower average figures -- 360 square feet for R&D and 490 square feet for commercial services.

In general, the trend has been toward roomier work environments for suburban workers. As Dowall [1987] notes, clerical and information-processing work pools typically need large expanses of floor area on one level. Most back-office facilities have floorplates (the square footage of a single floor of a building) exceeding 20,000 square feet. With this amount of space, "bullpen" clerical areas and computer networks can be more efficiently laid out than would be the case for multi-story installations. Thus, this trend has not only increased workspace area but has encouraged the construction of low-lying, squatty office buildings as well -- horizontal skyscrapers, of sorts.

Building Coverage and Heights

Table 3.2 also summarizes statistics on the average lot coverage and number of stories of buildings within SECs. The mean coverage ratio (footprint of a building divided by land area) is 0.31. In no instance could buildings consume more than 90 percent of a lot, and in most cases footprints were required to be far less land-enveloping. The 0.31 average closely matches the coverage restrictions found in land covenants of most office parks, with the total impervious coverage normally limited to 60 percent in order to maintain an open, park-like atmosphere [Cervero, 1986B].

With an average FAR of 0.98 and an average coverage rate of 0.31, one could infer that the "average" height of building in the SECs is slightly over three stories.[3] On average, the most frequently occurring building height (i.e., the "mode") is around four stories. This figure is no doubt skewed by the inclusion of some fairly highrise developments, such as Post Oak and Greenway Plaza in Houston, in the data base. On average, each SEC's lowest building is around one story and its highest building reaches nearly 16 stories in height (equivalent to around a 210 foot elevation). The highest building within any of the SECs is the 64-story Transco Tower in Post Oak, the world's tallest skyscraper outside of a downtown. Overall, the buildings within the SECs of this study appear to dwarf most of their suburban counterparts -- in 1983, 43 percent of all suburban office structures were one or two stories high, and only 8.9 percent exceeded ten stories [Institute of Real Estate Management, 1984]. Lastly, the majority of buildings of the master-planned SECs included in this study could be classified as "Class A" structures, typically featuring all-glass exteriors and tilt-up or steel frame construction.[4]

Building Lines, Lotting Practices, and Site Organization

Besides land area, the dimensions and shapes of office compounds, as well as the configuration of individual parcels within them, can exert a strong influence on circulation patterns, and in particular peoples' willingness to travel by foot. Take a 500 acre tract, for instance. If square, the diagonal distance (from corner to corner) is about 1.2 miles (Figure 3.2). If rectangular, the distance increases to 2 miles, two-thirds farther. To span such a distance would require a one-half hour walk (assuming a 3 m.p.h. walking speed), far more than the maximum threshold of ten minutes most suburban workers and residents are generally willing to invest in a walk [Untermann, 1984].

Lotting patterns of suburban technology parks typically consist of five-acre tracts that can be assembled into 25-acre tracts, or larger [Reimer, 1983]. From Table 3.2, the most frequently occurring lot size was eight acres for 44 of the case sites in this study. Within the SECs, the smallest lot tended to be 1.3 acres whereas the largest one averaged 71.4 acres, with considerable variation among cases. On average, the smallest lot within an SEC is one-twentieth the size of its largest lot.

Based on site inspections and survey responses, around 60 percent of the the SECs are comprised of lots of varying shapes and sizes whereas 40 percent have lots of fairly uniform dimensions. In the latter cases, lots tended to be rectangular in shape. A number of the denser suburban clusters, such as Post Oak, Bellevue, and Denver Tech Center, were originally platted on a superblock schema, with block faces of 1,000 feet or more not uncommon.

The way buildings are organized on a tract can also have a strong bearing on circulation patterns and travel choices. Some sites feature clusters of buildings fronting on sidewalks and common spaces that invite foot travel. Others host a single "signature" building that is sited

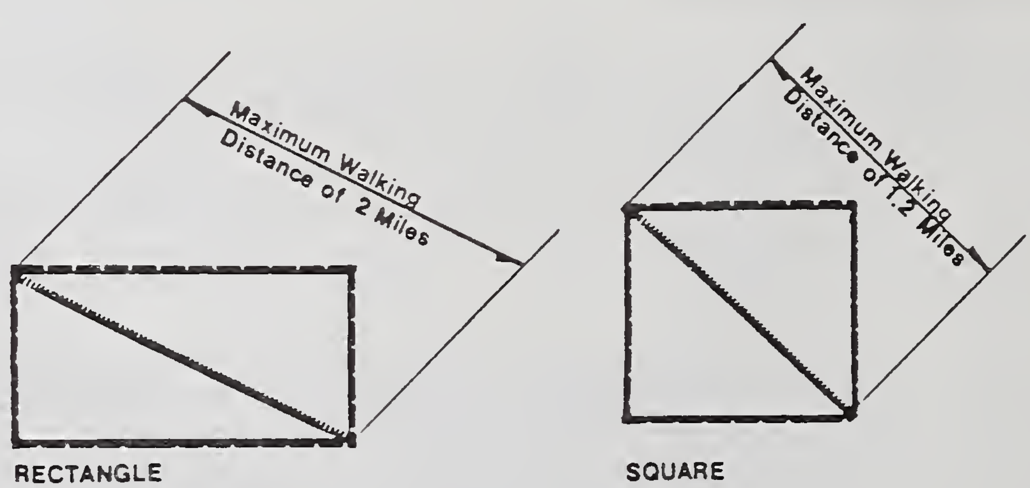


Figure 3.2 Alternative Configurations of a 500 Acre Parcel. Source: Anderson [1986].

thousands of feet from its nearest neighbor. Such inwardly-focused buildings have been criticized for not only discouraging walk trips but also for their "egocentricity" and "detachedness" [Galehouse, 1984; Lynch and Hack, 1984].

The notion of site organization is difficult to express in quantitative terms. Measures such as inter-building distances and building lines are sometimes used. Building lines are usually expressed in terms of front, rear, and side setbacks. Setbacks reserve areas of open space between structures and the edges of individual properties. They generally serve aesthetic purposes, providing a landscaped buffer between buildings and roadways. In his study of campus-style office projects in the U.S., Anderson [1986] found typical setback of 50 feet for sidelots and 75 feet in the front. For 48 of the case SEC sites in this study, the most frequently occurring setbacks matched Anderson's findings fairly closely -- averaging nearly 50 feet on the sides and 64 feet in the front (see Table 3.2).

Overall, setback regulations tend to push buildings toward the center of parcels, thereby discouraging a clustered development pattern that might be more favorable to transit and pedestrians. The general influence of site designs on the propensity of suburban workers to walk and choose travel options to the automobile are discussed in more detail in the fifth and sixth chapters.

Property Ownership

How many parties hold title to land and the degree of developer control over site decisions can exert a strong influence on the character, style, and evolution of an SEC. With fewer property-owners, there tends to be more centralized control over design decisions. The potential for more systematic, coordinated site plans might also be expected to increase with fewer deed-holders.

Table 3.2 reveals that the SECs included in this study average over 100 different property owners, with tremendous variation, from as few as one to nearly one thousand. On average, around two-thirds of land is owned by private developers and real estate interests, generally in the form of speculative rental space, with the remaining one-third owned outright by private businesses and firms.

How ownership influences the density, site design, and evolution of SECs is examined in Chapter Six. Based on interviews and questionnaire responses, it appears that around 29 percent of the SECs studied have evolved over the years as centrally-controlled, master-planned projects (Figure 3.3). Another 29 percent have evolved on the basis of periodic, sometimes year-by-year, revisions to master plans, more or less a hybrid of planned versus ad hoc evolution. The remaining 42 percent of SECs appear to have evolved in a more incremental, atomistic fashion.

3.3 Land Uses and Mixed-Use Activities

The Advantages of Mixed-Use Developments

The variety of land uses can have a profound influence on the travel choices of suburban workers. For single-use environments, such as business parks with exclusively office functions, an automobile can become indispensible for circulating within a project and accessing restaurants, banks, and other consumer services that are off site. A SEC with a lively mixture of activities, on the other hand, can internalize trips that otherwise would be

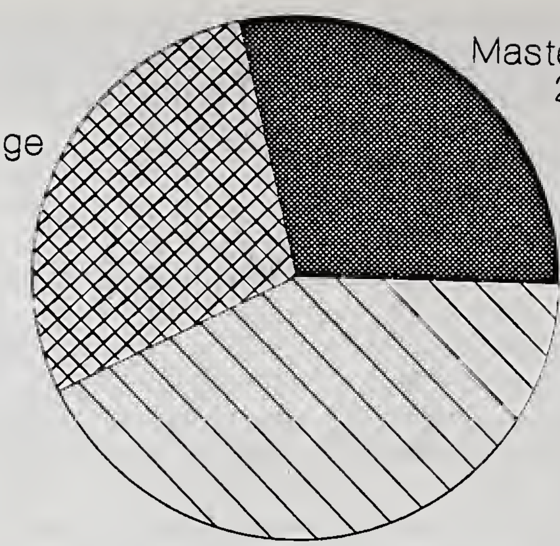


Figure 3.3 Percent of SECs in Three Growth Categories, Exclusive of Corridors

made on areawide roads. With mixed-use environments, larger shares of trips end up as foot traffic within individual buildings or between groups of buildings [Cervero, 1986B].

Mixed-Use Developments (MXD)[5] can potentially reduce motorized travel and congestion levels in several key ways:

1) Since uses have different trip generation rates, a given amount of floorspace spread among multiple activities will normally produce fewer trips than the same floorspace devoted to a single, more intensive use, such as office;

2) More travel is made by foot and bicycle, particularly during the noon hour, and to the extent workers are able to reside on-site, some motorized travel during morning and evening peak periods will also be replaced by walk and cycle trips; and

3) With a combination of office, retail, recreational, and other land uses, trips tend to be spread more evenly throughout the day and week, whereas with a single function, such as office, trips are generally concentrated in the congested peak.

Take a 100,000 square feet office development, for example. Using a trip generation rate of 12.3 weekday trips per 1,000 gross square feet of general office space from the Institute of Transportation Engineers' Trip Generation manual [ITE, 1987], this project could be expected to produce 1,230 daily trips, many of which would occur within a concentrated peak period. If this same floor area was split into 25,000 square feet of general office space, 25,000 square feet of R&D space, 40,000 square feet of multi-family apartments (assuming an average of 1,600 square feet per unit), and 10,000 square feet of specialty retail, based again on ITE rates, the daily trips would fall to 1,000, spread much more evenly throughout the day.[6] That is a 18.7 percent drop in daily traffic volume. Peak hour volumes would likely fall by at least twice this much.

While retail, hotel, restaurant, and other consumer land uses average far higher daily trip generation rates than office functions on a square footage basis, most trips to such establishments occur in the evening, on weekends, and during lunch time. Thus, adding such activities into a development will normally add hardly any traffic to the morning rush hour and far less to the evening rush period than a comparable amount of office space would. By spreading out trip-making, MXDs in a way accomplish what flex-time and staggered work hour programs accomplish without intrusion into business affairs. In the long run, MXDs can reduce the cost of expanding road facilities serving SECs and reduce the pace of sprawl by preserving land.

By allowing people to walk between nearby activities, MXDs also reduce vehicular traffic. For instance, office workers in a MXD might spend their lunch hour at shops and restaurants within the development. One study of MXDs in the greater Denver area, for instance, concluded that mixed uses could reduce trip generation of individual uses within the development by as much as 25 percent [Institute of Transportation Engineers, 1987].

MXDs offer two other noteworthy transportation advantages. One, they can be an inducement to rideshare. Unless restaurants, shops, and banks are nearby, most suburban workers will find it necessary to drive their own cars in order to reach lunchtime destinations and run midday and after-work errands. The problem is less one of more car traffic being generated at the <u>noon period</u>, and more one of suburban employees feeling compelled to drive during the <u>rush hours</u> in order to have a car available during the midday and after work. Several recent surveys reveal how important an automobile can be to suburban workers for taking care of personal business. The top two reasons given by 17,000 surveyed employees of the Warner Center in Los Angeles's San Fernando Valley for commuting alone were the need for a car after work (36 percent of respondents) or for running midday errands (32 percent of respondents) [Commuter Transportation Services, 1987]. Another survey of employees working at Orange County's South Coast Metro found that 83 percent felt they needed their cars at least once a week for personal business and 44 percent needed them at least three times a week [Ruth and Going, 1983]. Finally, a recent study of SECs in the greater Houston area found that suburban employees were 1.6 times more likely to leave the area for lunch than their CBD counterparts, in large part because of the absence of on-site eateries [Rice Center, 1987].[7]

A second additional advantage of MXDs is that they create opportunities for shared-parking arrangements. The parking demands of different land uses normally peak at different time periods [Barton-Aschman, 1983]. The same parking facility used by office workers from 8-to-5 on Mondays through Fridays can serve retaurant and movie goers during the evening and on weekends. It could serve as overflow parking for weekend shoppers as well. For multi-purpose trips, such as a work-shop-movie trip, only one parking space might be necessary in a MXD environment.[8] In general, MXDs lower the total parking requirements for a site far below what would be the sum of individual office, retail, and recreational uses. Developers of Los Angeles's Warner Center, for instance, were able to reduce parking in a central garage from 1,400 to 1,100 spaces because of land use mixes, saving over $3 million (1980 dollars) [Barton-Aschman, 1983]. Such a reduction in parking area can dramatically reduce the scale of a project and reduce the separation of buildings, thus inviting more foot travel.

Besides these many transportation benefits, MXDs also seem to add life to what sometimes are rather sterile suburban work environments. By replacing vehicle trips with people trips, a far more interesting and socially engaging milieu can be created. A setting with an after-work night life can also entice more employees to live near their workplace, thus cutting down on vehicular traffic even more. A common complaint voiced by suburban businesses today is that their employees, especially those who have been reassigned from

CBDs, are disenchanted by the barreness and lack of urban amenities around their workplaces. For this reason, MXDs are becoming increasingly attractive to high-end tenants and are perceived by many developers as providing a competitive market advantage. Based on a recent Urban Land Institute report, MXDs appear to be gaining in popularity -- 61 percent of the more than 200 MXDs studied had broken ground since 1980 [Schwanke, et al., 1986].

Land Use Composition and Consumer Services within SECs

How mixed are today's SECs? Based on survey results, only moderately and far less than their CBD counterparts. Among the 57 sites surveyed, the preponderance of floorspace is being devoted to office uses (Figure 3.4 and Table 3.3). Retail is the second most prevalent activity, followed by housing, manufacturing, warehousing, and other uses (e.g., restaurants, hotels, and banks). The relative mixture of uses do vary considerably among SECs, it should be noted, a topic which is examined more closely in Chapter Five.

Table 3.3 also reveals the average number of restaurants and banks -- important ingredients of any suburban mixed-use environments -- within those SECs which are either master-planned or highly clustered, or both.[9] Among the 18 cases for which data were available, there is, on average, approximately twenty eateries (ranging from restaurants to private delis, but excluding company cafeterias) and four to five banks or other savings institutions. The South Coast Metro in Orange County holds the distinction of having the most of both among the case sites -- 89 restaurants and 29 banks.

A larger subsample of fifty cases was available for studying the number of distinct retail centers within SECs.[10] The average is in the 4-to-5 range, with the 2,600-acre Schaumburg Village, northwest of Chicago, featuring the most -- 47 centers. Additionally, the average number of shopping centers with over 100,000 square feet of gross floorspace within three radial miles of an SEC was found to be 3.6. These nearby shopping centers averaged around 170,000 square feet of space -- an area comparable to a supermarket connected by around ten specialty stores.

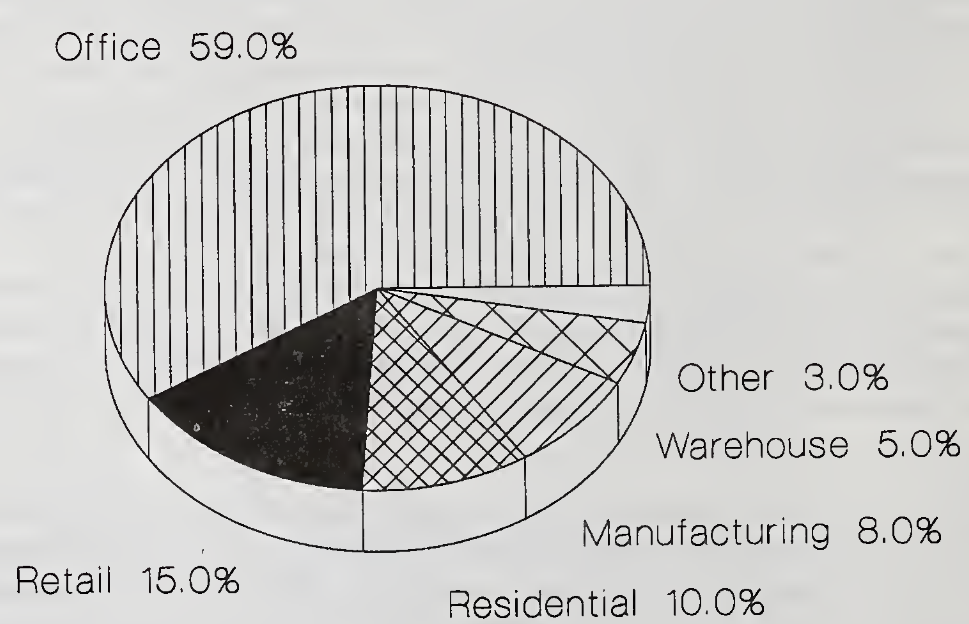


Figure 3.4 Percent of Floorspace in Land Use Categories

Table 3.3

Land Use and Mixed-Use Characteristics of SECs

	Mean	Std. Dev.	Min.	Max.	No. Cases
LAND USE COMPOSITION					
Percent of Floorspace in:					
Office Use	59	23	10	99	56
Retail Use	15	11	1	40	56
CONSUMER SERVICES					
Number of On-Site:					
Restaurants/Eateries[1]	19.6	27.3	0	89	18
Banks[1]	4.5	6.6	0	29	18
Shopping clusters and retail centers[2]	4.4	8.0	0	47	50
Employees/On-Site Restaurant[1]	3,715	7,335	281	30,000	18
Employees/On-Site Bank[1]	6,784	9,273	862	41,000	18
Employees/On-Site Retail Center[2]	8,640	11,097	550	64,700	50
Square Footage of Retail Space (millions) within 3 radial miles of SEC[2]	1.92	2.10	0.02	8.0	45
Square Footage of Nearby Retail Space/Employee[2]	170	329	12	2,215	45

Notes:
1. Exclusive of corridors, consisting mainly of master-planned projects.
2. Exclusive of corridors, consiting mainly of well-defined clusters.

Of course, the number of consumer establishments within an SEC is most relevant when compared to the number of on-site employees. Table 3.3 also summarizes several retail intensity statistics. For the subsample of 18 SECs, on average there are around 3,700 employees per eatery and 6,800 employees per bank, with considerable variation among sites. South Coast Metro again earns top honors -- with a restaurant and a bank for every 281 and 862 employees, respectively.[11] Additionally, the SECs were found to average around 8,600 workers for every on-site retail center and 170 square feet of areawide shopping center space per employee.

3.4 Jobs-Housing Balancing and On-Site Housing Provisions

Jobs-Housing Balancing

Among the benefits that might be expected from the suburbanization of office employment over the past decade are the transformation of suburbs into more "balanced" communities, a shortening of journeys-to-work, and generally less traffic. Evidence is somewhat mixed on this, however. In 1980, suburb-to-suburb work trips were, on average, 50 percent shorter than suburb-to-central city trips -- 8.2 miles versus 12.2 miles [Pisarski, 1987]. However, inter-suburban trips, the fast growing commuting market, increased in length by around 15 percent during the seventies. In addition, jobs don't appear to be getting closer to suburban residents. From 1977 to 1983, the mean journey-to-work for Americans residing outside of a central city (but within an urbanized area) increased from 10.6 miles in length to 11.1 miles [Klinger and Kusmyak, 1986]. Indeed, Americans continue to live in one community and work in another. According to the 1980 census, the majority of Americans do not work in the community where they live [U.S. Bureau of Census, 1984].

A "balanced" community is generally thought of as a self-contained one, whereby people live, work, and recreate within it [Burby, Weiss, et al., 1976]. This is a fairly abstract notion, however, that is difficult to express in any measurable terms. Margolis [1973] adopted the rule-of-thumb that communities are "balanced" when the ratio of jobs to housing units lies within the range of 0.75 to 1.25. With today's demographics of two wage-earner households, the upper end of Margolis's range is likely too low. With two working people living together, potentially fewer nearby houses are needed to accommodate a local workforce, especially when one of the persons is a secondary wage-earner -- stereotypically, a married woman entering the labor force. Nationwide, the percent of households with two or more wage earners rose from 42.7 percent in 1960 to 68.5 percent in 1984, confirming the on-going feminization of America's work force. Assuming that 90 percent of working adult Americans live in cohabitant households and that 70 percent of these are made up of two or more wage earners, a more reasonable ceiling for the jobs/housing ratio for signifying "balance" is around 1.5.[12] Any jobs/housing ratio above this means there is an insufficient supply of available housing to meet the needs of the local work force, resulting in a predominant pattern of in-commuting of workers in the morning and out-commuting in the evening.

Many of the fastest growing suburban communities have jobs-housing ratios that far exceed this 1.5 threshold. For instance, the Golden Triangle area of Santa Clara County, California, known more popularly as the Silicon Valley, epitomizes a jobs-rich/housing-poor environment. The Silicon Valley communities of Santa Clara, Sunnyvale, and Palo Alto, for instance, have jobs-housing ratios of 3.13, 3.16, and 3.08, respectively [Association of Bay Area Governments, 1985]. Along central New Jersey's booming Route 1 corridor, disparities are even greater. Two of the fastest growing municipalities along this corridor, Cranburg and Lawrence, have jobs-housing ratios exceeding 3.5 [Delaware Valley Regional Planning Commission, 1986]. In greater Atlanta, the two hottest office markets -- Midtown and Perimeter Center -- have more than five times as many jobs as housing units among census tracts encompassing both centers as well as tracts within a two mile radius of both [Atlanta Regional Commission, 1986].

Job-housing ratios only indicate the potential for greater balance. The degree to which that potential is realized is reflected by the share of jobs in a community actually filled by residents, and conversely the share of workers finding a place to live in that community. What this means is that besides numerical parity in jobs and housing, there must also be a match-up between the skill levels of local residents and local job opportunities as well as between the earnings of workers and the cost of local housing.

In many of the nation's largest suburban work centers, a fairly small share of workers reside locally. In the Bay Area suburbs of Walnut Creek, Mountain View, Palo Alto, and Santa Clara, for instance, less than one-fifth of all local workers reside in those communities [Cervero, 1986A].[13] And in the Chicago area, only 18.1 percent of Schaumburg workers reside in that community while in Oak Brook and Oakbrook Terrace under 3 percent of workers find a place to live locally. In the study of Schaumburg's work force, it was found that those finding local housing tended to work in the higher-salaried FIRE occupations [Sachs, 1986].

A number of powerful economic and demographic forces appear to be impeding the ability of Americans to reside in the community where they work. Among these are:

*) Fiscal zoning -- The practice of zoning land predominantly for high revenue-generating uses, such as commercial and industrial development, has generally limited the supply of housing and driven housing prices upward [Windsor, 1979; Rolleston, 1987]. Because of fiscal pressures, more and more communities are actively competing for attractive high-tech developments and the tax dollars they generate [Wasylenko, 1980]. At the same time, many are snubbing housing proposals. The "winners" of the competition have frequently become prosperous corporate centers (i.e., high jobs-housing ratios) while the "losers" have ended up a dormitory communities, left with housing the workers of these well to do places.

*) Growth restrictions -- Moratoria on building permits and downzoning have also depressed housing supplies in many suburbs. In response to mounting growth pressures, for instance, Nassau and Suffolk Counties east of New York City placed a minimum one acre restriction of new housing permits in 1982. More recently, at least a dozen communities along Boston's Route 495 corridor have taken steps to halt new housing construction by capping building permits, increasing minimum lot sizes, or imposing growth moratoria. Within SECs themselves, there are at least two precedents where new housing starts were either restricted or banned. At Bishop Ranch east of Oakland, developers originally intended to transform their entire 585-acre vacant parcel into a planned unit development (PUD) with a mixture of office, industrial, and housing components. A groundswell of citizen opposition to comingling uses forced the developers to eliminate the residential element of their plan [Cervero, 1986B]. Just six miles to the south at the 860-acre Hacienda Business Park, developers initially proposed building 3,500 rental housing units on-site, however citizen complaints forced this to be lowered to 650 units.

*) Worker Earnings/Housing Cost Mismatches -- By restricting housing supplies, fiscal zoning and growth restrictions have unavoidably increased suburban housing prices [Dowall, 1984; Ley, 1985]. Many moderate-salaried clerical and service-industry cannot afford the executive-priced, single-family homes and townhouses near many SECs. In California's two fastest growing non-rural counties, Contra Costa and Orange Counties, average home prices exceed $150,000, which requires roughly a $50,000 annual income to qualify for, yet the average worker in both counties earns less than $27,000 (1985 dollars). Forced to live in other counties, one-way commutes of fifty miles are becoming more and more common among displaced workers. Many suburban areas, moreover, are experiencing serious labor shortages,

forcing some businesses to operate special shuttles that transport inner-city residents to such job sites as hotels and fast-food restaurants. Class segregation has also been compounded by these mismatches. At Atlanta's booming Perimeter Center, notes Leinberger and Lockwood [1986], many black employees can be seen walking through parking lots on their way to bus stops every evening. Most live fifteen to twenty miles to the south of the Center and must endure one to two hour bus rides, twice a day.

*) Two wage-earner households -- The trend toward multiple wage earners has also contributed to job-housing imbalances. Where there is a clear distinction between primary and secondary wage-earners, most families could be expected to locate with reference to the "breadwinners" workplace, with the other spouse finding work close by. Where couples earn comparable salaries, however, the residential location choice is less likely to be one-sided in favor of a single spouse. In such households, familes could be expected to live somewhere in between the workplaces of both wage-earners in order to balance out commuting distances. Unless a region has a large share of households where both wage-earners work in the same vicinity, a certain degree of jobs-housing imbalances will be inevitable. In the case of California's Silicon Valley, most members of two-wager earner households do not work near each other -- 57 percent work in different cities [Communications Technologies, 1987].

*) Job Turnover -- A second trend influencing jobs-housing relationships is increasing rates of job turnover. Today's workers are changing jobs and careers more frequently than in years past, for a host of reasons, including the career-shifting affects of post-industrialization, increased corporate mergers, and continuing plant closings. For example, in fast-growing Naperville on the western edge of the Chicago area's I-88 corridor, a survey found that corporate executives average a job change every three years.[14] Thus, even if a person is able to buy a home within walking distance of his office, he may end up commuting long distances if he switches jobs, particularly given today's high cost of financing new home mortgages.

Clearly, market and demographic forces are giving rise to a situation where job-housing imbalances in suburban labor markets could reach serious levels in coming years. What benefits might be attained by reversing this trend? For one, closer jobs-housing balancing can shorten commute distances and increase the share of non-motorized trips (i.e., walking and cycling to work). This not only reduces the number of potential miles workers log on roads, but reduces energy consumption as well. Perhaps equally important, jobs-housing balancing helps to rationalize commutersheds by segregating local and through traffic. Around many SECs today, through travel conflicts with SEC-oriented travel because centers often straddle major arterials and freeway interchanges. Thus, the same high-volume facilities that provide regional access to outlying centers must also carry traffic not related to SECs. Bringing people closer to their jobs would reduce the need of many workers to use line-haul freeways, thus moderating the clash between local and through travel.

With a jobs-housing balance, local streets and collectors can also be used more efficiently. Local street have considerable untapped capacity, constituting around 85 percent of lane miles of roadway nationwide, yet carrying only about 15 percent of vehicle mileage [Federal Highway Administration, 1986; Levinson, 1976]. By shortening trips, jobs-housing linkages would allow local streets to be exploited more fully (whether by foot, bicycle, or car) while deflecting cars from already over-jammed freeways.

On-Site and Off-Site Housing Provisions

Table 3.4 reveals some of the characteristics of housing within and near the SECs surveyed in this report. On average, the non-corridor SECs had around 1,400 on-site units, with a substantial degree of variation among cases. The master-planned SEC with the largest

Table 3.4

Housing Provisions Within and Near SECs

	Mean	Std. Dev.	Min.	Max.	No. Cases
ON-SITE HOUSING PROVISIONS					
No. of On-Site Housing Units[1]	1,408	2,377	0	9,600	42
Percent of Units Multi-Family[1]	69	65	0	100	42
Employees/On-Site Housing Unit[1,2]	30.9	35.8	3.6	113.3	28
OFF-SITE HOUSING PROVISIONS					
Approximate number of Housing Units within a three mile radius of SEC[1,3]	11,100	18,400	0	83,100	41
Percent of Housing Units within a three mile radius that are multi-family[1,3]	35.0	25.0	0	99	41
Estimated Purchase Price of Single-Family Unit within a three mile radius ($1,000s)[1,3,4]	148.4	56.6	65	300	41
Esimated Monthly Rent of Multi-Family Unit within a three mile radius ($)[1,3,4]	593.5	143.5	325	900	41

Notes:
1. Exclusive of corridors, consisting mainly of master-planned projects and well-defined clusters.
2. This ratio is only for the 28 cases with some (at least one) housing units on-site (i.e., cases with zero values in the denominator were excluded).
3. Includes the housing units within the SEC.
4. In 1987 dollars.

on-site housing component is the Woodlands, a new town north of Houston, which has 9,600 units (and still growing). Other surveyed SECs with sizeable on-site housing offerings include the South Coast Metro, Chesterbrook, the Meadowlands, and the North Dallas Parkway.

Of the on-site housing units, on average, around 70 percent are multi-family townhouses, condominiums, and apartments. SECs such as the Perimeter Center in Atlanta, Greenway Plaza in Houston, and the Hacienda Business Park in the Bay Area, have multi-family units exclusively. In most cases these units are inhabited by families, although in several instances on-site units serve mainly as company condominiums for out-of-town visitors and business entertainment. Company condominiums obviously do little to balance jobs and housing.

The average ratio of on-site jobs to housing for the 28 surveyed SECs with some housing provisions was very high -- 30.9. Around half of these SECs fell within the range of 20 to 28 workers for every on-site housing unit. Only the Woodlands and Chesterbrook had more housing units than jobs in 1987, whereas the rest of the SECs had ratios that exceeded the 1.5 threshold of jobs-housing balance.[15] Both the Woodlands and Chesterbrook, however, were consciously designed as "balanced" communities whereas, almost by definition, the other SECs have evolved more as employment concentrations, so fairly high ratios could have well been expected. Regardless, it is apparent that the vast the majority of SECs today offer their tenants' employees relatively few on-site housing opportunities.

As noted earlier, more important than the ratio of jobs-to-housing is the share of workers who actually live in on-site units. Unfortunately, data were not available in most cases to assess this. From interviews, most developers and property managers of SECs with substantial residential components estimated that somewhere in the neighborhood of 5 to 10 percent of workers lived in those units. For the Warner Center in suburban Los Angeles, a 1985 survey of the tenants of on-site townhouses and condominiums indicated that 8 percent of the heads of households worked within the SEC [Cervero, 1986B]. Thus, even where there are on-site housing provisions, it is apparent that in at least some cases, relatively few workers are residing in them, ostensibly because either they cannot afford the units or they choose to live elsewhere.

Of course, it is not imperative that suburban employees live actually on a site to achieve the benefits of jobs-housing balance. More important is the match-up of housing with employees within a small subregion, say, within a three to five mile radius of the workplace. Table 3.4 indicates that for non-corridor SECs, the estimated amount of housing within three miles of the workplace averages around 11,000 units, with substantial variation among cases. Of these areawide units, only around 35 percent are multi-family. From site visits, a number of the SECs were found to be encircled by secluded ranch estates and exclusive neighborhoods with guards and gated security control. In most of these cases, the largest class of SEC employees worked in clerical positions, earning wages far below what would be required to purchase or rent nearby homes.[16]

From Table 3.4, the upscale character of nearby residences is further suggested by the high average estimated purchase price ($148,000) and monthly rent ($600) of units within a three mile radius of SECs. In every instance, estimated mean purchase prices and rents were higher than metropolitan-wide averages. That many workers are unable to live within three or so miles of these SECs seems inescapable, particularly in light of the fact that, as shown earlier, over forty percent of SEC employees have clerical, manufacturing, and other non-professional positions. This inference is further supported by the findings of other researchers that show clerical and manufacturing employees in SECs in the Atlanta and Chicago areas commute farther to work than any other class of employees [Hartshorn and Muller, 1987; Sachs, 1986].

3.6 Transportation Facilities and Services in SECs

In addition to land use features and jobs-housing relationships, of course, the amount and quality of both on-site and off-site transportation facilities and services influence the travel behavior of SEC workers. In particular, roadway capacity, parking provisions, and the availability of commute alternatives, such as vans and buses, can have a powerful influence on the modal choices of SEC workers.

On and Off Site Roadway Facilities

Table 3.5 summarizes some of the transportation facilities and services of the surveyed SECs. Among the eighteen master-planned SECs for which data were available, there are, on average, around nine directional miles of roadway within each site. This averages out to around 2,600 directional miles per employee. Most road networks within suburban office parks consist of a system of curvilinear streets that are laid out and interconnected in a grid-like manner [O'Mara and Casazza, 1982; Cervero, 1986B]. Some feature a main spinal road that penetrates the core of the project, flanked by minor loops that provide direct site access.

In many master-planned business parks, individual parcels have their own access roads. This enables main roads to function as through channels, with access and frontage roads providing direct ingress and egress to sites. Where buildings are far apart, those relying on their vehicles for on-site circulation must exit front one development onto a collector or arterial and promptly turn into the next development's autonomous entry road and parking lot. Such movements can interrupt traffic flows on main thoroughfares and create fairly circuitous travel patterns.

Of course, freeways play a vital role in linking many suburban workers to their residences. Over ninety percent of the non-corridor SECs are served by controlled-access freeways. On average, these SECs have 7.3 directional miles of freeway and 5.6 grade-separated interchanges within a five mile radius. This averages out to around 3,800 employees per directional freeway mile and 6,400 employees per interchange. The average spacing between interchanges is 2.5 miles (directional miles/interchanges).

On-Site Parking Provisions

The availability and price of parking are two of the most significant determinants of the modes commuters opt for [Shoup, 1982]. In most suburban work environments, parking is closely controlled, with zoning ordinances and site covenants usually governing the minimum number of spaces provided, the location of lots, and the permissibility of on-street parking.

From Table 3.5, the surveyed SECs average around 3.85 parking spaces per 1,000 gross square feet of floorspace, which comes out to a little over one space per worker. For developments with a large retail component, rates tend to be higher whereas the rates for centers dominated by office uses are generally somewhat lower. Still, compared to many of the other statistics cited, there is relatively little variation across sites in the parking rates. Other surveys of suburban office parks and activity centers across the country also show surprisingly little variation, with averages consistently falling in the range of 3.5 to 4.0 spaces per 1,000 square feet of floorspace [Lea, Elliott, McLean & Company, 1985; Gruen Gruen + Associates, 1986; Cervero, 1986B]. In general, the provision of roughly one parking space per office worker has become a universally accepted standard in the real estate industry [O'Mara and Casazza, 1982; Lenny, 1984]. Zoning codes which require ample parking as a hedge against vehicles spilling over into surrounding streets, pressures from financial lenders to exceed minimum parking standards in order to improve a project's marketability, and fears

Table 3.5

Transportation Facilities and Services

	Mean	Std. Dev.	Min.	Max.	No. Cases
ON-SITE ROAD FACILITIES[1]					
Directional roadway miles[2]	8.9	6.6	2.0	23.0	18
Employees/Roadway mile	2,584	2,194	400	8,333	18
OFF-SITE ROAD FACILITIES					
Freeway directional miles within 5 mile radius[2]	7.3	5.3	0	20	47
Employees/Freeway mile	3,827	4,420	157	20,000	46
Freeway Interchanges within 5 mile radius	5.6	9.7	0	11	56
Employees/Interchange	6,431	5,247	457	20,500	56
Freeway directional miles/Interchange[2]	2.5	1.5	0.6	9.0	47
ON-SITE PARKING PROVISIONS					
Parking Spaces/1,000 gross square feet of Floorspace	3.85	0.68	2.0	5.5	55
Parking Spaces/Employee	1.04	0.18	0.6	1.4	55
"Modal" daily Parking Price ($)[3]	0.60	0.90	0.0	3.50	48
TRANSIT AND RIDESHARING SERVICES[4]					
No. peak hour public Bus Runs:					
On-Site[5]	4.8	4.5	1	15	18
Within 3 mile radius	12.0	13.6	1	61	48
No. daily private Commuter Buses[5]	3.8	7.3	1	30	41
No. Firms sponsoring Vanpools[5]	2.5	3.9	1	20	41
No. Company Vans operating[5]	14.1	22.8	1	115	41

Notes:
1. Statistics only for well-defined, master-planned SECs, exclusive of all corridors.
2. Directional miles measure lineal distance in one direction.
3. Most frequently occurring daily price for parking.
4. Exclusive of corridors.
5. Statistics only for SECs with some bus or van services. Minimum values are one.

that a project will only be competitive if excess parking is provided have frequently combined to inflate parking supply in SECs.[17]

Several studies suggest that many suburban office centers have in the range of 60 to 70 percent excess capacity. A survey of actual usage rates in California and Texas found suburban office workers only required around 2.2 spaces per 1,000 square feet, even though 3.7 spaces per 1,000 square feet were being provided [Lea, Elliot, McGlean & Company, 1985]. Gruen Gruen + Associates [1986] study of nine business parks in suburban Philadelphia and San Francisco revealed that the highest occupancy rate during the peak period of parking was 60.6 percent. The researchers concluded that "...the business parks surveyed appear to be allocating too much space for parking as an inducement to attract tenants from more congested urban locations. The data suggest that a 2.0 parking ratio would be sufficient to take care of the parking needs of most business parks" [Gruen Gruen + Associates, 1986, p. 14]. Besides inducing workers to drive, an overabundance of parking, particularly when it is laid out as surface lots, can also space buildings so far apart as to effectively discourage walking between buildings.

A number of suburban developers and communities are beginning to recognize the wastefulness and high cost of excess parking and have taken actions to remedy the situation. The developers of the Galleria office-retail complex in suburban Atlanta, for instance, provided the usual 4.5 spaces per 1,000 square feet for the original 20 story building of the multi-phase project. After noticing that many spaces were empty around the clock, they lowered the rate to 4 spaces for the second office tower and eventually down to 3.3 spaces for the third phase of the project, saving millions in the process [Hartshorn and Muller, 1987]. Developers of the high-rise Howard Hughes Center in western Los Angeles chose the opposite approach, providing below-standard parking for the initial phase of the project and adjusting the amount of parking in subsequent stages according to how full garages were and the success of company-sponsored ridesharing programs [Cervero, 1986B]. Moreover, several suburbs with large employment bases, notably Bellevue, Washington and Palo Alto, California, have recently lowered minimum parking requirements to 2.0 spaces per 1,000 square feet. In the case of Bellevue, a maximum ceiling of 2.7 spaces per 1,000 square feet has been established for the downtown core [Freeman, et al., 1987; Kenyon, 1984].

Besides supply, there are several other distinguishing features of parking in SECs that deserve mention. Around three-quarters of SEC parking is in the form of surface space. Unlike CBDs, moreover, most SEC parking is associated with a specific building or property [Rice Center, 1987]. Multilevel, joint-tenant structures are generally limited to higher density clusters where land prices exceed $8 per square foot (1982 dollars) [O'Mara and Casazza, 1982]. A number of SECs around the country are dotted throughout with decked structures, including Tysons Corner, Perimeter Center, South Coast Metro, Greenway Plaza, and the Denver Tech Center, among others.[18]

Another prominent feature of SEC parking is its relative convenience. In many business parks, buildings are enveloped 360^{o} by asphalt parking, offering a short trek from one's car to one's desk. A Houston study found that SEC parkers walked, on average, one-half of a downtown-size block from their parking spot to their office, roughly half the distance of the typical downtown office worker. Moreover, around 80 percent of SEC parkers walked "zero blocks" to their offices, enjoying virtually front door parking privileges. Another study of 32 office parks around the country found a mean walking distance of 116 feet between main building entrances and the middle of the closest parking lot; by comparison, the nearest on-site bus stop was, on average, 480 away, approximately four times as far [Cervero, 1986B].[19] The same study found that around 7 percent of parking stalls in business parks are reserved for carpools and vanpools; these stalls were generally within fifty feet of building entrances. Preferential parking, however, can only be expected to influence mode choice in congested locales where it is difficult to finding parking. In the vast majority of SECs, this is not the case.

Not only do most suburban workers enjoy a guaranteed, convenient parking space; in the vast majority of cases, the space is free. From Table 3.5, the most frequently paid daily parking fee for long-term parking averaged out to sixty cents. This average, however, is skewed by several large centers where parking fees are generally collected, such as the South Coast Metro and central Stamford. At most SECs, free parking is provided as a marketing ploy. Even in several high-density centers, free parking is the norm. At Warner Center, for instance, 93 percent of workers have their parking expenses paid entirely by their employers [Commuter Transportation Services, 1987]. The Rice Center [1987], moreover, found that only 3.2 percent of Post Oak's workforce pays for parking, even though its office inventory exceeds that of downtown Atlanta.

Parking charges and restraints on supply have been shown to have a significant affect on mode choice [Shoup, 1982]. Following the passage of Bellevue's landmark parking ordinance, for instance, one of the city's largest employers succeeded in getting 77 percent of its 900 workers into carpools and buses by limiting parking to 410 stalls and charging $60 per month per space [Kenyon, 1984]. The majority of suburban employers are reluctant to charge for parking, however, since free parking represents an in-kind, tax-free benefits to their workers and is often looked upon as a "good will" gesture. Unless such hidden subsidies to motorists are eliminated, however, many SECs will be hard pressed to entice their tenants' employees into buses and vanpools.

Transit and Ridesharing Services

Historically, mass transit has played a minor role in suburban labor markets because of low employment densities as well as the prevalence of abundant, free parking [Orski, 1986A; Cervero, 1984]. From Table 3.5, for the 18 non-corridor case sites with the some on-site public transit services, the average number of peak hour bus runs is around five. Within a three mile radius of SECs, there is an average of 12 bus runs during the peak. On a daily basis, the surveyed SECs have, on average, nearly four private commuter buses operating on their premises. The two surveyed sites with the highest incidences of subscription bus operations are the Woodlands and the Meadowlands, where on an average weekday over 25 privately operated commuter buses serve their respective residents and employees. Successful private suburban bus operations can also be found in the greater Los Angeles and Norfolk-Virginia Beach regions, where thousands of suburban employees travel to work sites scattered throughout the metropolitan area every day in comfortable coaches offering headrests and guaranteed seats [Giuliano and Teal, 1985].

Only six of the surveyed SECs were found to have on-site shuttle operations.[20] Most are noon-hour circulators, interconnecting major office towers with nearby restaurants and retail centers. In the cases of Bishop Ranch and Hacienda Business Park in the Bay Area, shuttles also operate to and from Bay Area Rapid Transit (BART) stations.

From Table 3.5, each surveyed SEC averages between two and three tenants who sponsor vanpools for their employees. The mean number of vans operating among these firms is 14. The 3M Park in suburban St. Paul has the largest number of company vans in operation among the surveyed sites -- 110. Nationwide, large-scale vanpool programs also thrive in several other SECs, notably Lawrence Livermore Laboratory in suburban Alameda County, the Rockwell International headquarters in Golden, Colorado, and the Tennessee Valley Authority outside of Knoxville [Dingle Associates, 1982].

Most of the surveyed SECs appear quite committed to ridesharing. Nearly one-half have a staff member whose job assignments included ridesharing coordination and promotion, and 56 percent of the sites have an office or location devoted to ridematching and the dissemination of information on commute alternatives. In the majority of cases, ridesharing is somewhat incidental to the staff person's chief job assignment. The on-site rideshare office also usually consists essentially of a kiosk with bus schedules and other literature promoting the virtues of carpooling and vanpooling. Several centers, such as Tysons Corner and Bishop Ranch, do have highly visible on-site transportation offices also that are staffed with full-time rideshare coordinators who maintain active computerized ridematch listings and run carpool promotional efforts.

Cycling and Pedestrian Facilities

In order to promote cycling, around one-quarter of the surveyed SECs were found to have some on-site bike trails and other cycling amenities. Most bikepaths in suburban work settings are used for recreational rather than commuting purposes, however. Several large office parks, such as the Bay Area's Bishop Ranch, have also introduced covenants specifically requiring all buildings with large concentrations of employees to contain showers and lockers for cyclists and other recreationists.

Walkways are an essential ingredient of any work environment. While all SECs feature sidewalks, the overall quality of pedestrian facilities vary quite a bit. Many office parks and planned unit developments have nicely groomed, curvilinear footpaths, dotted with planting, sculptures and other displays that enhance with walking experience. At more congested SECs, grade-separated skybridges and underpasses can be found. In contrast, many unplanned, high-density SECs have a discontinuous, seemingly ad hoc system of sidewalks. In these settings, footpaths sometime end at property lines and all too often are lined by blank walls, vacant lots, and other undistinguishable spaces. Sometimes pedestrians are forced to search for a walkable route around shrubbery and curbs to reach roadways. The sight of office workers crossing busy roadways, dodging cars, and scurrying to find refuge at mid-block traffic medians has become commonplace in many SECs.

Besides the provision of sidewalks, the distances between buildings within SECs and the proximity of nearby commercial and residential activities strongly influence the amount of walking that takes place. In many office parks, pedestrians frequently face long walks across parking lots and open lawns to get between buildings. Even high density SECs pose challenging distances to many pedestrians. At Houston's Post Oak, the nearest high-rise office tower to the Galleria, Post Oak's premier retail center, is 2,000 feet away [Rice Center, 1987]. Studies show, however, that only around 15 percent of Americans are willing to walk 2,000 feet for non-leisure trips [Untermann, 1986], and that the maximum acceptable walking distance for suburban areas is perhaps under 1,000 feet [Lynch and Hack, 1984]. Consequently, pedestrian activity in places like Post Oak are infrequent, with the preponderance of on-site trips made instead behind a steering wheel.

3.7 SEC Commuting and Traffic Conditions

This section summarizes the characteristics of the journey-to-work trips of the employees of surveyed SECs as well as areawide traffic conditions on facilities serving SECs.

Time, Speed, and Distance of Journey-to-Work

The mean one-way travel times, distances, and speeds for journeys-to-work made by employees of the surveyed SECs are shown in Table 3.6.[21] Averaging across the SECs,

Table 3.6

Travel Characteristics of Workforce and Areawide Traffic Conditions

	Mean	Std. Dev.	Min.	Max.	No. Cases
JOURNEY-TO-WORK TRIP					
Average One-way Travel Time (minutes)	24.3	6.7	14	48	56
Average One-way Travel Distance (miles)[1]	11.1	3.6	7	22	12
Average Travel Speed (mph)[2]	28.5	8.9	8.5	48.5	56
Percent of Trips:					
Drive Alone	83	9	58	95	56
Rideshare	13	7	3	34	56
Average daily ridership of all bus runs serving SEC[3]	1,254	2,249	25	9.600	41
"Modal" Arrival Time (a.m.)[4]	8:16	--	7:30	8:45	55
"Modal" Departure Time (p.m.)[4]	4:56	--	4:30	5:30	55
AREAWIDE TRAFFIC CONDITIONS					
Average daily directional traffic volume on principal freeway or arterial serving SEC on typical weekday (thousands)[5,6]	67.9	46.7	6.0	215.0	48
Freeway miles per million population for region[7]	89.9	32.3	24.3	158.0	57

Notes:
1. Averages from worker travel surveys, representing a combination of straightline and elapsed distances.
2. For 35 cases with missing distance data, the average distance was assumed to be 11.1 miles, the average for the 12 SECs with available employee travel distance data.
3. Only for cases with at least one public or private bus run operating within the SEC.
4. Most frequently occurring time of arrival or departure.
5. Directional volumes are oneway traffic counts.
6. Exclusive of corridor cases.
7. Sources: Rodriquez, et al. [1985], Federal Highway Administration [1986].

mployees commute an average of around eleven miles one-way, at speeds of approximately 28 ı.p.h. and taking around 24 minutes, with only a moderate degree of variation across sites. 'his is farther, slower, and longer, time-wise, than journeys-to-work made by the "typical" uburban employee in 1980. That worker travelled, on average, around 9 miles in a little over 8 minutes at speeds of roughly 30 m.p.h. [Pisarksi, 1987]. The differences are surely linked ɔ the increase in congestion and the widening jobs-housing imbalance found around suburban mployment areas since 1980.

The average one-way distance of eleven miles for work trips made by SEC employees, it hould be noted, is actually farther than the ten mile average for all work trips made within '.S. metropolitan areas in 1980 [Pisarski, 1987]. With the relocation of office jobs to aditionally residential suburbs, one might expect SEC work trips to be relatively short. As oted in section 3.4, this discrepancy is likely due to the displacing effects of jobs-housing nbalances and, perhaps more directly, the mismatch between SEC employee earnings and the ost of nearby housing. More disaggregate surveys of commuting distances of individual SEC mployees have also found comparatively long commutes being made. Of the greater Houston rea's eleven SECs, the Rice Center [1987] found that workers in West Houston's Energy 'orridor, the farthest SEC from downtown, averaged longer commutes than workers from any ther SEC -- 9.8 miles (even farther than the 9.2 mile average for CBD workers). For two f the San Francisco Bay Area's largest and fastest-growing suburban employment markets, leasanton and the Golden Triangle of Santa Clara County, average one-way employee ommutes exceed 15 miles, over one-quarter longer than the regional average [Cervero, 1986B; 'ervero and Griesenbeck, 1988]. It is apparent that bringing jobs closer to population masses oes not guarantee shorter, or even easier, commutes.

Iode Splits for SEC Work Trips

As mentioned earlier, the low-lying, spread out profile of many SECs, combined with ıeir single-use nature and abundance of free parking, encourage many employees to drive to 'ork. Among surveyed SECs, on average, 83 percent of the workforce solo-commutes and 13 ercent either carpools or vanpools (Table 3.6 and Figure 3.5). These percentages closely ıatch those for the nation as a whole in 1980 [Pisarski, 1987].[22] These national figures, owever, include small and large metropolitan areas alike while the SECs surveyed were redominantly from regions with populations exceeding one million. For the 26 metropolitan reas in which the surveyed SECs are located, the share of drive-alone commute trips was 68 ercent in 1980.[23] Thus, on average, the share of SEC employees in these surveyed regions 'ho relied on their cars for commuting to work exceeded that of the typical worker by 15 ercentage points.

Among the surveyed SECs, there tended to be the most variation in the shares of mployees who carpool or vanpool (Table 3.6).[24] SECs with market shares of arpoolers/vanpoolers exceeding 20 percent are Bellevue, Bishop Ranch, BWI, Cyprus Creek, ast Farmingdale, Hunt Valley, the Meadowlands, Greenway Plaza, Post Oak, Stamford, and the M Park.[25] While these SECs vary in density and character, in all cases there is an active idematching campaign under way and at least one major tenant underwrites the costs of mployee vanpool services. Suburban areas, in general, average relatively high levels of idesharing because of the absence of suitable public transit services in many cases [Briggs, et l., 1986]. In many business parks, however, the dispersal of thousands of employees over everal square miles, coupled with the usual absence of internal circulators and the multitude f parking options, stack the odds heavily against ridesharing. Where employee residences are 'idely scattered, ridematching can be next to impossible. As discussed in Chapter Six, in laces with few larger employers there might not be enough of a critical mass to sustain a idesharing program. Despite active promotion, for example, the Denver Tech Center has been

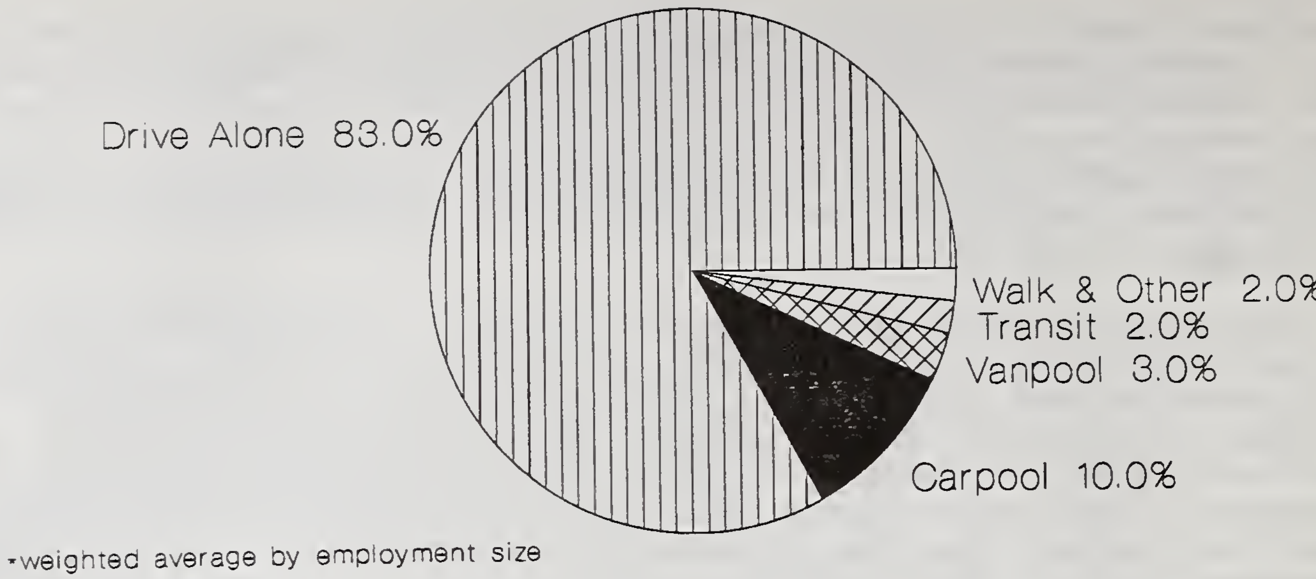


Figure 3.5 Percent of Work Trips to SECs by Mode

able to entice only around 10 percent of its labor force into carpools and vanpools, in part because over 400 individual tenants account for development's 16,000 workers.

Figure 3.5 also reveals that public and private transit serves, on average, only two percent of SEC employees.[26] This matches the nationwide average for work trips destined to suburbs [Fulton, 1986B]. Among the surveyed SECs, only Bellevue, Bishop Ranch, Hacienda Business Park, and the Meadowlands had transit mode splits exceeding the national average of 7 percent for metropolitan areas. In addition to its parking containment program, Bellevue's success can be attributable to the its superb transit services. Notably, a transit center in the heart of downtown Bellevue functions as a major transfer point for the region and is served by 17 Seattle Metro routes (136 buses during the 3-6 p.m. peak). The sponsorship of premium-type coach services for tenants' employees by the developers of Bishop Ranch and Hacienda Business Park east of San Francisco likely accounts for much of transit's success at these two projects.

Other SECs have had less success at enticing workers into buses. At mixed-use complexes, such as the Denver Tech Center, Post Oak, and South Coast Metro, fewer than 5 percent of employees commute by bus. This is despite the fact that these centers serve as major transfer points, with, in the case of the South Coast Metro, as many as 12 bus routes converging into the premises during peak hours. Low densities at the residential end of work trips likely account for transit's low market shares in these cases [Cervero, 1986B; Reichert, 1979]. Even SECs with direct rail transit connections tend to have low ridership levels. Travel surveys show that fewer than 5 percent of employees in office towers circling rail stations in the suburban San Francisco-Oakland (BART) and suburban Washington, D.C. (WMATA) areas patronize transit [Baker, 1983; Orski, 1985; Knack, 1986]. Low ridership levels can be attributed to low residential densities and free employee parking in many of these cases [Cervero, 1986B].

Lastly, Figure 3.5 reveals that walk and other (e.g., cycling, drop-off, etc.) trips only comprise around two percent of work journeys made to SECs. This is less than the 4 percent national share of work trips made by walking among suburban workers [Pisarski, 1987]. Again, the built-in design inducements to solo-commute and the lack of integrated sidewalk systems in many SECs have discouraged many employees for walking or cycling. In general, walk trips are more common for non-work purposes in SECs. The Rice Center [1987] study, for instance, found 19.5 percent of all trips in Houston area SECs were made by foot (0.7 walk trips/employee daily), one-third of which were made between 11 a.m.-2 p.m. However, of non-work trips within SECs, walking made up only 21.5 percent of the total. In centers like Post Oak, disconnected sidewalks, long block faces, and limited mid-block cross-walk opportunities have discouraged foot travel. Lunch-time walk trips of as long as one-half mile are most likely to occur in mixed-use environments. Workers are more apt to walk along avenues with shops, parks, and other interesting activities since a number of trip purposes can be accomplished along the way [Rice Center, 1987]. Along Bellevue's main pedestrian axis, for instance, walk trips comprise 32 percent of midday travel, in large part because the street is lined with interesting shops and eateries [DKS Associates, 1987].

Vehicle Occupancy

Suburban workplaces generally enjoy high vehicle occupancy levels because of the relatively high incidence of vehicle-pooling [Briggs, et al., 1986]. Although occupancy data were not compiled for SECs in this study, travel surveys for several case sites documented the following rates, expressed in persons per vehicle during the peak period: Bellevue (1.21); Bel-Red Corridor (1.10); Denver Tech Center (1.13); Greenway Plaza (1.19); Hacienda Business Park (1.17); Tysons Corner (1.06); Post Oak (1.15); and West Houston Energy Corridor (1.13). These rates hover around the 1980 average occupancy level for all U.S. metropolitan areas of 1.15 persons per vehicle [U.S. Bureau of Census, 1982]. Because of declining real gasoline prices and demographic trends (e.g., increases in single-headed households), however, national occupany rates have likely slipped some during the 1980s.

Time Period of Travel

Suburban work settings have a number of distinct peaking characteristics. The afternoon peak is usually longer and more pronounced than the morning peak since late afternoon traffic usually includes a broad mix of work-commuters, business and delivery vehicles, shoppers, and other personal trips. In the Seattle area, for instance, 57.7 percent of downtown trips from 4:30-5:30 p.m. are work trips, compared to a work trip share in the suburbs during this period of only 38.8 percent [Puget Sound Council of Governments, 1984]. Afternoon peaks in the suburbs tend to be elongated since most suburban retail outlets stay open late whereas most downtown shops close at 5 p.m. Moreover, suburban work areas tend to have distinct midday peaks, mainly due to vehicular lunch hour traffic. At Tysons Corner, the midday peak actually exceeds both the morning and the evening peak on the basis of the highest fifteen minute traffic count. Viewed over time, the hourly distribution of vehicle trips in many SECs looks more like the profile of a camel with three rather than two humps.

The most frequently occurring time period of arrival among the employees of surveyed SECs averaged out to 8:16 a.m. (Table 3.6). The modal departure time was just before five o'clock in the afternoon. Those SECs with large shares of investment brokers, accountants, and other financial positions tended to have earlier average arrival and departure times since these workers usually are on-board at the opening bell of the east-coast stock exchanges. Finally, among survey respondents, 65 percent associated the morning peak hour for SEC work trips with the 7:30-8:30 a.m. period; 70 percent defined the 4:30-5:30 p.m. period as the afternoon peak. In general, then, the heaviest hour of SEC-oriented commuting appears to coincide more or less with the peak hours of other work locales.

Trip Generation

Although trip generation rates were not measured directly in this study, several SECs reported rates empirically derived for trips made by office workers. The ITE [1987] Trip Generation manual presents the following rates, defined in terms of weekday trip ends per 1,000 gross square feet, for each of the below uses:

* General Office -- 12.3
  Buildings < 100,000 sq. ft. -- 17.7
  Buildings 100,000-200,000 sq. ft. -- 14.3
  Buildings > 200,000 sq. ft. -- 10.9

* Office Park -- 20.6

* Research Centers -- 5.3.

Thus, office parks average almost twice as many vehicular trips per square foot as large general office buildings, reflecting the effects of low densities, single-use activities, and excess parking on vehicle usage.

For several SECs, the below-listed weekday trip generation rates for office uses have been estimated (also on a square footage basis):[27]

* Bellevue -- 18.1
* Lake-Cook Corridor -- 19.98
* Naperville -- (single tenant -- 5.17;
  multi-tenant -- 12.97)
* Oak Brook -- (single tenant -- 9.48;
  multi-tenant -- 15.20).

With the exception of Bellevue, all of these SECs are located in the Chicago region. In general, these rates fall within the range of values found in the ITE manual. The wide variations suggest that a number of factors, including land use variables such as density and the variations in uses, influence office trip generation rates. From the Chicago data, it is apparent that tenancy is one influential variable -- multi-tenant rates were far higher than those of single-tenants. Multi-tenant buildings tend to be taller and more intensely used, producing higher trip rates. If all of these trips are made by automobile, then denser office areas can be expected to be more congested. If, on the other hand, significant shares of these trips are diverted to vehicle-pools, transit, cycling, and foot travel, then denser workplaces might be less congested. The relationship between density and mode choices for SECs is explored in Chapter Six.

Areawide Traffic Conditions

Traffic congestion around SECs has been referred to as a "looming crisis" [Orski, 1985]. Just how bad have things gotten? For 57 surveyed SECs, level of service information was obtained for the primary arterial and freeway serving each SEC, based on both survey responses and local engineering records.[28] Figure 3.6 shows the distribution of peak hour levels of service for the main arterial serving SECs. In one-third of the cases, arterials operate at level of service D (80-89 percent of capacity), a service quality generally associated with congested conditions in suburban settings. And in around 30 percent of the cases, level of service falls below D during the peak (whereby volumes exceed 90 percent of capacity and most motorists require two or more light changes to pass through a signalized intersection).

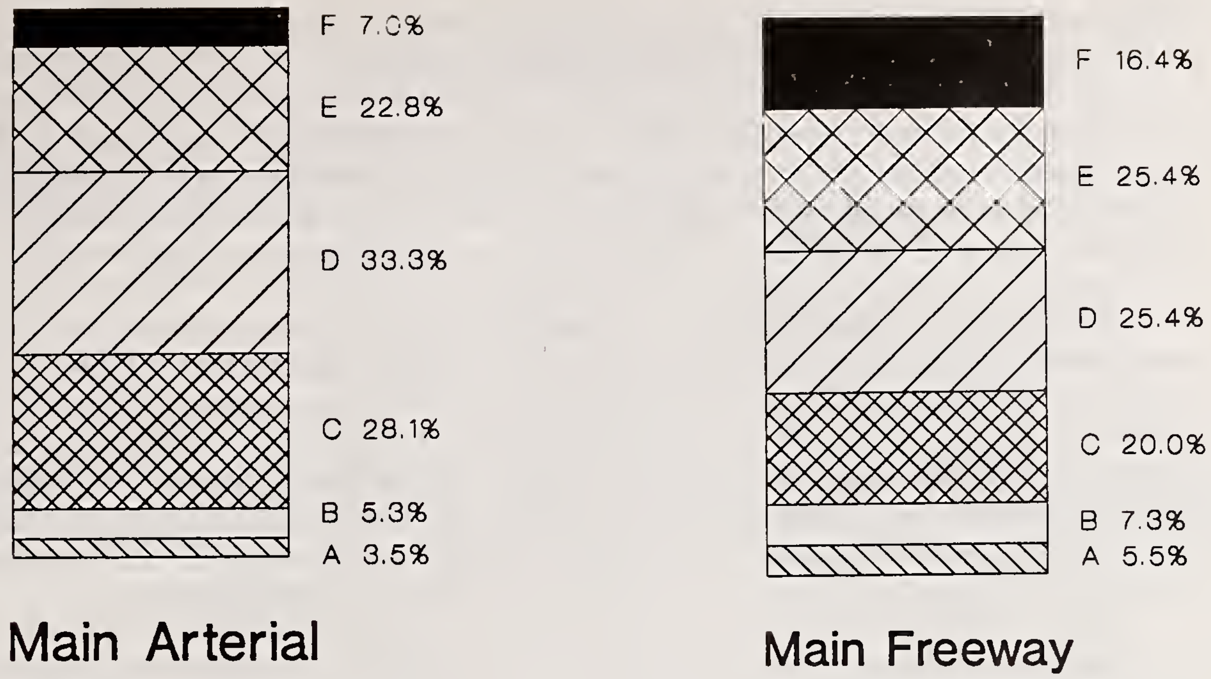


Figure 3.6 Percentage Breakdown of Average Level of Service on Main Roadways Serving SECs

Comparing the righthand side of Figure 3.6, service conditions appear even worse along the principal freeway serving the surveyed SECs. In over 40 percent of the cases,[29] peak hour traffic flowed at level of service E or worse (which for restricted-access, non-signalized facilities such as freeways means forced flows with no driver ability to select lanes or speeds). This high incidence of freeway congestion suggests that many SECs are indeed approaching serious traffic conditions that rival those of many downtowns and inner-city corridors.

From the bottom rows of Table 3.6, the daily volumes on these connecting freeways are, on average, rather high -- nearly 70,000 vehicles per day. SECs with the highest freeway traffic counts, in some cases exceeding 200,000 vehicles per day, are the Golden Triangle in Santa Clara County (Rte. 101 -- Bayshore Freeway), the North Dallas Parkway, South Coast Metro (I-405), Cyprus Creek (I-95), and Warner Center (Rte. 101 - Ventura Freeway). Around 52 percent of the surveyed SECs are in metropolitan areas with predominantly radial-ring freeway networks, 14 percent are in regions with grid-like networks, and the remaining one-third are situated in areas with more or less irregular networks.[30] On average, the metropolitan areas with SECs that were surveyed have around 90 freeway miles per million population, which is slightly above the average of 84.7 miles for the twenty largest U.S. metropolitan regions.[31] On the whole, then, the surveyed SECs appear to have reasonably good freeway provisions.

3.8 Summary

This chapter has discussed a range of transportation and land use issues affecting SECs by both reviewing the literature and summarizing general statistics on the 57 centers and corridors surveyed for this study. The SECs were found to be diverse in many ways, so making generalizations about them can be hazardous. On the whole, however, they tend to be quite large, encompassing several square miles, with millions of square feet of floorspace and well over 10,000 employees. The workforces of SECs tend to be equally diverse, with clerical workers forming the largest single occupational group.

Most SECs have low floorspace and employment densities, generally with FARs below 2.0 and under 20 workers per acre. Many master-planned, campus-style projects cover less than a third of land with structures, producing long setbacks and segregating buildings. When surrounded by surface parking, walking distances can become excessively long.

SECs were also found to vary considerably in their degree of land use mixture. Some have over ninety percent of floorspace devoted solely to office use. Mixed-use environments, it has been argued, could reduce trip generation levels, encourage walking and ridesharing, spread trip-making more evenly throughout the day, and allow parking facilities to be shared. Equally important, the provision of more affordable housing near SECs could shorten commute distances and help segregate local and through traffic. Around many SECs, there appears to be a wide disparity between the earnings of workers and the cost of nearby housing, setting the stage for long commutes and traffic tie-ups along connecting arteries.

Another prominent feature of SECs is the abundance of free, convenient parking. Most offer around one parking space per employee. This becomes a self-fulfilling prophecy, of sorts, with most workers filling their allotted parking spot by driving. While most SECs are connected by buslines and have an assortment of ridesharing services, five out of six work trips nonetheless normally involve an employee commuting alone. SEC commuters generally average speeds under 30 m.p.h., more often than not, on connecting freeways and arterials that are approaching unstable flow conditions.

It bears repeating, however, that SECs come in all shapes and sizes. Perhaps only by classifying centers into homogenous groups and comparing differences among the groups can one gain an appreciation for their distinguishing features as well as some insight into how varying land uses and site designs influence travel behavior. The following two chapters attempt to do this, first by grouping the cases into one of six different SEC classifications and then by studying differences among the groups.

Notes

1. The ratio of standard deviation to mean is sometimes called the coefficient of variation. Coefficients exceeding one signify a fairly dispersed distribution of values.

2. This average is based on the mean of the ratio of current FAR to allowable FAR for the 35 cases. This is higher than the "average of the average", which would be 0.98/2.34 = 0.42, or 42 percent.

3. FAR/Coverage Ratio = 0.98/0.31 = 3.16.

4. Class A space is a general term used to connote the highest quality of office building. The Urban Land Institute defines it as "buildings which have excellent location and access, attract high quality tenants, and are managed professionally. Building materials are high quality and rents are competitive with other new buildings" [O'Mara and Casazza, 1982, pp. 18-19].

5. The abbreviation MXD has been adopted by the Urban Land Institute [1986] and is used throughout the remainder of this report.

6. ITE [1987] daily trip rates are: 5.3 weekday trips per 1,000 gross square feet of R&D, 6.1 trips per apartment unit, and 40.7 trips per 1,000 gross square feet of specialty retail. Thus, for this scenario, the trip volume can be calculated as: {[25,000 office sq. ft. * (12.3 trips/1,000 office sq.ft.)] + [10,000 R&D sq. ft. * (5.3 trips/1,000 sq. ft. R&D)] + [(40,000 sq. ft. apartments/(1600 sq. ft./apartment unit)) * (6.1 trips/apartment unit)] + [10,000 sq. ft. specialty retail * (40.7 trips/1,000 sq. ft. specialty retail)]} = 999.5.

7. Among CBD employees, 46.3 percent ate lunch in the immediate area (but away from their office) while 4.3 percent ate outside the immediate area. For SECs, 37 percent of employees had lunch on-site (but away from their office) while 6.7 percent left the premises for lunch.

8. The Barton-Aschman [1983] study, for instance, found 28 percent of employees of MXD patronized the same or nearby development, while only 19 percent of workers from single-use sites did so.

9. Reliable data could only be obtained from 18 of the SECs which are either master-planned or clustered, or both.

10. Exclusive of corridors.

11. A high retail intensity level means a low value for the ratio of employees to retail establishments.

12. This normative ceiling for "balance" is based on: [(1.7 jobs/cohabitant household) * (0.9 cohabitant households)]/households = 1.53, or approximately 1.5 jobs/household.

13. In 1985, the shares of workers residing locally were: Walnut Creek (19.9 percent); Mountain View (19.7 percent); Palo Alto (19.7 percent); and Santa Clara (16.8 percent) [Cervero, 1986A].

14. Time magazine, June 15, 1985, p. 17.

15. It should be noted, however, that this threshold is most relevant when comparing jobs to housing at the community, rather than SEC, level.

16. Of course, one's ability to purchase a close-by home depends to a large degree on whether a person is the sole wage-earner in a household or not. The ability to purchase more expensive homes obviously increases with the number of wage-earners in a household.

17. From the survey of 50 non-corridor SECs, respondents from 41 of the developments considered their parking rates to be at or above the rates of comparable developments in the region. Additionally, 84 percent of the respondents indicated that parking exceeded the minimum parking requirements.

18. Decked structures generally cost $18 to $20 per square foot (1985 dollars), or roughly twice the footage cost of typical suburban land [Lea, Elliot, McLean, 1985].

19. The study found that walking distances to on-site parking lots increased with the size of a project. The correlation between acreage of a project and average walking distance to on-site parking was 0.33.

20. This is about the same proportion -- approximately ten percent of studied sites -- with on-site shuttle services that was found in an earlier study of office developments in the U.S. [Cervero, 1986B].

21. These statistics are actually "means of means". That is, they are the averages of the "average" travel time, distance, and speed of SEC employees. Reliable distance data were available only for twelve of the surveyed sites. See footnote 2 of Table 3.6.

22. These shares also match the modal distributions of work trips from the 1985 survey of 120 U.S. office parks [Cervero, 1986B].

23. Sources: Briggs, et al. [1986]; Rodriquez, et al. [1985].

24. The standard deviation relative to the mean is much higher for ridesharing than drive-alone commuting.

25. Non-corridor cases only.

26. From the table, the transit trips were made on bus runs serving around 1,250 riders per day, on the average.

27. Sources: DKS Associates [1987]; Transportation Facts, Vol. 4, No. 2, Chicago Area Transportation Study, March, 1987.

28. Level of service is a qualitative measure used to describe the degree of traffic congestion, general speeds, and levels of driver maneuverability on a particularly section of roadway. The letter values are related to the following expressions of traffic volumes as a percent of capacity: A = < 60 percent (free flow); B = 60-69 percent (mainly free flow); C = 70-79 percent (stable flow); D = 80-89 percent (approaching unstable flow); E = 90-99 percent of capacity (unstable flow); and F = 100 percent or > (jammed, forced flow).

29. Exclusive of the Central Corridor and Camelback Corridor in Phoenix, since no freeways exist in either area.

30. See: Institute of Transportation Engineers [1985] for a detailed discussion of these network types.

31. Sources: Rodriquez, et al. [1985]; West Houston Association, Limited-Access Divided Highways in America's Twenty Largest Metropolitan Complexes, 1984.

CHAPTER FOUR

Classifying Suburban Employment Centers

4.1 Forms of Suburban Growth

Urban geographers, regional scientists, and city planners have long classified forms of metropolitan growth in an attempt to both understand the forces shaping it as well as the consequences of the evolving patterns. Classification, whether used for studying cities, diseases, or insects, is an indispensible tool for distilling sometimes unwielding volumes of information into more understandable subgroups. Additionally, it illuminates important relationships among variables by sifting out patterns and differences among classified groups. Following a brief review of theories and writings on suburban growth patterns and spatial forms of office growth, this chapter classifies SECs and assigns case sites to one of six groups based on a number of discriminating variables. The low-to-high ranges of some of the variables discussed in the previous chapter are presented for each of the six SEC groups as well. Case synopses for three of the SECs within each group are also presented. The intent of this chapter is not to create another schema for defining forms of suburban growth, but rather to provide a foundation for sorting out transportation-land use relationships among the case sites studied.

The three classic models of metropolitan structure are concentric zone [Burgess, 1925], the sector [Hoyt, 1939], and multiple nuclei [Harris and Ullman, 1945]. Burgess saw regions forming as a series of concentric rings of distinct land uses focused on a dominant center, while Hoyt described cities in terms of lineal sectors emanating from the core along major transportation routes, such as railways. Both models dealt primarily with the patterns of residential growth and only considered a single commercial center, though Burgess did acknowledge that some regions seemed to be evolving as "centralized decentralized systems". Harris and Ullman formalized this notion in their characterization of metropolises as a hierarchy of individual centers, each featuring a unique pattern of land uses and a separate laborshed. The interdependence of these uses and the scales, forms, and functions of centers were generally overlooked in these early writings.

The migration of factories and retail outlets to the suburbs, ushered in, in part, by the dawning of superfreeways, gave rise to still other visions of metropolitan growth. Some authors characterized the evolving form of urban change as counterurbanization -- the erosion of a single-centered metropolis. Others described growth as a scatteration of activities -- the seemingly random sprawl of tract housing, shopping malls, and industrial parks, each locating without any specific attraction to particular focal points [Blumenfeld, 1964]. Many saw this emerging form as a mixed blessing, on the one hand increasing the consumption of land and other finite resources, yet on the other hand easing traffic congestion in the inner-city [Clark, 1954]. Others cautioned that although downtown congestion would be relieved, the growth in cross-hauling could eventually overwhelm suburbs with traffic [Schnore, 1959].

Unsatisfied by this notion of random, unstructured growth, a number of urban economists have developed theories over the past forty years aimed at explicating the spatial relationship among land uses in some systematic way [Carroll, 1952; Wingo, 1961; Alonso, 1964; Mills, 1972; Solow, 1973]. Industrial location theories viewed the locational decisions of firms with regard to proximity to raw materials, consumer markets, and labor. Other writers focused on patterns of residential location, generally expressed as involving a trade-off of housing and transportation expenses, with the rate of substitution depending on household preferences for low density living. Over the years, a unified theory of either business or residential location has failed to emerge, in part because empirical work has demonstrated that a multitude of factors influence locational choices [Quigley and Weinberg, 1977; Clark and Burt, 1980]. In particular, with the shift in the nation's economy from a manufacturing to a service base, businesses are becoming increasingly footloose, less encumbered by the need to be near raw materials or transportation lines.

In studying metropolitan growth and change, some authors have sought to define the forms and styles of office and commercial development in the suburbs specifically. In his analysis of the first-wave of commercial development outside of central cities, Berry [1959] described four types of business location: 1) urban arterial; 2) highway-oriented; 3) nucleated; and 4) localized. Establishments were said to be drawn to one of these locations according to their degree of specialization in addition to their labor and consumer access requirements. In a later study of office decentralization in Great Britain, Daniels [1974] defined office growth in terms of both scale and form. His four classifications were: 1) small centers; 2) large centers; 3) sprawl; and 4) widely scattered. Baerwald [1982] chose a more basic dichotomy of clustered versus corridor growth in examining office development in the Minneapolis-St. Paul region. A number of more recent studies have similarly differentiated between office growth that is clustered versus more auto-oriented patterns laid out along axial arterials and freeways [Hughes and Sternlieb, 1986; Leinburger and Lockwood, 1986].

Lastly, several researchers have concentrated on the evolution of suburban economic activities over the post-war era, tracing the transformation of suburbs from predominantly bedroom communities to more mature, urban-like places. Erickson [1983] has described suburban growth in the U.S. through 1960 as a process of "dispersal/differentiation", followed by a subsequent phase (1960-present) of "infilling/multinucleation". More recently, Hartshorn and Muller [1986] have chronicled suburban growth in terms of changing land uses and built environments as well. They conclude that American suburbs have evolved in four distinct stages: 1) "bedroom communities" (pre-1960); 2) "independence" (1960-70, underscored by the arrival of shopping malls and industrial parks that allowed suburbs to become more self-sufficient); 3) "catalytic growth" (1970-80, whereby the addition of offices and other diverse uses ushered in an era of maturity); and 4) "high-rise/high-technology" (post-1980, reflecting dramatic shifts in the nation's economy and the emergence of downtown-like densities).

In summary, suburban growth in general, and suburban office growth in particular, has been described in a number of ways, each with a slightly different connotation in terms of size, density, location, and land use make-up. The wealth of terms used to describe suburban concentrations in the late 1980s -- urban villages, satellite centers, outer cities, megacenters, and suburban downtowns -- suggests that these places are widely diverse and perhaps resist classification. Based on the findings of the previous chapter, however, it appears that the SECs examined in this study have a number of distinctive characteristics that bear on transportation-land use relationships and thus deserve more systematic analysis. The remainder of this chapter classifies these SEC cases in an effort to decipher underlying transportation-land use relationships. In that the next section is more technical, those less interested in the methodological details used in classifying the SECs can skip ahead to the third paragraph of section 4.3 for a discussion of the six SEC groups that emerged and the cases which fall into each of the six groups.

4.2 Factors for Classifying SECs

As discussed in the previous chapter, SECs can be described along a number of dimensions -- size, density, land use composition, site design, ownership patterns, transportation facilities, and so on. Each of these dimensions can be expressed by several different variables, no one of which, alone, fully portrays that dimension, but which together provide a fairly good perspective on size, density, and land use make-up. Some dimensions, such as site design, are fairly qualitative concepts that almost defy measurement and which certainly require more than a single variable to capture their full complexity.

In light of this need to use sets of variables to capture the many-sided dimensions of SECs, the multivariate technique of factor analysis was relied upon. Factor analysis is a statistical method used to identify a relatively small number of underlying factors that can be used to represent relationships among sets of many interrelated variables [Norusis, 1986; Dunteman, 1984]. By merging variables together, it enables large numbers of variables to be distilled down to a handful of underlying factors. In our case, it allows variables such as FAR, floor space per worker, and land coverage ratios to be linearly combined to represent the concept of "density". Thus, factor analysis can help elucidate some of the underlying, though not always observable, land use dimensions of SECs.

Several features about the factor analysis methodology used in this study should be pointed out. One, since this study focusses on how land use factors influence SEC-related travel behavior, the objective was to classify cases with respect to land use, rather than transportation, variables. Thus, only land use variables entered into the factor analysis. Second, one of the main reasons for carrying out the factor analysis was to obtain factor scores for each of the cases that could then be used for classification in the subsequent cluster analysis. This point is expanded upon in the next section. Lastly, the seven large corridor cases, each of which exceeded over 80 square miles in area, were not included either in the factor or cluster analysis since, by virtue of their sheer magnitude, they would have dominated all of the other cases and, in addition, would have had disproportionate influence over such dimensions as "size" and "scale".[1] Thus, "large office corridors" were combined together as one of the eventual six SEC groups at the outset of this classification effort. Accordingly, 50, rather than 57, cases were used in the following factor and cluster analyses.

The intent of this factor analysis was to combine sets of variables that could collectively capture at least the following four dimensions of the SECs: 1) Size and Scale; 2) Density; 3) Land Use Composition; and 4) Site Design. Not all of the candidates for representing these dimensions entered into the analysis because some variables had a number of missing cases. Their inclusion would have whittled the data set down to those SEC observations for which complete information was available, a fairly small subset.[2] An exploratory study of the correlation matrix of remaining variables resulted in a further expulsion of some variables in order to prevent certain pairs with high multicollinearity from dominating the analysis.[3] As a result, thirteen land use variables for which complete information were available entered into the analysis.

The final, most interpretable factor matrix that was obtained for defining basic factors is shown in Table 4.1.[4] In all, four factors were extracted, meaning that it was possible to distill the thirteen variables down to four underlying factors and retain much of the original information.[5] As shown in the bottom row of this table, these four factors together explained about 88 percent of the variation in the original variables -- that is, only around a 12 percent loss in information is incurred by the 70 percent reduction in the number of "variables" from 13 to 4.

To improve the interpretability of Table 4.1, variables are listed in order of the size of their factor loadings (i.e., coefficients), first on factor one, then on factor two, etc. Also, only those loadings higher than 0.40 (in absolute terms) are shown. Looking at the loadings, it is apparent that the first factor, which accounts for over one-third of the variation in the data, represents DENSITY. Based on both the size and signs of loadings, moreover, one sees that the factor routine grouped together those density-related variables which capture cases

Table 4.1

Factor Loadings and Summary Statistics for SECs

Variables:	FACTOR 1	FACTOR2	FACTOR3	FACTOR4
AVGSTORY	.982			
EMP/ACRE	.880			
FAR	.872			
PARK/EMP	-.745			
COVERAGE	.733		-.443	
EMPLOYMT		.952		
FLOORSPC		.898		
RESTAURT		.820		
ACREAGE			.924	
SQFT/EMP			.871	
OFFICE			.730	-.477
USEENT				.641
RETAIL				.554
AVGLOT				-.527
Summary Statistics:				
Eigenvalue	4.490	3.292	2.171	1.467
Percent of Variation Explained	34.5	25.3	16.7	11.3
Cumulative Percent of Variation Explained	34.5	59.9	76.6	87.9

Variable Definitions:

AVGSTORY = Number of stories of "average" building, in terms of most frequent height.
EMP/ACRE = Employees per acre.
FAR = Floor Area Ratio.
PARK/EMP = Number of parking spaces per employee, on average.
COVERAGE = Proportion of land covered by buildings, on average.
EMPLOYMT = Size of work force (thousands).
FLOORSPC = Square feet of floorspace in office-commercial-industrial uses (millions).
RESTAURT = Number of on-site restaurants and eateries.
ACREAGE = Total land acreage.
SQFT/EMP = Square feet of floorspace per employee.
OFFICE = Proportion of floorspace in office use.
USEENT = Land use mix entropy index. See section 4.2 for further definition.
RETAIL = Proportion of floorspace in retail use.
AVGLOT = Acreage of "average" lot, in terms of most frequent parcel size.

with high average stories, high FARs, high counts of employees per acre, high land coverage ratios, and relatively low numbers of parking spaces per employee.

The second factor, explaining one-quarter of the variation, clearly captures the SIZE dimension of SECs. It reflects those situations with large numbers of employees, vast amounts of floorspace, and numerous eateries. The inclusion of the restaurant variable suggests that it picks up some of the mixed-use characteristics of cases as well.

The third factor, explaining 16.7 of the variation, seems to be more or less a DESIGN measure emphasizing the scale and degree of spaciousness of projects. It seems to be tapping the dimensions of some cases related to their amount of open space (COVERAGE), working area (SQFTEMP), and scale (ACREAGE). In this sense, it captures some of the amenity and site design features of SECs, along with some information on size and coverage. Based on the signs of the loadings, it seems to tap into cases which have large acreages, generous amounts of floor area per worker, low levels of lot coverage, and high shares of office usage -- i.e., roomy, high-amenity environments. These characteristics seem to fit the definition of many master-planned, campus-style high-technology parks, such as the Research Triangle outside of Raleigh and Technology Park northeast of Atlanta.

The final factor, which accounts for 11.3 of the variation, is primarily a LAND USE indicator, capturing information on land composition as well as general lotting practices. In addition to OFFICE and RETAIL, it loads high on a variable that was created to reflect the degree of land use mixture within each SEC -- USEENT. USEENT is an index of "land use entropy", measured as:

$$USEENT = - \{ [OFFICE * \log_{10}(OFFICE)] + [RETAIL * \log_{10}(RETAIL)] + [HOUSING * \log_{10}(HOUSING)] + [OTHER * \log_{10}(OTHER)] \}, \text{ where:}$$

$0 \leq USEENT \leq lg_{10}(K)$,

OFFICE	= proportion of floorspace in office use,
RETAIL	= proportion of floorspace in retail use,
HOUSING	= proportion of floorspace in residential use,
OTHER	= proportion of floorspace in industrial, warehousing, restaurants, hotels, and other uses, and
K	= number of categories, which, in this case, is 4, with categories removed from calculations if the proportion of floorspace is zero.[6]

USEENT provides a logarithmic index for gauging the degree of land use mixture. As used here, it ranges in values from zero (total homogeneity, with all floorspace in one category) to 0.6021 (maximum heterogeneity, with an even mixture of land uses).[7] Thus, single-use developments (like an office park) will score low USEENT values while projects with an equal amount of floorspace in office, retail, housing, and other uses will score high values.

The fourth factor, LAND USE, loads high on cases with high shares of retail and a high level of mixed uses (i.e., a high USEENT value), and low on cases with high shares of office and large average lot sizes. Thus, it appears to be tapping into situations with varied mixed-use, retail oriented environments that are on relatively small lots and where office space is not the pre-eminent activity. SECs such as Post Oak and South Coast Metro appear to be represented by the fourth factor.

In summary, factor analysis was successful in providing a multi-variable description of the underlying land use and development dimensions of SECs. The extracted factors and their relationships to the original variables are logical and interpretable. The number of extracted factors suggests there are four key underlying dimensions of SECs -- DENSITY, SIZE, DESIGN, and LAND USE. Among these dimensions, DENSITY is the most dominant, followed by SIZE. Intuitively, there is a certain degree of intercorrelation among the factors themselves -- i.e., cases with high LAND USE (i.e., mixed-use) scores could also be expected to have high DENSITY scores. With regards to how such scores can be used to classify cases into distinct groups, we turn to the next section.

4.3 Classification of Case Sites into SEC Groups

The grouping of SEC cases into homogenous categories was accomplished through the technique of cluster analysis.[8] Factor scores for each of the fifty observations served as the primary inputs to the analysis.[9] The process involved combining cases into clusters on the basis of their "nearness" to each other when expressed as squared Euclidean distances.[10] Using the technique of agglomerative hierarchical clustering, clusters were sequentially formed by grouping cases into bigger and bigger clusters until all cases were a member of a single cluster.[11]

The results of the cluster analysis are summarized in the hierarchical graph, called a dendrogram, presented in Appendix II. This shows the clusters being sequentially combined and the normalized values of the coefficients (i.e., squared Euclidean distances) at each step. The judgemental part of cluster analysis is deciding at what stage to stop joining clusters. This is normally done when the distance coefficients dramatically increase from one agglomeration step to another. For this analysis, this was between the 44^{th} and 45^{th} stage of merging clusters, which meant that five distinct clusters of cases were derived.[12] Because "large office corridors" where set aside as a separate group at the outset, this means that a total of six clusters of SECs were derived for this study.

While in several instances cases which did not fit neatly into any single cluster were subjectively assigned to a group,[13] overall the cluster analysis did provide an intuitive and decipherable grouping of cases. The following descriptions seem to fit the six groups, including the "large office corridor" grouping, that emerged from the cluster analysis:

* Office Parks

* Office Concentrations and Centers

* Large-Scale Mixed-Use Developments

* Moderate-Scale Mixed-Use Developments

* Sub-Cities

* Large Office Growth Corridors.

The SECs that clustered together within each group are listed in Table 4.2. The largest single group is "large-scale MXDs", comprised of fourteen SECs. Both "office parks" and "sub-cities" groups each have ten cases, while "office concentrations" and "moderate-scale MXDs" have eight. The smallest group consists of the seven "large office growth corridors".

Table 4.3 suggests why these particular titles were chosen for describing the six SEC groups. This table presents the low-to-high ranges of several key density, size, land use, and design variables (shown as the next-to-lowest to next-to-highest values).[14] Accordingly, it provides both minimum and maximum thresholds which could be used in assigning other SECs

Table 4.2

Listing of Cases Within the Six SEC Groups

Office Parks	Office Concentrations	Large Mixed-Use Developments	Moderate Mixed-Use Developments	Sub-Cities	Office Growth Corridors
APOC	Central Ave. Corridor	BWI Area	Bel-Red Corridor	Central Bellevue	Golden Triangle
Bishop Ranch	Central Ft. Lauderdale	Camelback Corridor	Chagrin Blvd. Corridor	Central Stamford	I-5 Portland Corridor
Corporate Woods	Central Walnut Creek	Cyprus Creek	Chesterbrook Village	Central Towson	N. Houston North Belt
Hacienda Bus. Park	Greenway Plaza	East Farmingdale	College Blvd. Corridor	Denver Tech Center	Route 1/ Princeton
Inverness Bus. Park	Greenwood Plaza	East Garden City	Fairlane Town Center	North Dallas Parkway	Route 9/ Boston
Maitland Center	Lake-Cook Corridor	Edina/I-494 Corridor	Hunt Valley	Perimeter Center	Route 128/ Boston
New England Exec. Park	Research Triangle	Gwinnett Place	North Lake	Post Oak-Galleria	Route 495/ Boston
Technology Park	Rocksprings Park	The Meadowlands	Rockside/I-77 Corridor	South Coast Metro	
3M Park-Minnesota		Naperville/ I-88 Corridor		Tysons Corner	
3M Park-Texas		Oak Brook/ I-88 Corridor		Warner Center	
		Plantation/ Broward County			
		Schaumburg Village			
		West Houston Energy Corridor			
		The Woodlands			

Table 4.3

Low-to-High Thresholds for Six SEC Groups[1]

SIZE:	Office Parks	Office Centers	Large MXDs	Medium MXDs	Sub-Cities	Large Corridors
Acreage (thousands)	.25-1.0	.25-2.8	2.6-19.7	.35-.86	.33-2.24	30.0-300.0
Employment (thousands)	4.1-11.9	6.0-20.3	5.0-53.0	2.2-15.3	16.0-59.5	39.0-480.0
Sq. ft. office, commerical, industrial & floorspace (millions)	1.7-4.3	2.0-10.8	3.6-29.0	1.3-7.1	6.5-25.3	11.0-31.5
DENSITY:						
FAR	.24-.42	.30-2.7	.50-1.30	.33-.92	.85-3.10	.20-.60
No. stories of highest bldg.	5-10	8-30	6-27	3-13	20-28	14-23
DESIGN:						
Parking spaces/ 1,000 sq. ft.	4.0-5.0	3.3-4.0	3.3-5.0	4.0-4.6	3.0-4.0	3.5-4.5
Coverage ratio	.20-.40	.20-.75	.25-.55	.25-.48	.33-.75	--
LAND USE MIX:						
% Floor space: Office	65-99	85-99	16-66	30-60	50-70	52-74[a]
Commercial	01-10	02-10	08-26	10-30	12-34	08-20[a]
No. retail centers	0-1	0-2	1-20	1-4	2-8	--
No. on-site dwelling units	0-100	0-380	0-9,000	0-500	200-5,600	--
Land use mix entropy index[2]	.25-.35	.22-.35	.45-.58	.47-.56	.41-.51	.37-.50

Notes:
1. Based on the range of the next-to-lowest to the next-to-highest values for each variable.
2. Ranges from 0 (least mix) to 0.60 (most mix). See section 4.2.

around the country to one of the six categories. Some of the noteworthy traits of each of the six SEC groups are discussed below.

Office Parks

The distinguishing characteristics of office parks are their low densities and building profiles, their heavily landscaped, park-like environment, their prodigious supply of parking, and their highly controlled, master-planned appearances. Many attract large corporate tenants who value high-quality, spacious surroundings. Others emphasize R&D, high-technology, and light-manufacturing activities. Oten, speculative space is found in buildings that are grouped together in a campus-like cluster while larger, single-tenant structures and company headquarters are often set off to themselves.

From Table 4.3, it is evident that office parks have the lowest ranges of density, coverage, and building heights and among the highest levels of single-use activities and parking provisions. They frequently have little, if any, on-site housing and at most one small retail center. None have regional shopping facilities. Compared to the other SECs, they are also fairly small in acreage, employment, and square footage. As master-planned developments, their territorial boundaries are almost always well-defined.

Based on these ranges, SECs that are classified as office parks should have: 1) $\leq$ 1,000 acres; 2) $\geq$ 65 percent of space in office uses and $\leq$ 10 percent in retail; 3) FARs $\leq$ .45 and coverage rates $\leq$ .40; and 4) $\geq$4 parking spaces per 1,000 gross square feet. They also should be master-planned, high-quality work environments with closely coordinated building designs.

Office Centers and Concentrations

These SECs have some of the characteristics of office parks, however they tend to be much larger and denser. Notably, they generally have about the same proportion of office and retail space as the office parks and comparably few numbers of retail centers and on-site housing units. While office parks are highly controlled and master-planned, these SECs are more agglomerations -- i.e., they tend to be concentrations of a number of freestanding office buildings that have sprouted, sometimes independently, in a reasonably well-defined geographic area. Some, such as Greenway Plaza and Greenwood Plaza, have been master-planned and have an architecturally unified character. Thus, they are more like centers than concentrations. Others, such as Phoenix's Central Avenue corridor, have evolved in a more ad hoc manner and thus represent concentrations. While many of these agglomerations focus on freeways, they tend to be more nodal and far less elongated in shape than some of the SECs defined as "large-scale office corridors".

To some extent, this cluster is a hybrid of the "office park" and "large-scale office corridor" groupings. Some of the large-scale corridors are essentially a collection of office concentrations; in these instances, then, "office centers and concentrations" could be viewed as a subset of large-scale corridors. Other cases, such as the Research Triangle, are low-density, park-like settings, but which are far greater in size than the office parks listed in Table 4.2. Thus, this group consists of SECs that do not fit neatly into either the "park" or "corridor" clusters, but which share the common trait of consisting predominantly of office uses.

To fit into this cluster, then, SECs should: 1) be larger, have generally higher densities, and offer less parking per worker than most office parks; 2) have at least 2 million square feet of floorspace, with at least 85 percent in office use; and 3) have more the character of an agglomeration than a highly controlled, master-planned office development that is focussed on a single cluster of buildings.

Large Mixed-Use Developments (MXDs)

The two distinguishing features of these SECs is that they feature a mix of land use activities and encompass a fairly large territory, at least three square miles and usually much more. Additionally, most of these MXDs are widely recognized as being primary growth areas within their perspective regions.

Some of these large-scale MXDs are oriented along freeways and major arterials, and thus have a corridor form (e.g., Edina/I-494; Oak Brook/I-88). Others are more nodal (e.g., the Meadowlands; Schaumburg Village). Many resemble some of the "sub-cities" listed in Table 4.2, but have far more acreage and generally less of a high-rise profile. Many are also similar to "office concentrations" in density and workforce size, although MXDs generally enjoy a far greater balance of office, commercial, and light-industrial activities. All have at least one major retail center, and most feature a regional shopping center mall of at least 500,000 square feet. Moreover, most have at least several thousand housing units within their perimeters.

The boundaries of many large MXDs are not always clear. In many instances, they are defined in terms of a "study area" that has been designated by the local planning agency (e.g., Camelback corridor; Cyprus Creek). In some cases, a business association or transportation management association (TMA) has been formed to deal with emerging growth problems and has accordingly designated boundaries for the MXD.

While in no instance do offices comprise more than two-thirds of floorspace for the cases in this group, non-office functions are not always dominated by banks, restaurants, and retail outlets. Some of the large MXDs (e.g., BWI; Oak Brook/I-88; East Farmingdale) have well over 30 percent of their floorspace supporting light-industrial and warehousing functions. In all instances, the land use entropy index for large MXDs was at least 0.45 (compared to an average index for all cases of 0.42). The hallmarks of this SEC group, then, are: 1) a large territory of at least 2,000 acres in size; and 2) a mixture of activities, with offices comprising no more than two-thirds of total floorspace.

Moderate-size Mixed-Use Developments (MXDs)

In almost every respect, these SECs resemble the large MXDs discussed above, with the notable exception that they have far less acreage. Most have only one-third the acreage of the smallest member of the "large-scale MXD" category. In addition, these more moderate-size MXDs tend to be less dense, featuring a varied low-rise/mid-rise skyline. Many, moreover, have a more well-defined core, with clusters of buildings that are architecturally integrated. In general, the growth problems associated with these SEC are not considered to be as serious as those of their larger-scale counterparts.

The mixture of land uses among these SECs span across office, commercial, industrial, residential, and institutional activities. Offices remain the largest activity in all cases, comprising between 30 percent and 60 percent of floorspace. The land use entropy indices for all of the moderate-size MXDs exceed 0.47.

SECs that are candidates for this group, then, should: 1) be less than 1,000 acres in size and have relatively well-defined boundaries; and 2) have a variety of land uses, with office space comprising no more than two-thirds of total floor area.

Sub-Cities

These are the places that have been called "urban villages", "megacenters", "suburban downtowns", "satellite cities", among other catchnames. They are noted for being downtown-like in their densities and land use mixtures, yet retaining suburban-like qualities and possessing an aura of "newness". Located on the fringes of America's largest cities, however, all remain secondary office and retail centers within their respective metropolitan markets. In this sense, they are second-tier markets, or sub-centers, even though they rival the downtowns of many medium-size cities in size and density. Thus, the term "sub-city" -- which suggests the idea of both a sub-market and a suburban-city -- has been chosen here.

The activities found in these sub-cities read like an inventory of traditional downtown activities -- offices, corporate headquarters, hotels, boutiques, conventional halls, performing arts centers, health clubs, doctor's offices, nightclubs, and more. Offices, however, are always a prominent land use. Tysons Corner has more office space than downtown Baltimore or Miami. Nationwide, Houston's Post Oak-Galleria area ranks ninth in office inventory, exceeding that of downtown Atlanta. In many cases, new office towers have gone up at a dizzying pace, with as much as five million square feet being added to previously vacant parcels in as few as three years. The North Dallas Parkway, for instance, witnessed a quadrupling of floorspace between 1980 and 1986. Because of this rapid-fire pace of growth, grass-roots opposition to new office and commercial projects has generally been more vocal around sub-cities than in any other group of SECs.

The sub-cities defined in this study vary along several dimensions, despite the fact they joined together in the cluster analysis. While most are fairly new (e.g., Perimeter Center, Tysons Corner), others have existed for decades (e.g., central Stamford; central Towson). Densities also vary somewhat. Some are punctuated by a series of high-rise towers, with only limited amounts of open space (e.g., Post Oak; central Bellevue). Others are more like higher-density, multi-use versions of campus-style office parks, featuring attractively landscaped open spaces and prominent signature buildings. Some sub-cities have been centrally planned and are architecturally coordinated (e.g., Denver Tech Center; Warner Center), whereas others have evolved incrementally, without the benefit of any unifying plan (e.g., Tysons Corner; Post Oak).

Because of their relatively high densities and land values, all sub-cities have decked parking structures, with commercial rates charged for public spaces. All also feature a premium-quality regional shopping mall, generally well over one million square feet in total retail space. At least one hotel with convention facilities can be found in each as well. Additionally, all sub-cities have a significant housing component, usually consisting of condominiums and townhouses that are priced for the professional worker.

To qualify as a sub-city, then, an SEC should have: 1) over 10,000 office workers and over 5 million square feet of office and commercial floorspace; 2) fairly high average densities, with the tallest office tower being at least 15 stories high and with some buildings falling within the 20-30 story range; 3) a mixed-use character, with retail and commercial activities comprising at least 10 percent of floorspace; 4) a regional indoor shopping mall and major convention hotel; 5) on-site housing; and 6) a wide recognition as being the "other" central place within the region, second only to downtown.

Large-Scale Office Growth Corridors

What distinguishes these SECs from others are their tremendous expanses, some of which extend well over twenty miles in length covering a land area exceeding 80 square miles. In a sense, these cases are a breed apart from the other SECs, representing less of an agglomeration and more of a large swath of office and mixed development within an urbanized region or state. Accordingly, in much of the analysis which follows, this group is treated separately.[15]

All of these large office corridors focus on one or more freeways or major arterials and have a distinct linear form. All are dotted by numerous unrelated office parks, industrial parks, retail centers, commercial strips, and tract housing, much of which evolved in a piecemeal fashion. Most of these developments tend to be much smaller than any of the office parks and other SECs examined in this study; the cumulative effects of numerous small freestanding projects, however, has generally exerted tremendous strains on public infrastructure, including streets, sewers, and water lines. Accordingly, unbridled growth is a politically sensitive issue along all of these corridors. In some cases, the existence of multiple political jurisdictions along the corridor has hampered efforts to coordinate growth.

In general, densities along these mammoth-size corridors are low. Many of the density and site design features of "office parks" and "office concentrations" characterize much of development profiles of individual projects along these corridors. Mid-rise hotels and large regional shopping malls also tend to be common. Though housing tracts can be found off in isolated pockets of these corridors, residential development is generally subsidiary to the office functions of these corridors. Most suffer a significant jobs-housing imbalance.

The noteworthy characteristics of cases which belong to this final class of SECs, then, are: 1) expansive land areas, generally encompassing over 20,000 acres; 2) a predominant freeway or arterial spine which serves to channel growth; 3) a mixture of land uses, with office functions being dominant; 4) low average densities; and 5) an employment population that generally far exceeds the residential population.

4.4 Brief Case Summaries of each SEC Group

As a prelude to the tests of hypotenses in the next two chapters, this final section briefly describes several of the cases within each of the SEC groups. The intent is not to necessarily present the most representative SECs of the six categories, but rather to provide a finer-grained perspective into the general make-up of individual centers and corridors within each group. The seventh chapter offers a further discussion of SEC cases in three metropolitan areas -- Seattle, Houston, and Chicago.

Office Park Cases

(1) Bishop Ranch: A 585-acre, master-planned office and light industrial development which fronts on Interstate-680 in the city of San Ramon, a fast-growing suburb about 35 miles east of downtown San Francisco. The present workforce of 13,000 employees is expected to reach 25,000 employees at build-out, sometime around the year 1995. Around 85 percent of floorspace is in office use, roughly a quarter of which is speculative space. Five companies own all of the parcels within Bishop Ranch. Three have major company headquarters staffed primarily by back office workers, one has a light industrial plant which manufactures precision instruments, and the other has a warehouse employing under 100 workers. Numerous covenants control the architectural features of the park and maximum coverage and floorarea ratio limits of 0.35 preserve open space. Plexi-glass, enclosed bus shelters lace the park. A fare-free luxury shuttle for tenant employees connects the Bay Area Rapid Transit (BART) station in Walnut Creek and provides noon-hour service to a nearby shopping center. An on-site Transportation Center has also been created to promote ridesharing and other commute alternatives.

(2) Maitland Center: A 250-acre planned business park located in central Florida just north of Orlando along Interstate-4. Over 12,000 employees are spread among 2.89 million square feet of primarily class A office space. The project includes a 400-room hotel, 3,500 square feet of retail space, and 105 condominium units. Strict development controls and considerable attention to landscaping have created a premium work environment. Covenants require that 40 percent of parcels be left as open space and set minimum front yard setbacks of generally 35 feet or more. Over 20 one-to-six story buildings, most with glass-dominated facades, are spread throughout the compound. Most structures are encircled by surface parking built at 5 spaces per 1,000 square feet. A large interior commons area features exercise trails. A walkpath also meanders throughout the park. One complex, Maitland Colonnales, is built around a 15-acre lake, with over one-half mile of windows overlooking the lake. The four-story building features floor plans designed for flexibility and a ground-level deli.

(3) New England Executive Park: A mature 82-acre park with 1.27 million square feet of first-class office space, located off of Route 128 sixteen miles north of downtown Boston in the community of Burlington. Figure 4.1 shows the project's site plan. The typical building is a 2-to-4 story structure with a 26,000 square feet footprint and a mix of brick and glass construction. Maximum coverage ratios of 0.36 and fifty feet front lot setback requirements maintain a certain spaciousness throughout the park. Most of the land is covered by asphalt, however. Next to the park is Burlington Mall, New England's largest, featuring more than 100 stores, including 22 restaurants. Also nearby is the Market Place, which offers a variety of restaurants, shops, and business specialty stores. New England Executive Park also boasts a fitness center, a professionally-staffed child-care center, and a helipad where a connection can be made to Logan Airport in eight minutes.

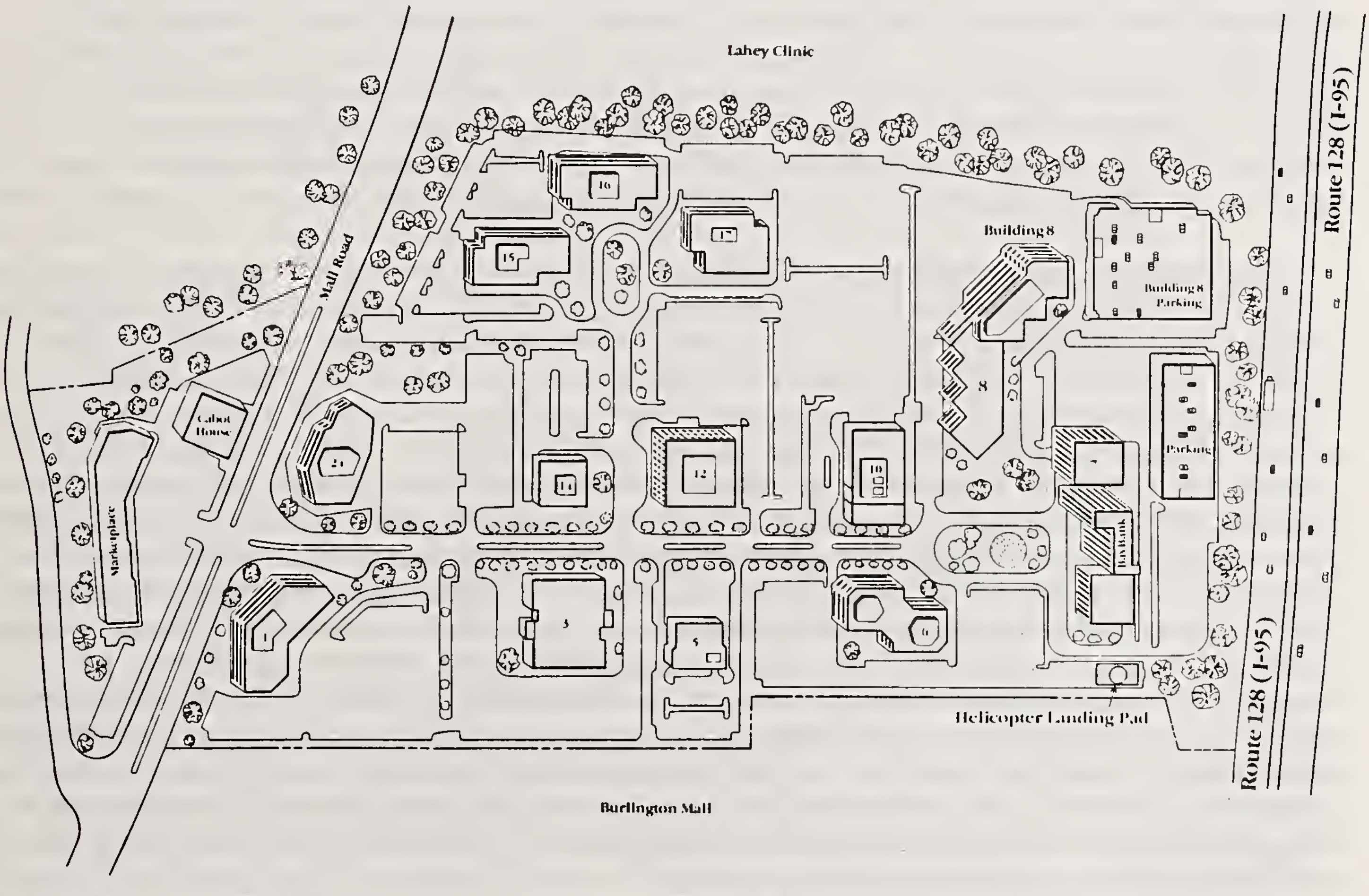


Figure 4.1 New England Executive Park Site Plan. Source: Spalding Investment Company.

Office Centers and Concentrations

(1) Central Avenue Corridor: This roughly two-mile long stretch uptown of downtown Phoenix has several million square feet of office space, including four post-1980 towers totaling 1.3 million square feet. Each of these towers has an anchor tenant and several entry-level retail outlets. The remaining speculative space is leased primarily to financial, legal, and other professional service firms. A number of smaller, freestanding garden office complexes are aligned along the north-south corridor as well. Interspersed among these offices are an assortment of specialty stores, medical buildings, and several condominium complexes. Two major regional shopping centers are also within the corridor. Most low-rise commercial establishments are situated on lots comprised of an assemblege of former 6,000 square feet residential parcels. Although the Central Avenue corridor is not presently served by freeway, it will eventually be at the heart of a 231-mile freeway system, currently under construction, that will be superimposed on Phoenix's one-mile grid arterial system.

(2) Central Walnut Creek: A clustering of some 1.3 million square feet of modern mid-rise office space in an area of around one-square mile, huddled near an interchange off of Interstate-680 as well as an aerial BART station. Bordered by the freeway and two major thoroughfares, the area is known locally as the Golden Triangle. Most office towers within this triangle have been constructed since 1980 and feature a mixture of granite, marble, and reflective-glass, providing a premium, high-tech look. Footprints generally envelop 90 percent of a site, so open space is limited. Property is divided among some fifteen different landholders. A free shuttle connects the triangle area with downtown Walnut Creek, located about a mile to the south. The shortage of nearby restaurants and shops has attracted over 600 passengers shuttling to downtown every day. The prevalence of free parking for employees of several large tenants has encouraged many Golden Triangle workers to drive to work, despite the existence of a BART station within short walking distance. The mixture of these workers' automobiles with the cars of BART patrons who are using the Walnut Creek station to park-and-ride to San Francisco has created a serious congestion problem during peak periods. In response, the citizens of Walnut Creek passed a referendum in late-1985 which halts all future office-commercial development over 10,000 square feet until peak-hour traffic falls below 85 percent of capacity (level of service D) at 75 key intersections. Although this growth-control ordinance has been challenged in court and remains in legal limbo, a spirited debate continues over how much more office growth can be supported.

(3) Research Triangle Park: A massive 6,600 acre park with over 11 million square feet of floorspace and some 30,000 employees, many of whom are employed in R&D, engineering, and technical-professional positions. Situated between the educational centers of Raleigh, Durham, and Chapel Hill, the Research Triangle is the consummate research and high-technology center, replete with contemporary smart buildings, flexible floorplate designs, and an overall spacious, architecturally-coordinated built environment. Although the Research Triangle resembles a traditional campus-style development in many ways, its gargantuan size and regional dominance give it more of an agglomeration character. The compound has several multi-building light-industrial complexes of up to 440,000 square feet in size. Several low-profile research campuses have one million square feet of space each. Interspersed amongst these complexes are a number of individual six-story towers. Four banks, a restaurant, and a retail center are also within the park. In all, some forty private parties hold title to the Research Triangle property. While a comprehensive set of covenants govern building designs and lotting practices, the park sets no limits on parking other than requiring that all facilities be off-street. A ridesharing office within the park actively promotes employee carpooling and vanpooling. Since the Research Triangle lies in between three urban centers, a variety of through and local trips are inter-mixed along the five major highway corridors serving the park, giving rise to worsening rush-hour snarls.

Large Mixed-Use Developments (MXDs)

(2) Cypress Creek: A 5 square-mile mixed-use district approximately six miles northwest of downtown Fort Lauderdale, containing over 6 million square feet of office, retail, and light-industrial floorspace and over 10,000 workers. Much of the growth centers on Executive Airport and the Interstate-95 axis north of the airport. Office complexes are generally of moderate densities, with many buildings ranging from five to ten stories in height and floor area ratios averaging around one. The typical building has 120,000 square feet of class A floorspace, reflective glass exteriors, and first-floor retail services. Several moderate-size business parks are also in the area. One, Radice Corporate Center, is situated on a 33-acre site that includes a 5.5-acre natural preserve with fitness trails and a four-acre lake. Three office towers with a total of 368,000 square feet and a 15-story hotel grace the site. Because of shrinking land tracts and high land prices, most recent projects in the Cypress Creek area have a distinct mixed-use character. Corporate Park, for instance, features three restaurants, several banks, and a 250-room hotel, in addition to premium leasing space. The Zaremba Southeast development, when completed, will feature three office buildings, a convention hotel, a retail center, and a centrally located eight-acre aquatic preserve. Traffic problems along the Interstate-95 corridor have escalated in tandem with Cypress Creek's expansion. Because of a shortage of lower-priced multi-family housing nearby, many of the area's workers solo-commute, resulting in rush hour tie-ups.

(2) East Garden City: Located about 27 miles east of Manhattan in Nassau County, this is Long Island's fastest growing office area, with over three-quarters of space having been erected since 1980. In all, approximately 9.50 million square feet of mixed office, commercial, and industrial floorspace is concentrated in a four square mile area focussed on Mitchell Field, a former military base that has been converted to civilian use. Most of the estimated 21,700 employees in the area are white-collar workers, split among professional-technical, clerical, administrative, and sales occupations. The typical office building in the East Garden City area is a four-to-eight story glass-facade luxury tower with around 200,000 square feet of space. Many feature on-site amenities, such as health clubs, banks, and retail shops. Major office complexes include European American Bank Plaza (1.1 million square feet), Corporate Center I and II (425,000 square feet), and Mitchell Field Corporate Center (220,000 square feet). Also in the area are several colleges, a sports stadium, a racetrack, and two regional shopping centers. Since only around 300 housing units are sited in the area, the vast majority of workers commute to work -- about 75 percent coming from the eastern two-thirds of Hempstead Township, 13 percent coming from Suffolk County, and most the remainders traveling from New York City. Expansion plans continue for the East Garden City area. Ultimately, 1,170 acres in and around Mitchell Field will be developed, including a proposed college expansion, hotels, office and light industrial space, and assorted R&D projects.

(3) The Meadowlands: A massive 19,730-acre mixed-use district located mainly in Secaucus, New Jersey, around six miles east of midtown Manhattan, with portions of the district in the cities of North Bergen, East Rutherford, Jersey City, Carlstadt, and Kearny as well. The Hackensack Meadowlands Development Commission (HMDC) has been charged with the responsibility for planning the Meadowland's growth since it was formed by the state legislature in 1968. Seven major developers and more than 1,800 companies of all sizes, employing over 50,000 workers, are involved in the Meadowland's development. About one-quarter of the district is zoned primarily for low-density residential use, about one-half is split among office, light-industrial, warehousing, and commercial activities, and most of the remainder is in the form of open space and estuary preserves. Among the Meadowland's major office complexes is Berry's Creek East, featuring a 430,000 square foot, 15 story office tower, a luxury hotel, and several restaurants. Two of the district's largest mixed-use centers are Harmon Cove (over 2 million square feet of office space, 500 residential units, and a flagship hotel) and Harmon Meadow (1.2 million square feet of office, two retail plazas, two luxury

hotels, several theaters, and numerous stores and restaurants). Other major land uses within the district are the Meadowlands Sports Complex and Teterboro airport.

Moderate-Size Mixed-Use Developments (MXDs)

(1) Chesterbrook Village: A 865-acre corporate-retail village that is the centerpiece of the larger master-planned residential community of Chesterbrook, located off of Route 202 some seventeen miles west of downtown Philadelphia and just to the south of the booming King of Prussia area. Around three-quarters of the corporate center is complete, which is slated to eventually have around 1.5 million square feet of office space, sometime in the 1990s. Corporate tenants, including law firms and brokerage companies, dominate most of the class A speculative office space. Typical office buildings are three story brick structures with floorplates of 30,000 square feet and cover around 30 percent of a lot. Most have coordinated designs and are clustered around commons areas. Six restaurants, two banks, a hotel, and a retail center also populate the core. The most substantial use in Chesterbrook, however, is residential, with over 3,000 housing units priced for varying incomes located within easy walking distance of the corporate center. Over 90 percent of these are attached, multi-family units. A free shuttle connects surrounding residents with the corporate center as well as a local train station during peak periods.

(2) College Boulevard: A three-mile long office-retail corridor, encompassing 867 acres, that is aligned in an east-west direction just south of Interstate-435 in Overland Park, Kansas, across the stateline from Kansas City, Missouri. Over six million square feet of office-commercial floorspace is spread along the corridor, with much of the office area found in Corporate Woods, Executive Hills, and Renaissance Office Park. These parks house mainly regional and branch office facilities that are populated largely by middle management and support staff. The workforce exceeds 22,000 and is expected to more than double in size by the mid-1990s. Most office buildings are low-lying, occupying less than a quarter of land tracts. Four hotels also line the corridor, providing over 1,000 rooms in total. The Shannon Valley Shopping Center occupies a central parcel along the corridor. Total retail square footage, spread among three large centers and several freestanding establishments, exceeds one million. Near the corridor, residential construction is booming, with approximately 9,600 dwelling units, half of which are single-family, lying within a mile radius.

(3) Hunt Valley: A 1,000-acre development that has become Baltimore County's most prestigious corporate address. Located approximately 15 miles north of downtown Baltimore next to Interstate-83, Hunt Valley has been the recipient of over half of the county's office space additions since 1980. Mid-rise office buildings, hotels, and a large retail-restaurant complex occupy Hunt Valley's core, surround by surface parking and low-rise industrial, warehousing, and office space. Most buildings offer speculative space with flexible floor plans. Typical lots are one acre in size, with front and side lot setbacks of 25-35 feet. Hunt Valley's 850,000 square foot mall features a variety of specialty retail, entertainment, and business service functions. In all, retail uses comprise nearly 20 percent of total floorspace. The absence of any residential units within the development has resulted in heavy in-commuting and spot congestion at the project's connecting cloverleaf interchange.

Sub-Cities

(1) North Dallas Parkway: Situated along a T-shaped corridor bounded by the L.B.J. Freeway (I-635) and Dallas North Tollway, and located 12-15 miles north of downtown Dallas. The Parkway area contains over 17 million square feet of office space distributed among more than 150 buildings, 7.4 million square feet of commercial inventory, and 5.4 million square feet of light-manufacturing uses, all spread over a 5.6 square mile area. Future office development totaling over 24 million square feet has been announced and additional space awaits zoning

approval. The area currently has 60,000 workers and could eventually reach 125,000 if all proposed development proceeds. The Parkway area has become a choice location for corporate tenants, rivaling downtown Dallas and the new town of Las Colinas as the region's most prestigious office address. Most office structures are in the 2-4 FAR range, with all-glass facades and well-groomed surroundings. Lots are generally of varying shapes and sizes. The Parkway is noted for having three regional malls, ranging in size from 870,000 to 1.6 million square feet. Eight hotels, providing 3,160 rooms, are also prominently sited near several major interchanges. Among "suburban downtowns" nationwide, North Dallas Parkway has the largest residential population -- approximately 14,800 dwelling units are within its boundaries, the overwhelming majority of which are multi-family units. As with most other sub-cities, growth management is a widely discussed issue in the area.

(2) Perimeter Center: Located approximately 12 miles due north of downtown Atlanta near the connection of Interstate-285 and Georgia 400 and within unincorporated portions of DeKalb and Fulton Counties. The Perimeter Center began developing around a large regional mall comprised of three anchors and 1.4 million total square feet. Numerous 1-2 story office buildings built near the mall in the early 1970s were eventually replaced by new 6-18 story executive office towers. Today, over 17 million square feet of office space dots the two square mile area, with each structure generally covering 25 percent of a site. So far, Perimeter Center has been unrivaled in the Atlanta market at attracting corporate tenants. Two-thirds of employees work in service, financial, insurance, real estate, or wholesaling jobs. No other location in Atlanta, including the CBD, has as many national and regional headquarters of Fortune 500 firms as the Perimeter Center. In addition to several retail centers, four hotels with over 1,400 rooms can be found in the development. Rapid land conversions has been a particularly noteworthy feature of the Perimeter Center area. Five residential subdivisions around Perimeter Center have been bought out entirely since the early 1980s to make way for advancing office growth. Landmarks Concourse, for instance, a 65-acre complex with 432,000 square feet in three office buildings and a large hotel, was built on land assembled by the Aruba Circle neighborhood. The clash between office-commercial and traditional residential uses remains a hotly contested, politically charged issue along the Georgia 400 corridor.

(3) Tysons Corner: Located approximately 12 miles west of downtown Washington, D.C. near the confluence of Interstate-495 and the Dulles Airport Access and Toll Road in fast-growing Fairfax County, Virginia [Figure 4.2]. Only a crossroads general store several decades ago, Tysons is today easily the largest office-commercial center in Virginia or Maryland. Tysons boasts over 60,000 predominantly white-collar workers within its roughly 1,700 acre boundaries. Its 15 million square feet of office space is complemented by a regional shopping mall, numerous specialty shopping plazas, several hotels, and a high-rise residential building. Currently under way is Tysons II, which will add another 500,000 square feet of office, an 800,000 square foot fashion mall, and two convention-size luxury hotels, all interconnected by pedestrian plazas. In some ways, Tysons Corner is a nodal version of strip development. Despite the best efforts of Fairfax County planners to orchestrate growth, Tysons remains largely an assemblege of independent buildings, with very little of an architectural theme and limited offerings of sidewalks and trails between adjoining parcels. Besides routine mile-long traffic tie-ups, Tysons Corner is also experiencing a labor shortage problem, particularly in low-salaried, unskilled positions. As a result, a number of hotels and retail outlets in the area have found it necessary to sponsor bus services that connect many inner-city residents of Washington, D.C. with Tysons. Shortages of nearby affordable housing have also led to increased long distance commuting from all corners of Fairfax County as well as neighboring counties.

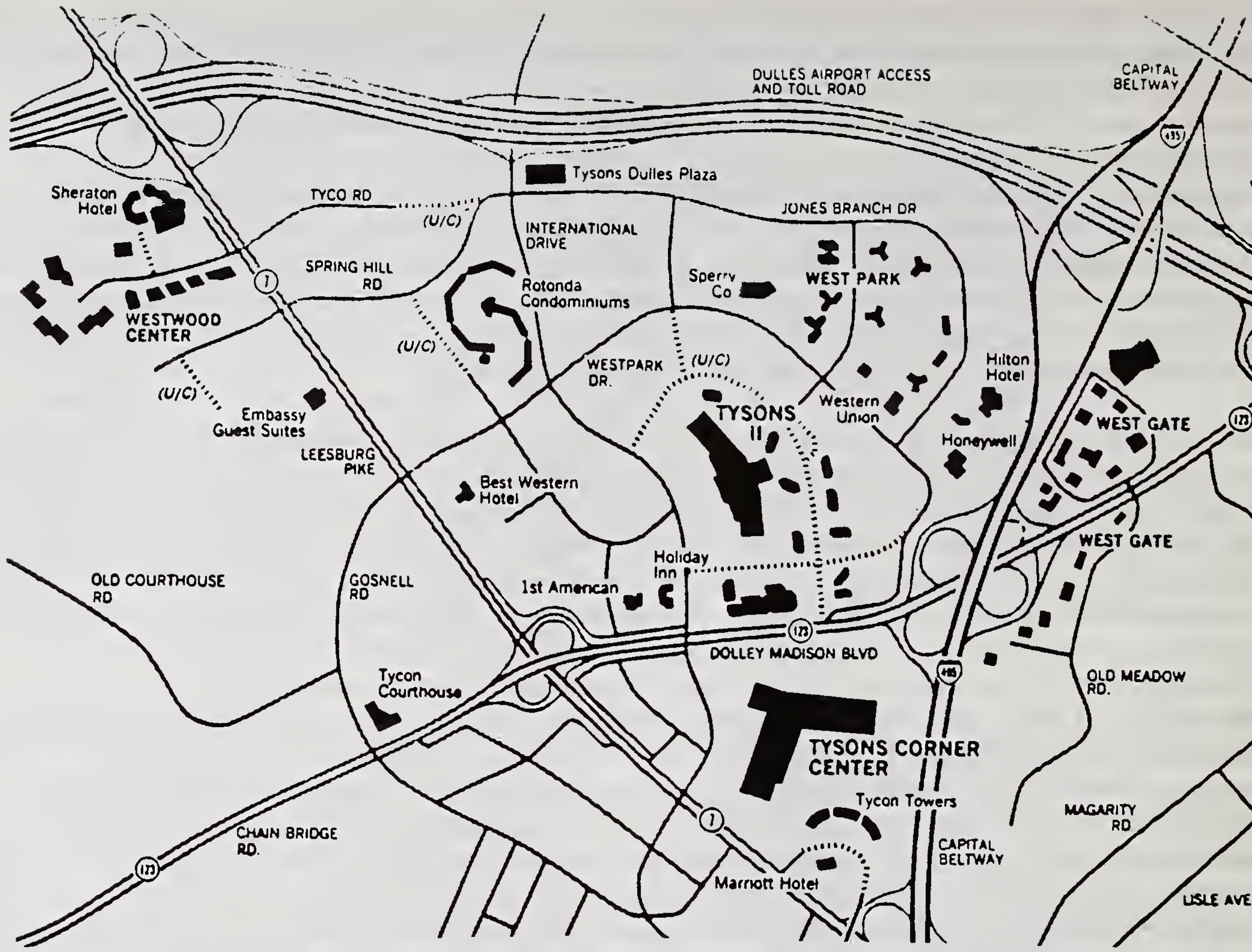


Figure 4.2 The Sub-City of Tysons Corner. Source: Fairfax County Planning Department.

Large-Scale Office Growth Corridors

(1) Interstate-5 Portland Corridor: An 8-mile long mixed-development corridor nestled along Interstate 5 and Route 217 whose northern edge is approximately six miles south of downtown Portland, Oregon. The corridor lies in both Washington and Clackamas Counties within the communities of Tigard, Lake Oswego, Tualatin, Rivergrove, King City, Sherwood, and Wilsonville. The I-5 Corridor Association, a coalition of local business representatives and landowners, has defined the boundaries of this corridor as an area encompassing over thirty square miles, rivaling many of Oregon's larger cities in population size and employment. Along with the Sunset Corridor and Columbia Corridor in the Portland area, I-5 has been a primary recipient of offices which have relocated out of downtown Portland. Many new start-up businesses have also taken up residence there. In all, the corridor boasts over 10.5 million square feet of commercial-office space, around 32,000 employees, and even a larger number of housing units; accordingly, it has a fairly even jobs-housing balance. A mixed bag of business campuses, industrial parks, warehousing districts, retail complexes, and tract housing populate the corridor's landscape. Many business parks feature mid-rise, class A office space in nicely landscaped surroundings. Among the larger office parks in the corridor are Park 217 Business Center (450,000 square feet), Koll Business Center (277,000 square feet), 4000 Kruse Way Place (145,000 square feet), and the Centerpointe (100,000 square feet). The corridor also contains several large shopping facilities, including the Washington Square mall with one million square feet of retail space.

(2) Route 1 Princeton "Zip Strip": An eight-mile long stretch, near Princeton, of the larger 19-mile long Route 1 "high-technology" corridor, lying roughly midway between New York City and Philadelphia in the center of the nation's northeast megalopolis. Most of the development is focussed on the "Zip Strip", which gets its name because businesses in this area enjoy the prestigious Princeton address and its accompanying zip code of 08540. An estimated 10 million square feet of office-commercial floorspace spans the corridor, an amount which is projected to reach 13.7 million square feet in 1992 and 29.1 million square feet in 2005. Historically, a number of large scientific and corporate research facilities have located near Princetown to take advantage of the area's exceptional educational offerings. What triggered much of the ensuing growth, observers agree, was the opening in the early 1970s of the Princeton Forrestal Center, a 1,604-acre, university-owned, multi-use research and office park. A handsomely landscaped, spaciously designed work environment, the center contains over 50 businesses, foundations, and research institutions, more than 5,000 workers, a 300-room conference center, and residential clusters of townhouses, duplexes, and garden apartments. Many of the office buildings are technologically and architecturally sophisticated, laced with fiber optic cables and state-of-the-art telecommunications equipment. Soon to follow the Forrestal Center's footsteps were the 520-acre Carnegie Center, Nassau Park, Greenlands, Princeton Park, and numerous smaller, independent office projects of one to three buildings. The 1 million square foot Quaker Bridge Mall is the largest retail facility in the area. Most research parks have comparatively little retail space; less than 4 percent of the Forrestal Center's 4 million square feet of floorspace, for example, is devoted to retail use. Because major freeways in central New Jersey do not serve the zip strip directly, the largely four-lane Highway 1 has been flooded with traffic in recent years, leading to wrenching traffic jams. Pressures for regional management of growth continue to mount despite New Jersey's strong home rule form of governance. Tremendous disparities in jobs and housing growth among townships led to the Mount Laurel decision requiring municipalities to zone for a fair share of the regional need for low and moderate income housing. Proposed legislation providing county planning boards with jurisdiction over major development seems to be gathering bipartisan support.

(3) Route 495: A fast-growing corridor of predominantly computer-related industries and communications, electronics, and engineering firms, located around the confluence of the Interstate-495, U.S. Route 20, and State Route 9, some 25 miles due west of downtown Boston. Much of the recent growth has concentrated around Marlborough, a community that has begun charging impact assessments on new commercial projects to cover the cost of expanding infrastructure. An estimated 11 million square feet of predominantly office and light-industrial floorspace and nearly 40,000 workers can be found in the area. Floor area ratios for office and industrial properties range from 0.15 to 0.60. Although high-tech, light manufacturing, and R&D facilities dominate the Route 495 corridor, interest in speculative office buildings and corporate headquarters has intensified around several major interchanges. Most research parks consist of low to mid-rise buildings set in campuslike surroundings and feature sophisticated telecommunications and utilities. Restrictive zoning bylaws introduced by several communities along the Route 495 corridor have limited new commercial construction, increased land prices, and contained residential growth. Traffic and growth management have become controversial issues in Marlborough, Westborough, Northborough, Southborough, and several other communities in the Route 495 area.

4.5 Summary

In this chapter, the techniques of factor analysis and cluster analysis were used to combine the 57 case SECs into six fairly homogenous groups: 1) office parks; 2) office centers and concentrations; 3) large-scale MXDs; 4) moderate-size MXDs; 5) sub-cities; and 6) large office growth corridors. Office parks are generally master-planned developments under 1,000 acres with low FARs and over 65 percent of total floorspace in office use. Office centers tend to be larger in acreage and floorspace, denser, and, architecturally, less unified than office parks. Large MXDs are over 2,000 acres in size and support a wealth of activities, with offices accounting for no more than two-thirds of all space. Moderate-size MXDs are fairly similar in makeup, however they tend to be more nodal in form than large MXDs, encompassing no more than 1,000 acres of land. Sub-cities are downtowns in virtually every respect, except they are relatively new and, of course, on the fringes of large metropolitan areas. Finally, large office growth corridors are expansive stretches of office, light-industrial, and spot commercial development along major highway axes, with generally low densities and little coordination of designs among projects. Overall, the 57 surveyed SECs were found to be split fairly evenly among the six classes, with large MXDs accounting for the largest number of cases -- 14, or nearly one-quarter of the sample.

This chapter also presented a brief case summary on three SECs for each of the six groupings. Geographically, these projects are spread around the country, with no one region showing a particular dominance in any one type of SEC. To the matter of how significantly land use and transportation characteristics vary among these six groups, we now turn to the next chapter.

Notes

1. As noted previously in section 3.2 of Chapter Three, these seven large corridors are: Routes 9, 128, and 495 in the greater Boston area; Portland's I-5; the Golden Triangle area in Santa Clara County; and the North Houston beltloop area.

2. Factor analysis requires a listwise deletion of missing values, which means that the entire case is purged if any one of its variables used in the analysis has missing information.

3. As might be expected, factor analysis results are strongly influenced by the variables that are chosen for the analysis. Extremely high multicollinearity can distort the analysis by making certain factors overly dominant. See Thurstone [1947] or Dunteman [1984] for further discussions on this.

4. This is the final rotated factor pattern matrix. Initially, communalities of one were placed in the lead diagonals of the correlation matrix, a concession to no prior knowledge of what share of variation for each variable is common versus unique. This initial phase, then, involved the investigation of Principal Components. Using these estimated R-squared values as the communalities in subsequent iterations during the extraction process, four factors were obtained. In order to improve the interpretability of these factors, the Varimax method of rotation was employed. Orthogonal rotation was chosen over oblique rotation because it provided the clearest interpretations and because there was no compelling a priori reason to believe that the underlying factors were highly intercorrelated. This was confirmed by the fact that the highest correlation among factors (from the factor correlation matrix) was only 0.203. For further discussion of these points, see Dunteman [1984].

5. Only factors with eigenvalues above one were extracted. This means that only factors which explained at least as much of the covariation in the data as any single variable were extracted. The fifth factor, which did not enter the analysis, had an eigenvalue of only 0.64.

6. This is because the $\log_{10}$ of zero is meaningless. See Willemain [1981] for a more detailed discussion of the entropy index.

7. The maximum value of 0.6021 derives from $\log_{10}(K)$, where K is the number of categories, in our case four (land use groups).

8. For a detailed discussion of cluster analysis, see Everitt [1980].

9. Factor scores for each case are derived by multiplying the factor loadings for each variable by that variable's standardized value and summing across variables. In this analysis, factor scores have been used as standardized weights for input into the cluster analysis. The same results could have been obtained by inputting the sum of standardized values (Z scores) across all thirteen variables for each case.

10. The measure used for joining clusters was the average linkage between groups, often called UPGMA (unweighted pair-group method using weighted average) [Norusis, 1986]. Here, the distance measured between two clusters is the average of distances between all pairs of cases in which one member of the pair is from each of the clusters.

11. Under this approach, all cases are initially considered separate clusters -- i.e., there are as many clusters as cases. At the second step, the two cases with the most comparable squared Euclidean distances (i.e., the ones whose sum of squared factor scores are the are most alike) are combined into a single cluster. At the third step, either a third case is added to the cluster already containing two cases, or two additional cases are merged into a new cluster. The process continues until all cases are group together. See Norusis [1986] for further discussion of this approach.

12. 49 (total hierarchical steps) - 45 (cut-off steps) = 5 clusters.

13. Several SECs did not fall into a cluster until after the 45th stage of agglomeration, so they had to be subjectively assigned. This was done by seeing which groups the cases matched most closely based on some of the key factor analysis variables, such as FAR and employment size. To ensure clusters were of somewhat comparable size, moreover, certain clusters were identified based on agglomerations that occurred prior to the 45th stage. See Appendix II for further discussions on this.

14. These low-to-high ranges are "windsorized", meaning the lowest and highest values are purged -- i.e., the next-to-lowest and the next-to-highest values are actually shown. Windsorizing clips the far tails of the distribution off so as to provide a better sense of the range of more representative cases and to remove possible outlier cases. Because of sizeable variation the data, even when groups are clustered, windsorized ranges were felt to be more appropriate for setting thresholds.

15. In the tests of hypotheses in Chapter Six, these large corridor cases are not used.

16. For this study, data were only available for the DeKalb County portion of the Perimeter Center which is smaller in size -- comprising around 11.2 million square feet in a 950 acre area.

CHAPTER FIVE

Comparison of Land Use and Transportation Characteristics Among SEC Groups

5.1 Introduction

This chapter analyzes the six SEC groups more closely in terms of how they differ in size, density, land uses, employment bases, design features, and various measures of workforce mobility. A combination of statistical tests and summary graphs are presented. Most of the tests compare differences in mean values of variables across the six SEC groups, using the method of Analysis of Variance (ANOVA). The degree to which these differences are statistically significant are highlighted. Bar graphs and diagrams are also used to sift out patterns in the relationships among variables. To the extent that land uses and employee travel behavior vary among SEC groups, inferences can be drawn on how development and design practices might influence commuting choices. The specific tests of the affects of scale, density, site design, and land use mixture on travel choices, however, are presented in Chapter Six. This chapter, then, uses SEC groups as the lense for exploring transportation-land use relationships whereas the follow-up chapter concentrates on how specific land use variables influence commuting choices and travel conditions.

Several caveats about the statistical tests and the materials presented in this chapter should be mentioned at the outset. One, only those variables for which reasonably significant statistical results were obtained are shown in the chapter's tables and discussed in some depth. Second, for some of the variables studied, particularly those where the size and scale of SECs were intervening factors, the "large corridor" group was not included in the anlaysis, reducing the number of SEC groups to five. In some instances, furthermore, the "office park" and "office concentration" groups were combined, as were the "large MXD" and "moderate-size MXD" groups, further reducing the number of SEC groups to three. In these cases, size and scale were generally considered to be incidental factors, allowing the analysis to be simplified. Finally, it should be noted that because many of the SECs were selected for this study based on data availability, the sites do not necessarily provide a completely random, unbiased sample in the purest of senses. Nonetheless, since the cases capture a fairly large share of the universe of the nation's largest SECs, the approximate order of magnitude of differences among SEC groups should be reasonably on target. In general, the precise statistical differences in variables are felt to be less important than the general pattern of relationships among land use and transportation factors that emerge from the analysis.

5.2 Differences in Size, Location, and Employment Among SEC Groups

Since size and employment were two factors used to assign cases to groups, differences across the six SEC categories could be expected. Just how significant are these differences? Table 5.1 shows the ANOVA results for several of the size, location, and employment variables.

Scale and Size

The SEC group with the largest acreage is large-scale corridors, followed by large MXDs and then office centers/concentrations. The amount of office, commercial, and industrial floorspace is also significantly different among groups, with all other groups paling in comparison to large corridors. Large MXDs and Sub-cities average comparable amounts of floorspace, while office parks average the least footage. Ignoring the large corridor cases,

Table 5.1

Comparison of Size, Location, and Employment Among SEC Groups

Variables	Means of SEC Groups: Office Park	Office Center	Large MXDs	Moderate MXDs	Sub-City	Large Corridor	F Stat. (prob)[1]
Size:							
ACREAGE	549.1	2593.0	7813.0	697.4	1223.3	120530.0	11.73 (.000)
FLOORSPC	2.97	5.69	12.29	3.77	12.72	26.48	4.65 (.001)
Location:							
CBDMILES	18.0	15.4	20.4	13.0	15.7	25.0	1.56 (.188)
Employment:							
EMPLOYMT	8.14	12.91	27.47	7.49	33.56	236.91	13.11 (.000)
MANAGEMT	10.0	17.1	11.1	20.7	18.7	8.8	2.84 (.028)
ADMINIST	20.3	15.9	12.3	15.3	13.9	8.9	2.31 (.061)
TECHNICL	39.1	22.5	15.2	15.5	18.6	19.4	3.05 (.020)

Variable Definitions:

ACREAGE = Total land acreage.
FLOORSPC = Square feet of floor space in office-commercial-industrial uses (millions).
CBDMILES = Approximate radial miles to regional CBD.
EMPLOYMT = Size of full-time workforce (thousands).
MANAGEMT = Estimated percent of workforce in management positions.
ADMINIST = Estimated percent of workforce in administrative positions.
TECHNICL = Estimated percent of workforce in technical positions.

Notes:
1. F statistic and probability.

sub-cities have the largest amount of expected future space at buildout -- an average of just over 20 million square feet. They also have the longest expected time horizon until buildout -- an average expected year of completion of 2008. By comparison, the average office park and center can be expected to reach buildout around 1996 while MXDs are slated for completion, on average, right at the turn of the century. In terms of the percentage of project completion, no discernable pattern was found, with all groups averaging between 50 percent and 60 percent of each SEC in the group being built out.

Regional Locations

Table 5.1 also reveals general differences in the regional locations of SEC groups. Large corridors tend to be the farthest removed from the CBDs of regions, although this is partly due to their expansive sizes. The next farthest group is large-scale MXDs, averaging a distance of 20 miles from downtown. Moderate-size MXDs, on the other hand, tend to be closest to CBDs -- around 13 miles away.

Employment Characteristics

Table 5.1 also compares employment characteristics among groups. Ignoring the massive corridors, sub-cities average the largest employment base -- over 33,000 full-time workers. Moreover, the table shows differences in the percentage of employees in several occupational categories. Moderate-size MXDs and sub-cities, for instance, average the largest percentage of management employees. Office parks, on the other hand, tend to have relatively higher shares of administrative staff, quite often consisting of accountants, billing agents, personnel staff, and financial clerks. Office parks average the largest proportion of technical staff (e.g., engineers, scientists, and professional consultants, etc.), owing largely to the fact that many parks are aggressively marketed as research and development projects. There is far less variation among groups in the percentage of clerical employees, although office parks and office concentrations average the most -- around 25 percent for both groups. Sub-cities and MXDs, on the other hand, have the largest shares of sales personnel, while large-scale corridors have, by far, the largest contingencies of manufacturing and warehousing workers.

If one considers management, administrative, and technical staffs to represent the "professional" component of suburban labor forces, Figure 5.1 reveals that office parks and centers average the largest shares of these groups -- over 50 percent in both cases. Large-MXDs tend to have the smallest representation of professionals -- only around one-third of their workforce. Overall, the predominantly office-use workplaces average the highest shares of technical, administrative, and clerical staffs, reflecing the branch office character of many of these places. MXDs tend to have high shares of managers (e.g., stockbrokers, real estate brokers, and corporate executives) and sales forces. Large corridors generally average the highest shares of light-industrial workers.

5.3 Comparison of Densities, Lotting, and Ownership Patterns Among SEC Groups

Density

Group differences in a number of density indices are shown in Table 5.2. Floor area ratios vary significantly among the six SEC groups. Sub-cities average the highest FARs, followed by office centers, settings where freestanding mid-rise and high-rise office towers are common. MXDs average FARs in the .76 to .89 range, whereas office parks and large-scale office corridors generally have FARs under 0.36. Table 5.2 also shows that the zoning ordinances of sub-cities and large MXDs generally allow, on average, the highest maximum FARs.

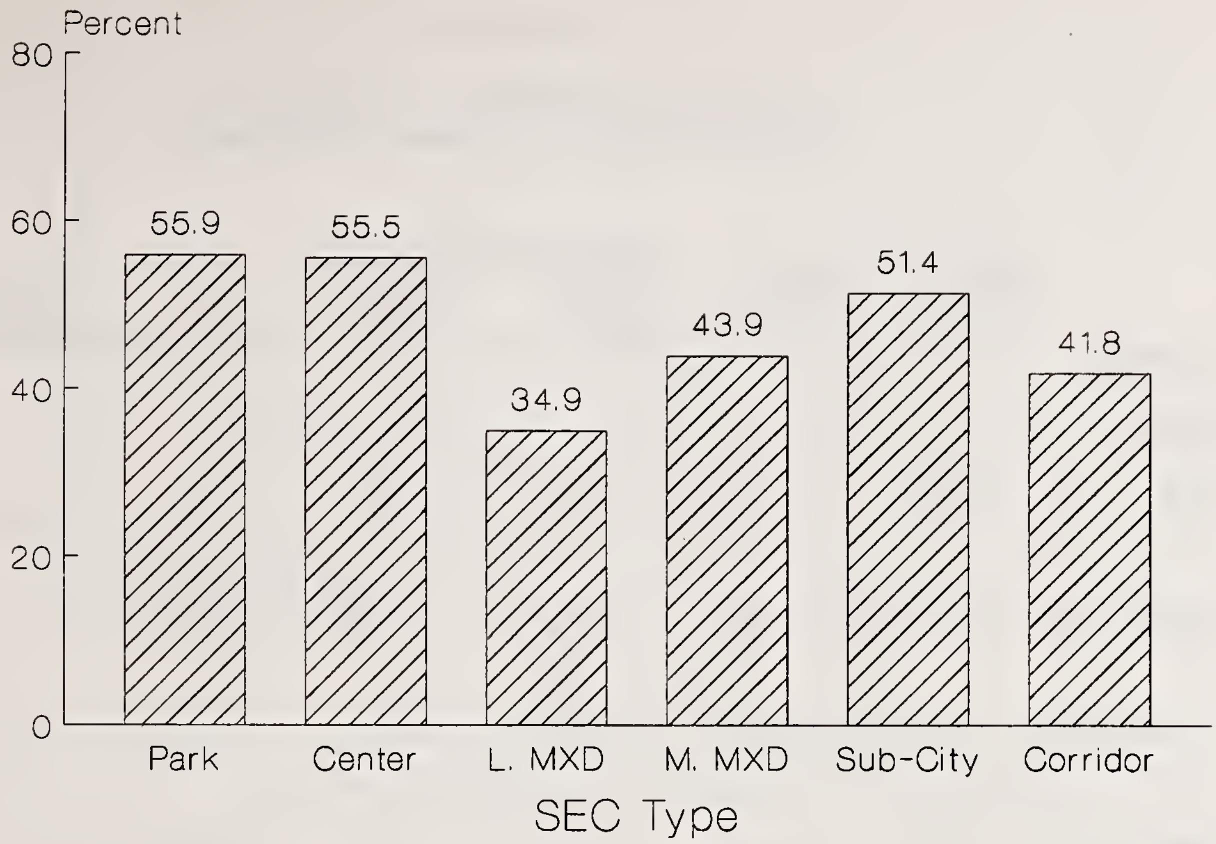


Figure 5.1 Share of Workforce in Professional Job Categories by SEC Type

One relationship of interest is the correlation between the size of SECs and densities. Are there any differences among SEC groups in how size and density are related? Figure 5.2 offers some perspective on this. Overall, the random-appearing pattern in the scatterplot suggests that the relationship between the size of labor force and FARs is fairly weak among the non-corridor cases. Within SEC groups (whereby office parks and centers are combined, as are MXDs), more of a decipherable pattern is apparent. Among office centers (i.e., parks and concentrations), a modest negative correlation appears -- as they get bigger, FARs tend to drop. Among MXDs, there is a slight positive correlation; as their employment base increases, so does generally their densities. Among sub-cities, however, there appears to be a fairly strong inverse relationship -- the bigger ones average the lowest FARs. Thus, even though many sub-cities and MXDs share similar land use mixtures, the relationship between size and density seems to be qualitatively different among the two groups.

Table 5.2 also shows mean differences in the most frequently occurring office building height, expressed in stories, among groups. As with the FAR variable, sub-cities and large-MXDs likewise appear to average the tallest skylines. When the lowest and highest building stories are compared, several other patterns emerge (see Figure 5.3). Sub-cities tend to have the tallest average skyline (26 story buildings), followed by office centers. Thus, although the typical building within large-MXDs are taller, office concentrations usually have the tallest building among the two groups. All of the SECs tend to have comparably low heights for the lowest building, except office concentrations/centers, wherein the lowest building is generally over two stories. This average is inflated somewhat, however, by the inclusion of several high-rise centers with no buildings under five stories, such as Greenway Plaza in Houston. Figure 5.3 also reveals that sub-cities tend to have the greatest variation in skyline, with 25 or so stories separating the lowest and highest office buildings, on average.

Table 5.2

Comparison of Density, Lotting, and Ownership Patterns Among SEC Groups

Variables	Means of SEC Groups: Office Park	Office Center	Large MXDs	Moderate MXDs	Sub-City	Large Corridor	F Stat. (prob.)
Density:							
FAR	0.33	1.55	0.89	0.76	1.80	0.36	3.19 (.014)
MAXFAR	0.61	2.40	3.14	1.59	4.03	1.05	1.53 (.225)
AVGSTORY	2.9	7.3	3.5	3.3	9.2	2.9	5.39 (.001)
EMP/ACRE	18.7	20.4	5.4	11.7	44.7	--	5.47 (.001)
COVERAGE	.26	.46	.31	.24	.30	--	1.59 (.193)
Lotting:							
SMALLLOT	2.11	2.54	0.79	1.08	0.36	0.20	1.77 (.141)
LOTVARY	.096	.086	.022	.062	.023	.005	1.72 (.154)
Ownership:							
PROPOWN	13.0	33.5	249.3	248.6	82.4	--	3.01 (.031)
DEVOWN	44.7	67.5	70.0	70.7	75.9	--	2.29 (.081)

FAR = Floor area ratio, building square feet/lot size.
MAXFAR = Maximum allowable FAR under current zoning.
AVGSTORY = Most frequently occurring number of stories for office buildings.
EMP/ACRE = Employees/acre.
COVERAGE = Proportion of land covered by buildings.
SMALLLOT = Acreage of smallest lot.
LOTVARY = Smallest lot as a proportion of largest lot.
PROPOWN = Number of property-owners, non-residential land only.
DEVOWN = Percentage of non-residential property owned by developers.

Figure 5.2 Plot of FAR Versus Employment Size by Three SEC Groups

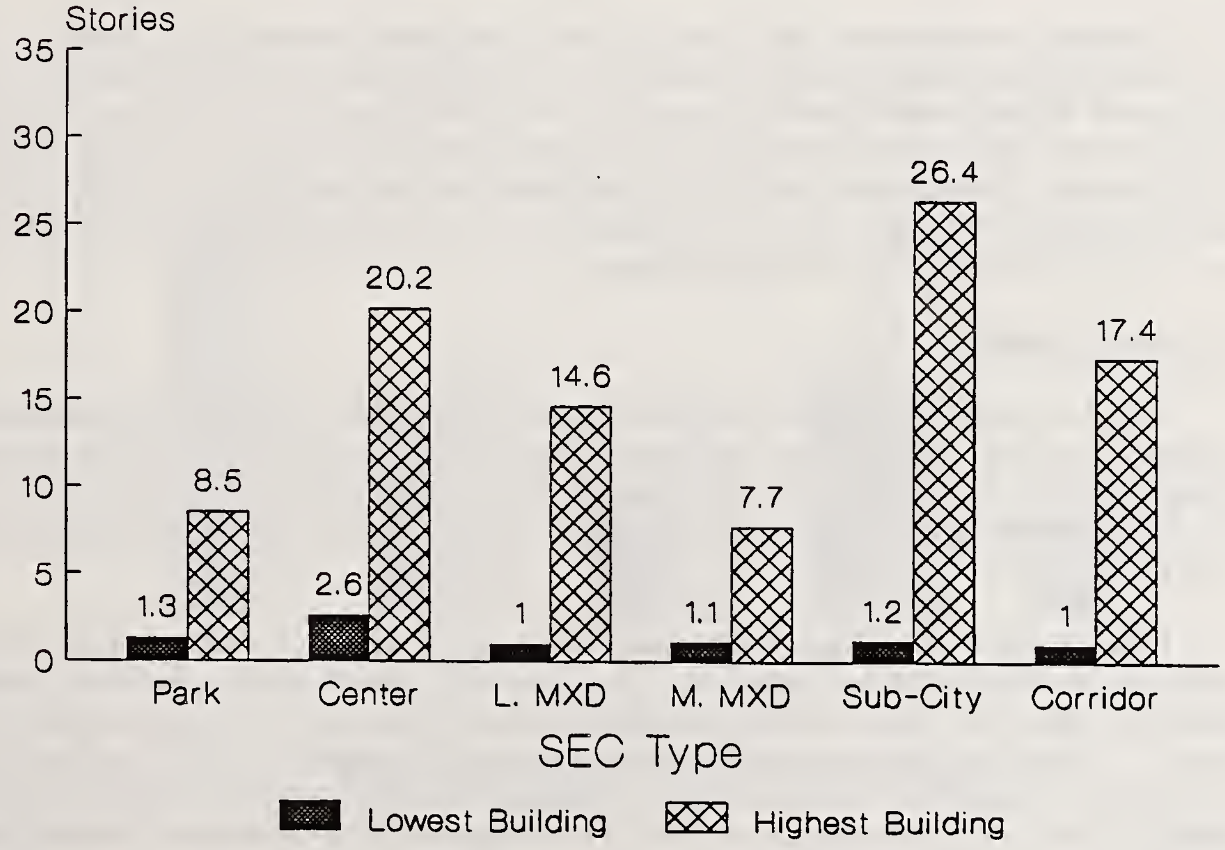


Figure 5.3 Average Stories of Lowest and Highest Buildings by SEC Groups

When density is expressed on an employees per acre basis, Table 5.2 shows that sub-cities again rank the highest -- in general, there are over twice as many workers per acre as in any of the other SEC groups. Additionally, Table 5.2 compares average coverage ratios among the groups. All SECs tend to have low building coverage rates, with parking lots, streets, and open space representing well over one-half of total land area, and in the case of office parks, generally around three-quarters. Office centers, on the other hand, average the least amount of open space.

A final indicator of relative employment density is the amount of square feet per employee -- an "elbow-room" index. Figure 5.4 reveals that differences are fairly insignificant, with the exception of moderate-size MXDs. Their working environments tend to be more spacious, though part of the explanation is due to the fact that some of these SECs average relatively high shares of retail, light-industrial, and warehouse workers, thus inflating the average. Compared to traditional downtowns, however, the workers of all of these SEC groups enjoy more work room -- in general, over twice as much space per employee [Cervero, 1986B].

Lotting

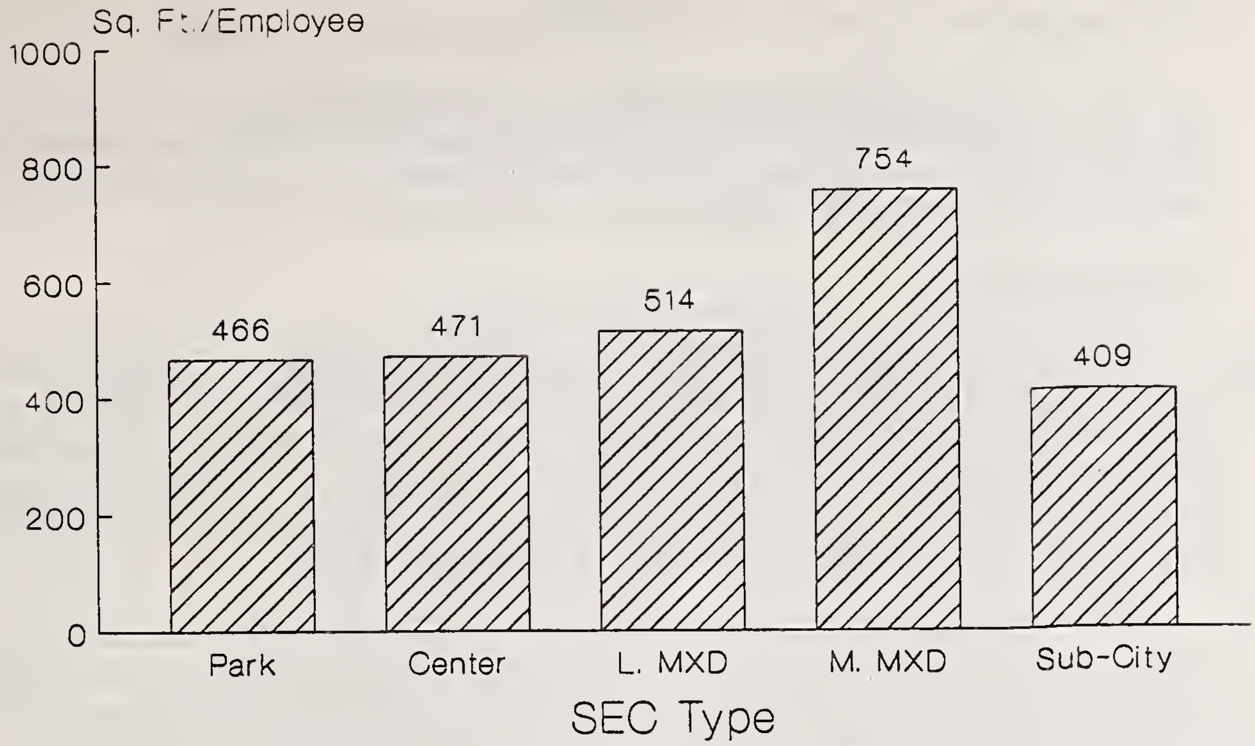
Differences in average front lot and side lot setbacks among SEC groups are summarized in Figure 5.5. Among non-corridor SECs, sub-cities average the shortest setbacks while office parks feature the longest ones. Particularly in the case of company headquarters and signature buildings, setbacks exceeding 100 feet in length are not uncommon in many office and executive parks. Another pattern of note from Figure 5.5 is the fact that the relative differences among SEC groups in side versus front setbacks are quite similar. Additionally, it is evident that in all SEC environments, front setbacks tend to be 10 to 20 percent longer than side ones. In most cases this is because buildings lie closer to the narrower sides of rectangular lots, often with proportionally more front and rear lot space devoted to surface parking.

Average lot sizes were not found to vary significantly among SEC groups. Smallest lots do, however. In general, single-use SECs -- i.e., office parks and office concentrations -- have much bigger small-size lots than any of the other groups. If one looks at the smallest lot as a proportion of the largest one, office parks and office centers show the least amount of difference. The greatest variability in lot sizes can be found in large MXDs, sub-cities, and large-scale corridors, where 6,000 square foot residential parcels are sometimes less than one $1/100^{th}$ the size of the largest property.

Property Ownership

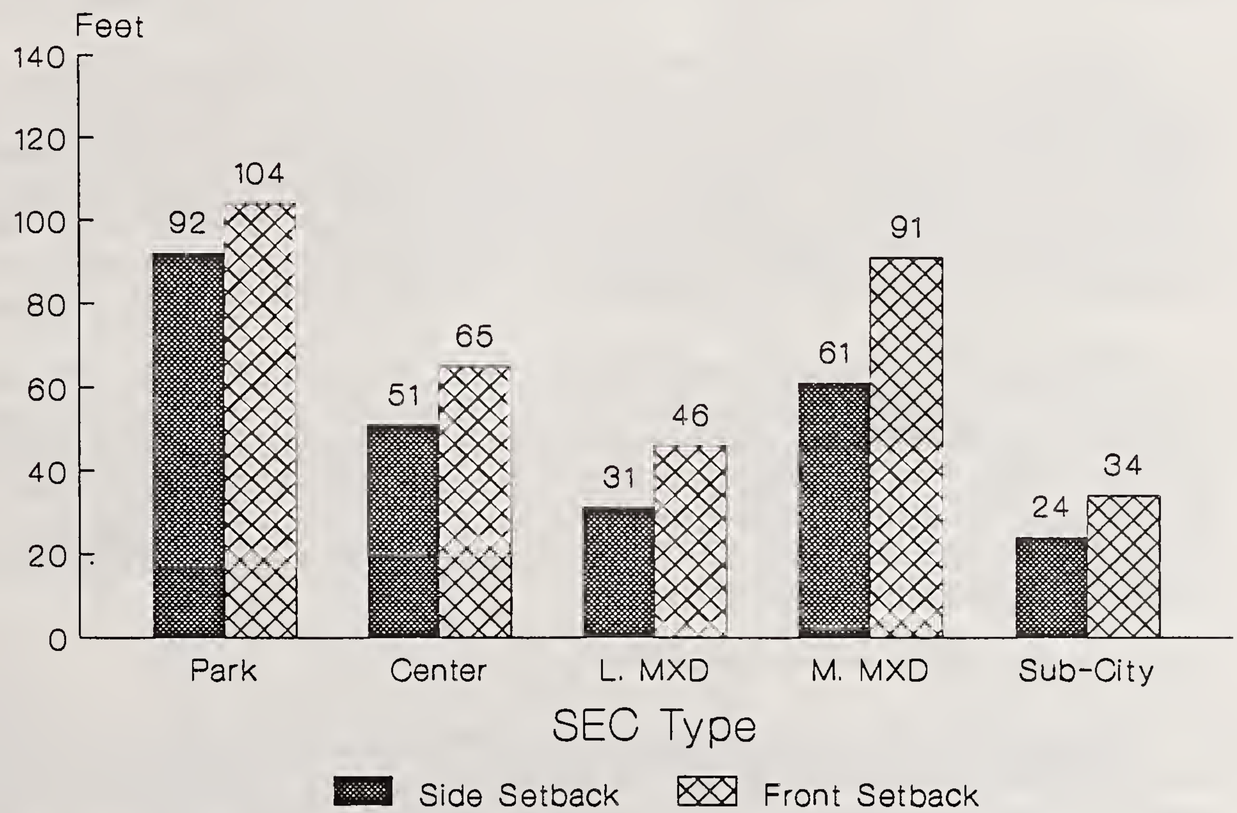
Table 5.2 also compares differences in the number of landholders of non-residential properties among SEC groups. Because of their widely varying uses, MXDs tend to have far greater numbers of property owners than any of the other groups. This likely accounts for why MXDs usually have less of an integrated architectural theme than many sub-cities and most office parks.

Differences in the percentage of land owned by developers versus private companies are shown in the final entry in Table 5.2. All of the SEC groups average between two-thirds and three-quarters of all land in private developer ownership, with the lone exception being office parks. In parks, less than one-half of land is generally owned by a development company. In many parks, large tracts are sold to major firms which in turn build company headquarters or branch offices, with developers normally retaining control over design features through land covenants and during plan reviews.



exclusive of corridors

Figure 5.4 Average Building Square Footage per Employee in Five SEC Groups



lineal feet from property line to bldg.

Figure 5.5 Average Setbacks for Front and Sides of Buildings by SEC Groups

5.4 Comparison of Land Use Compositions among SEC Groups

Since land use was another variable used to discriminate between groups when clustering SEC cases together, differences in land use mixtures can certainly be expected among groups. This section discusses the magnitude of these differences, concentrating on the relationship between office, retail, and housing components among SEC classes.

Land Use Mixtures

Office activities are the predominant function within all of the SECs examined in this study. Among SEC groups, however, the level of office domination varies quite a bit. Almost by definition, office parks and office centers/concentrations have the highest average shares of office floorspace -- over 80 percent in both cases (Table 5.3). Excluding sub-cities, all of remaining SECs average less than half of their non-residential floorspace in office uses. The SECs least oriented to office functions are large-scale MXDs.

The dual relationship between office space and retail space is shown in Figure 5.6. Where office uses are most dominant, retail space tends to be minimal, and vice-versa. On average, sub-cities have the largest shares of commercial-retail space among the SEC groups, owing in large part to the existence of a one million square feet or larger mall at most of these megacenters. Figure 5.7 offers a slightly different perspective on this relationship. The scatterplot shows that for MXDs and sub-cities, as more floorspace goes for office functions, relatively more goes for retail space as well, obstensibly as support services for office tenants. This suggests that other uses (e.g., housing, warehousing, hotels, etc.) tend to get squeezed out as MXDs and sub-cities gather more of a premium office space character. For office centers and parks, however, the share of retail space remains fairly low, whether the development has 75 percent or nearly 100 percent office activities. This suggests, then, as office parks and centers begin to diversify, they do so by adding warehousing, manufacturing, hotel, and other business ancilliary uses as opposed to adding retail functions.

Table 5.3 also shows variation in light-industrial activities among SECs, what normally is the third largest use following office and commercial-retail activities. MXDs general have the highest percentages of manufacturing activities while sub-cities and office concentrations average the least amount. Thus, the existence of light-industrial activities appears to be another factor, besides size and density, which distinquishes MXDs from sub-cities. Among some of the other uses, large MXDs tended to have the largest share of warehousing as well as the largest share of other activities (notably, hotels and entertainment offerings).

The degree of variation among different land uses for non-corridor SEC groups is shown in Figure 5.8. Ordered from the group with the smallest to the one with the largest entropy index, the figure reveals that office centers are the least varied while large MXDs are the most diversified. (As discussed in the previous chapter, this index ranges from 0 to 0.60, with the low range representing little land use variation and the high range signifying a lot.) In general, office parks tend to be a little more diversified than centers, whereas MXDs are slightly more diversified than sub-cities.

Consumer Services

Comparisons of different levels of consumer and tenant-support services for SEC groups are also shown in Table 5.3. By far, sub-cities average the largest number of on-site eateries -- over 50 per SEC. Office parks, on the other hand, generally have fewer than three on-site eateries, often in the form of first-floor delis and snack shops. Significant differences in the number of on-site banks were also found. While sub-cities average around 12 banks and

Table 5.3

Comparison of Land Use Compositions and Housing Provisions Among SEC Groups

Variable	Office Park	Office Center	Large MXDs	Moderate MXDs	Sub-City	Large Corridor	F Stat. (prob.)
	Means of SEC Groups						
Land Uses:							
OFFICE	81.9	88.3	39.8	49.5	60.7	40.2	19.8 (.000)
INDUSTRY	5.2	1.5	16.2	11.0	1.6	4.7	4.65 (.002)
Services:							
RESTAURT	2.4	14.3	23.0	10.5	54.7	--	8.22 (.004)
SHOPCENT	1.8	2.4	6.9	2.0	2.8	--	2.03 (.098)
RESTINT	3875	10490	914	546	675	--	1.08 (.368)
Housing:							
HOUSUNIT	84	275	2988	583	2496	--	3.61 (.014)
MULTIFAM	40.0	37.7	21.2	36.3	87.0	--	4.70 (.004)
AVGRENT	625	477	549	550	664	--	1.90 (.117)

Variable Definitions:

OFFICE	= Percent of floorspace in office use.
INDUSTRY	= Percent of floorspace in light-industrial and manufacturing use.
RESTAURT	= No. of eateries and restaurants on-site.
SHOPCENT	= No. of shopping centers over 100,000 sq. ft. of floorspace within 3 miles.
RESTINT	= Restaurant intensity index -- Employees per on-site restaurant.
HOUSUNIT	= No. of on-site housing units.
MULTIFAM	= Percentage of dwelling units within 3 mile radius that are multi-family.
AVGRENT	= Estimated monthly rent of multi-family units within a 3 mile radius.

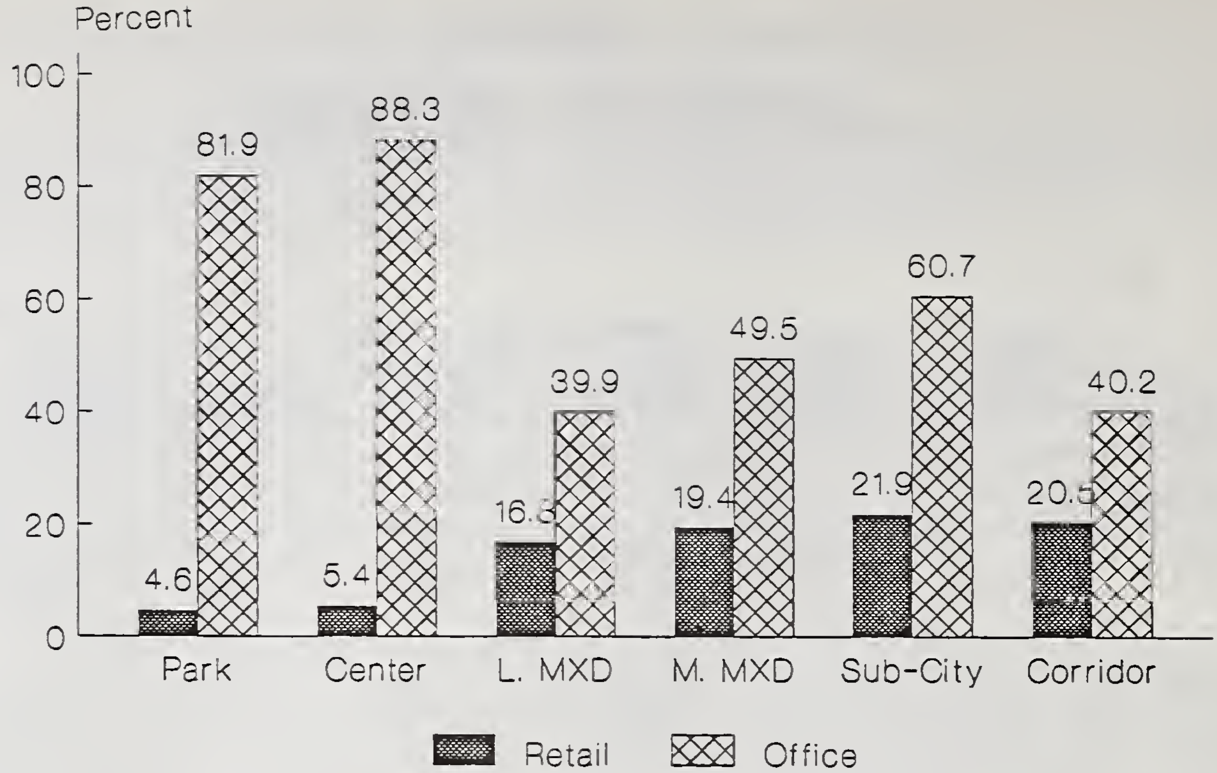


Figure 5.6 Percentage of Floorspace in Retail and Office Uses by SEC Groups

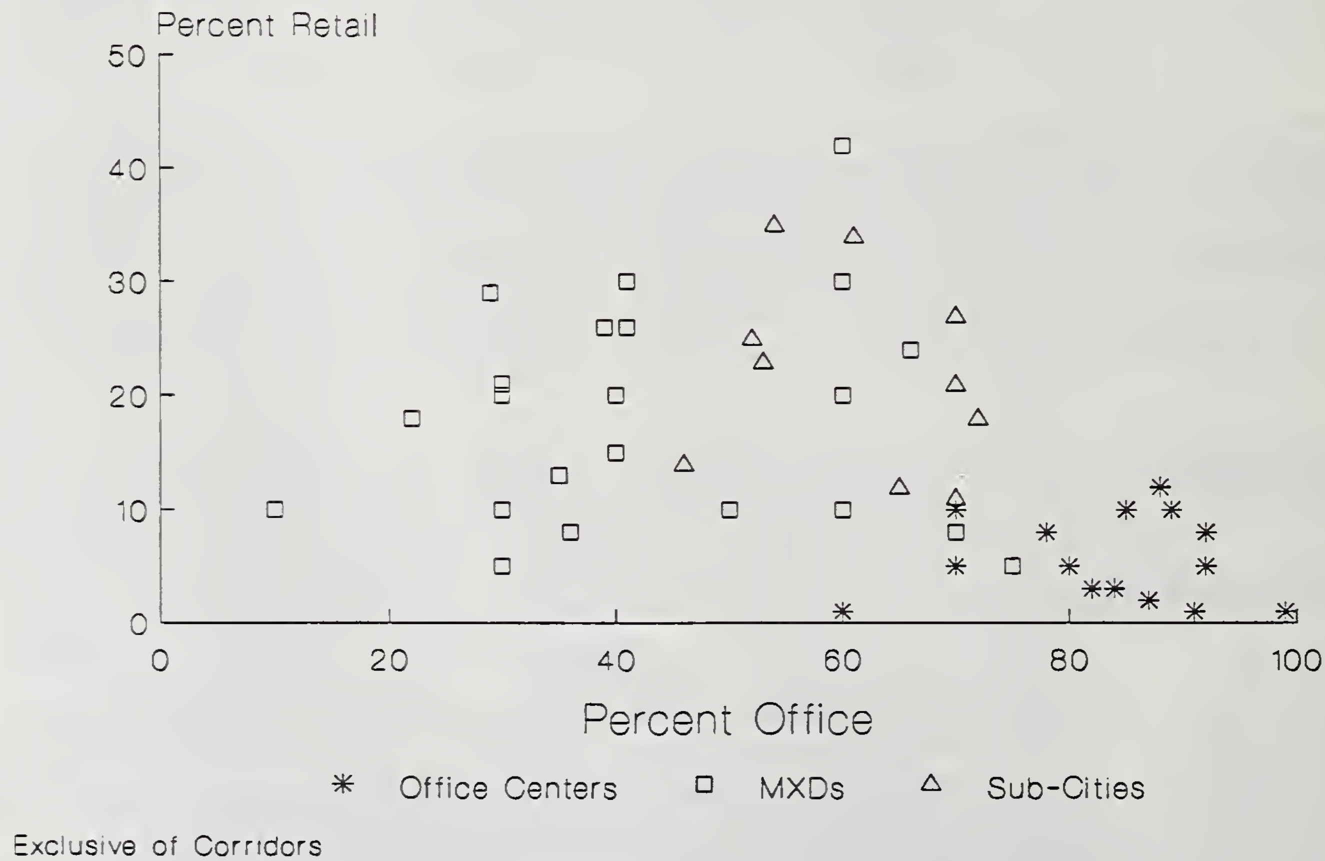


Figure 5.7 Plot of Percent of Floorspace in Retail Versus Office Use, by Three SEC Groups

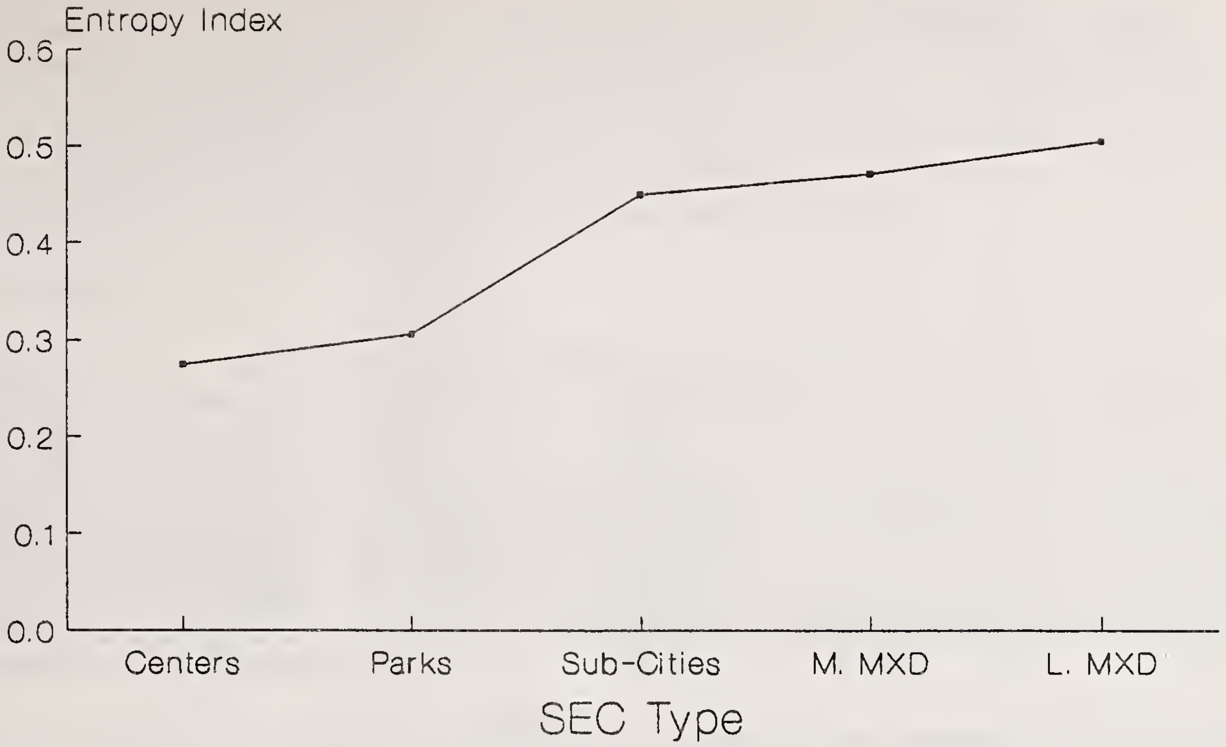


Figure 5.8 Comparison of Land Use Entropy Index Among Five SEC Groups. See Chapter Four, Section 4.2 for a definition of this index.

savings institutions each, the other SEC groups (excluding corridors) generally have no more than four, and in the case of office parks, normally only around one.

As shown in Figure 5.9, the SEC group averaging the largest number of retail centers exceeding 50,000 square feet in floor area, equivalent to at least a retail plaza of around five shops and a large grocery store, is large-scale MXDs -- about nine per site. Only around one-half of the office parks, by comparison, have shopping plazas or centers of at least this size. The degree to which the number of retail plazas and centers vary as a function of density is shown in Figure 5.10. The scatterplot reveals that as SECs become denser, the number of on-site retail centers generally falls. The relationship is the strongest for MXDs and the weakest for office centers and parks. This finding likely reflects two factors. One, other uses, such as offices and hotels, outbid retail establishments for prime real estate in high-density MXDs, resulting in high rates of land conversion. Second, in denser MXDs, smaller, more local-oriented retail plazas are often consolidated or sometimes replaced by large regional shopping centers and malls. This is somewhat confirmed by Table 5.3, wherein large MXDs average, by far, the largest number of shopping centers exceeding 100,000 square feet within a three-mile radius of the site -- on average, around seven. None of the other SEC groups average more that three large-size shopping centers either on-site or nearby.

As discussed in the previous chapter, the availability of on-site and nearby retail facilities is best expressed when these variables are indexed to the number of SEC employees, producing a retail intensity measure. The sixth row of Table 5.3 shows differences in the average number of employees per on-site restaurant/eatery (RESTINT). Although the relationship in not statistically significant, in part because of missing values for a number of cases, it is apparent that office centers and parks offer their tenants' employees the fewest lunch-time opportunities. Moderate-size MXDs and sub-cities, by comparison, have roughly fifteen times the restaurant intensities of office centers/concentrations. For MXDs and sub-

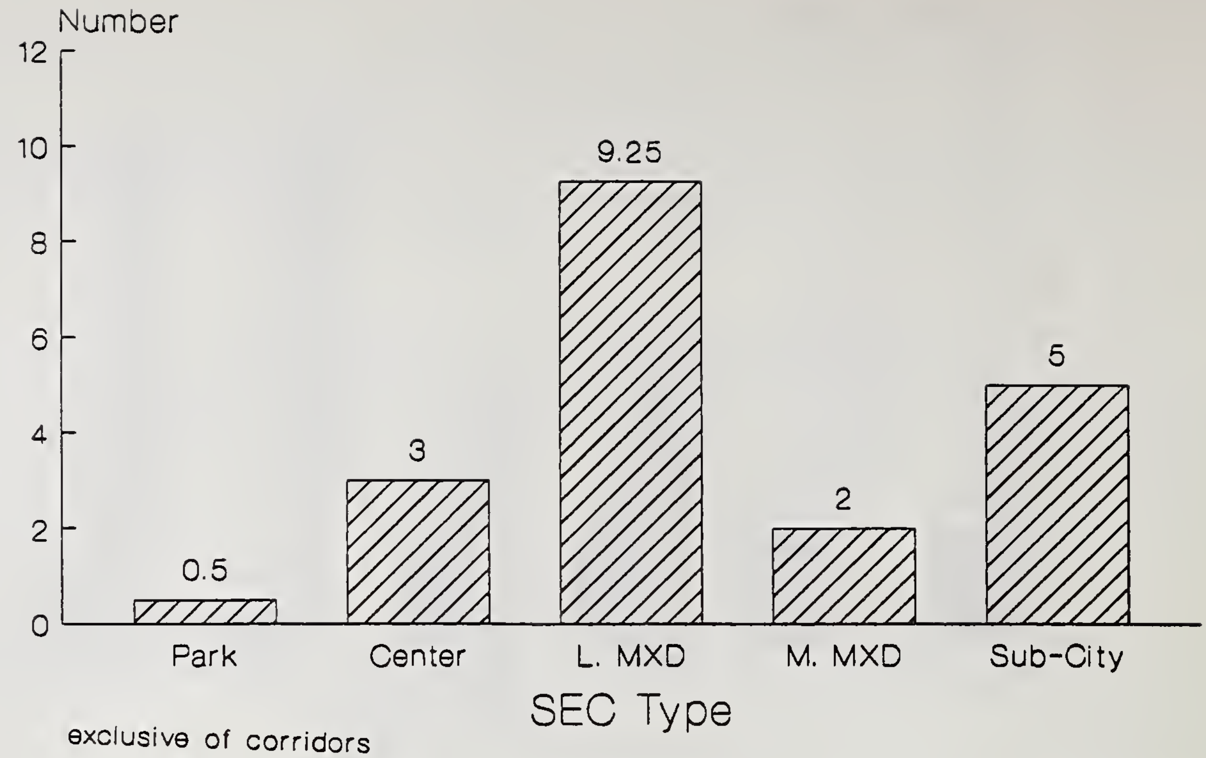


Figure 5.9 Average Number of Retail Centers With Floorspace Over 50,000 Square Feet

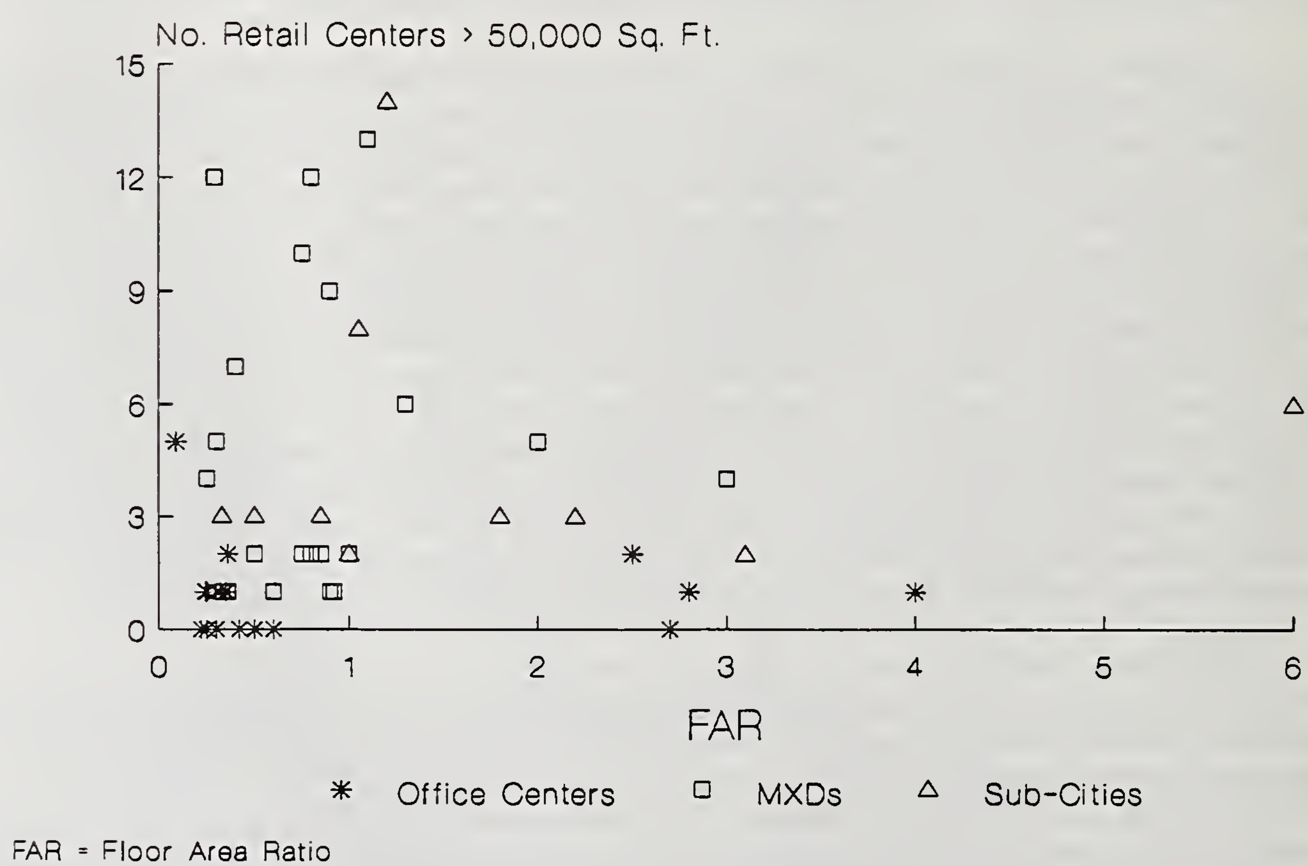


Figure 5.10 Plot of Number of Retail Centers Versus FAR by Three SEC Groups

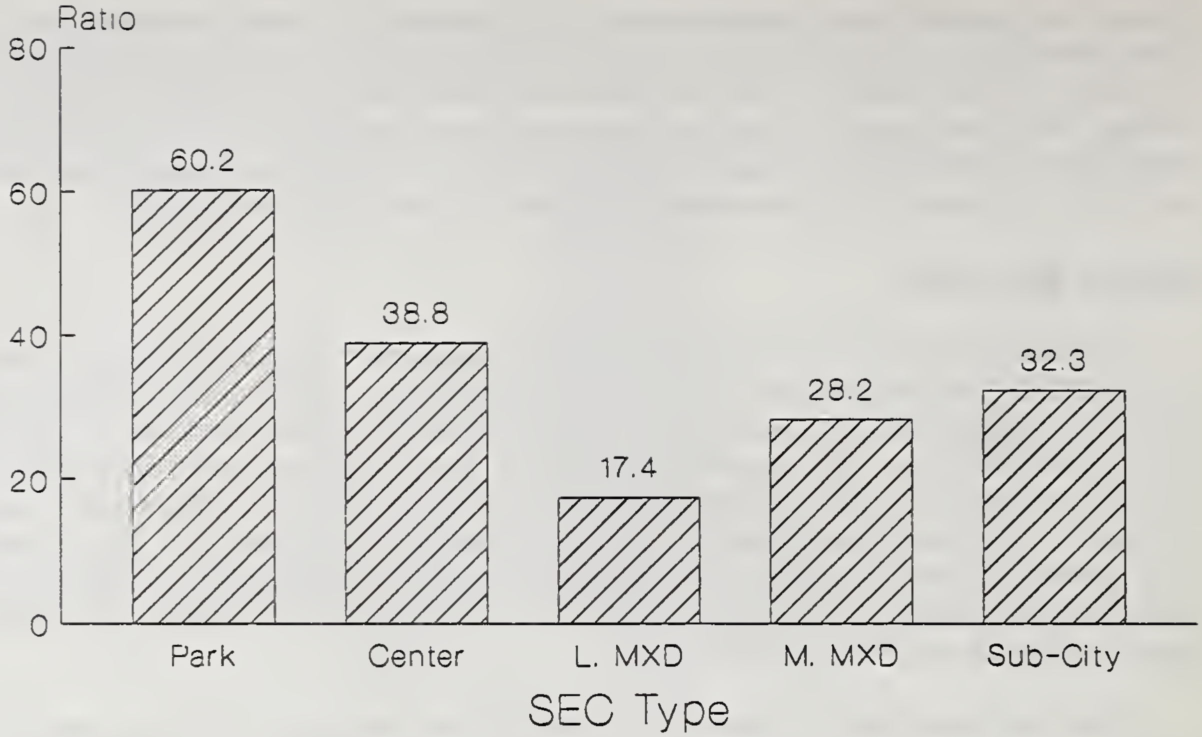
cities, there generally are no more than 1,000 workers for every on-site eatery. These groups also tend to have the greatest level of retail intensity when the number of employees is indexed to the number of on-site banks and retail centers, though the relationship is not as strong. One could expect, then, that the incidence of employee ridesharing is relatively high in MXDs and sub-cities because of the availability of nearby consumer services. The extent to which this is borne out is presented in section 5.6 and the sixth chapter.

Housing Provisions

Differences in the number of on-site dwelling units are summarized in the bottom section of Table 5.3. In part because of their sheer sizes, large-MXDs and sub-cities average the largest number of on-site units -- well over 2,000 each. Office parks, by comparison, average fewer than 100 units. The percentage of these units which are multi-family is also shown. Sub-cities tend to be made up predominantly of multi-family condominiums and townhouses, whereas the housing component of large MXDs consists primarily of single-family dwellings. This housing orientation seems to be another qualitative difference that distinguishes sub-cities from MXDs. All other SEC groups have, on average, fewer than one-half of their housing stock in the form of multi-family units.

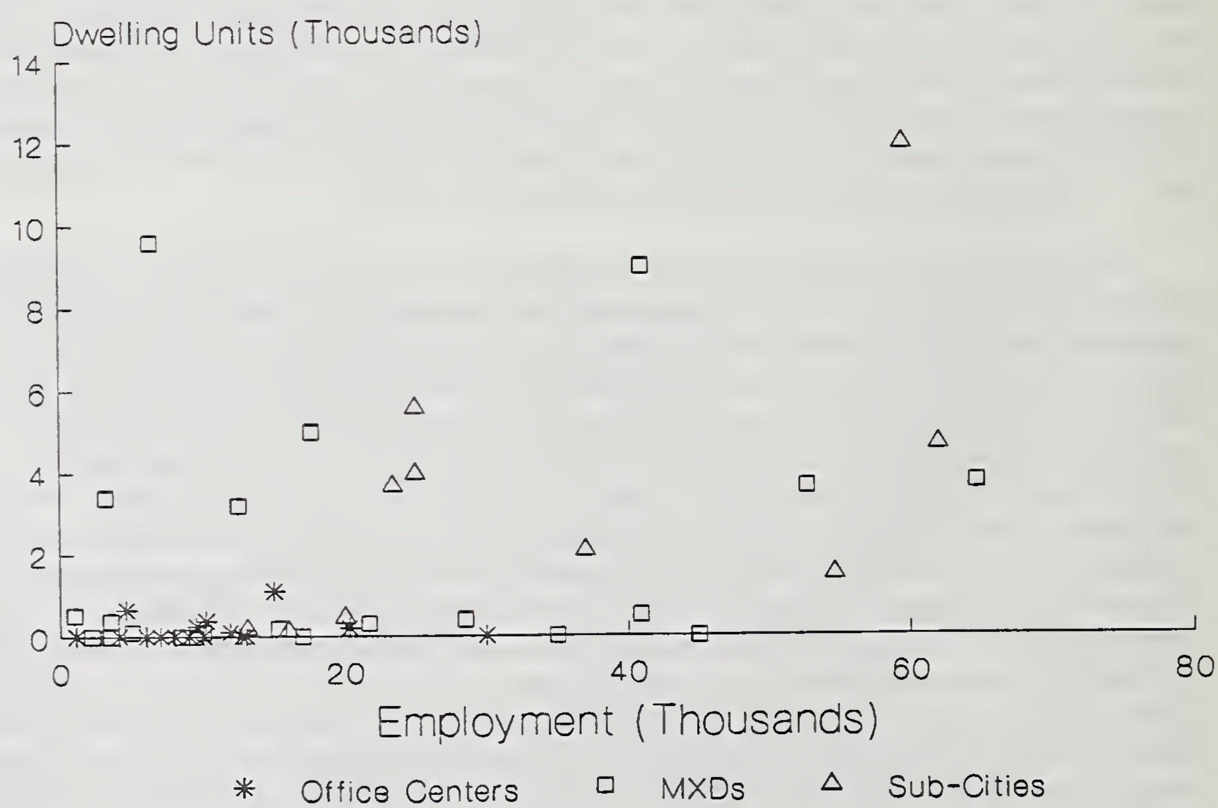
Most relevant from a transportation standpoint, however, is the general balance of jobs and housing. Figure 5.11 compares differences across five SEC groups. While the mean ratio of jobs-to-housing is around 30 for all cases combined, the two groups which vary most dramatically from this average are office parks and large MXDs. Parks tend to have the least housing offerings while large MXDs have the most, with the two groups differing in jobs/housing by a factor of about four. This is further revealed in Figure 5.12, where dwelling units and employment are plotted against one another. In general, regardless how large the employment base might be, office centers and parks average the fewest number of on-site housing units. For MXDs, dwelling units generally increase with employment size, however the correlation is fairly modest. In the case of sub-cities, the relationship between these two variables is the strongest -- the sub-cities with the largest employment bases (e.g., North Dallas Parkway and Tysons Corner) also tend to have the largest number of on-site housing units. One might expect, then, that because of their availability of nearby multi-family housing, larger shares of the work forces in MXDs would be walking and cycling to work. This hypothesis is explored in section 5.6 as well.

From a mobility standpoint, more important than the number of on-site units is the availability of housing within a reasonable commutershed of an SEC. Office parks and moderate-size MXDs were found to generally have the most number of nearby housing units relative to their work force sizes, whereas large-scale MXDs tended to have the fewest, although the relationship was not statistically strong. In general, these nearby housing units tend to be single-family dwellings for all SEC groups, with sub-cities featuring the largest share of multi-family units within a three mile radius. As was discussed in the third chapter, just because there is some degree of equinimity between jobs and housing units does not necessarily mean that SEC workers will reside nearby and enjoy easy commutes. The affordability of these units, and in particular the match between employee earnings and housing costs, likely strongly influences how close employees reside to work. The last entry in Table 5.3 shows that average monthly rents for multi-family units are generally the highest in the vicinity of sub-cities and office parks, while they tend to be the lowest near office centers. Generally, the same pattern held in terms of differences in the average purchase price of nearby housing, although this variable was statistically insignificant. Office parks, it should be recalled, average the highest shares of clerical workers while sub-cities tend to have the largest shares of sales personnel -- two occupational groups with traditionally low earnings levels. While differences in housing rents are not glaring across SEC groups, there does appear to be some degree of mismatch between workforce earnings and nearby housing



Ratio = Employees/Housing Units

Figure 5.11 Average Jobs-Housing Ratios for Five SEC Groups



exclusive of corridors

Figure 5.12 Plot of Dwelling Units Versus Employment by Three SEC Groups

costs that could account for some of the mobility problems around America's office parks and sub-cities.

5.5 Transportation Facilities and Services

In addition to land use and design characteristics of SECs, of course, the amount and quality of transportation facilities and services also influence commuting choices and local traffic conditions. This section compares differences in the supply-side characteristics of the six SEC groups.

On and Off Site Roadway Facilities

The directional miles of roads within SECs vary to a large extent according to the acreage of each SEC. Among the non-corridor SECs, large MXDs and sub-cities tend to have the most miles of collectors and major arteries since they encompass the largest geographic areas. A better indicator of the relative supply of roadways is the ratio of employment size to directional miles for an SEC. Table 5.4 compares this ratio among SEC groups for on-site surface roads (EMP/RWM) and freeway facilities within five radial miles of an SEC (EMP/FWM). A similar pattern is evident for both variables. Office concentrations and office parks average the largest supply of road space and freeway capacity per employee whereas sub-cities average the least. Moderate-size MXDs are closer to office centers in their levels of roadway supply while large MXDs more closely resemble sub-cities.

Table 5.4 also compares the relative number of access points, expressed as nearby freeway interchanges, among the SEC groups. Based on the ratio of employment to the number of freeway interchanges within a five mile radius of SECs, the table shows that office parks enjoy the highest level of site accessibility from freeways. Sub-cities, on the other hand, tend to have the fewest number of freeway interchanges relative to their work force size. Among the six groups, all average spacings of around 2 to 2.5 freeway miles between interchanges, with the exception of office centers, wherein interchanges are normally spaced four miles apart. This longer spacing reflects the fact that most office centers and concentrations abut a single interchange whereas other developments tend to be spread out over several interchanges.

In all, it is evident that office parks enjoy the highest relative level of roadway supply among the SEC groups, while sub-cities have the least in relation to their employment base. Accordingly, one would expect, all things equal, office parks to be most oriented to auto-commuting and sub-cities to be the least among the groups. The extent to which this is the case is discussed in the next section.

On-Site Parking Provisions

The supply and cost of parking likely influence employee travel behavior as much as on-site and nearby roadway supply, and perhaps even more. Table 5.4 compares the average number of parking spaces per employee (PARK/EMP) and per 1,000 square feet (PARK/SFT) among the six SEC groups. In general, there is not very much variation -- all groups average relatively high levels of parking supply, roughly one space per worker. Because of their higher densities and land values, sub-cities tend to have the lowest level of parking provision, however parking is still plentiful even in these settings. Evidently, developers of virtually all SECs appear to be heeding the advice of their financiers and brethren to "overbuild parking when in doubt".[2]

Table 5.4

Comparison of Transportation
Facilities and Services Among SEC Groups

Variable	Means of SEC Groups: Office Park	Office Center	Large MXDs	Moderate MXDs	Sub-City	Large Corridor	F Stat. (prob.)
Roadways:							
EMP/RWM	1357.3	1250.6	2197.5	1498.3	2796.1	--	2.21 (.045)
EMP/FWM	2099.4	1797.6	3488.8	2339.6	8067.2	--	3.87 (.005)
EMP/INC	2789.5	5804.7	7317.1	3521.3	11685.6	8077.5	3.27 (.013)
SPACING	2.56	4.09	2.33	2.33	2.20	2.03	2.05 (.089)
Parking:							
PARK/EMP	1.04	0.95	1.10	1.09	0.96	1.13	1.49 (.212)
PARK/SQF	3.90	3.58	4.02	4.13	3.55	3.90	1.29 (.284)
PARKING$	0.00	1.17	0.73	0.00	1.08	--	3.93 (.009)
Buses/Vans:							
COMUTBUS	1.5	3.8	8.8	0.3	2.6	--	1.68 (.164)
EMP/VAN	1068.9	3394.6	3920.8	1284.3	3196.5	--	1.26 (.314)

EMP/RWM = Employees/directional mile of roadways within site.
EMP/FWM = Employees/directional mile of freeways within 5 miles of SEC.
EMP/INC = Employees/freeway interchange within five miles of SEC.
SPACING = Freeway directional miles/interchange.
PARK/EMP = Parking spaces/employee.
PARK/SQF = Parking spaces/1,000 gross square feet.
PARKING$ = Most frequently occurring daily price for parking, in dollars.
COMUTBUS = Number of daily private commuter buses serving SEC.
EMP/VAN = Employees/company-sponsored van operation.

While the supply of parking is fairly constant across SEC groups, general pricing practices do not appear to be. Table 5.4 shows that while all office parks and moderate-size MXDs studied provided free parking for everyone, the most frequent all-day rate for office centers and sub-cities averaged over one dollar.[3] Large-MXDs averaged around seventy-five cents as the most frequent daily rate. Commercial parking rates, of course, do not reflect what employees actually pay. As discussed in the preceding chapter, an overwhelming majority of workers in many office settings receive vouchers to pay for most, if not all, of monthly parking expenses. On the whole, office workers in most SECs pay nothing to park, an in-kind subsidy that acts as a strong inducement for many to drive to work alone.

Transit and Ridesharing Services

Few significant statistical patterns emerged when various measures of public transit provisions were compared across SEC groups. In general, sub-cities average far more bus runs both on-site and nearby than the other SEC groups. When indexed to the size of workforce, MXDs were found to have the highest relative level of transit services, however again the relationship was statistically weak.

A somewhat stronger pattern emerged when the level of private commuter bus operations were compared among groups. Table 5.4 shows that large MXDs average, by far, the largest number of subscription bus services, with approximately nine buses serving each center daily. Most of these are premium services offering office workers guaranteed padded seats, a pleasant temperature-controlled climate, and front-door drop-off.

Differences were also evident in the level of company support of vanpool services among SEC groups. Figure 5.13 shows that large-MXDs and sub-cities tend to have the most companies underwriting van services for their employees, in the neighborhood of three to four firms in both cases. These firms sponsor, on average, around four vans each, for a total operation of fifteen or more vans within each SEC. While office parks generally only have one company running employee van services, compared with the other groups, these were large operations, averaging around 22 vans per company. Thus, whereas the other SEC groups tend to have multiple companies sponsoring fairly moderate-size van services, office parks tend to have one large company that operates nearly two dozen vans. As shown in the final entry of Table 5.4, moreover, office parks also tend to enjoy the highest intensity of van services -- around 1,000 or so employees per van in service.

Finally, Figure 5.14 compares differences in levels of rideshare support among the six SEC categories. The group with the highest proportion of full-time or part-time rideshare coordinators is office centers -- nearly two-thirds of its SEC cases have coordinators. Sub-cities, on the other hand, have the largest proportion of designated ridesharing offices -- 7 of the 10 cases have a specific on-site office devoted to ridematching, marketing, and other support services. Moderate-size MXDs tend to be least involved in rideshare promotion and coordination.

5.6 Comparison of Commuting Choices and Local Traffic Conditions Among SEC Groups

So far, differences in the general land use and transportation supply characteristics of SEC groups have been examined. Most significant from a policy standpoint, however, is the degree to which commuting behavior and local traffic conditions vary among the six groups. To the extent certain patterns are evident, inferences can possibly be drawn regarding how variations in land use patterns are related to variations in transportation conditions. This section attempts to illuminate any such patterns that exist.

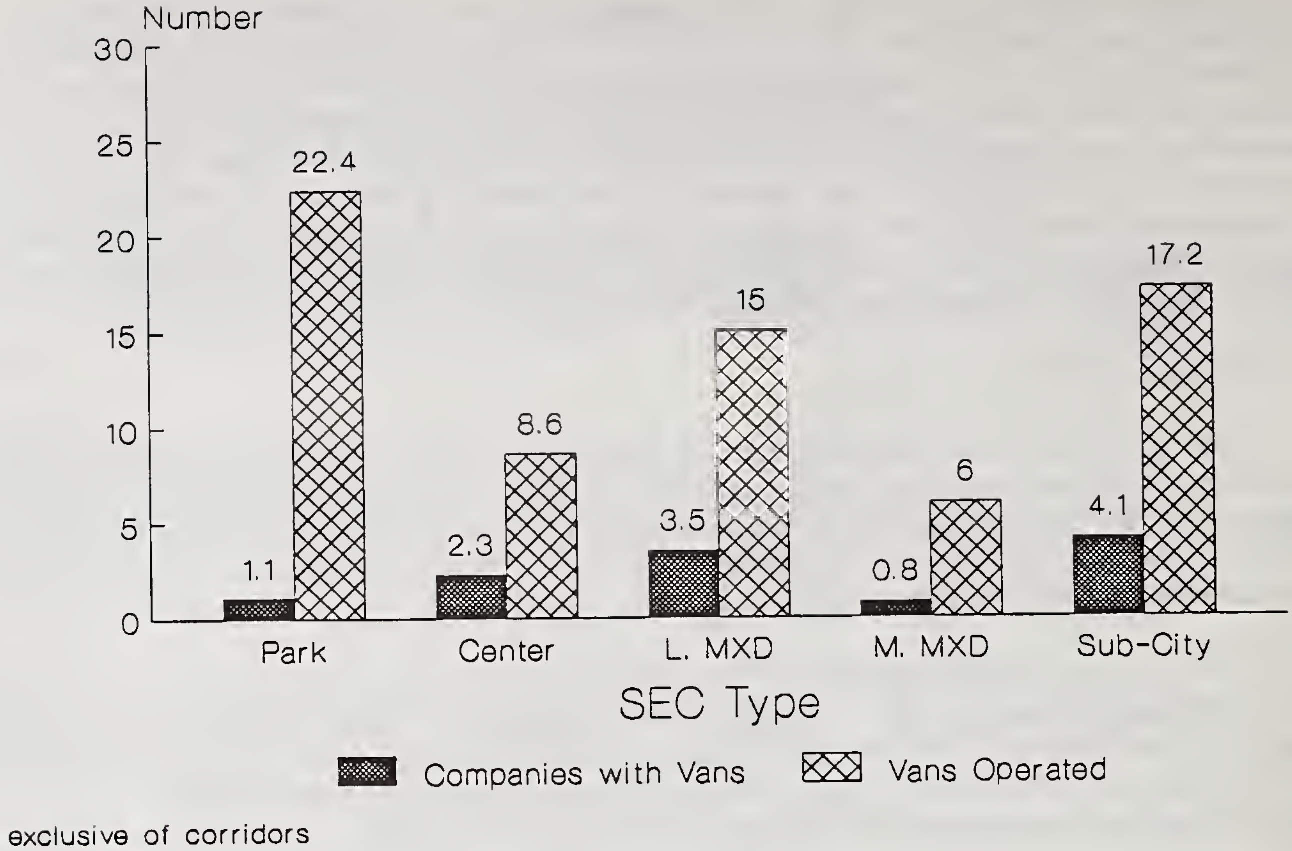


Figure 5.13 **Average Number of Companies Sponsoring Vanpools and Vans Operating in SECs**

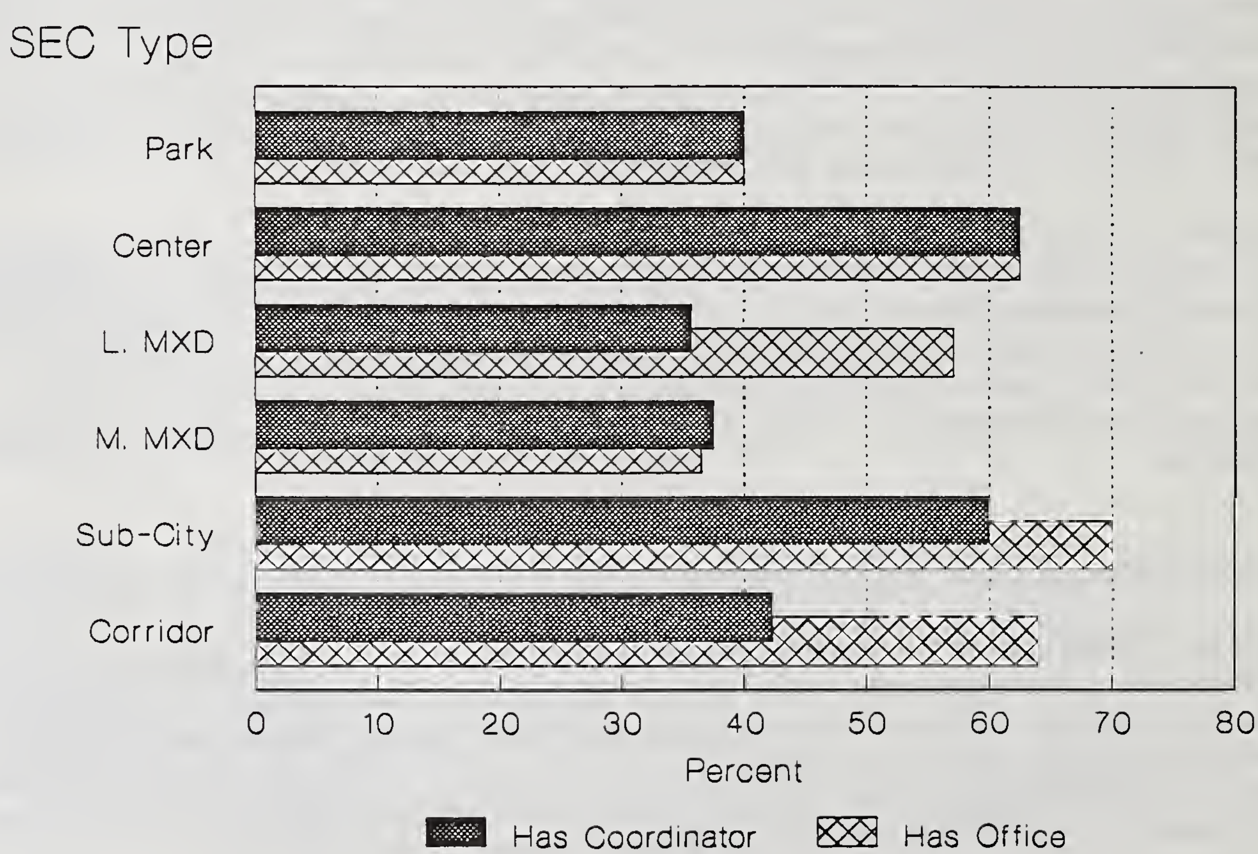


Figure 5.14 **Average Percent of SECs with Rideshare Coordinators and Offices**

Time, Speed, and Distance of Journey-to-Work

Mean travel times and distances for journeys-to-work among SEC groups were found to be fairly comparable.[4] Oneway commutes ranged from a low average travel time of 21.6 minutes for office center workers to a high of 25.9 minutes for sub-city workers. Oneway distances were also fairly similar, ranging from an average of 9.55 miles for sub-city employees to a high of 11.9 miles for office park workers. Because of the relative high variation in travel times and distances within SEC groups, these differences were insignificant from a statistical standpoint, however.

A slightly stronger pattern emerged when average commuting speeds were compared among SEC groups. As shown in the first row of Table 5.5, average commuting speeds were in the range of 29 to 32 m.p.h. for all of the groups except large MXDs (27.4 m.p.h.) and sub-cities (22.9 m.p.h.). Thus, even though sub-city employees reside, on average, closest to work, they tend to commute at comparatively slow speeds.

The most plausible explanation for why sub-city and, to a lesser extent, large-MXD employees commute at slower average speeds is that these centers tend to be relatively dense and consequently more crowded, both inside buildings and out on the street, all things equal. This chapter has already shown that sub-cities average FARs and employees/acre levels that are over 15 percent higher than any other SEC group. Additionally, as discussed previously, both sub-cities and large-MXDs tend to have the least amount of road capacity per employee among the SEC groups. Thus, higher densities and more moderate supplies of road space likely account for, at least in part, these lower average speeds.

Modal Choices for Work Trips

The built environment likely has as much influence on the travel modes workers opt for as any single aspect of commuting. Figure 5.15 compares the average percent of work trips made by the two dominant mode of commuting -- drive-alone auto and ridesharing (carpooling and vanpooling combined).[5] Two things stand out in this figure. One, driving alone is by far the dominant means of commuting among all SEC groups, comprising at least four out of five work trips made to SECs within each group, on the average. Second, the SEC groups which average the lowest levels of solo-commuting are large-MXDs and sub-cities; these groups, by no coincidence, also average the highest shares of vehicle-pooling. In the case of large-scale MXDs, on average, slightly over 15 percent of all journeys-to-work take place in carpools or vanpools.

The comparatively high incidence of ridesharing among large-MXDs and sub-cities seems to confirm several hypotheses set out in this research. One, the SEC groups with the highest densities average the highest share of vehicle-pooling. And second, these two groups also tend to have the greatest variety of land uses, and in particular the most significant retail components. The inference is clear: SECs that are denser and have restaurants, shops, banks, and other consumer services on-site can be expected to enjoy relatively high rates of vehicle-pooling, all other things equal.

For specific non-auto modes (e.g., carpools, vanpools, transit, walking, and cycling), variations in mode splits among SEC classes were generally found to be modest, in part because these individual modes represent such a small share of total trips.[6] The largest group differences were for vanpooling and walking. From Table 5.5, the share of commutes via vanpools is the highest in large-MXDs, followed closely by office parks. As noted above, vanpooling's relative popularity in large-MXDs can be partly attributed to density and retail services. Company support of vanpools in large-MXDs has also likely induced vanpooling. For office parks, supply alone explains much of vanpooling's relatively high market shares. As

Table 5.5

Comparison of Workforce Travel Characteristics and Areawide Traffic Volumes Among SEC Groups

Variable	Means of SEC Groups: Office Park	Office Center	Large MXDs	Moderate MXDs	Sub-City	Large Corridor	F Stat. (prob.)
Work Trip:							
SPEED	29.1	30.6	27.4	32.2	22.9	30.6	1.21 (.317)
VANSHAR	3.4	2.1	3.6	2.0	2.6	1.2	1.16 (.340)
WALKSHAR	0.3	0.5	1.2	0.5	1.4	--	2.01 (.053)
DRIVDIFF	9.1	13.0	6.4	10.9	6.8	--	1.43 (.229)
BUSRIDE	139.4	525.6	1614.3	248.3	3041.1	--	2.89 (.036)
ARIVTIME	8:10	8:10	8:25	8:26	8:05	8:17	1.51 (.205)
DEPRTIME	4:49	4:57	4:58	5:00	5:01	4:55	1.10 (.371)
STAGGER	38.0	26.1	21.3	17.9	21.8	--	1.03 (.411)
Traffic:							
ADT	45.3	70.3	61.5	45.6	113.0	78.2	3.29 (.012)

Variable Definitions:

SPEED = Estimated average travel speed for work trip in m.p.h.
VANSHAR = Percentage of work trips in vanpools.
WALKSHAR = Percentage of work trips by walking.
DRIVDIFF = Drive alone work trip percentage minus regional drive alone percentage.
BUSRIDE = Average weekday ridership of all bus runs serving SEC.
ARIVTIME = Most frequently occurring time of arrival, a.m. peak.
DEPRTIME = Most frequently occurring time of departure, p.m. peak.
STAGGER = Estimated percentage of workforce with staggered work hour privileges.
ADT = Average daily directional traffic volume on main freeway or roadway serving SEC.

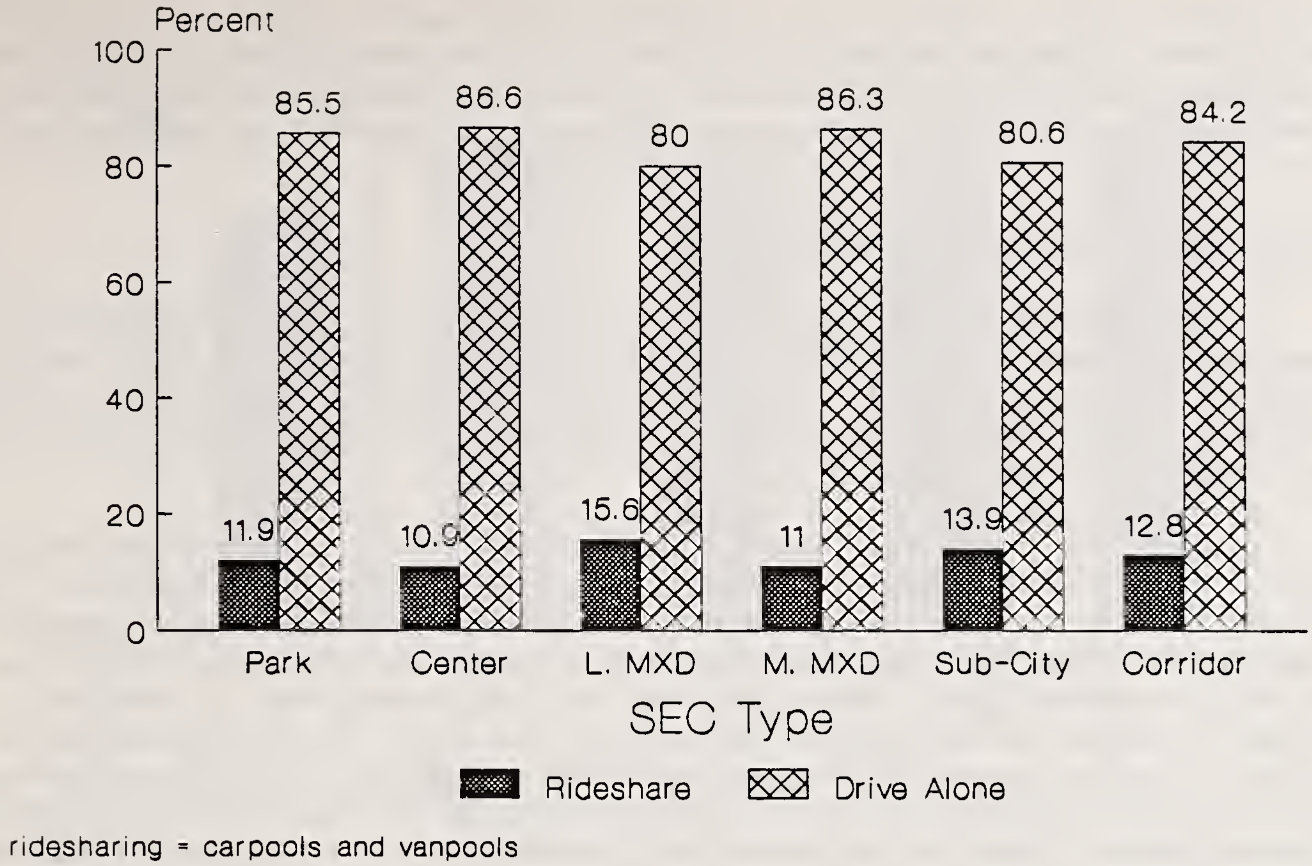


Figure 5.15 Average Percent of Work Trips Made to SECs by Drive Alone Versus Ridesharing

discussed earlier, office parks average more company vans per worker than any other SEC class. For the variable WALKSHAR, the SEC groups with the highest densities and land use mixtures -- large MXDs and sub-cities -- again average the highest shares. The relatively high proportion of walk commutes made to large MXDs is also consistent with the earlier finding that MXDs tend to have the highest shares of multi-family housing nearby. A reasonable inference, then, is that the close proximity of apartments and townhouses has enabled larger shares of MXD workers to reside close by and walk to work.

Of course, mode splits are influenced by far more than the site characteristics of individual SECs. For instance, the quality of regional bus services, along with a host of other contextual factors, could be expected to influence transit modal shares quite a bit. So far, such factors have been treated as constants. One way to account for regional differences in the quality of transit services and other commute alternatives is to enter in a control variable. This is done with the variable DRIVDIFF in Table 5.5. DRIVDIFF is equal to the percent of work trips to an SEC that are drive-alone minus the percent of all work trips in that SEC's region that are drive-alone.[7] Thus, a positive value indicates that a larger share of SEC employees solo-commute than the "typical" workplace in the region. The magnitude of this percentage point difference reflects roughly just how much more SEC workers appear to be auto-dependent than all other workers within the region. Since mode shares for both worker groups are influenced by the quality of regional transit services, the cost of automobile usage, and other factors, these influences are controlled for when differences are taken between the two percentages.

From Table 5.5, office center employees appear to be the most dependent on their automobiles for commuting relative to all other workers in the region. On average, workers in office centers solo-commute 13 percentage points more than employees in other work settings in the region. Employees in large-MXDs and sub-cities, on the other hand, seem to be less heavily dependent on their cars than workers in the other SEC groups. Thus, even when factors such as quality of regional transportation are controlled for, large-MXDs and sub-cities prevail as the SEC environments which are least oriented to solo-driving and, accordingly, most favorable to other commuting options.

Other Worker Commuting Characteristics

Table 5.5 compares group differences for several other indicators of employee travel behavior. Consistent with what has been said so far, the SEC groups with significantly higher ridership levels for bus routes serving their employees (BUSRIDE) are sub-cities and large-MXDs. Thus, these two groups average comparatively high levels of transit usage in both absolute and percentage terms.

Table 5.5 also shows differences in average employee arrival and departure times among groups. Although differences are not statistically significant, several time values are noteworthy. One, the later average arrival times for MXDs reflect their higher shares of retail workers. Many sales personnel do not arrive to work until 9:00 a.m., or later, thus inflating the average figure. Also of note is the fact that the workforces of sub-cities average the earliest arrival times and the latest departure times -- that is, they seem to be putting in more hours per day than their counterparts in other SECs. What these figures most likely reflect, however, is the variety of occupational roles found in sub-cities, which together produce widely disparite arrival and departure times. The presence of stock brokers who punch in early time clocks, for instance, deflates the average arrival time figure for many sub-cities. The relatively high share of, say, restaurant and theater employees during the evening, on the other hand, inflates the average evening departure time for others. Most importantly, it appears that the mixed-use character of sub-cities has served to spread out worker arrival and departure times, thereby reducing the intensity of peaking.

The level of work-hour staggering is revealed by the next-to-last entry in Table 5.5. Office parks appear to have the highest estimated percentage of employees working under staggered arrangements -- around 38 percent. This percentage reflects the high share of clerical and back office employees found in office parks, the majority of whom work in staggered shifts. MXD firms, by comparison, appear to offer their employees fewer staggered work opportunities.

Areawide Traffic Conditions

The final set of comparisons made among SEC groups looked at differences in areawide traffic volumes and conditions. The last entry in Table 5.5 reveals a significant difference in average daily traffic (ADT) volumes in the vicinity of sub-cities relative to average ADTs for other SEC groups. Sub-cities average well over 100,000 daily vehicle trips per direction on the main freeway or arterial serving them. Major roadways serving office parks and moderate-size MXDs, by comparison, average less than half this volume. Large growth corridors average the second highest directional traffic volumes along their primary road axis, however these volumes are still only around two-thirds of the daily counts found on freeways serving sub-cities.

Traffic conditions are best reflected, of course, when vehicle volumes are indexed to road capacity. Average peak-period volume-to-capacity ratios for the major surface arterials and major freeways serving SECs are compared among the five non-corridor groups in Figure 5.16.[8] Along both surface streets and freeways, peak traffic conditions are generally the worst around sub-cities. On average, peak traffic volumes on the primary freeway serving sub-cities are 89 percent of capacity, whereas the major connecting arterial operates at

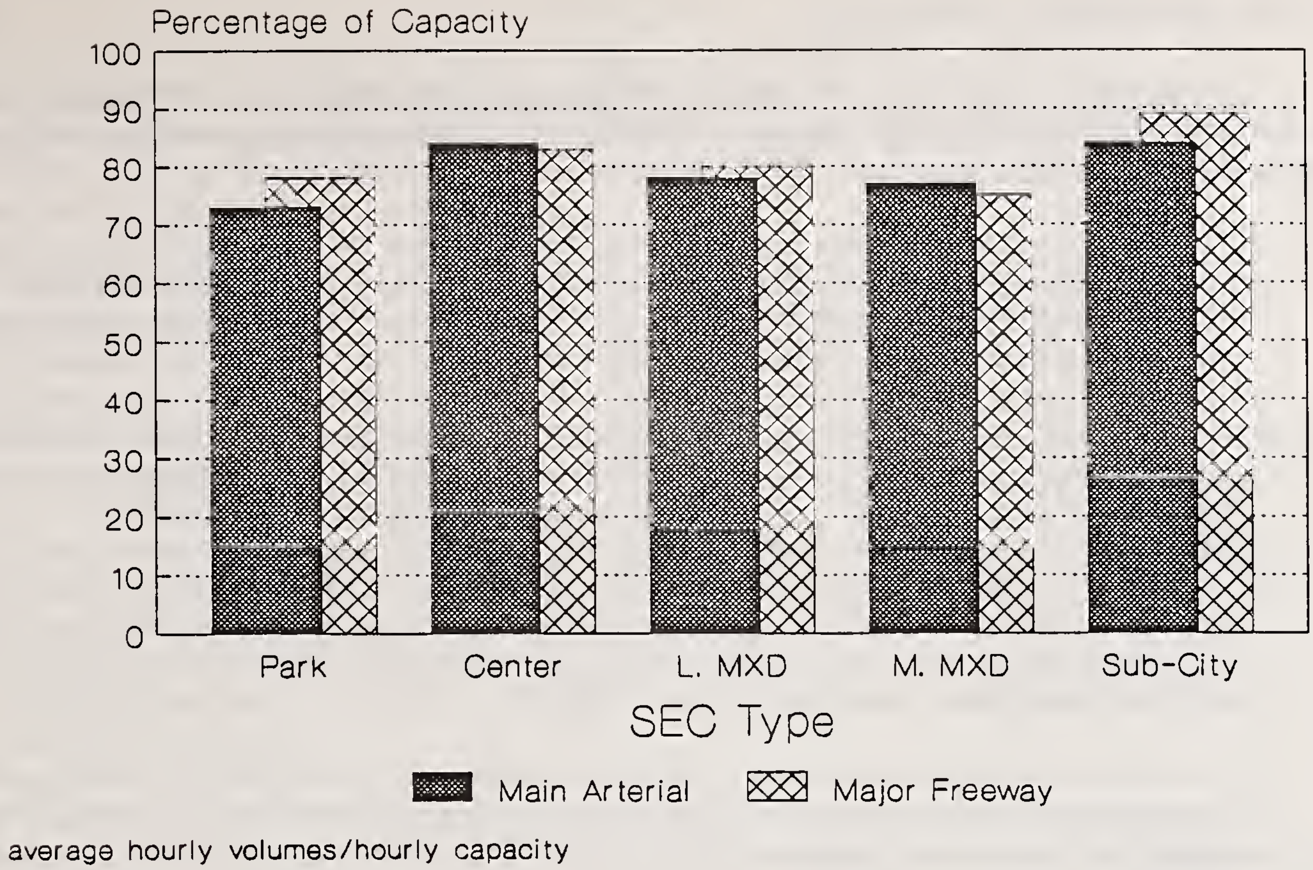


Figure 5.16 Average Traffic Volumes as Percent of Capacity on Main Roadways Serving SECs

around 83 percent of capacity. The next most congested SEC setting appears to be office centers, wherein nearby freeways and arterials operate, on average, at around 82 percent of capacity. Thoroughfares serving large-MXDs are generally the third most congested. Office parks, on the other hand, average the least congestion on adjoining surface streets while moderate-size MXDs tend to have the least congested adjoining freeways. For both groups, the primary connecting roadways tend to operate at level of service C during the peak -- that is, volumes remain under 80 percent of capacity, with relatively stable flow conditions.

The common feature of the SEC groups with the most congested traffic conditions is their relatively high employment densities. In SEC settings, then, density appears to be a double-edge sword: while it works in favor of ridesharing and other commute alternatives, it at the same time generate traffic volumes that frequently saturate local thoroughfares. The decision of local policy-makers to restrict densities in some SECs reflects the preference given to accommodating the automobile over the encouragement of ridesharing or transit commuting. In many cases, this is likely a rational choice since the marginal gains in vehicle-pooling produced by densities are insufficient to make up for the higher levels of nodal congestion. Density, however, must be viewed within a time context. Although denser working environments may increase congestion in the near term, in the long run, density may provide sufficient concentrations of activities to make ridesharing and mass transit viable alternatives to solo-commuting. A general tenet of density in suburban work settings might be: short-term pain is necessary for long-term gain.

5.7 Summary Policy Inferences

This chapter's comparison of land use and transportation differences among SEC groups yielded serveral valuable policy insights. Invoking the ceteris paribus assumption, the following can be said:

* The share of commute trips made in some manner other than driving alone increases as a SEC becomes denser and gains a wider variety of land uses. Large-MXDs and sub-cities average the highest share of non-solo commuting. This is so even when the quality of transportation services and other contextual variables are controlled for.

* The incidence of ridesharing is the highest in both sub-cities and MXDs, multi-use settings with substantial retail components. The availability of commercial activities appears to induce a number of employees to carpool and vanpool to work.

* The share of work trips made by foot is the highest at MXDs, the SEC groups with the highest proportion of multi-family housing units within a three mile radius. This suggests that the availability of moderate-priced housing could be inducing some employees to reside nearby and walk to work.

* Sub-cities appear to have the least degree of peaking of commute trips. This is most likely due to the ability of varied land uses to shift higher shares of commute trips toward the shoulders of the peak and to encourage a more even temporal distribution of travel.

* SECs with the slowest average speeds for employee commutes and the most congested local streets and freeways are sub-cities and large-MXDs, the two groups with the highest employment densities.

Based on these findings, the three major site variables which appear to influence employee travel behavior and local traffic conditions around SECs the most are density, scale, and land use mixtures. The SEC groups with the highest densities have the highest incidence of ridesharing and transit usage as well as the most congested local traffic conditions. Thus, dense suburban work areas offer both pluses and minuses. In the near term, the minuses of density are likely to outweigh the pluses for many suburban work settings; in the long run, however, density may make other commute alternatives attractive enough so as to reduce overall congestion levels. Additionally, ridesharing tends to be most prevalent in large SECs, suggesting that a critical mass of employees might be necessary for its success. Lastly, those SECs with the greatest variety of land uses likewise experience the highest shares of non-solo commutes, including walks trips. In tandem, then, density, size, and mixed-development emerge as necessary, though probably not sufficient, prerequisites if reasonably significant levels of ridesharing, transit usage, cycling, and foot travel are to be achieved.

It bears repeating that these inferences are based on comparing differences among SEC groups and fleshing out patterns that emerge. How variables such as density, size, and land use mixes influence travel choices and traffic conditions directly are tested in the chapter which follows.

Notes

1. For some of the variables, the "large corridor" group is not included in this analysis, reducing the number of groups to five. And in some instances, the "office park" and "office concentration" groups are combined, as are the "large MXD" and "moderate-size MXD" groups, distilling the analysis down to three groups.

2. For a discussion of this general industry rule to overbuild parking, see Lenny [1984] and O'Mara and Casazza [1982].

3. Recall that this is the average of the most frequent rate. For some centers, parking was entirely free while for others the most frequent rate was, say, over $3 per day. The average of these most frequent rates tended to result in a figure somewhere in between these extremes. In general, the average of the most frequent rate is not representative of the specific rates charged, but does provide an accurate gauge of the relative differences among groups.

4. The figures in this subsection, it should be recalled, are "averages of averages" -- that is, they are averaged across cases within each SEC group based on the average statistics for employees within each SEC.

5. The summary statistics for variation across groups were: drive-alone (F statistic = 1.78; probability = .163) and ridesharing (F statistic = .708; probability = .620). Thus neither mode registered statistically significant variation across groups, although drive-alone percentages do seem to be moderately influenced by SEC type.

6. Differences in transit modal shares were quite small across groups (F statistic = 0.682; probability .649). The same was so for carpooling. Consistent with expectations, the two SEC groups with the highest transit shares and carpool shares are sub-cities and large-scale MXDs. Large corridors average the highest shares of "other" modes (e.g., drop-off).

7. Regional drive-alone percentages are for 1980 and were obtained from Rodriquez, et al. [1985].

8. These were estimated by computing the "average" level of service within each group, wherein a level of service A was assigned a value of 1, B was assigned a value of 2, C was assigned a value of 3, and so forth. The average level of service of 3.30 for main arterials serving office parks, for instance, was translated as 73 percent of capacity since it was 3 percentage points above the floor for level of service C (70 percent of capacity) and 7 percentage points below the floor for level of service D (80 percent of capacity).

CHAPTER SIX

Land Use and Work Site Factors Influencing Commuting Choices in SECs

6.1 Introduction

How the land use and site characteristics of SECs directly influence the commute choices of SEC employees and local traffic conditions are studied in this chapter. While the previous chapter focussed on variations in different work site and travel variables among SEC groups, this one concentrates specifically on land use-transportation relationships within SECs.

The primary purpose of this chapter is to empirically test the hypotheses posited in the first chapter of the report. The basic hypothesis, again, is that the low-density, single-use, and non-integrated character of SECs, combined with their tendency to provide plentiful, free parking, have compelled many workers to rely upon their automobiles for accessing work and circulating within projects. Thus, the primary dependent variable used in the analysis is the percent of work trips made by solo-commuters. Various density, land use mixture, and site design variables are entered into the analyses to evaluate the hypothesis. In addition to modeling mode choice decisions, this chapter tests how land use and site characteristics appear to influence local traffic conditions, measured in terms of average commute speeds and levels of service on connecting facilities.

While the thrust of the analysis is on land use-transportation interactions, several other relationships are studied as well. For one, site factors most related to high parking standards are probed. Additionally, variables which seem to be associated with high jobs-housing imbalances, both on-site and nearby, are identified. Land ownership patterns are also modeled to investigate what site environments seem to be most related to multiple property holdings.

In studying all of these relationships, the technique of stepwise regression analysis was employed. Here, the emphasis is placed on uncovering those combinations of variables which best account for variation in the dependent variable. In stepwise analysis, each variable which enters the equation adds something new, providing some information about the dependent variable that none of the other variables offer. Because of the high inter-correlation among various land use and site variables gathered for this study, the stepwise approach was considered to be most appropriate. If a number of closely correlated land use and site design variables were forced into the equation, the models would have broken down due to multicollinearity problems. Thus, although stepwise results do not provide insight into the influences of all variables of interest, they do offer a foundation for understanding the unique influences of those few variables that do enter into the analysis.[1]

One of the shortcomings of modeling land use and transportation relationships for areas (like SECs) rather than for people is that aggregation biases invariably occur. It is individuals, not SECs, who make choices on how, when, and where to travel. Just because the "average" parking fee is not related to the "average" rate of solo-commuting among SECs does not necessarily mean that parking costs have no influence on whether individuals will drive alone to work. By aggregating data, some of the richness in choice decisions is unavoidably lost. With this in mind, this chapter also presents a sub-analysis of how various work site characteristics are related to modal choices and time periods of travel of employees from the suburban community of Pleasanton, California. The intent here is to enrich the more aggregate-level study by providing a finer-grain perspective on the influence of work site characteristics on commute choices in a particular suburb.

Following these analyses, the chapter concludes with a summary overview of the results of the empirical tests. Our general state of knowledge on land use-transportation in suburban employment settings is discussed.

6.2 Factors Influencing Mode Choices in SECs

Land uses and design practices are thought to influence the modal choices of suburban workers as much as any one aspect of commuting. This section presents the stepwise regression findings of those variables that do the best job at explaining drive-alone, ride-sharing, and walking-cycling choices.

Drive-Alone Models

Table 6.1 summarizes the stepwise results for the dependent variable DRIVALON -- percentage of work trips by drive-alone mode. For the 46 SEC cases with complete data,[2] a model with reasonably good predictive powers was obtained, explaining over 43 percent of the variation in DRIVALON. Three "supply-side" variables and one "land use" explanatory variable entered the stepwise equation. On the supply-side, the model indicates that the share of work trips to SECs by solo-commuters declines as the number of vans in operation (VANSRUN) increases and the relative number of site access points decreases (i.e., EMP/INTC rises),[3] all else equal. The equation also suggests that, ceteris paribus, drive-alone shares fall around 3.4 percent if there is a designated rideshare coordinator at the SEC (RIDECOOR).[4] Promotion and support of vanpools and carpools, then, seems to be paying off in SECs. According to the model, an SEC with twenty vans in operation and a rideshare coordinator could be expected to reduce the share of work trips made by solo-commuters by about 5 percent over an SEC with no vanpools or coordinator position.

The sole land use variable that entered the stepwise equation was OFFICE -- the percent of floorspace in office use. Based on the sign on the variable OFFICE, as SECs become more office-oriented, the share of solo-commute trips can be expected to rise. All else equal, an SEC with a share of total floorspace in office use that is 20 percent higher than another SEC can be expected to have a 2.4 percent higher share of work trips made by solo-commuters. This finding, then, clearly supports the hypothesis that single-use office environments induce vehicle commuting. By inference, then, mixed-use work environments will reduce auto-dependency and encourage workers to seek out other commute options.

As was discussed in the previous chapter, the analysis of site factors that influence solo-commuting generally ignores the affects of larger regional influences (e.g., the quality of the regional bus system) on mode splits. These regional factors can be controlled for by taking the difference in drive-alone shares for an SEC and drive-alone shares for an entire region. The variable which measures these differences, DRIVDIFF, was modeled, and the stepwise results are shown in Table 6.2. The results are fairly similar to those of the previous model, except two land use variables, and only one supply-side variable, entered this model. A reasonably good fit of the data was obtained and all of the variables that entered the model have coefficients which match a priori expectations.

The table shows, as before, that the introduction of a modal competitor, namely vanpools, decreases the dominance of the private automobile in SECs.[5] Every twenty vans reduces the share of trips made to an SEC by solo-commuters by about two percent over the share for a typical workplace in the region. And as before, office environments seem to increase the relative dependency of SEC workers on their automobiles (i.e., relative to the "typical" worker in the region). The additional land use variable that has entered this second model gauges

Table 6.1

Stepwise Regression Results on
Factors Influencing Percentage of Work Trips by Drive-Alone Mode

Dependent Variable: DRIVALON

Variable	Beta Coefficient	Standard Error	t Statistic	Probability
OFFICE	0.12073	0.04973	2.428	.0200
VANSRUN	-0.09058	0.02762	-3.279	.0022
EMP/INTC	-0.00053	0.00019	-2.713	.0100
RIDECOOR	-3.36511	2.32610	-1.446	.1562
Intercept	82.24903	3.70500	22.200	.0000

Summary Statistics:

Number of observations = 46
R-Squared = .436
F Statistic = 7.345
Probability = .0002

Variable Definitions:

DRIVALON = Percentage of work trips by drive-alone mode.
OFFICE = Percentage of total floorspace in office use.
VANSRUN = Number of company vans in daily operation.
EMP/INTC = Employees per freeway interchange within a five mile radius.
RIDECOOR = Rideshare coordinator in SEC: 1 = yes, 0 = no.

Table 6.2

Stepwise Regression Results on Factors Influencing SEC Drive-Alone Commuting Relative to Regional Average

Dependent Variable: DRIVDIFF

Variable	Beta Coefficient	Standard Error	t Statistic	Probability
OFFICE	0.13623	0.05803	2.347	.0255
RSFT/EMP	-0.00969	0.00427	-2.269	.0304
VANSRUN	-0.09665	0.03141	-3.077	.0043
Intercept	0.09738	0.03897	0.028	.9402

Summary Statistics:

Number of observations = 37
R-Squared = .373
F Statistic = 6.145
Probability = .0021

Variable Definitions:

DRIVDIFF = Drive alone work trip percentage minus regional drive alone percentage.
OFFICE = Percentage of total floorspace in office use.
RSFT/EMP = Retail square footage within 3 mile radius of SEC per on-site employee.
VANSRUN = Number of company vans in daily operation.

the relative amount of retail space nearby (RSFT/EMP). The negative sign for this variable suggests that the relative automobile dependency of SEC workers declines as the amount of retail space per employee in reasonable proximity to the SEC increases. As an indicator of land use diversity, it is clear that nearby retail and other mixed-use offerings encourage workers to choose other commuting options.

In sum, the primary site factor which seems to influence how dominant solo-commuting will be in an SEC setting is land use composition. Specifically, the share of space in office use and the relative availability of nearby retail activities appear to have a significant affect on the share work trips that are driven alone. Other work site variables, such as density, size, and lotting practices, did not enter either equation. This does not necessarily mean that these factors are irrelevant, but rather that land use composition appears to a particularly influential factor. Despite the relatively high explanatory powers of these models, however, land use, in and of itself, did not emerge as a tremendously strong predictor of mode choice. For instance, an SEC with 20 percent of floorspace devoted to office use could be expected to average only around a six percent smaller share of work trips made by solo-commuting than an SEC with 70 percent office space that was otherwise identical. Thus, land use mixing only seems to yield marginal dividends in reducing solo-commuting. Combined with other initiatives, however, this could mean the difference between gridlock and circulation in some settings. Overall, more varied land uses appear to offer a reasonably good potential for reducing auto-dependency in SEC settings.

Rideshare Model

Solo-commuting constitutes over 80 percent of all work trips made to the overwhelming majority of SECs studied. The only serious competitor in most instances is vehicle-pooling, whether by private automobile or van. Table 6.3 presents the best model obtained for predicting RIDESHAR -- the percent of work trips by vanpool or carpool. The model, which explained one-half of the total variation in RIDESHAR, offers a slightly different perspective on the mode choices of SEC workers from the two prior ones.

The two supply-side variables that entered the equation reinforce what was learned from the prior models. The share of work trips by vanpools or carpools rises as more vans are sponsored by companies and the relative number of access points to the site falls (i.e., EMP/INTC rises). Both variables are statistically significant at the .05 probability level.

The variable OFFICE further confirms the importance of land use mixing on commute choices. The equation suggests that as office uses become more dominant, ridesharing can be expected to slip in its share of the commuting market. It follows that unless other activities take place at a site -- most importantly, consumer services such as restaurants and banks -- then SEC employees will be less inclined to share rides.

The inclusion of the other land use variable in Table 6.3 poses as interesting paradox, of sorts. The variable J/HAREA suggests that when there is a relative shortage of nearby housing, employees are more likely to live farther away and vehicle-pool. By extension, when housing is more plentiful nearby, relatively fewer commutes will be made in carpools or vanpools. Thus, jobs-housing balances tend to work against carpooling and vanpooling. For short distances, ridesharing is unattractive because the time spent picking up other passengers en route is generally viewed as excessive. Thus, balancing jobs and housing can not be expected to necessarily reduce solo-commuting. It might even encourage some to drive to work. The difference is, however, that more commuters in a balanced environment would be driving short distances on mainly local streets rather than mixing with through traffic on freeways. The other primary benefit of jobs-housing balances, of course, is that some

Table 6.3

Stepwise Regression Results on Factors Influencing Percentage of Work Trips by Rideshare Modes

Dependent Variable: RIDESHAR

Variable	Beta Coefficient	Standard Error	t Statistic	Probability
VANSRUN	0.15264	0.03618	4.218	.0002
EMP/INTC	0.00044	0.00017	2.582	.0151
J/HAREA	0.08632	0.04566	1.850	.0804
OFFICE	-0.05686	0.03477	1.635	.1089
Intercept	11.10422	2.96415	3.746	.0008

Summary Statistics:

Number of observations = 35
R-Squared = .499
F Statistic = 7.226
Probability = .0004

Variable Definitions:

RIDESHAR	= Percentage of work trips by vanpool or carpool.
VANSRUN	= Number of company vans in daily operation.
EMP/INTC	= Employees per freeway interchange within a five mile radius.
J/HAREA	= Ratio of on-site employees to estimated housing units within a three mile radius of SEC.
OFFICE	= Percentage of total floorspace in office use.

employees would be more inclined to walk or cycle to work. The next subsection explores whether this has been the case.

Walking-Cycling Models

The difficulty in studying the influence of job-housing levels on the incidence of walking and cycling trips is that the majority of SEC cases have no on-site units. Thus, the inclusion of the variable measuring on-site jobs indexed to on-site housing units would eliminate many cases from the analysis. Accordingly, two separate models were produced for estimating the shares of trips by walking and cycling modes -- one without the jobs-housing variable and the other with it.

The first model is shown in Table 6.4. It fits the data fairly closely, explaining about two-thirds of the variation in the dependent variable WALKBIKE. The supply-side variable that entered the first equation reflected the level of vanpool service (EMP/VAN). The sign on EMP/VAN's coefficient suggests that where there are few vans relative to the number of employees, the share of commutes made by foot or via bicycle increases, all things equal. This probably reflects less the fact that walking can serve as a substitute for vanpooling and more the fact that more balanced, mixed-use settings tend to have high shares of walking and relatively low shares of vanpooling. One can surmise, then, that factors like jobs-housing balance and land use mixtures are intervening influences on the relationship between walking and vanpooling.

The two land use variables that entered the model shown in Table 6.4 are RETAIL and EMPLOYMT, tapping the "compositional" and "size" dimensions of SEC sites. Importantly, the equation suggests that walking and cycling trips are more likely to occur as the share of floorspace devoted to retail activities increases. The availability of on-site retail activities, one can infer, allows workers to take care of personal business and other chores by foot, freeing them of the need to have an automobile available. The equation further suggests that as the employment base of an SEC increases, walking and cycling likewise tend to increase.

The second model sought to explore the direct influence of jobs-housing balances on the variable WALKBIKE. The resulting equation, which is summarized in Table 6.5, was based on 18 fewer cases since a number of SECs had missing values for JOB/HOUS. As in the first model, both EMP/VAN and RETAIL entered this model of reduced cases, suggesting that these variables are fairly robust.[6] The sign on JOB/HOUS is consistent with expectations. In general, where there are many more jobs than on-site housing units, the share of commutes made by foot or bicycle falls. Although the relationship is not very strong, the equation does suggest that one of the marginal benefits of jobs-housing balancing is to invite more foot travel.

Summary of Mode Choice Models

Overall, the models presented in this section seem to confirm the hypotheses posited regarding the affects of mixed-use environments.[7] Single-use office settings seem to induce solo-commuting, whereas work enviroments that are more varied, both on-site and nearby, generally encourage more ridesharing, walking, and cycling. Particularly important to ridesharing is the availability of consumer retail services. While the synchronization of job and housing growth in an SEC setting could be expected to encourage more foot and bicycle travel, at the same time, ridesharing and vehicle occupancy levels could be expected to fall off some. The benefits of jobs-housing balancing, therefore, relate more to the shortening of vehicular trips and the easing of local-through traffic conflicts than to inducing people to walk or cycle to work.

Table 6.4

Stepwise Regression Results on Factors Influencing Percentage of Work Trips by Walking and Cycling Modes

Model One

Dependent Variable: WALKBIKE

Variable	Beta Coefficient	Standard Error	t Statistic	Probability
EMP/VAN	0.00009	0.00002	5.323	.0000
RETAIL	0.05861	0.02363	2.480	.0190
EMPLOYMT	0.00529	0.00303	1.746	.0910
Intercept	-0.01309	0.04455	-0.029	.9768

Summary Statistics:

Number of observations = 36
R-Squared = .663
F Statistic = 19.727
Probability = .0000

Variable Definitions:

WALKBIKE = Percentage of work trips by walking or cycling.
EMP/VAN = Employees per on-site company sponsored van in operation.
RETAIL = Percentage of total floorspace in retail use.
EMPLOYMT = Size of full-time work force, in thousands.

Table 6.5

Stepwise Regression Results of Factors Influencing Percentage of Work Trips by Walking and Cycling Modes

Model Two

Dependent Variable: WALKBIKE

Variable	Beta Coefficient	Standard Error	t Statistic	Probability
EMP/VAN	0.00011	0.00003	4.507	.0009
JOB/HOUS	-0.01757	0.00963	-1.825	.0885
RETAIL	0.05486	0.02739	2.007	.0622
Intercept	0.70761	0.78366	0.903	.3859

Summary Statistics:

Number of observations = 18
R-Squared = .693
F Statistic = 8.271
Probability = .0037

Variable Definitions:

WALKBIKE = Percentage of work trips by walking or cycling.
EMP/VAN = Employees per on-site company sponsored van in operation.
JOB/HOUS = Employees per on-site housing unit.
RETAIL = Percentage of total floorspace in retail use.

6.3 Factors Influencing Traffic Conditions Around SECs

This section examines the affects of site variables on average commuting speeds, travel times, and levels of service on principal thoroughfares serving SECs. Since so many other off-site factors affect local traffic conditions, the estimated models rest heavily on ceteris paribus assumptions. Thus, the analyses presented below examine the joint affects of density, scale, and workforce composition on traffic conditions, with all other influences held constant.

Commuting Speed Model

Table 6.6 summarizes the best fitting model for explaining average commuting speeds to SECs based on available data. All of the variables that entered the stepwise model seem logical and the overall model has reasonably good predictive abilities, as suggested by the R-squared statistic of .53.

The variable which reflects the relative level of highway capacity is EMP/FWYM. All else equal, the more employees per mile of freeway within a five mile radius of the SEC, the slower workers generally travel to work. Thus, employees working at large office complexes served by a single freeway can generally expect to commute at slower average speeds than a contemporary who works in a small development served by two freeways.

The two work site variables that entered this equation are JOB/HOUS and EMP/ACRE. Those who work in settings with far more jobs than on-site housing units and large numbers of workers per acre can generally expect to commute at relatively slow average speeds. For the typical SEC with a jobs-housing ratio of 30, workers generally could be expected to commute at speeds 2.6 m.p.h. below workers in new towns with roughly comparable numbers of jobs and housing units. The relationship between jobs-housing levels and commuting speeds, of course, is an indirect one. Most likely, SECs with high ratios of jobs-to-housing have other characteristics which influence commuting speeds, such as higher densities and single-use characters that increase the relative auto-dependency of workers. The inverse relationship between SPEED and EMP/ACRE does suggest that high employment densities are associated with slower average travel speeds.

Travel Time Model

The best-fitting model developed for explaining average commute times of SEC employees demonstrates fairly modest predictive abilities. From Table 6.7, only two variables entered the model. EMP/FWYM again reflects the relative supply of nearby freeway capacity. In general, where there are comparatively few directional miles of freeway per SEC employee, travel times increase. The other variable that entered, EMPENT, reflects the degree of job diversification at the work site. Those working in SECs with the greatest variety of jobs among administrative, technical, and clerical positions seem to enjoy shorter average commutes. Of course, the relationship here is an associative one rather than a direct causal one. Since EMPENT was found to be slightly negatively correlated with average commuting distances, one can infer that the shorter commute times for more varied workforce settings is due, in part, to the fact that employees of these places tend to reside closer to their jobs.

Level of Service Models

Of course, the two factors that directly account for level of service are the volume of traffic and the amount of roadspace. In this analysis, the intent was less of building a predictive model and more of identifying what set of site variables were most closely associated with levels of service. Since level of service is a qualitative concept, using a regression framework to account for variations in service quality can be problematic.

Table 6.6

Stepwise Regression Results of Factors Influencing Average Commuting Speeds

Dependent Variable: SPEED

Variable	Beta Coefficient	Standard Error	t Statistic	Probability
EMP/FWYM	-0.00059	0.00032	-1.852	.0789
JOB/HOUS	-0.09093	0.04079	-2.229	.0374
EMP/ACRE	-0.10190	0.05178	-1.968	.0631
Intercept	37.22287	2.31963	16.047	.0000

Summary Statistics:

Number of observations = 26
R-Squared = .532
F Statistic = 7.555
Probability = .0014

Variable Definitions:

SPEED	= Average travel speed for journey-to-work trip (m.p.h.). See footnote 2 of Table 3.6 for further definition.
EMP/FWYM	= Employees per directional mile of freeways within five miles of SEC.
JOB/HOUS	= Employees per on-site housing unit.
EMP/ACRE	= Employees per acre.

Table 67

Stepwise Regression Results of Factors Related to Average Journey-to-Work Travel Time

Dependent Variable: TIME

Variable	Beta Coefficient	Standard Error	t Statistic	Probability
EMPENT	-74.97186	22.08247	-3.395	.0016
EMP/FWYM	0.00047	0.00021	2.188	.0349
Intercept	63.22291	12.13402	5.210	.0000

Summary Statistics:

Number of observations = 44
R-Squared = .305
F Statistic = 8.337
Probability = .0010

Variable Definitions:

TIME = Average one-way travel time for journey-to-work, in minutes.

EMPENT = Employment entropy index, computed as: $\Sigma\, p_i * (\log_{10} p_i)$, where p_i is the proportion of employees in job classification i. In this analysis, five job classifications were used: management; administrative; technical; clerical; and all others. The minimum value for this index is zero, signifying all jobs are within one category. The maximum value is $\log_{10}$ (K), where K is the number of categories which in this case is 5, which thus equals 0.699. This signifies maximum heterogeneity, which means an equal spread of jobs among all groups. Thus, this index is used to reflect the relative degree of job variation across employment classifications for each SEC. See chapter Four, section 4.2, for a further discussion of the entropy index.

EMP/FWYM = Employees per directional mile of freeways within five miles of SEC.

Specifically, least squares estimation rests on the assumption that the dependent variable is continuous and that the unknown sources of variation (represented by the error term) are normally distributed. Since cases were assigned values of 1 for level of service A, 2 for B, 3 for C, and so on, the dependent variable that was used was ordinal, meaning that the normality assumption of least squares estimation was violated. Regression analysis, however, can still provide useful insights into factors affecting ordinal variables like level of service, and generally provides reasonably reliable estimates when there are five or more discrete ordinal values, such as in this case [Blalock, 1979]. As long as the goodness-of-fit statistics are interpretted with caution, models estimated for ordinal-scale dependent variables can prove informative.

Table 6.8 summarizes the stepwise equation estimated for the variable FWYLOS -- level of service on the primary freeways serving SECs. Three work site variables entered the model. In interpretting these variables, it should be kept in mind that high values of FWYLOS denote congested service quality (i.e., levels of service D, E, and F). Thus, major connecting freeways tend to be most congested around SECs with large amounts of office-commercial floorspace, high employment densities, and large jobs-housing imbalances. Thus, size, density, and land use composition seem to be working in tandem to influence levels of service on nearby freeways. All things equal, SECs that are big, dense, and housing-free in character tend to have worst nearby freeway conditions.

Site factors associated with level of service on major arterials serving SECs were found to be only slightly different. From Table 6.9, it is seen that surface arterials tend to be most congested around large, dense suburban work settings as well. Take, for instance, an SEC with one million square feet of non-residential floorspace, a FAR of one, and a peak hour level of service of C on its main connecting arterial. Based on the coefficients in Table 6.9, if that same SEC were to double in size and if the FAR was to catapult from one to five, then, all else equal, peak hour level of service could be expected to fall one notch to D. The workforce variable in Table 6.9 that was found to be most associated with roadway level of service was PROFSHAR -- the percentage of employees in professional positions. Where this percentage is high, traffic on surface streets tends to flow more smoothly. The most logical explanation for this is that, although professional workers tend to be heavily auto-reliant, they also tend to enjoy more flex-time privileges, giving rise to a more even temporal distribution of trip-making during morning and evening hours. This point is confirmed in the Pleasanton analysis in section 6.7.

<u>Summary of Models on Traffic Conditions</u>

The analysis in this section was able to demonstrate that several site characteristics are closely related to local traffic conditions. Denser and large-scale SEC settings tend to have more congested nearby thoroughfares and relatively slow employee commutes. Where jobs far exceed housing, average commute speeds also tend to be slower and connecting freeways are more likely to be jammed. Where there is a closer match-up between jobs and housing, on the other hand, freeways tend to flow better, possibly because the conflict between through and local traffic is reduced.

While land use composition emerged as the key site factor influencing mode choices of SEC workers, density appears to exert the most influence on local traffic conditions. In many ways, density performs a multiple role. By inducing congestion, it encourages people to find alternatives to driving to work. At the same time, higher densities enable alternative modes, like bus transit, to operate more efficiently and successfully compete with the private automobile. The transfer of trips from automobile to buses and vans in turns helps to free up road space and perhaps induce latent travel. To the extent that alternatives to the automobile are available, then, the congestion-producing affects of high density SECs may only

Table 6.8

Stepwise Regression Results on Factors Related to Level of Service on Main Freeways Serving SECs

Dependent Variable: FWYLOS

Variable	Beta Coefficient	Standard Error	t Statistic	Probability
FLOORSPC	0.03638	.01301	2.796	.0072
EMP/ACRE	0.01792	.00694	2.581	.0127
JOB/HOUS	0.01279	.00713	1.794	.0872
Intercept	3.36931	.25909	13.005	.0000

Summary Statistics:

Number of observations = 26
R-Squared = .335
F-Statistic = 6.492
Probability = .0030

Variable Definitions:

FWYLOS = Numeric index of peak period level of service on primary freeway serving SEC, wherein ordinal values are assigned to level of service as follows: A = 1; B = 2; C = 3; D = 4; E = 5; F = 6. Thus, a low value represents a high, or free flow, level of service. A high value for FWYLOS, on the other hand, represents a low, or forced flow, level of service. See Chapter Three, section 3.7 for further discussion on level of service.
EMP/ACRE = Employees per acre.
JOB/HOUS = Employees per on-site housing unit.

Table 6.9

Stepwise Regression Results on Factors
Related to Level of Service on Main Surface Arterials Serving SECs

Dependent Variable: RWYLOS

Variable	Beta Coefficient	Standard Error	t Statistic	Probability
FAR	0.2320	.0938	2.475	.0166
PROFSHAR	-0.02189	.0083	-2.619	.0115
FLOORSPC	0.0291	.0105	2.772	.0077
Intercept	4.3448	.4384	9.911	.0000

Summary Statistics:

Number of observations = 57
R-Squared = .272
F Statistic = 6.377
Probability = .0009

Variable Definitions:

RWYLOS	= Numeric index of peak period level of service on primary surface roadway serving SEC, wherein ordinal values are assigned to level of service as follows: A = 1; B = 2; C = 3; D = 4; E = 5; F = 6. Thus, a low value represents a high, or free flow, level of service. A high value for RWYLOS, on the other hand, represents a low, or forced flow, level of service. See Chapter Three, section 3.7 for further discussion on level of service.
FAR	= Floor area ratio, equals to total square footage of floorspace divided by total square footage of land in SEC.
PROFSHAR	= Percentage of workforce in management, administrative, or technical job classifications.
FLOORSPC	= Total commercial-office-industrial floorspace, in millions of square feet.

be transitional. In the long term, higher density work environs could be expected to lure enough employees to buses and vans so as to keep congestion conditions below what they would have been if workers had remained highly auto-dependent.

6.4 Factors Related to Parking Standards at SECs

This section investigates those site factors that appear to be most closely associated with high levels of parking at SECs. Table 6.10 presents the best-fitting stepwise model developed for the dependent variable PARK/EMP -- average parking spaces per employee in an SEC. Several different dimensions are reflected in this model. One, parking rates are generally the highest in SECs with proportionally high shares of retail use. Many parking spaces for retail establishments, however, are designed for customers rather than employees, so average parking rates become inflated. The equation also indicates that parking per employee generally decreases as daily parking fees rise. Prices, then, appear to ration parking demand, reducing the number of spaces offered. Finally, the size of the labor force also interacts negatively with rates of parking supply -- SECs with the largest employment bases tend to have the fewest number of parking stalls per worker.

When parking standards are examined on a per square foot basis, several other variables enter into the best-fitting equation. Table 6.11 shows that besides retail percentages and employment size, parking rates per 1,000 square feet are influenced by density and regional location as well. The model suggests that parking rates tend to be lower in denser, closer-in SECs. This most likely reflects influences of higher land values in higher-density, more central suburbs, prompting developers to cut back some on their parking supplies. According to the model, a suburban office building with a floor area ratio of 3.5 could be expected to have one less parking stall per 1,000 square feet of space than an otherwise comparable building with an FAR of 1.0. Where parking seems to be most overbuilt, then, is at low density SECs situated some distance from downtown, which seems to describe campus-style business parks in most regions of the country.

The relationship between parking supply and the independent variables FAR and RETAIL are further revealed in Figures 6.1 and 6.2. The first figure shows the slight inverse relationship between parking per 1,000 square feet and FAR among all cases. Within SEC groups, however, slightly different patterns emerge. The strongest inverse relationship between parking supply and density is for MXDs. The lower parking supplies of denser MXDs likely reflect the tendency of businesses and shopkeepers in these areas to share parking facilities, particularly in the face of higher land prices. A far weaker pattern exists for sub-cities. Most sub-cities appear to provide facilities at the level of 3 to 4 spaces per 1,000 square feet, regardless of density levels. Office parks and centers do seem to shave their parking supplies per worker as they densify, however the relationship is not a particularly strong one.

Figure 6.2 shows the influence of retail space on supply levels. Among all SECs, the relationship appears to be fairly weak, appearing as a cloud of points in the scatterplot. Among groups, however, a stronger pattern emerges. For office parks and centers, parking rates clearly increase as the share of floorspace in retail use rises. For MXDs, however, rates appear to decline slightly as retail becomes more dominant, perhaps reflecting the existence of more shared-use arrangements in these settings. Finally, as was the case for the FAR variable, sub-cities seem to provide consistent parking levels regardless how prevalent the retail component is.

In sum, high densities and large employment bases seem to lower parking standards of SECs while retail uses generally inflate parking levels. It should be kept in mind, however,

Table 6.10

Stepwise Regression Results of Factors Related to Parking per Employee Standards

Dependent Variable: PARK/EMP

Variable	**Beta Coefficient**	**Standard Error**	**t Statistic**	**Probability**
RETAIL	0.00674	.00251	2.688	.0104
PARKING$	-0.06781	.02634	-2.574	.0139
EMPLOYMT	-0.00079	.00052	-1.510	.1390
Intercept	1.01285	.04255	23.804	.0000

Summary Statistics:

Number of observations = 43
R-Squared = .316
F Statistic = 5.537
Probability = .0031

Variable Definitions:

PARK/EMP = Parking spaces per employee.
RETAIL = Percentage of total floorspace in retail use.
PARKING$ = Most frequently occurring daily price for parking, in dollars.
EMPLOYMT = Size of full-time work force, in thousands.

Table 611

Stepwise Regression Results of Factors Related to Parking per Square Footage Standards

Dependent Variable: PARK/SQFT

Variable	Beta Coefficient	Standard Error	t Statistic	Probability
FAR	-0.2926	0.0898	-3.259	.0025
RETAIL	0.0382	0.0108	3.539	.0012
CBDMILES	0.0257	0.0106	2.431	.0203
EMPLOYMT	-0.0042	0.0023	-1.819	.0775
Intercept	3.3015	0.2624	12.583	.0000

Summary Statistics:

Number of observations = 43
R-Squared = .375
F Statistic = 5.246
Probability = .0020

Variable Definitions:

PARK/SQF	= Parking spaces per 1,000 gross square feet of floorspace.
FAR	= Floor area ratio, equal to total square footage of floorspace divided by total square footage of land in SEC.
RETAIL	= Percentage of total floorspace in retail use.
CBDMILES	= Approximate radial miles to regional CBD.
EMPLOYMT	= Size of full-time work force, in thousands.

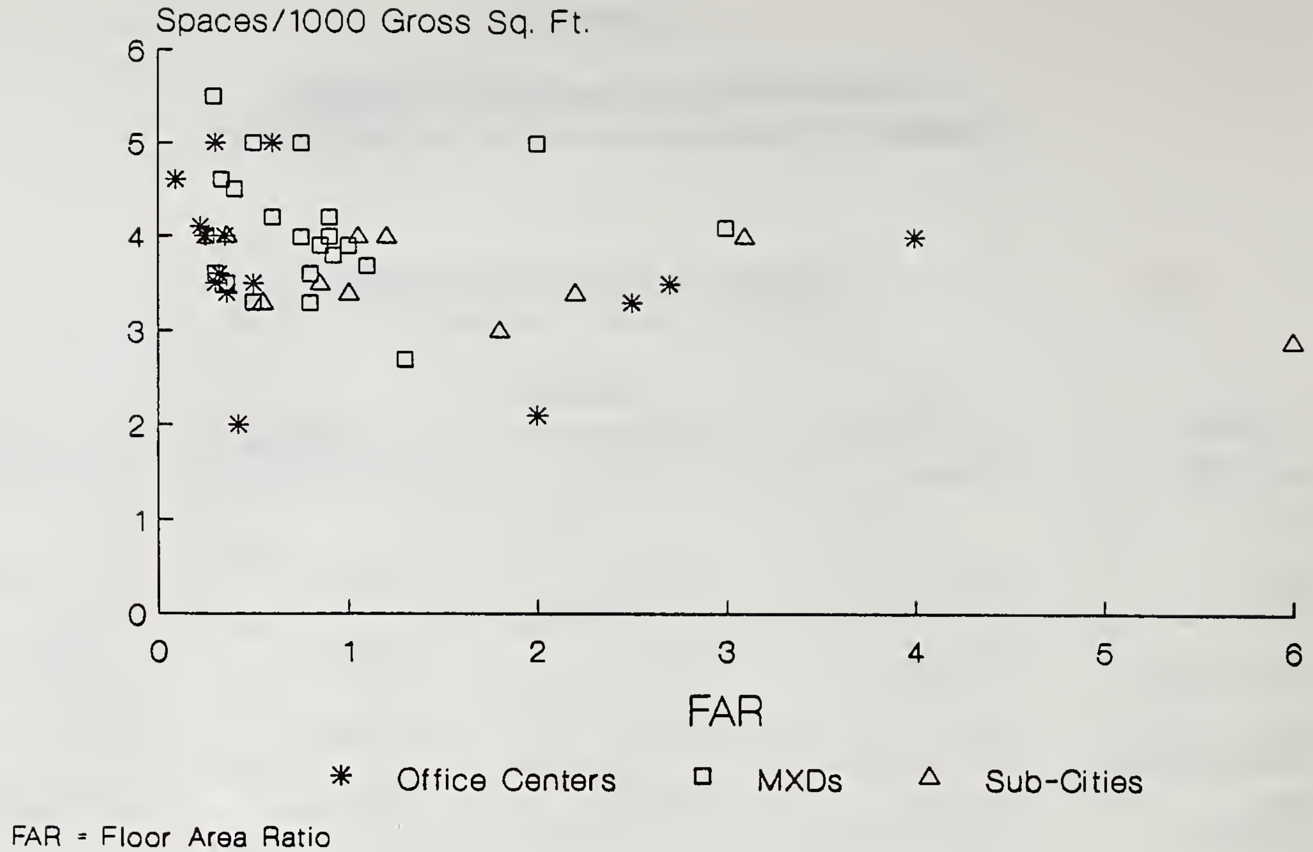


Figure 6.1 **Plot of Parking Supply Versus FAR by Three SEC Groups**

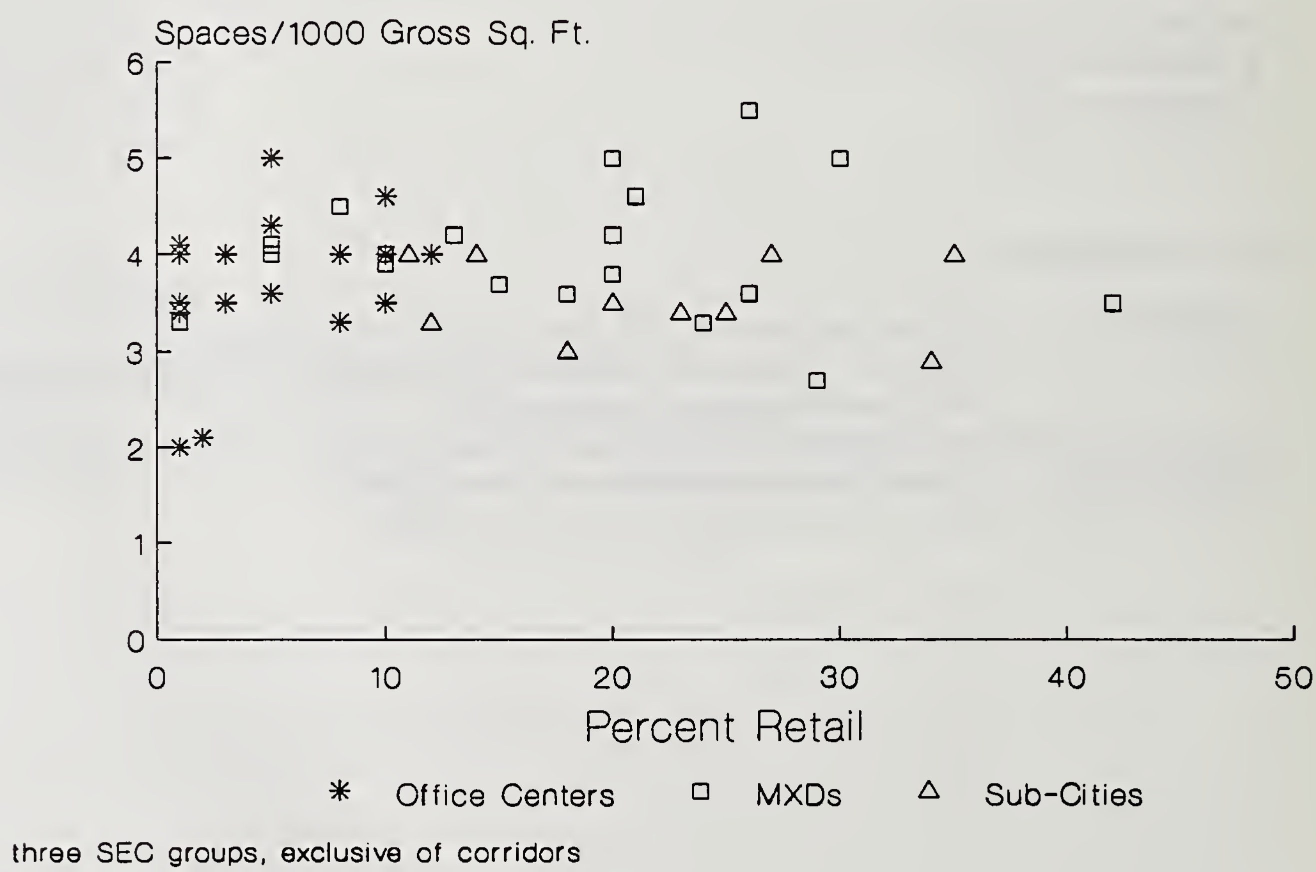


Figure 6.2 **Plot of Percent of Floorspace in Retail Use Versus Supply by SEC Groups**

that many retail spaces are reserved for customers as opposed to workers. On the one hand, retail settings drive up parking standards to meet peak season demands for parking. On the other hand, retail settings can help lower parking standards because shared-use possibilities increase. In general, the net impact of retail uses in SECs has been to raise parking supplies slightly.

6.5 Factors Related to Jobs-Housing Levels Around SECs

This research has demonstrated that jobs-housing mismatches induce SEC workers to use motorized travel modes to get to work and lower the incidence of walking and cycling commutes. While around 4 percent of suburban workers in the U.S. walked or cycled to work in 1980 [Pisarski, 1987], among the SECs studied, the average share was about 2 percent. Moreover, it has been argued, jobs-housing mismatches force larger shares of SEC commuters onto regional thoroughfares, setting the stage for conflicts between SEC-oriented traffic and through trips. Providing nearby housing targetted to the earnings levels and taste preferences of suburban workers, it is felt, could reduce these mismatches.

What site factors seem to be related to jobs-housing levels both within and close to SECs? Table 6.12 shows the stepwise results for predicting JOB/HOUS -- the ratio of SEC employment to on-site housing units. A very good fit was obtained for the 21 cases with complete data, evidenced by the high R-squared and F statistics.

Looking at the signs of the coefficients, there appears to be the highest excess of jobs over housing units within SECs in the settings where: the workforce is made up predominantly of professional employees; densities are low (reflected by the square feet of workspace per employee); average single-family homes nearby are comparatively expensive; and the SEC is relatively close to the regional CBD. Of all of the predictors, the composition of the labor force appears to be most strongly related to jobs-housing levels. The model suggests that every one percent increase in the share of jobs in professional positions is associated with an increase in the ratio of jobs relative to on-site housing units of about three. Overall, it appears that the fewest on-site housing provisions tend to be provided in SECs that are low-density, professionally oriented office parks that are located in more inner-tier suburbs.

Again, people do not have to live and work within the same compound for the benefits of jobs-housing balancing to accrue. Striking a balance in job and housing growth within a reasonable radius of a SEC is perhaps more important from a regional mobility standpoint. Table 6.13 presents those site variables that were found to be most closely associated with the ratio of SEC jobs to housing units within a three mile radius of the SEC, expressed as the variable J/HAREA. In general, SECs with the least amount of nearby housing relative to their workforce sizes tend to have large shares of retail space and clerical workers, and comparatively few management personnel. Thus, SECs comprised of significant shares of clerical workers, a group that usually earns moderate salaries, tend to have the fewest housing opportunities nearby.

An interesting relationship between jobs-housing levels and workforce composition has thus emerged from this analysis. SECs with high shares of non-professional (e.g., clerical, sales) workers tend to have more housing units on-site however comparatively little housing opportunities nearby. The previous chapter showed that the housing units available near SECs with high shares of non-professional workers also tend to be more expensive. The inference that can be drawn seems well-supported: many SEC employees are unable to live within short commuting distances of their workplaces because nearby housing tends to be in short supply and relatively expensive.

Table 6.12

Stepwise Regression Results of Factors Related to On-Site Jobs-Housing Ratios in SECs

Dependent Variable: JOB/HOUS

Variable	Beta Coefficient	Standard Error	t Statistic	Probability
PROFSHAR	3.1518	0.4842	6.509	.0000
SQFT/EMP	-0.0437	0.0199	-2.191	.0458
CBDMILES	-1.0698	0.4021	-2.661	.0186
AVGHOUS$	0.1612	0.0892	1.807	.0922
Intercept	-7.5153	20.8232	-0.361	.7236

Summary Statistics:

Number of observations = 21
R-Squared = .818
F Statistic = 15.736
Probability = .0000

Variable Definitions:

JOB/HOUS = Employees per on-site housing unit.
PROFSHAR = Percentage of workforce in management, administrative, or technical job classifications.
SQFT/EMP = Square feet of non-residential floorspace per employee.
CBDMILES = Approximate radial miles to regional CBD.
AVGHOUS$ = Estimated average purchase price of single-family housing unit within a three mile radius of SEC, in thousands of dollars.

Table 6.13

Stepwise Regression Results of Factors Related to Ratio of Jobs to Nearby Housing Units

Dependent Variable: J/HAREA

Variable	Beta Coefficient	Standard Error	t Statistic	Probability
RETAIL	0.5532	0.2138	2.588	.0147
CLERICL	0.4582	0.2498	1.834	.0766
MANAGEM	-0.3558	0.2215	-1.606	.1187
Intercept	-7.2178	8.3901	-0.860	.3965

Summary Statistics:

Number of observations = 35
R-Squared = .245
F Statistic = 3.241
Probability = .0358

Variable Definitions:

J/HAREA	= Ratio of on-site employees to estimated housing units within a three mile radius of SEC.
RETAIL	= Percentage of total floorspace in retail use.
CLERICL	= Percentage of workforce in clerical positions.
MANAGEM	= Percentage of workforce in management positions.

6.6 Factors Related to Property Ownership Patterns in SECs

A final set of relationships explored in this chapter involved land ownership patterns. It has been hypothesized that centralized control over SEC projects allows more coordinated designs as well as the sharing of facilities, such as access roads, parking, and tenant support services. As a result, projects developed by relatively few landholders could be expected to have higher average densities and be less spread out.

Do SECs with fewer "chefs in the kitchen" average higher site densities? The stepwise regression results shown in Table 6.14 shed some light on this. Ignoring the large corridor cases, the model reveals that the number of non-residential property owners within an SEC tends to be large in settings with relatively large retail components (RSQT/EMP) and low employment densities (LAND/EMP). Predominantly office environments, on the other hand, are associated with comparatively few property owners. This equation, it should be noted, is not meant to be a causal expression. In fact, the causality between the variables shown in Table 6.14 is probably in the other direction -- i.e., the number of property owners influences density and land use composition, not vice-versa. Still, the hypothesis postulated above appears to be borne out. SECs associated with fewer property owners tend to have higher average employment densities (i.e., less land area per employee).

Table 6.15 provides an additional perspective on SEC land ownership influences. SECs with higher FARs and closer match-ups of employees and on-site housing units tend to have larger shares of land owned by developers than private firms.[8] While the statistical fit of this model is only of moderate significance, it does appear that in SEC settings where developers retain control over most of the land, densities are higher and on-site jobs and housing units tend to be more closely aligned.

6.7 Case Summary of Work Site Factors Influencing Commute Choices in Pleasanton, California

To supplement the national-level analysis, a disaggregate study of commute choices among individual employees of Pleasanton, California, a fast growing suburb in the San Francisco Bay Area, was conducted. The below analysis focuses on how work site characteristics were related to the travel choices of Pleasanton workers, with choice expressed in terms of mode and time period of travel.

Case Setting and Data Sources

The city of Pleasanton was selected as a case setting, both because it has a substantial suburban office concentration and because survey data on the travel characteristics of Pleasanton's workers have been collected annually since 1984. Figure 6.3 depicts the location of Pleasanton in the San Francisco Bay Area. The community lies approximately 35 miles east of downtown San Francisco in the north-central portion of Alameda County, near the confluence of two major freeways, Interstate-580 and Interstate-680. Pleasanton's population jumped from 18,328 in 1970 to 45,500 in 1986 [California Department of Finance, 1986]. Employment has similarly grown at a rapid pace, rising from 9,090 in 1980 to an estimated 18,500 in 1985. Consequently, Pleasanton has become more of a mixed community over time, changing from a place with a predominantly bedroom character to one with more of a balance of jobs and residents.

A significant share of Pleasanton's office growth since the early 1980s has occurred in the Hacienda Business Park, one of the case SECs used in this study. The 860-acre Hacienda project presently has over 5,000 workers and is expected to grow to over 40,000 at build out,

Table 6.14

Stepwise Regression Results on Factors Related to Property Ownership Patterns

Dependent Variable: PROPOWN

Variable	Beta Coefficient	Standard Error	t Statistic	Probability
OFFICE	-3.8575	0.9752	-3.956	.0004
LAND/EMP	0.0030	0.0007	4.133	.0002
RSQT/EMP	0.2241	0.0566	3.958	.0004
Intercept	287.0762	74.0195	3.878	.0004

Summary Statistics:

Number of observations = 40
R-Squared = .740
F Statistic = 33.18
Probability = .0000

Variable Definitions:

PROPOWN = Number of property-owners, non-residential land only.
OFFICE = Percent of total floorspace in office use.
LAND/EMP = Square feet of land per employee, in thousands.
RSQT/EMP = Retal square footage of floorspace within a three mile radius per on-site employee.

Table 6.15

Stepwise Regression Results on Factors Related to Developer Land Ownership Shares

Dependent Variable: DEVSHARE

Variable	Beta Coefficient	Standard Error	t Statistic	Probability
JOB/HOUS	-0.2067	0.1145	-1.805	.0899
FAR	5.1850	3.1051	1.670	.1144
Intercept	0.7225	0.0731	9.886	.0000

Summary Statistics:

Number of observations = 22
R-Squared = .291
F Statistic = 3.276
Probability = .0642

Variable Definitions:

DEVSHAR = Percentage of non-residential land owned by developers.
JOB/HOUS = Employees per on-site housing unit.
FAR = Floor area ratio, equal to total square footage of floorspace divided by total square footage of land in SEC.

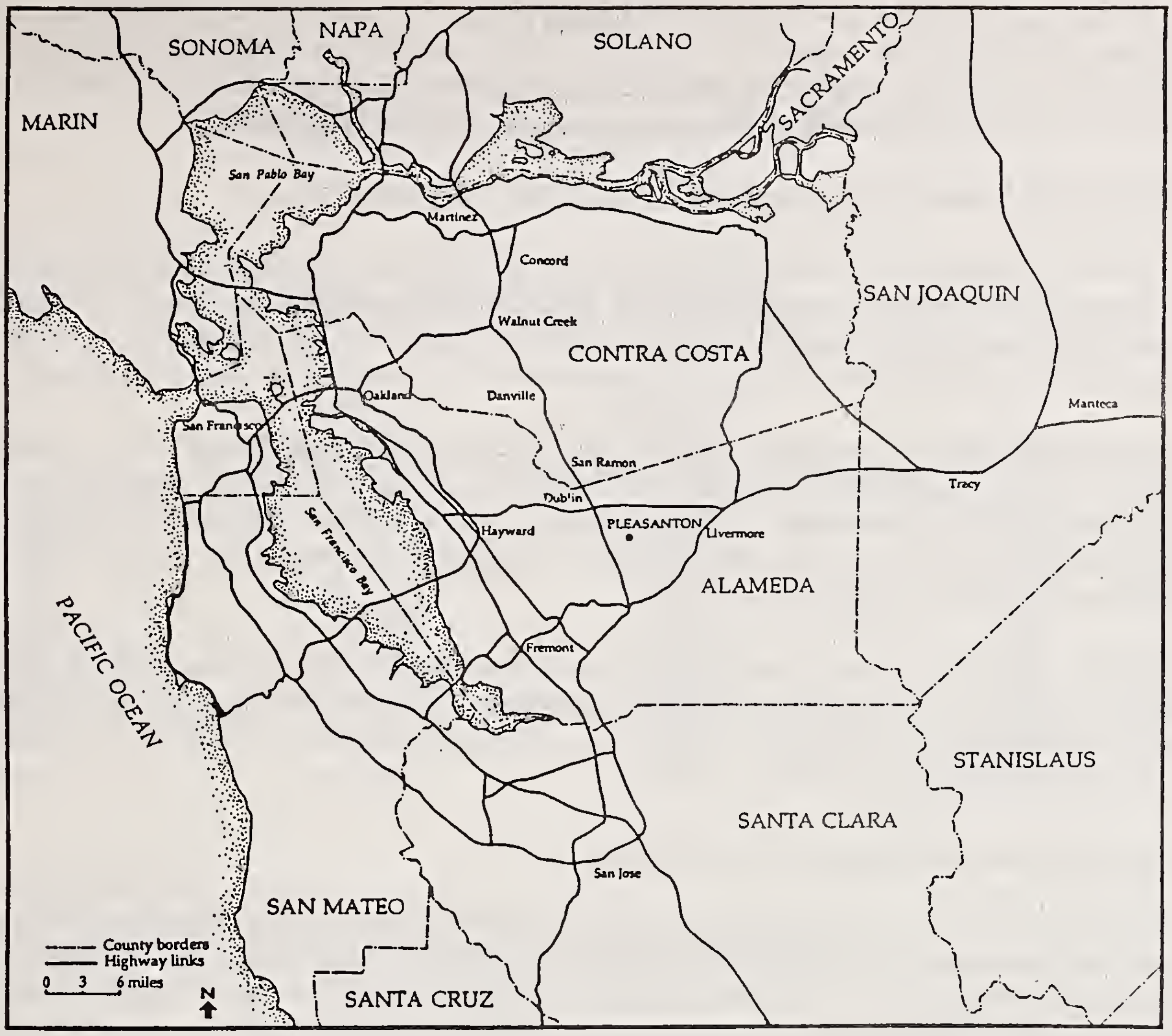


Figure 6.3 Location of Pleasanton in the San Francisco Bay Area

sometime after the year 2000.[9] It was the announcement of the Hacienda project, coupled with steadily worsening congestion on local thoroughfares, that prompted a number of Pleasanton citizens to form an action committee in the early 1980s to respond to mounting traffic problems. The overwhelming consensus of local citizens was to hold employers accountable for the traffic impacts of their workers and to take action to contain peak hour, single-occupant automobile travel. In response, a Transportation System Management (TSM) ordinance was passed by local referendum in late 1984 [Diamond, 1985; Cervero, 1986B]. The ordinance stipulates that no company with fifty or more employers (or firms in multi-tenant complexes) can have over 55 percent of its workforce driving alone to work during peak hours in 1988. Moreover, all participating employers are required to appoint a "workplace coordinator" to promote ridesharing, post information on vanpooling and other commute alternatives, and conduct annual surveys to monitor progress toward meeting the ordinance's goals. Those failing to comply with the ordinance are subject to fines of $250 per day, or more.

The 1986 Pleasanton Employee Travel Survey formed the basis for the analysis presented in this section. The surveys were mailed to Pleasanton workers in the spring of 1986, eliciting responses on mode, distance, time period, and other characteristics of the commute trip. The 1986 survey secured a response rate of 77 percent of all Pleasanton workers, representing 14,424 cases among the 1,074 Pleasanton firms subject to the TSM ordinance. In that a large share of these responses were from employees of the Hacienda Business Park and adjoining office parks, this data base offers insights into the travel choices of employees working in a mixed office park/office concentration type of SEC setting.

Summary Workforce Composition and Commuting Characteristics

The 1986 survey revealed that Pleasanton's workforce was made up predominantly of management/administrative personnel (26.2 percent), followed by clerical (21.1 percent), service (21.0 percent), and professional-technical workers (17.6 percent). Pleasanton's workforce was also predominantly female in 1986 -- 62 percent of all survey respondents were women.

As in other SECs around the country, the survey showed that the drive-alone automobile was, by far, the most prevalent means of commuting among Pleasanton workers in 1986. Despite Pleasanton's pioneering TSM ordinance, 84.3 percent of the work force solo-commuted in 1986, while only 10.2 percent shared rides. Bus transit carried just 1.7 percent of Pleasanton employees to work in 1986.

Finally, the survey also showed that around one-third of Pleasanton workers enjoyed flex-time privileges. The average one-way commute distance was found to be 15.1 miles, markedly higher than the 11.1 mile average home-work distance for Bay Area workers as a whole [Bureau of Census, 1982].

Workplace Factors Influencing Mode Choice

To explore factors influencing the modal choices of Pleasanton's workers, binomial logit analysis was performed. Because the Pleasanton survey did not collect information on the cost and service characteristics of different modes, the influences of these variables could not be directly explored. Rather, the survey compiled data primarily on the characteristics of the workplace, allowing the modal influences of factors such as employer size and tenant composition to be studied. Thus, it was only possible to examine the affects of a handful of site variables, notably scale and tenant mixture, on commuting behavior. Accordingly, the collective influences of other factors are assumed to be constant in the analyses which follow.

Table 6.16 summarizes the maximum likelihood estimation results of the stepwise logit model derived from the 1986 survey, where mode choice was expressed in terms of choosing either drive-alone (value=0) or all other travel options (value=1). Because of the dominance of solo-commuting in Pleasanton, mode selection was treated as a simple binary choice -- either drive alone or commute by an alternative means. Moreover, since over two-thirds of the remaining commute trips were by carpool or vanpool, the "other" category largely captured shared-ride forms of commuting. Thus, in the discussion below, the alternative to "drive-alone" is referred to as "shared-ride".

From Table 6.16, all of the explanatory variables were highly significant and had signs consistent with a priori expectations.[10] The pseudo R-squared statistic suggests that the model has modest predictive abilities, however, this statistic is only a rough gauge of goodness-of-fit for discrete choice models and is not inviolable [Ben-Akiva and Lerman, 1985]. All things equal, Table 6.16 suggests that Pleasanton workers are most likely to rideshare if they commute relatively long distances, work for a large company at a single-tenant site, and work in non-professional and non-management positions (i.e., clerical and sales). The tendency to share rides declines, however, when flex-time programs exist and workers arrive to and depart from work at times that vary substantially from the norm.

Table 6.16

Binomial Logit Results on Likelihood of Selecting Share-Ride Modes

Dependent Variable: SHARIDE

Variable	Beta Coefficient	Standard Error	t Statistic
DIST	0.0237	0.0015	248.21
EMPTYPE	-0.3148	0.0501	-39.37
TENANT	0.3301	0.0559	34.78
NUMEMP	0.0007	0.0002	16.67
FLEXTIME	-0.1452	0.0528	-7.56
ARRIVDIF	-0.0003	0.0001	-4.78
DEPARDIF	-0.0002	0.0001	-2.44
Intercept	-2.0660	0.0541	-1457.93

Summary Statistics:
- Number of observations = 13,483
- Chi-Square = -2(log likelihood ratio) = 447.78, p = 0.000
- Pseudo R-Squared = 1 - (likelihood ratio) = 0.192

Variable Definitions:

- SHARIDE = Commute by shared ride or other non-drive alone mode: 1=yes, 0=no.
- DIST = Respondent's reported one-way trip length, in miles.
- EMPTYPE = Employment type: 1=professional/management, 0=all other.
- TENANT = Tenant composition at worksite: 1=single tenant, 0=multi-tenant.
- NUMEMP = Total number of employees at respondent's workplace.
- FLEXTIME = Flexibility of respondent's work hours: 1=work hours flexible by 45 minutes, 0=work hours not flexible by 45 minutes.
- ARRIVDIF = Difference between respondent's reported arrival time and the modal arrival time at his or her worksite, in minutes.
- DEPARDIF = Difference between respondent's reported departure time and the modal departure time at his or her worksite, in minutes.

A number of dimensions of mode choice are being tapped in these findings. Distance works in favor of ridesharing because only over long distances does the time spent picking up carpool and vanpool passengers become a relatively small portion of the total travel time. The propensity to rideshare increases with company size because a critical mass of employees is generally needed if workers are to be successfully matched into carpools. Having workers concentrated in a single-tenant complex also favors ridesharing; multi-tenant complexes, on the other hand, seem to impede the formation of carpools and vanpools because the coordination of ridematching among multiple employers tends to be more complicated than within a single company. Clearly, the odds of attracting suburban workers into carpools and vanpools are much higher for a national headquarters staffed with 5,000 employees than for a building housing 5,000 workers divided among numerous small firms.

From Table 6.16, factors that work against ridesharing are equally revealing. The negative association between professional employment and ridesharing was expected, reflecting both the affect of higher incomes on mode choice as well as the fact that professionals and managers generally place a higher premium on flexible and convenient forms of transportation, notably the drive-alone automobile, than other commuters. The affects of flexible working arrangements and atypical arrival and departure times on ridesharing also seems intuitive since the need to pool rides is less imperative as peak demand is spread over a longer period. Ridematching, moreover, becomes more difficult as workers' arrival and departure times vary more. Cross-tabulating survey results, it was found that only 7.6 percent of Pleasanton workers with flex-time privileges carpooled or vanpooled, compared to 11.4 percent of the entire Pleasanton workforce. Clearly, the existence of flex-time opportunities has hampered ridesharing efforts in the case of Pleasanton. This is consistent with the findings of Wegmann and Stokey [1983] that giving employees at the Tennesee Valley Authority near Knoxville greater choice in working hours reduced participation in the Authority's ridesharing program.

While Table 6.16 summarizes statistical associations between mode choice and various workplace factors, it discloses little about the probability of Pleasanton commuters opting for different modes under different circumstances. Figures 6.4 and 6.5 provide a graphic perspective on how sensitive Pleasanton workers are to changes in trip length and firm size as well as several categorical variables when making mode choices. Comparing both figures, it is evident that ridesharing is more strongly influenced by shifts in trip distance than by changes in employer size. For a clerical employee in a single-tenant project who has not flex-time opportunities, all else equal, the probability of ridesharing is 0.37 if he makes a fifty mile tirp and only 0.17 if he commutes four miles. However, if this four mile commuter is a professional in a multi-tenant project who is able to flex his work schedule, the probability of ridesharing falls even more, to 0.08. From Figure 6.5, the probability of ridesharing also drops noticeably as the firm size variable is perturbed. The clerical worker in a single-tenant project with no flex-time arrangements has a 0.27 probability of ridesharing if his company has 500 workers compared to a 0.20 probability if the company has just forty workers.

Overall, the incidence of ridesharing among Pleasanton workers is highly sensitive to changes in commute distance and moderately influenced by changes in company size. The fact that the lines for the minimum and maximum ranges in both figures are not parallel, moreover, indicates that significant interaction exists between the variables. Because the top lines are steeper as one moves to the right in both figures, one can infer that the affects of employment type, tenant mix, and flex-time work arrangements on mode choice are proportionally greater for someone traveling fifty miles versus someone traveling five miles.

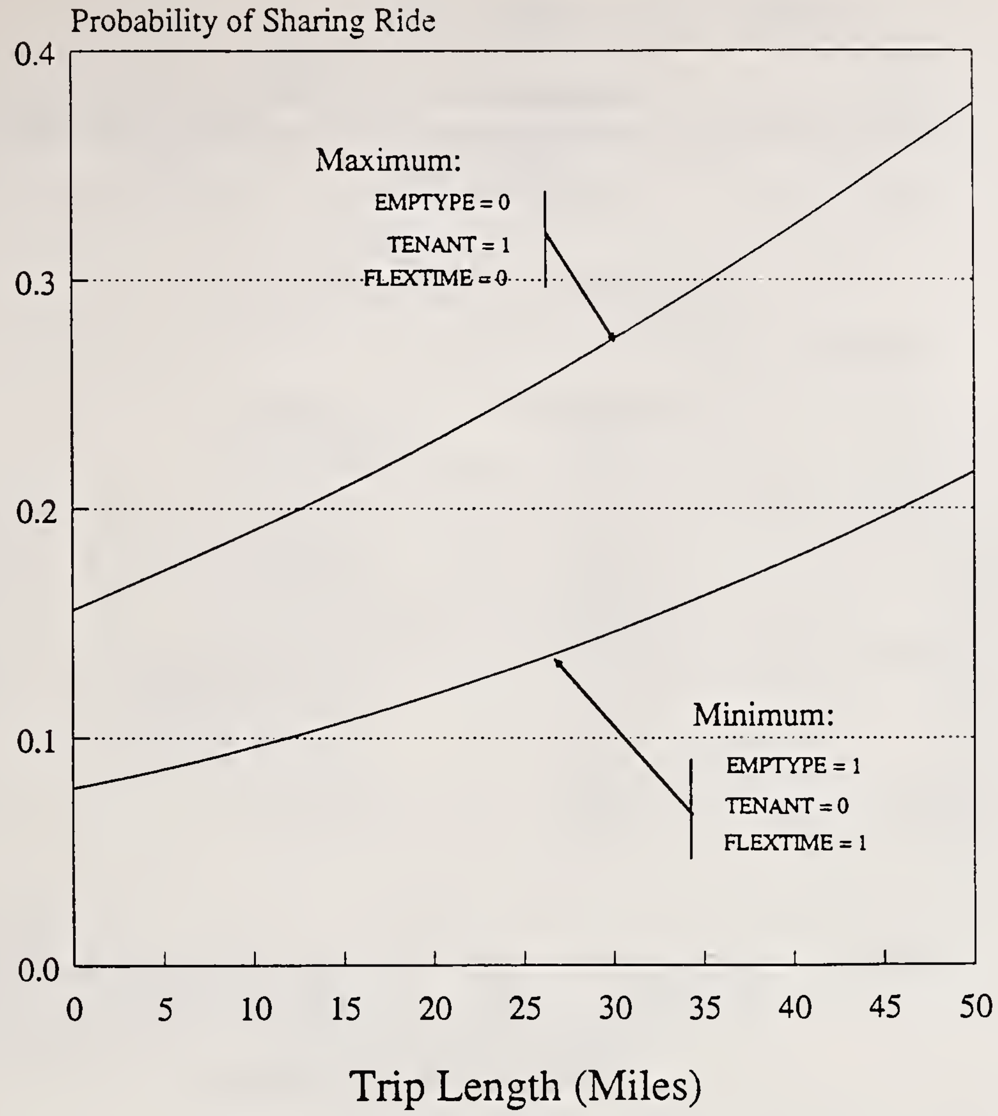


Figure 6.4 **Probability of Shared Ride Commute by One-Way Trip Length for Employees of Pleasanton, California**

Factors Influencing Time Period of Travel

The Pleasanton data also allowed the peaking characteristics of travel to be studied. The logit results summarized in Table 6.17 shows factors which are causally related to workers commuting outside of Pleasanton's designated morning peak (7:30-8:30 a.m.) and evening peak (4:30-5:30 p.m.).

The model's coefficients indicate that the likelihood of commuting outside of both peaks increases as an employee's arrival and departure times vary significantly from his co-workers' and his commute distance increases and when he enjoys flex-time privileges. Several variables related to characteristics of the worker and workplace were also significant. The chances of an employee commuting outside of both peaks appear to be the highest when that person is in a non-professional occupation and works for a small, single-tenant company. One can infer that because professional-managers shoulder major business responsibilities, they tend to arrive at work during peak periods when most other employees arrive.

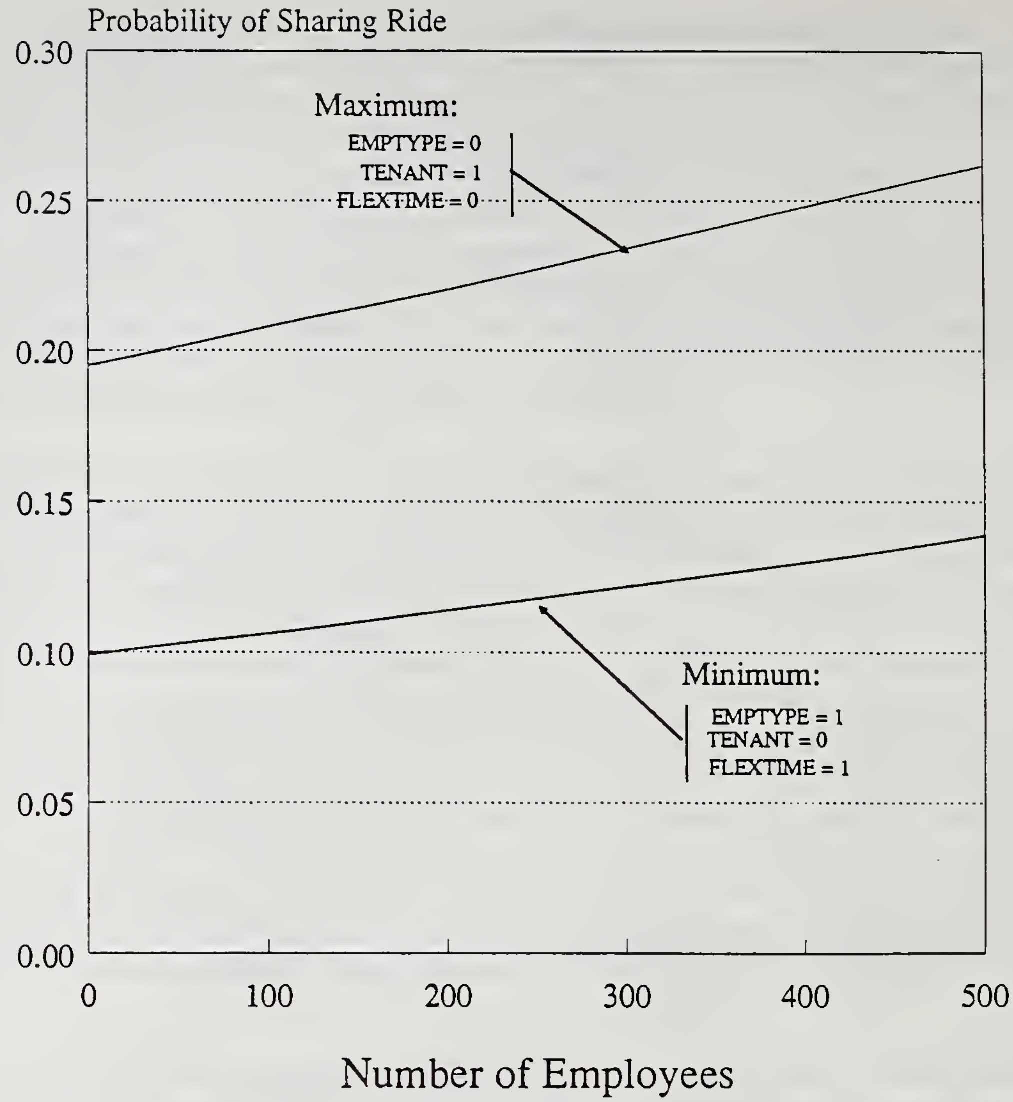


Figure 6.5 **Probability of Shared Ride Commute by Number of Employees at Work Sites in Pleasanton, California**

A sensitivity analysis for the variable OUTPEAK as a function of number of employees (NUMEMP) is shown in Figure 6.6. The figure indicates, for instance, that if John Doe works for a company with 100 employees, the probability that he commutes outside of both peaks is 0.24 if he is a professional-manager who works in a multi-tenant complex, drives alone, and has no flex-time opportunities. If Jane Smith works for a similar size company, but is a clerical worker in a single-tenant complex, shares a ride, and is allowed to flex her work schedule, her probability of commuting outside of both peaks is much higher -- 0.47. It is clear from the graph that the likelihood of someone commuting in non-peak periods is strongly related to their employer's size, their flex-time opportunities, and whether their workplace has a mixture of tenants.

Summary of Pleasanton Case Analysis

Pleasanton is fairly representative of other suburban areas around the country experiencing rapid growth. It has a largely back office workforce which predominantly solo-

Table 6.17

Binomial Logit Results on Whether Employee Commutes Outside of Both Peak Hours

Dependent Variable: OUTPEAK

Variable:	Beta Coefficient	Standard Error	t Statistic
ARRIVDIF	0.0071	0.0002	897.03
DEPARDIF	0.0024	0.0001	421.29
SHARIDE	0.4239	0.0586	52.32
NUMEMP	-0.0013	0.0002	-46.89
FLEXTIME	0.2807	0.0465	36.35
TENANT	0.2345	0.0528	19.75
DIST	0.0039	0.0015	6.74
EMPTYPE	-0.1108	0.0451	-6.05
Intercept	-1.6452	0.0497	-1097.41

Summary Statistics:
- Number of observations = 12,332
- Chi-Square = -2(log likelihood ratio) = 2911.91, p = 0.000
- Pseudo R-Squared = 1 - (likelihood ratio) = 0.433

Variable Definitions:

- OUTPEAK = Commute outside both the morning (7:30 to 8:30) and evening (4:30 to 5:30) peak hours: 1=yes and 0=no.
- ARRIVDIF = Difference between respondent's reported arrival time and the modal arrival time at his or her worksite, in minutes.
- DEPARDIF = Difference between respondent's reported departure time and the modal departure time at his or her worksite, in minutes.
- SHARIDE = Commute by shared ride or other non-drive alone mode: 1=yes, 0=no.
- NUMEMP = Total number of employees at respondent's workplace.
- FLEXTIME = Flexibility of respondent's work hours: 1=work hours flexible by 45 minutes or more, 0=work hours not flexible by 45 minutes.
- TENANT = Tenant composition at worksite: 1=single tenant, 0=multi-tenant.
- DIST = Respondent's reported one-way trip length, in miles.
- EMPTYPE = Employment type: 1=professional/management, 0=all other.

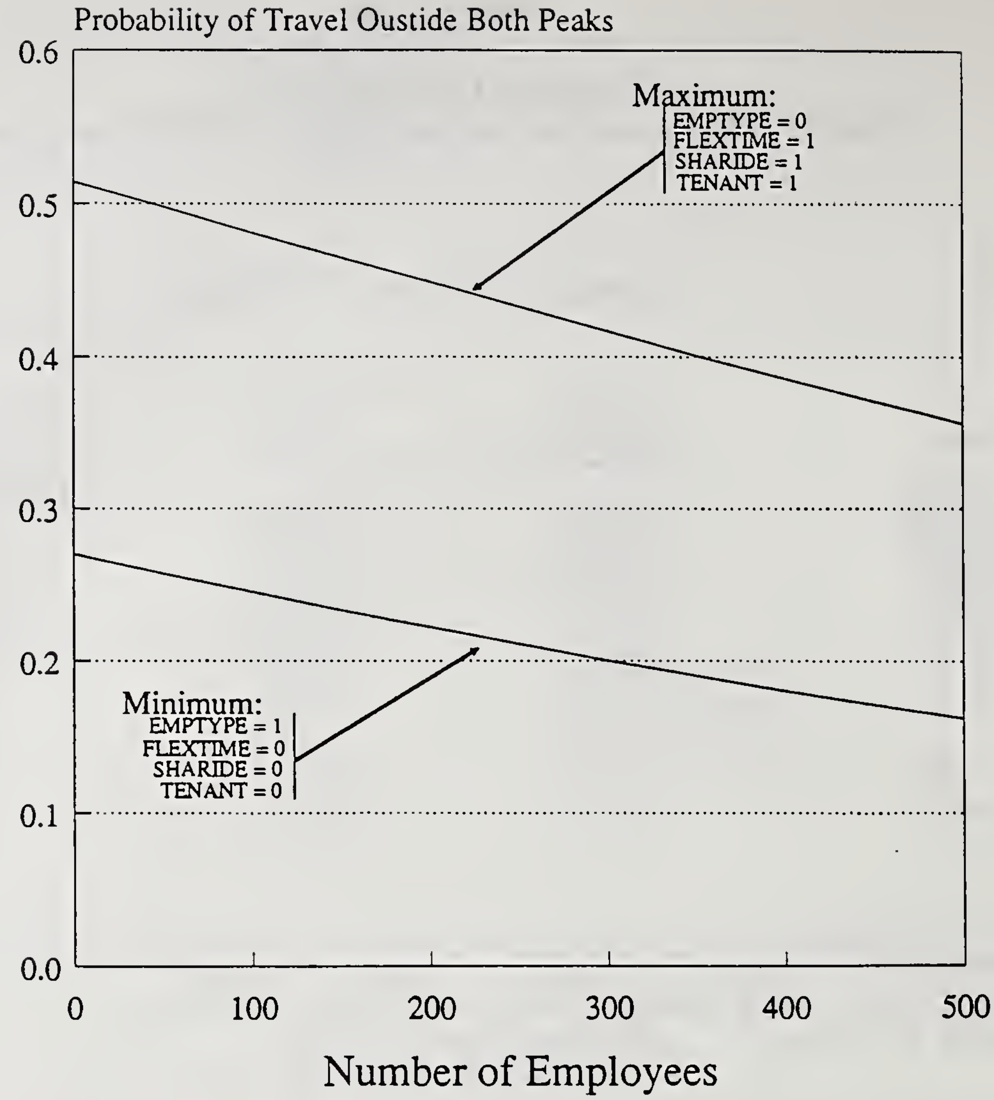


Figure 6.6 Probability of Travel Outside of AM and PM Peak Hours by Number of Employees at Work Sites in Pleasanton, California

commutes. From this analysis, the following work site characteristics were found to have a strong influence on commute choices in Pleasanton:

Employment Composition: The incidence of ridesharing increases as the share of the workforce in non-professional occupations increases. Non-professionals are more likely than other workers to commute during the peak period, in part because they tend to enjoy fewer flex-time privileges.

Firm Size: The share of commute trips in carpools and vanpools increases with company size. Larger firms also average larger shares of employees commuting at peak hours, also partly because they tend to offer their workers fewer flex-time opportunities.

Tenant Mixtures: If a work site is occupied by a single tenant, the odds are greater that employees will share rides.

Collectively, these findings suggest that companies which relocate their predominantly clerical back-office staffs in large single-tenant sites and which have rigid work schedules will tend to have relatively high shares of employees who carpool and vanpool to work. On the other hand, they will also tend to have large shares of their employees commuting during peak hours. The implication, then, is that SECs that are designed to accommodate back-office workers in large branch facilities are most likely to experience the highest rates of ridesharing as well as the greatest degree of peaking. If ridesharing is deemed important to preserving mobility in an area, then developments catering to large, back-office firms might be sought. If, on the other hand, a primary objective is to spread out peak loads, then other kinds of developments might be considered more appropriate for an area.

6.8 Summary of Hypothesis Tests

The affects of specific site and land use factors on SEC mobility levels are summarized below.

Density -- Employment densities and FAR appear to influence local traffic conditions more than any single site factor. High density SECs average the slowest employee commutes and the worst levels of service on connecting freeways and arterials. Additionally, high densities appear to work in favor of commute alternatives to the drive-alone automobile. High density SECs also generally have relatively low levels of parking supply, a factor which also likely reduces the share of solo-commutes.

Land Use Composition -- Among all of the site variables examined, the degree of land use mixing appears to influence the modal choices of SEC workers the most. Single-use office developments encourage solo-commuting. The availability of nearby retail services, on the other hand, induces ridesharing. On-site retail facilities were found to attract more walking and cycling work trips. In general, highly mixed-use centers allow workers to take care of personal chores on foot in a contained area, freeing some of the need to have an automobiles at their disposal. Mixed-use environments also appear to induce more shared parking arrangements.

Size and Scale -- The size of SEC activities appears to influence both local traffic conditions and mode choice. SECs with large floorareas average the poorest levels of service on connecting freeways and arterials. Large developments also tend to experience greater peaking of employee arrivals and departures. Large-size employers, on the other hand, are generally more successful in winning their workers over to carpools and vanpools. Buildings occupied by single-tenants, moreover, generally have relatively high shares of carpoolers and vanpoolers. Overall, suburban work environments with a critical mass of employees appear to be an important prerequisite for successful ridesharing programs.

Jobs-Housing Balances -- SEC settings with a more even balance of jobs and housing tend to have higher shares of employees walking and cycling to work, however they at the same time average lower percentages of ridesharing. These more balanced environments also tend to have less congestion on connecting roadways, possibly because the conflicts between SEC-oriented trips and other through travel are reduced. Jobs-housing mismatches appear to be most common in areas with large shares of employees in clerical, sales, and other non-professional positions. Nearby housing in these settings also tends to be relatively expensive. A logical inference is that appreciable numbers of clerical and service-industry workers in many SEC settings are prevented from residing near their workplaces and end up driving to work alone as a consequence.

Overall, the hypotheses posited in this research appear to be borne out by these empirical findings. While the relationships that were found were not as strong as might be hoped for, in view of the fact that the analysis occurred at a fairly aggregate scale, the findings appear convincing nonetheless. Clearly, changes in site designs, land use mixtures, and densities, in and of themselves, will not bring about dramatic shifts in commuting behavior, at least not in the near term. Other initiatives not directly studied in this research -- such as regional TSM ordinances, new freeway construction, or improved areawide transit service -- also strongly affect commuting behavior. In tandem with broad-based programs to manage traffic congestion, however, it is felt that the design of higher-density, more mixed-use suburban workplaces with nearby affordable housing could yield substantial mobility dividends in the long term.

Our knowledge of the affects of site and land use variables on suburban commuting behavior is still only partial. Further research is needed, for instance, on the influences of site practices, such as lot configurations and building placements, on travel choices. More work on the affects of parking standards and jobs-housing mismatches on commuting to suburban centers is also called for. Still, the findings of this research provide some insight into these topics and, in general, should provide a useful framework for designing future suburban employment centers with mobility objectives in mind.

As a follow-up to this empirical work, the next chapter offers some embellishment on these relationships by discussing various transportation-land use issues in SECs in three metropolitan areas: Seattle, Chicago, and Houston. It is followed by the concluding chapter on recommended policy directions for the future.

Notes

1. For a thorough discussion of the stepwise method, see Blalock [1979].

2. Multiple regression equations delete cases listwise. If data are missing for any single variable under consideration, the case is removed from the analysis. Since some variables had a number of missing cases, their inclusion would have substantially reduced the size of the data base. Accordingly, variables with more than six missing cases were not considered in the stepwise analysis.

3. Keep in mind that high values of EMP/INTC represent low levels of site access. Thus, the negative sign on EMP/INTC suggests that as site access improves (i.e., EMP/INTC rises), then the percent of trips by solo-commuters drops off.

4. RIDECOOR is a dummy variable. If it takes on values of 1 (i.e., a rideshare coordinator position exists at the SEC), then DRIVALON rises by 3.36 percent.

5. While vanpool provisions appear to influence solo-commuting, the availability of transit services was found to have little affect. This is consistent with the findings of other researchers that "modal split to suburban offices is not significantly affected by the availability of public transit " [Brown, et al., 1984, p. 20-4].

6. That is, both variables resisted change when the sample size was reduced, demonstrating their strength at predicting WALKBIKE in both small sample and comparatively large sample situations.

7. It should be noted that no model was developed for predicting transit usage because the relationships that were produced during the stepwise process were fairly weak. No site variables were found to have any significant predictive abilities in explaining transit modal shares for this particular data base.

8. Again, the causality likely lies in the direction of property ownership patterns influencing density and land use, rather than vice-versa.

9. For a more in-depth discussion of the Hacienda Business Park, see Cervero [1986B].

10. The high significance could have been anticipated because of the large number of cases (13,483) that entered into the analysis.

CHAPTER SEVEN

Case Studies of Land Use-Transportation Issues in SECs in Greater Seattle, Chicago, and Houston

7.1 Introduction

Insights into specific land use and transportation issues affecting SECs can also be gained by examining case experiences. This chapter summarizes an assortment of topics regarding site designs, land use planning, parking standards, jobs-housing relationships, and other issues for SECs in three metropolitan areas -- Seattle, Chicago, and Houston. Of course, these and other issues vary considerably among metropolitan areas in degree of importance and level of local response. No one case, in and of itself, can represent the full depth of any single topic. Cases, however, help bring issues down to the field level, offering a finer-grained perspective into land use-transportation relationships.

Much of the information for the cases that follow was obtained through field research. Interviews with developers, employers, and local officials were conducted in each instance. They were supplemented by local reports, newspaper accounts, and other information sources gathered during the course of field study. Thus, compared to the prior chapters, the summaries which follow are based on both factual information and the opinions and impressions offered by others.

The three cases presented in this chapter, it should be noted, are not meant to be comprehensive. Emphasis is placed on highlighting assorted land use, site development, and mobility issues surrounding some of the SECs in these metropolitan areas. Success stories as well as problem areas are discussed. In most instances, SECs are still growing and thus it is too early to tell what affects certain design and land use strategies will have on mobility. Still, the assortment of issues covered in the following sections should offer insights into important transportation-land use issues around some SECs and the kinds of policy responses that are being designed to preserve future mobility.

7.2 Seattle Area Case Study

In the greater Seattle area, two of the primary areas of office growth outside of downtown Seattle since 1980 have been downtown Bellevue and the Bel-Red corridor just east of it. (See Figure 2.18 in Chapter Two for the general location of these two areas.) The case summary in this section concentrates mainly on downtown Bellevue, in part because some of the most innovative responses at managing traffic through land use initiatives anywhere in the country can be found there.

<u>Overview of Growth and Development Trends</u>

The eastern shore of Lake Washington, known locally as Eastside, has been one of the fastest growing corridors in the greater Seattle area in recent years. From 1980 to 1987, the city of Bellevue grew from 73,900 to 82,000 residents, an eleven percent rise. Just to the north, Redmond's population rose even faster during this period, from 23,300 to 30,300, nearly a 30 percent increase. In both places, however, employment has significantly outpaced population growth, increasing at rate exceeding five percent annually since 1980.

Downtown Bellevue encompasses a 330 acre zone east of Interstate-405, a major north-south facility serving the Seattle area (see Figure 7.1). This district contains around 8 million square feet of office and commercial floorspace and supports a workforce numbering over 20,000. Since 1980, Bellevue has been in a state of transition from Eastside's primary retail center to a major regional employment hub.[1] Prior to 1980, office buildings comprised less than half of downtown Bellevue's floorspace, with retail outlets ranging from neighborhood convenience stores to a regional shopping center dominating the streetscape. This built environment was best suited for motorized travel. Most businesses provided over 5 parking spaces per 1,000 square feet of floor area. Offices and shops were generally spread throughout downtown, prompting many workers and shoppers to use their cars when circulating between buildings. In general, central Bellevue was not distinguishable from other suburban communities of the 1960s and 1970s.

Since 1980, downtown Bellevue has undergone a dramatic face-lift. One of the major catalysts behind this transformation was the upgrade of Bellevue Square from a suburban community shopping center to a super-regional mall. An overhaul of the downtown master plan in 1981 soon gave way to higher densities and parking reductions. Within a few years, many of Bellevue's one to two story office and retail buildings were replaced by high-rise office towers set atop underground parking facilities. Most new office additions have ranged from 10 to 25 stories in height, with floor area ratios between 6.0 to 8.0, comparable to the downtown densities of many medium-size cities. Today, Bellevue is the archetype suburban city, featuring a high-rise skyline and a lively mix of offices, shops, restaurants, hotels, and theatres.

The Bel-Red corridor is poles apart from downtown Bellevue in both land use and employment composition. Short for the Bellevue Redmond Road axis, Bel-Red is largely a strip of freestanding 1-2 story office buildings, small business and industrial parks, warehousing, and independent retail centers. Over 7 million square feet of non-residential floorspace straddles the four mile corridor from Interstate-405 to the southern portion of Redmond. Since over 90 percent of the corridor is already built out, however, the role of land use and design initiatives in shaping travel behavior along the Bel-Red corridor is somewhat limited. Still, traffic congestion continues to worsen along the corridor. In response, the Eastside Transportation Program was formed in 1987. Comprised of transportation professionals from surrounding communities, the program aims to forge a subregional consensus on managing growth and traffic along the Bel-Red corridor as well as other major concentrations of development on the eastside of Lake Washington.

<u>Redesign of Downtown Bellevue</u>

The 1981 Downtown Plan was a watershed in Bellevue's transformation. The central idea was to convert downtown from a place for automobiles to a place for people. The primary instrument for doing this was land use regulations. Bellevue's downtown was rezoned to allow a "wedding cake" pattern of densities, with a high-rise central core surrounded by a tapering of densities toward the edges. Setback requirements were also eliminated so that structure could be built closer together.

One of the obstacles faced in creating a pedestrian environment was the layout of much of downtown Bellevue on a superblock grid. Many parcels in central Bellevue are quite large, spanning 600 feet or more on each side, thus creating long walking distances between properties. The response to this was to create several pedestrian spines with first-floor retail and people-oriented places that could enhance the walking experience. N.E. 6th Street, which links Bellevue Square with high-rise office buildings to the east, was designated as the principal spine along which pedestrians would receive priority over cars. An ordinance was subsequently passed that requires all buildings along these spines to have ground-level retail

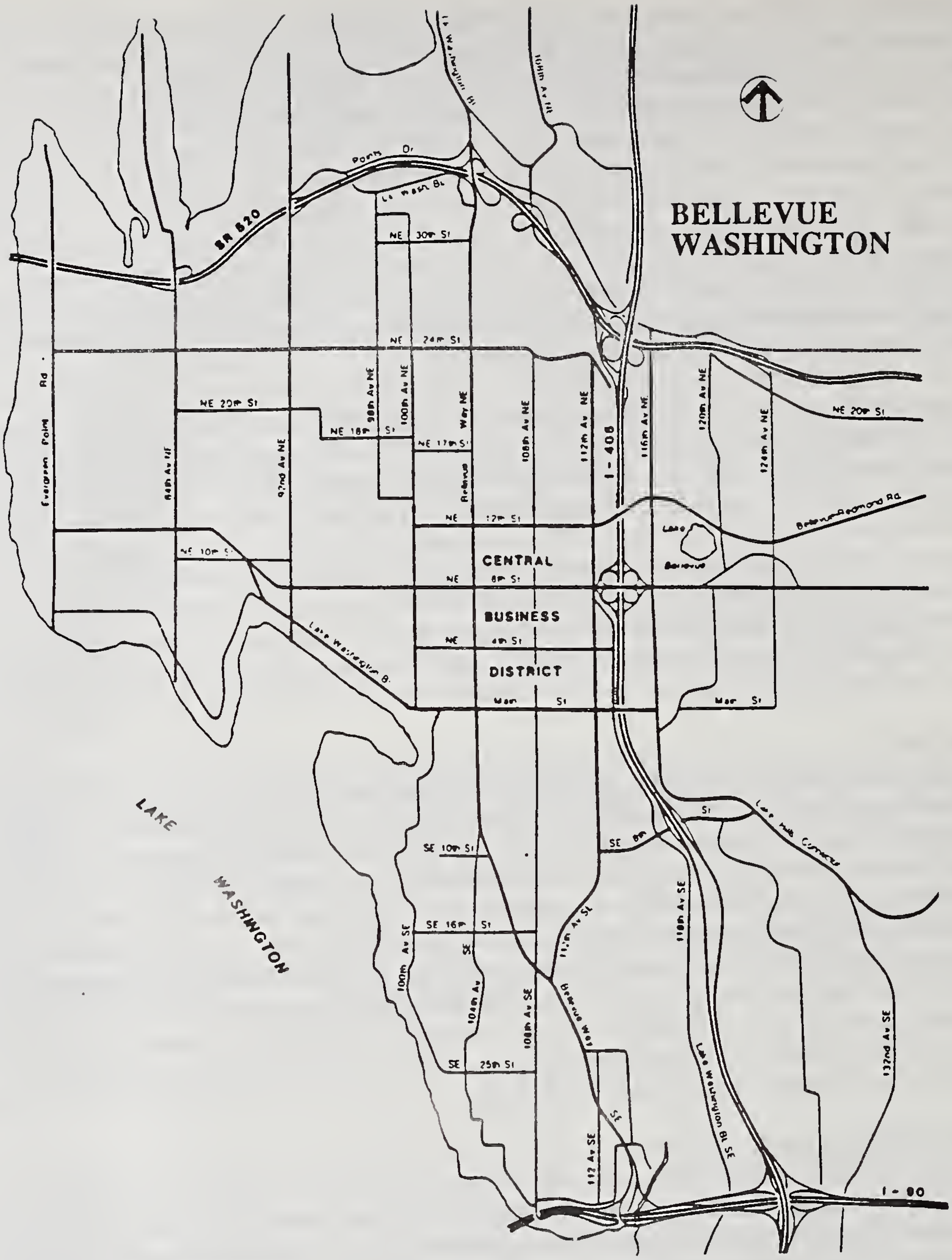


Figure 7.1 Location of Bellevue CBD

shops, office structures included. A system of "edge conditions" was also set governing the orientation of buildings to sidewalks and the massing of abutting structures. Requirements were introduced to ensure that all new buildings provide distinguishing features at the ground level, such as arcades, artwork, or architectural recesses, so as to make passageways more interesting visually. In sum, the overriding objective of these measures was to create a unified and aesthetically pleasing series of pedestrianways that would make walking through downtown Bellevue's large superblocks enjoyable.

Density Bonus System

In addition to ordinance requirements, Bellevue has enticed developers to provide pedestrian amenities and introduce mixed-use activities through a progressive system of density bonuses. Referred to as the "FAR Amenity Incentive System", developers are given bonuses as high as 10 additional square feet of building space for every square foot of amenity provided, with amenities defined as including: enclosed plazas, arcades and marquees, public sculptures, water fountains, and performing arts space. In some zones, moreover, developers can add two square feet of office space for every square foot of retail space provided. Throughout the downtown district, developers receive an 8-to-1 floorspace exchange for providing child care facilities.

Bellevue's bonus system also encourages jobs-housing balances. For most downtown zones, developers can build four additional square feet of office space for every square foot of housing provided. As a result, a 15-story residential tower was completed in 1985 and a number of other large-scale residential projects are in various stages of completion. Through this bonus system, Bellevue policy-makers hope to create a core which is active 24 hours around the clock.

While density bonuses have created a more pedestrian-oriented environment, they have also played a vital role in increasing the amount of transit services Bellevue residents and employees receive. This is because of a novel agreement entered into between the city of Bellevue and Seattle Metro, the regional transit authority, in the early eighties. The agreement outlined a schedule of Metro transit service increases that were indexed to the city increasing its employment densities and lowering its parking ratios over time. By 1984, Bellevue had earned nearly 4,000 annual hours of additional bus service. In Bellevue, higher densities and higher levels of transit service have mutually reinforced one another.

Parking Standards

The containment of parking was also considered to be essential in creating a more people-oriented environment in downtown Bellevue. Since 1981, the city has gradually reduced parking by setting both minimum and maximum allowances that fall every two years. In 1987, the code required a minimum of two spaces and a maximum of 2.7 spaces per 1,000 net square feet of office space, far below that found in most suburban work settings. The city also allows up to a 20 percent reduction in required parking for developments in mixed-use complexes that share parking. The introduction of a parking ceiling is a particularly novel feature of Bellevue's ordinance, preventing developers from following the common practice of overbuilding parking as a marketing ploy.

Other features of Bellevue's parking program are also noteworthy. Because surface parking often pushes buildings apart, thus creating an environment less conducive to walking, Bellevue officials have also introduced zoning incentives to encourage the placement of new facilities underground. Every two square feet of parking built below surface allows an additional square foot of office space to be provided. Since a typical parking stall consumes nearly as much space as the typical suburban worker, this amounts to a substantial increase in potential building space. Because of the higher cost of providing underground parking, moreover, most office developers have opted for the minimum parking requirement of 2 spaces per 1,000 square feet over the 35 percent higher maximum. Parking fees have also become fairly common in downtown Bellevue. A recent survey found that one-half of those who park in garages underneath new high-rise offices pay for parking, on average around $20 per month.

Transit Center

One of the centerpieces of downtown Bellevue is the new transit center. At the eastern edge of the pedestrian corridor, the center is the largest terminal-transfer point for the Metro system outside of downtown Seattle. Designed with six bus bays, an overhead canopy, benches, informational kiosks, and a sheltered waiting area, the center is served by seventeen transit routes. During the midday, up to twelve buses arrive and depart in synch every thirty minutes to facilitate transfers. The transit center is viewed as a vital element in creating a people-friendly suburban work environment. In light of the fact that 7 percent of Bellevue's workforce commute via transit each day, a much higher percentage than that attained by most other suburban workplaces around the country, the transit center seems to have been a worthwhile investment.

Future Development

A number of major projects currently under way promise to accelerate Bellevue's transformation to a major suburban center. One is Bellevue Place, a massive mixed-use complex that will add over 1 million square feet of additional floorspace, spread among a 21 story office tower and smaller companion, a 25 story 400-room hotel, a retail center, a restaurant, a bank, and an athletic club. As a condition of the project's approval, city officials required that a Bellevue Place transportation management program be created. The program calls for the creation of a transportation coordinator position and institution of various educational programs to promote ridesharing. The developer is also being held accountable for introducing programs that restricts single-occupancy vehicle travel to certain allowable limits at various stages of project occupancy. Another set of performance standards restricts the maximum amount of peak employee parking to 1,117 spaces. Where these maximums are exceeded, certain initiatives, such as the sponsorship of subsidized transit passes, will become mandatory.

Case Summary

In summary, Bellevue has introduced some of the most aggressive policies anywhere designed to create a rich environment of density, transit service, and pedestrian activity. A variety of density bonuses and performance standards have been introduced to ensure that future development is consonant with the objective of creating a people-friendly environment, one where the interests of pedestrians take priority over the private automobile. No other SEC in the country has sought to restrain parking as much as Bellevue. While some spillover problems are being encountered at retail centers during peak season, overall the parking containment program, along with the density incentives, seem to be paying off. Among SECs nationwide, Bellevue has one of the lowest rates of solo-commuting -- only 75 percent. One out of five currently arrive to work by carpool or vanpool. Given the city's ambitious program to harness automobile usage, if anything, the market percentages for ridesharing and transit usage should increase in coming years.

7.3 Chicago Area Case Study

Several corridors and townships have received the lion's share of office growth outside the city of Chicago since 1980. These have been: the Interstate-88 East-West Tollway between Oak Brook and Naperville; the village of Schaumburg; the Chicago O'Hare Airport area; and the Lake-Cook corridor straddling the line between these two counties, among others. (See Figure 2.8 in Chapter Two for locations.) This section discusses growth trends in these areas, along with issues related to site designs and jobs-housing mismatches.

Development Trends

In 1986, 12.7 million square feet of office space was added to the Chicago market; approximately 4 million square feet of this went downtown, while the remaining 8.7 million square feet ended up in the suburbs [Urban Land Institute, 1987]. This explosive pace of growth has wreaked havoc on many suburban roadways. Worsening traffic congestion has led some Chicago area suburbs to take more restrictive stands on new development. Several suburban communities have begun asking developers to downsize their projects as a condition of permit approval. Development trends in specific subareas are summarized below.

(1) I-88 East-West Tollway: This is an 18-mile stretch of burgeoning office development from Oak Brook on the east end to the booming community of Naperville on the west. Suburbs along the tollway have coalesced into a massive linear complex of office parks, company headquarters, R&D facilities, retail centers, warehouses, hotels, and upscale restaurants. Total office floorspace exceeds 12 million square feet along the corridor, accommodating an estimated 77,000 workers. The eastern and western poles of the I-88 corridor are quite distinct. Around Oak Brook, office buildings are fairly tall, offering an impressive array of interior and exterior amenities. The west end, near Naperville, is dotted with well-manicured office complexes, averaging much lower densities. High technology and research parks have become particularly prominent in the Naperville area.

A number of fairly large office complexes have been built along the I-88 corridor since the mid-1970s. Among the largest have been: Commerce Plaza (1.50 million sq. ft.); Naperville Office Park (1.29 million sq. ft.); Corporate West (1.25 million sq. ft.); and the Corporetum Office Campus (1.10 million square feet). Office functions are the dominant activity in most developments along the tollway, with relatively few mixed-use complexes existing. Three regional shopping malls, each with 1.4 million square feet of floor area or more, are also major trip generators along the corridor.

(2) Schaumburg: Located 26 miles northwest of Chicago near the intersection of Interstates 90 and 290, Schaumburg has experienced phenomenal population and employment growth in recent years. From 1970 to 1980, its population doubled from 50,500 to 104,000. No longer just a bedroom community, over 45,000 people presently work in Schaumburg. Current office and retail floorspace exceeds 22 million. Many office structures are class A high-rises, featuring glass-textured exteriors and atrium entrances. The largest regional shopping complex in the Chicago area, the Woodfield Mall, is in the heart of Schaumburg. Sales from the mall and ancillary businesses make Schaumburg second only to Chicago in total retail sales for the entire state of Illinois. Schaumburg has thus become a major destination for both workers and shoppers in recent years. In 1970, for instance, only 2,385 work trips were made to Schaumburg; by 1980, this figure ballooned to 34,799 work trips [Regional Transportation Authority, 1987].

(3) Lake-Cook Corridor: This corridor straddles the line between Lake and Cook Counties. Most of the growth along this corridor has taken the form of light-industrial parks and freestanding office complexes, concentrated in the communities of Deerfield and

Riverswood in Lake County and Northbrook in Cook County. Projects slated for completion by 1995 will increase employment to an estimated 45,000 workers and total floorspace to over 10 million square feet. Compared to some of the Chicago area's other growth corridors, there are relatively few retail activities along the Lake-Cook Corridor, giving rise to a workforce that is becoming increasingly automobile reliant. With an average of 4.5 parking spaces per 1,000 square feet of office floorspace along this corridor, solo-commuting has become quite prevalent, capturing around 92 percent of all work trips made.

(4) O'Hare Airport Area: Over 8 million square feet of predominantly mid-rise speculative office space was built around the perimeter of O'Hare International Airport from 1980 to 1985. Major projects in the area have included the 273 acre Forest Creek Industrial Park and the 224 acre Hamilton Lakes Business Park. The intermixing of airport-destined traffic with workers heading to nearby office complexes has overburdened major freeways in the area.

Site Design Issues

The suburbs of Chicago offer a case context where the issue of site design has received serious attention. This has been especially so along the Interstate-88 corridor from Oak Brook to Naperville. As discussed above, much of this stretch consists of independent office parks and freestanding towers that are unrelated to one another in any design sense. Buildings between parcels are typically thousands of feet apart and have few sidewalk amenities connecting them. Site layouts and circulation paths do little to roll out the welcome for mass transit vehicles. Many parks along the I-88 corridor offer few transit amenities, such as front-door boarding and drop-off areas. If a worker is motivated enough to patronize mass transit to work, typically he alights the bus off-site, facing long walking distances to his office, compounded by vast parking areas, wide boulevards, disconnected sidewalks, imposing freeway interchanges, and other physical barriers. Such physical settings create transit-hostile environments, dissuading even the strongest transit advocates from busing to work.

In recognition of this problem, the DuPage County Development Department recently formed a committee of public and private interests to look at design issues along the I-88 corridor. Model site planning guidelines were developed as part of this effort. These guidelines call for a number of site planning and design treatments that are more conducive to transit access. The overarching theme of these guidelines is to create higher densities that will form the ridership base to support transit. FARs exceeding 0.3, representing densities higher than those typically found at campus-style office parks, are recommended for new office developments in areas currently supported by transit services. Besides higher densities, the guidelines also call for the following design reforms along the I-88 corridor:

* Future buildings should be clustered, with main entrances oriented as close to the street as possible. This would limit the number of bus stops and minimize walking distances.

* Plans should ensure that site access is coordinated with adjacent office complexes and other nearby land uses. Access between office clusters, whether by frontage road, sidewalks, or side access points, should be designed to minimize travel time.

* Parking layouts should not create long walking distances between buildings and off-site land uses. Close-in, priority parking should be given to vanpools and carpools, to encourage ridesharing.

At present, these are only guidelines. However, the DuPage County Development

Commission hopes to eventually use these and other pre-established policies during the development review process of new office and commercial applications with an eye toward creating more transit-sensitive work environments.

Jobs-Housing Imbalances

The Chicago metropolitan area also represents a case context where jobs-housing mismatches have received considerable attention. Acute housing shortages near job centers have forced a growing number of workers to reside long distances from their workplaces. Much of jobs-housing imbalance can be attributed to the shortage of housing suited to the earnings of the workforce. In DuPage County, for instance, there are an estimated 6,400 more service jobs than there are service workers who live there [DuPage County Development Department, 1986]. One can infer that at least several thousand service workers are residing outside of the 332 square mile county because housing tends to be inaffordable.

Perhaps the most serious mismatches are at the eastern edge of the county near the Oak Brook axis of the I-88 East-West Tollway. This area is jobs-rich but housing-poor. Oak Brook's 1985 employment count was around 35,100, compared to a residential population of only 6,600 -- roughly five jobs for every resident [Sachs, 1986]. Consequently, the overwhelming majority of Oak Brook employees in-commute from outside the city every morning and out-commute in the evening. Figure 7.2 shows where Oak Brook workers are coming from. Workers' residences fan out in all directions. With such an expansive laborshed, freeways serving the Oak Brook area become jammed as workers converging on the area merge with traffic heading elsewhere. For instance, appreciable numbers of workers reverse-commuting from Chicago to the booming area of Schaumburg mix with Oak Brook-destined traffic along major suburban freeways such as Interstate-294; a comparison of origin-destination patterns along this corridor between Figures 7.2 and 7.3 suggest this. Thus, while the individual laborsheds of suburban centers might appear reasonably well-contained, when one begins superimposing these, one on top of the other, the congestion problems posed by thousands of workers sharing the same limited freeways to commute long distances becomes evident.

The Chicago area's jobs-housing dilemma is further revealed by recent surveys on the percentage of employees who live and work in the same municipality [Sachs, 1986]. Only 18.1 percent of Schaumburg's 1985 workforce of 32,000 resided in the community. In Oak Brook, just 2.5 percent of the 35,100 workers live there. The survey further showed that two-thirds of Schaumburg employees resided more than ten miles from their workplaces (a distance corresponding to Chicago's regional average). In Oak Brook, just over 60 percent of workers commuted farther than 10 miles each direction. The survey further revealed that employees in traditionally lower-paying manufacturing and service jobs in both places averaged longer commutes than those working in finance and administrative positions [Sachs, 1986]. Clearly, part of the jobs-housing mismatch problem around the Chicago area's suburban centers is rooted in the shortage of nearby affordable housing for moderate-salaried workers.

Besides creating traffic problems, there is some indication that these mismatches are retarding economic development and possibly reducing the job opportunities of unemployed residents of poor Chicago neighborhoods. From a survey of employers in suburban Chicago, when asked the hardest jobs to fill, clerical-support ranked the highest -- 30.6 percent of respondents felt these positions were the most difficult to fill, compared to 21.8 percent for management and professional positions [Sachs, 1986]. The same survey, moreover, found that the highest job vacancies were in clerical-support positions, which comprised 31.7 percent of total vacancies. Another study demonstrated how inaccessible suburban employment areas have become to Chicago's poor. For the 35 quartersection zones in the city with the highest unemployment rates, the average zone-to-zone travel time to major suburban employment

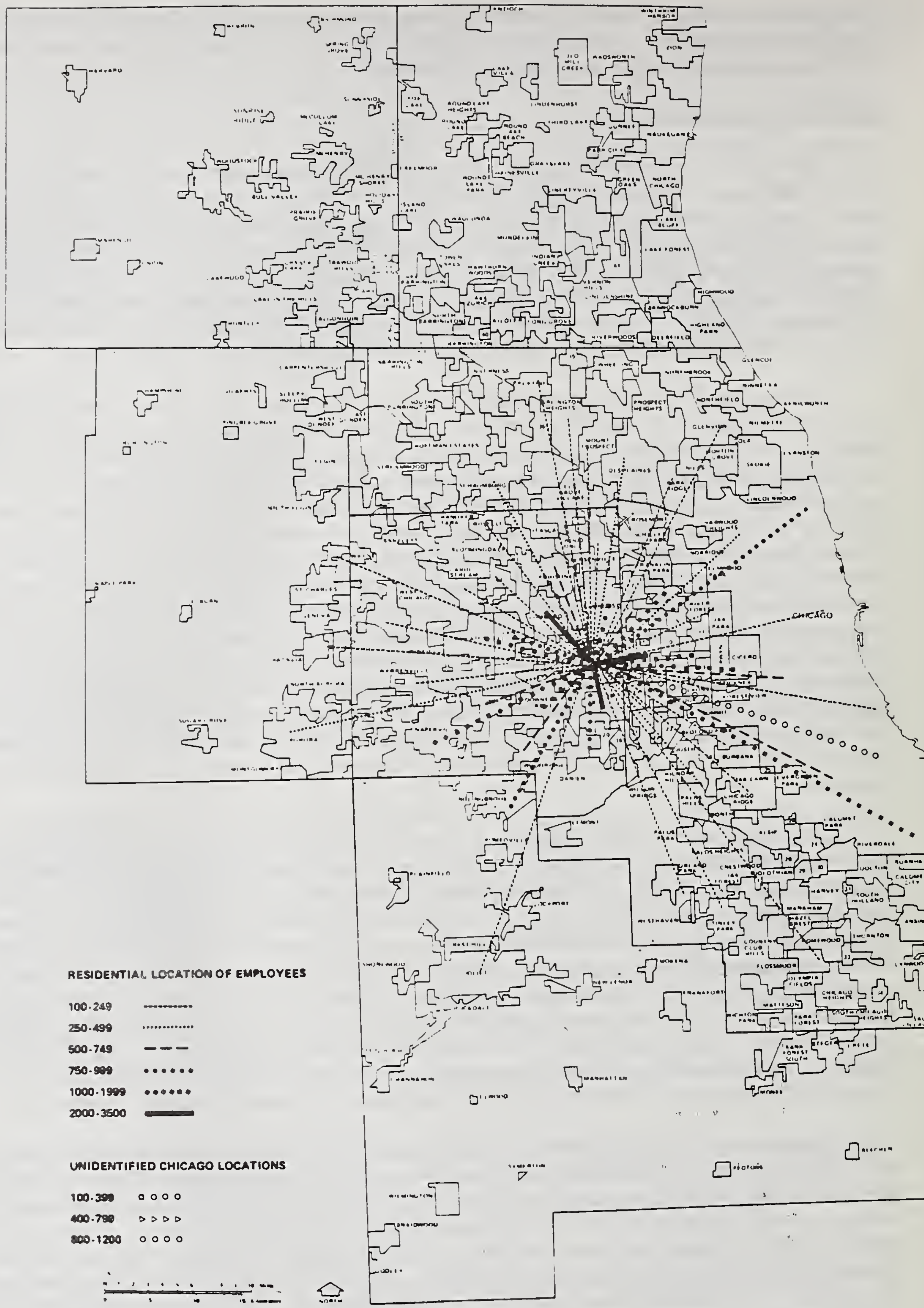


Figure 7.2 **Residential Locations of Oak Brook, Illinois Employees.**
Source: Northeastern Illinois Planning Commission [1986].

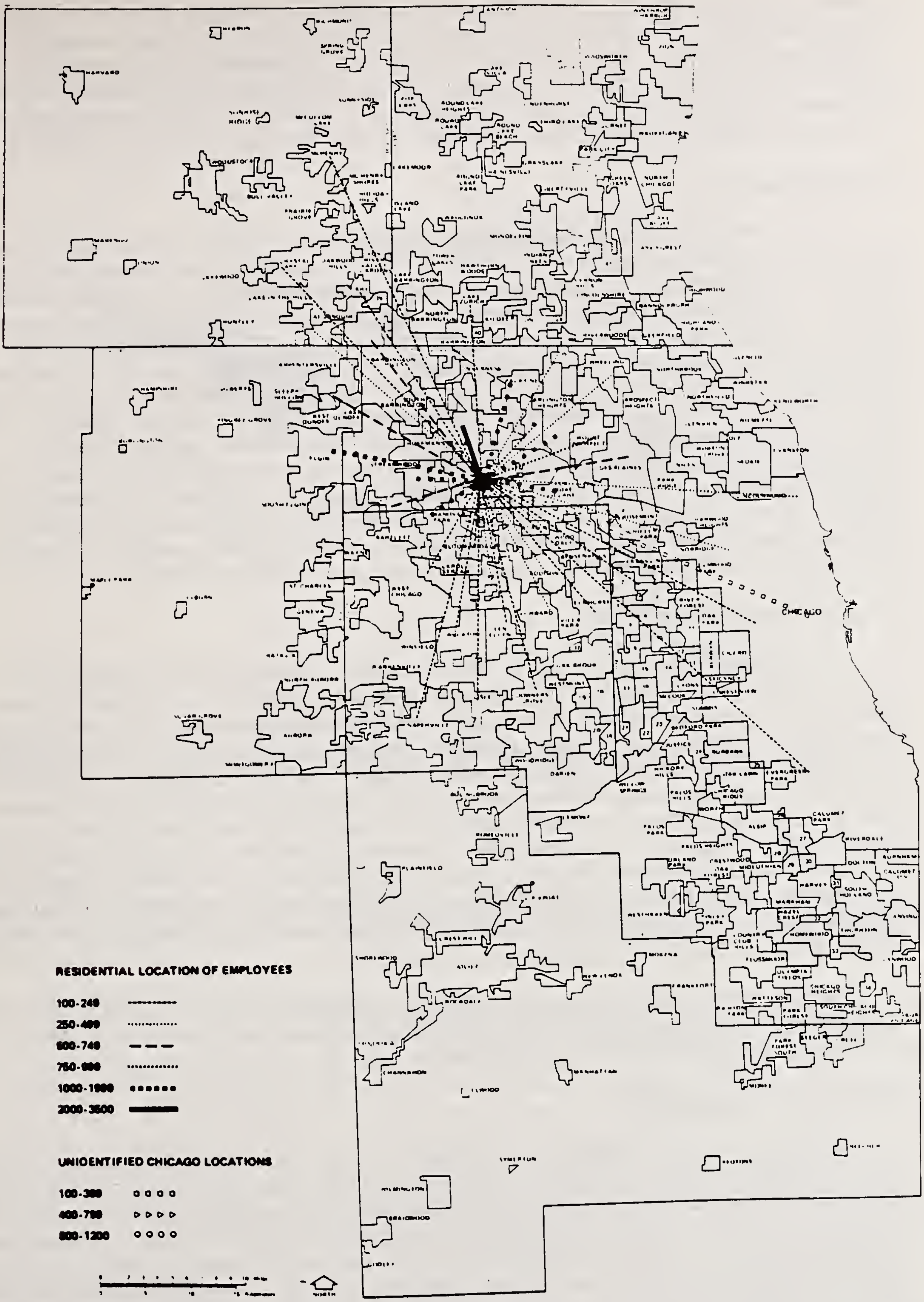


Figure 7.3 **Residential Locations of Schaumburg, Illinois Employees.**
Source: Northeastern Illinois Planning Commission [1986].

centers was estimated to be around 45 minutes in 1980 [Northeastern Illinois Planning Commission, 1984]. This travel time was found to be double the regional average for access to suburban job centers. The analysis concluded that: "individuals in high unemployment areas are already spending more than the average amount of time travelling to work; many major job sites are, for all practical purposes, inaccessible to residents of high unemployment areas by reason of excessive travel-times" [Northern Illinois Planning Commission, 1984, p. 1].

Case Summary

Office growth in suburban Chicago has generally been linear in form, aligned along major thoroughfare corridors like the I-88 East-West Tollway and Lake-Cook Road. There generally has been little coordination among independent projects, resulting in a settlement pattern of disconnected office complexes with site plans that emphasize circulation within, rather than between, developments. Site plan guidelines have been formulated to encourage closer project coordination and to promote work environments that are more transit-sensitive. Another land use problem in suburban Chicago has been severe jobs-housing imbalances in several major work centers. Surveys suggest that significant numbers of lower-salaried employees in Oak Brook and Schaumburg are priced out of the local housing market, forced to reside considerable distances from their workplaces. Jobs-housing mismatches have been recognized as a critical problem linked to growing suburban congestion, however little consensus has emerged on what to do about it. In general, the multitude of jurisdictions in DuPage and suburban Cook Counties has hampered efforts to forge any regional program that would work toward providing more affordable housing near major suburban job centers.

7.4 Houston Area Case Study

Houston is a city of centers. While the city's overall density is relatively low, under 3,000 persons per square mile, there are at least 22 identifiable high-density employment centers. The locations of some of the larger ones, including downtown, Post Oak, Greenway Plaza, and the West Houston Energy Corridor, are shown in Figure 7.4. Overall, the Houston area probably has the largest number of widely dispersed activity centers of any major city in the world. Some observers attribute this to the free-wheeling, entrepreneurial policies of local government, perhaps best exemplified by Houston's rejection of zoning as a land use planning tool. Because of few natural restrictions on growth, moreover, there is generally developable land in abundant supply in almost every direction. The possibility that the free market, unencumbered by zoning constraints and left to plow its way along a flat landscape, has given rise to high-density, well-defined employment nodes is an intriguing one that invites spirited policy debates.

This case study examines the scope of office-commercial growth in several of Houston's larger suburban activity centers. Issues related to pedestrian circulation, mixed-use development, and parking standards are covered.

Growth and Traffic Trends

Houston's booming oil economy triggered a surge in office construction during the first half of the 1980s, when over 60 percent of Houston's 164 million square feet office inventory went up. In 1985, more than three quarters (124 million square feet) of this office space was located in the suburbs [Urban Land Institute, 1987]. Post-1980 office additions have been of all shapes and sizes, featuring a potpourri of small office centers, campus-like business parks, office-commercial strips, and well-defined high-rise clusters. Many large petroleum companies opened up branch offices throughout suburban Houston during the 1980s. Several international headquarters were also built in the suburbs, notably along the Energy Corridor of west Houston. The downturn in Houston's economy following the recession of 1982-1984 has since

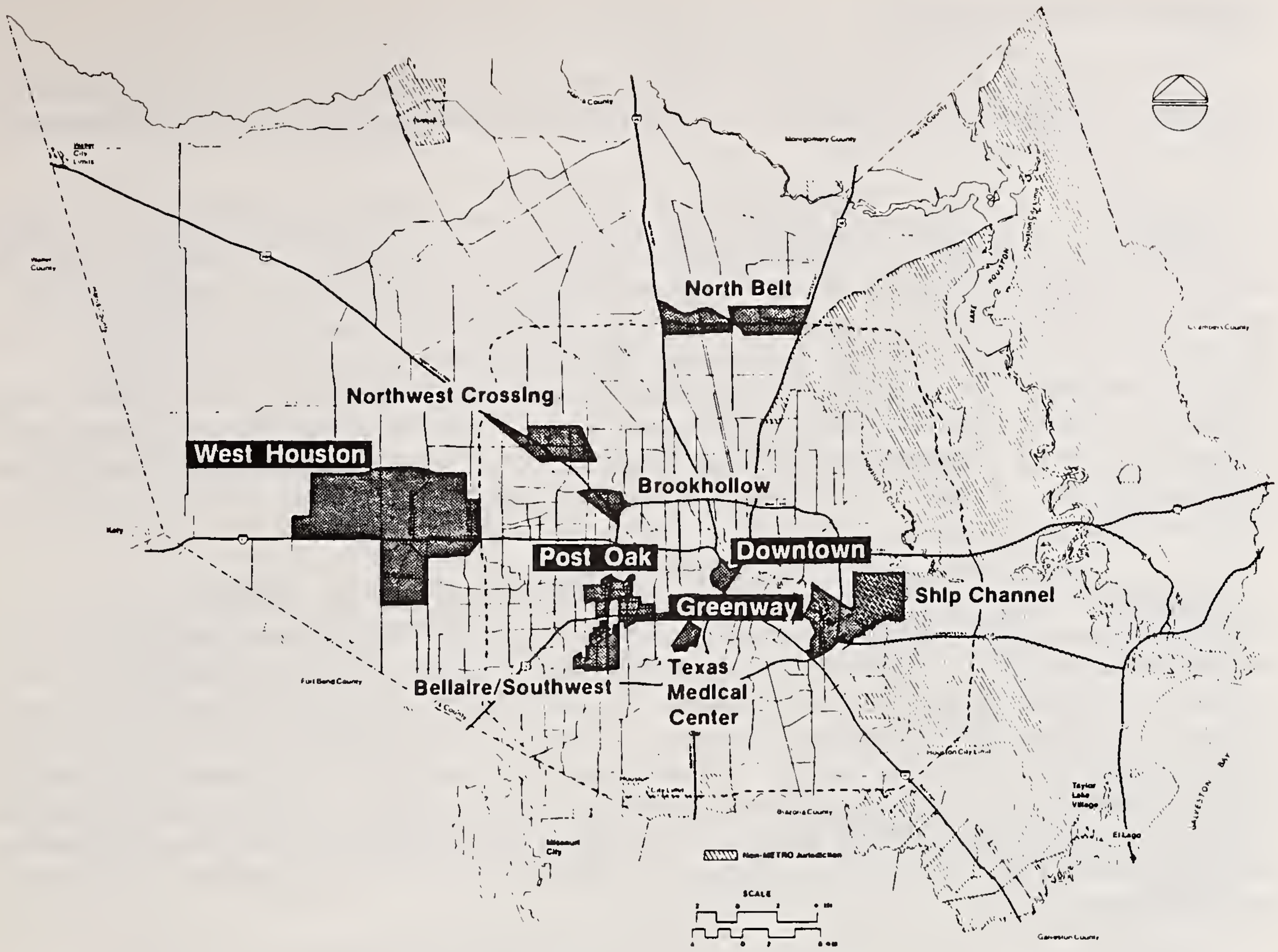


Figure 7.4 **Major Activity Centers in Houston.** Source: Rice Center [1987].

given rise to a severe oversupply situation. While office vacancy rates hover around the 50 percent mark in some areas, several million square feet of new retail space is still being added to Houston's office inventory annually [Urban Land Institute, 1987].

The rapid pace of office construction and employment growth in Houston over the past two decade has taken its toll on areawide thoroughfares. Average speeds on Houston's freeways during the afternoon peak fell from 36.6 m.p.h. in 1969 to 24.4 m.p.h. in 1979.[1] The congested period increased from an average of less than three hours in 1970 to nearly eight hours in 1980. In some areas, 12 to 14 hour rush periods are not uncommon. The Houston Chamber of Commerce [1982] has estimated that every Houstonian pays a "traffic congestion tax" of almost $800 apiece each year due to loss time, wasted fuel, and vehicle depreciation. Public opinion polls further suggest how serious the situation is. An overwhelming majority -- 53 percent -- of citizens polled in 1985 cited traffic congestion as the biggest problem facing Houston, three times the percentage of the second most frequently cited problem, crime. In response to worsening congestion, the world's most extensive system of vanpools and park-and-ride bus services can be found in Houston. Around 70 miles of restricted busways and traffic lanes have been provided along Houston freeways, part of a planned total of 209 miles when the system is completed. Still, mile-long traffic tie-ups remain common in Houston, prompting calls for growth management, even in zoning-less Houston.

Suburban Activity Centers

The varying densities and styles of office growth in the Houston area are evidenced by the variety of activity centers that exist. Five major suburban concentrations of employment are described below.

Post Oak -- The Post Oak/Galleria area six miles west of downtown Houston has come to be recognized as the largest suburban downtown in the nation, boasting 25 million square feet of office-commercial floorspace and a day-time workforce of 76,000. In recognition of its pre-eminence as Houston's second downtown, the local business association has chosen to call the area Uptown in recent years. Prominent within the Uptown area are the Galleria shopping complex, one of the nation's most celebrated fashion malls and the landmark Transco Tower, the tallest building outside of a downtown anywhere. Although Uptown resembles a downtown in terms of density and skyline, most buildings occupy a defined space and feature spacious setbacks. Because of the long distances separating many towers, the area generally has few walking trips.

Greenway Plaza -- Whereas Post Oak has evolved in a piecemeal fashion over the past several decades, Greenway Plaza, several miles to the southeast, is a master-planned development, featuring a mixture of uses spread over 13 towers of ten stories or more. The 127-acre, 5 million square feet complex boasts a luxury hotel, underground retail, 378 on-site executive condominiums, assorted restaurants, a health club, and the Summit, Houston's 18,000-seat sports and entertainment facility. Unlike other suburban centers in Houston, Greenway Plaza is architecturally unified, giving the appearance of a carefully thought-out development. Although five skywalks connect buildings, only 60 percent of surface streets have sidewalks [Rice Center, 1987]. As a consequence, many trips made within the compound and to nearby destinations are by car.

Around one-quarter of Greenway Plaza employees travel to work in a vanpool, one of the highest rates in the nation for a suburban center. The existence of a rideshare coordination office, company-sponsored vanpools, private commuter bus connections to residential areas (including the new town of The Woodlands), and the restriction on parking to just over two spaces per 1,000 square feet of floorspace have all had a part in vanpooling's success.

(3) West Houston Energy Corridor -- The entire West Houston area has experienced tremendous population and employment growth since 1980. In all, 27.8 million square feet of office space, two-thirds of which was built from 1981 to 1983, is spread over 41 business parks in an area of around 7,500 acres. Most office growth has concentrated on the ten-mile axis of the Katy Freeway (Interstate-10) shown in Figure 7.5. Since a number of world headquarters of petroleum firms line this stretch, it has become known as the Energy Corridor. Projects along this corridor are generally unrelated, with low and mid-rise buildings spread over large tracts of land. Among the major business parks are Park 10, Oakbrook, and Sundown, each offering nicely landscaped environs and class A rental space. Although most retail is internal to individual developments or else absent, two shopping malls -- West Oaks Center and Town and Country Mall -- with over 1 million square feet of space each are major trip generators in the area.

(4) North Belt -- Over twenty office parks are located near the Houston International Airport in an area known as North Belt. Office inventories total over 15.5 million square feet spread among 157 buildings, varying from single story to mid-rise towers. Most office parks in the area are master-planned and have few on-site retail services. Among the largest office complexes in the North Belt area are Greenspoint Plaza, Greenspoint Park, and Northchase. The entire north Houston area does have a substantial retail component, however. In all, over 13 million square feet of retail space is spread among 77 centers, including three large

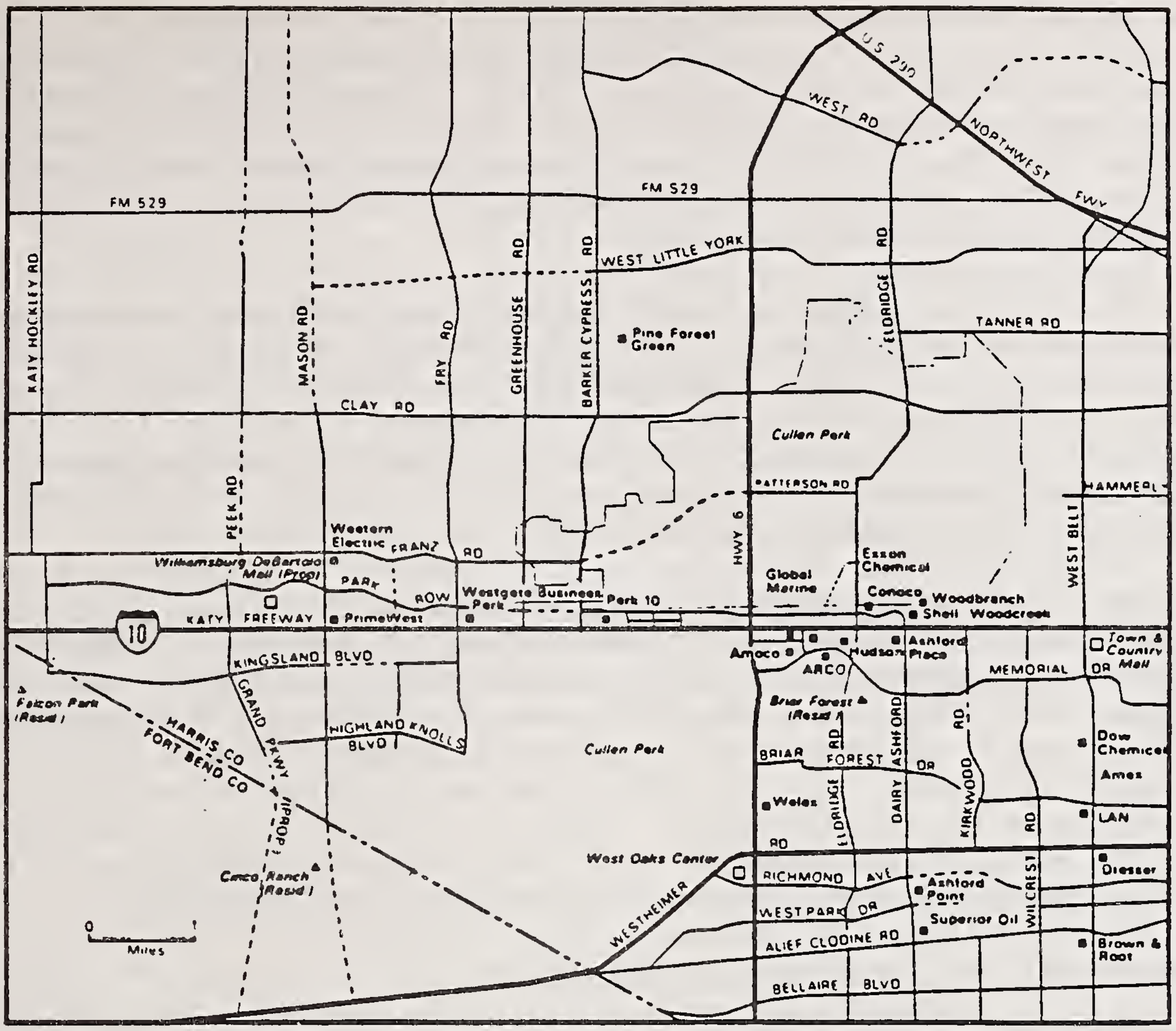


Figure 7.5 **West Houston Energy Corridor.** Source: West Houston Association.

regional malls. The 22-mile Hardy Toll Road, presently under construction, will eventually link many of the office parks and retail centers near the airport to Interstate-610 to the south and residential developments to the north.

(5) <u>The Woodlands</u> -- A master-planned suburban community 25 miles north of downtown Houston, The Woodlands has matured beyond a residential new town to become a major employment destination in recent years. The heart of the 23,000-acre development is Metro Center, a mixture of offices, light-industrial uses, and retail stores. Over 6,000 employees work in low-rise buildings surrounded by shade trees and open spaces. The Metro Center will eventually feature a technology park, a medical park, and a regional shopping mall.

<u>High Densities and Mixed-Uses in Houston's Suburban Centers</u>

Compared to most other suburban centers around the country, Houston's centers are extraordinarily dense and multi-use in character. The average heights of office buildings in Greenway Plaza and Post Oak are 12 and 24 stories, respectively. Both centers, moreover, enjoy a rich mix of office, commercial, and residential activities. In Houston, it is not uncommon to find an office tower, hotel, and apartment building standing side-by-side. Indeed, many premium-quality office complexes on Houston's burgeoning west side are surrounded by apartments, condominiums, and moderate-to-expensive single-family housing tracts. This intermingling of land uses has generally given rise to closer jobs-housing balances in outlying Houston than in many suburbs around the country. This is evidenced by the short average one-way commutes for employees of many centers. Employees of Post Oak, for instance, average oneway distances of 7 miles, while those working in nearby Greenway Plaza commute an average of 9.5 miles in each direction, both under the regional average of 10 miles [Rice Center, 1987]. The 24 to 28 percent modal shares of work trips captured by vanpools and buses in both places, moreover, suggests that higher densities have help curb worker dependency on the private auto.

The common explanation given for Houston's high nodal densities and comingling of uses is the absence of zoning controls. In Houston, planning has occurred in the guise of deed restrictions placed on the land. Deeds normally govern aesthetics, with matters such as density or land use mixture often receiving less attention. By removing land use restrictions and allowing the market to mediate suburban development, it could be argued, Houston's centers have become more heterogeneous and less segregated from residential housing than their counterparts elsewhere around the country.

While the unique affect of non-zoning on Houston's development patterns is difficult to isolate, there can be little doubt that higher densities and greater land use diversity have been net benefits from a mobility standpoint. Vanpooling's success in suburban Houston relative to other parts of the country is a testament to that. As applied in most other suburban areas around the country, zoning has been an obstacle to mixed-use development. The strict segregation of residences, offices, and commercial centers into distinct zones has become one of suburbia's trademarks. It could very well be the case that from a mobility perspective, non-zoning is preferable to the zoning ordinances of most American suburbs. Houston's experiences certainly seem to lend credence to this proposition.

Pedestrian Circulation within Activity Centers

While many of Houston's activity centers have very high densities by suburban standards, paradoxically, they tend to be ill-suited for walking. A study by the Rice Center [1987] found that only around 20 percent of non-work trips made by workers of these centers were by foot; CBD employees, by comparison, walked for two-thirds of all non-work journeys. Two factors seem to account for the difference. One, there's an undersupply of sidewalks in most suburban centers. While 100 percent of the streets in downtown Houston have sidewalks, only 77 percent of those in Post Oak do. Along the Energy Corridor, less than one out of every four miles of roadway are bordered by sidewalks. Of the sidewalks that do exist, many fail to connect together, offering pedestrians a discontinuous pathway of pavement intermixed with dirt and grass. The second deterrent to walking in Houston's suburban centers has been the vast spaces separating most buildings. Even in mixed-use centers, activities tend to be so far apart that most people find it easier to hop in their car when traveling beyond one-quarter of a mile. The lack of amenities, such as benches and canopied building fronts, has also discouraged foot travel in many outlying centers. In general, most employees of these centers are only willing to walk within their immediate complex.

The infrequency of pedestrian travel in Post Oak is particularly noteworthy given that it resembles a large downtown in so many ways. Post Oak has several distinct nodes of high rise towers, interspersed with a variety of retail shops and other mixed-uses. Most buildings, however, have been designed on the premise of vehicular access, offering few direct pedestrian connections to adjoining properties. Post Oak's long block faces, moreover, result in a high incidence of pedestrian-auto conflicts at mid-block points. In addition, heavy traffic volumes result in long waits at most signalized intersections. With 45,000 parking spaces in the Post Oak area (double that in downtown Houston) and only 3.7 percent of workers having to pay for parking, the automobile has become the mode of choice when traveling beyond 500 feet. Not only is parking plentiful and cheap in Post Oak, it is also convenient. The Rice Center

[1987] study found, for instance, that 86 percent of Post Oak workers park "zero blocks" (i.e., virtually right next to) their offices, compared to only 25 percent of downtown workers.

Perhaps epitomizing Post Oak's pedestrian-free environment is the lack of foot traffic to the Galleria, the combined mall-office-hotel complex that is Uptown's centerpiece. While everyone travels by foot once inside the Galleria complex, virtually no one walks to get there, except from the parking lot. The sea of parking surrounding the Galleria and the relative isolation of surrounding office towers has made walking simply too burdensome for many. The nearest major high-rise tower to the north, Post Oak Central, is 2,000 feet away from the main structure of the Galleria, beyond what many Americans are willing to walk even under the most favorable conditions [Rice Center, 1987; Untermann, 1984].

The Uptown Association, the "chamber of commerce" for the Post Oak area, has recognized the problems facing pedestrians trying to circulate in the area and have sought to do something about them. The current plan calls for adding new sidewalks, building mid-block skybridges, and embellishing the streetscape with benches, artwork, and other amenities. Perhaps the key policy lesson offered by Post Oak and other Houston area activity centers is that density and mixed-use developments, by themselves, are not enough to get people out of their cars, even for short distances. Unless efforts are made to contain parking and interlink buildings with suitable pathways, most suburban office workers will remain wedded to their automobiles for both long and short distance travel.

Case Summary

Houston's suburban office market has been one of the fastest growing in the country during the course of the 1980s. New office developments have generally been quite varied, ranging from low-profile parks to towering office centers. On the whole, however, suburban office development has been denser and more integrated with complementary uses than in other parts of the country. One consequence appears to be relatively high levels of vehicle-pooling and comparatively short commuting distances. One explanation for Houston's high-density, nodal style of suburban office growth is the absence of zoning. With deeds, there appears to be fewer constraints on density, building heights, and land use mixing. Despite the high-rise profile of Houston's suburbs, there tends to be relatively little pedestrian traffic between buildings, even in mixed-use environments like Post Oak. The prevalence of free parking and the shortage of interesting pathways has discouraged foot travel in many of Houston's higher density suburban centers. A useful policy lesson seems to be that parking containment and pedestrian amenities are important ingredients in reducing auto-dependency, even in a higher density, mixed-use environment.

7.5 Summary Remarks

These three cases provide a cross-section of land use and transportation issues currently affecting suburban office centers in the United States. The Bellevue case suggests what can be achieved when suburban centers are transformed to places where people take priority over the automobile. Parking containment has been a pivotal part of Bellevue's concerted program to create a pedestrian-friendly downtown. Bellevue's system of density bonuses has also been instrumental at encouraging private sponsorship of pedestrian amenities, such as public squares and steet-level retail functions. While many of Houston's suburban centers have densities that match Bellevue's, foot travel tends to be less frequent in these places mainly because the long spacing between buildings and abundance of free parking invites car traffic. Nonetheless, Houston's high suburban employment densities and multi-use environs have enticed many workers to commute via vanpools and bus transit. Finally, the Chicago case emphasizes the importance of careful site planning and jobs-housing coordination in areas experiencing strip-like development of office parks and freestanding buildings. Shortages of affordable housing near some of Chicago's suburban office corridors have displaced some workers, setting the stage for long-distance freeway commuting. Initiatives that might be taken to remedy problems such as these are discussed in the final chapter.

Note

1. The statistics in this section are estimates provided by the Transportation Task Force of the Houston Chamber of Commerce in the Regional Mobility Plan for the Houston Area, 1982.

CHAPTER EIGHT

Linking Land Use and Transportation in SECs

8.1 Overview of Research Findings

For the most part, the hypotheses posited at the beginning of this study appear to be borne out by both the empirical and case study findings of this research. SECs with the smallest shares of work trips made by the private automobile are generally relatively dense and varied in their land use make-up. Large-MXDs and sub-cities, such as Bellevue and Post Oak, were found to have particularly high shares of their workers commuting via carpools, vanpools, and buses. On-site and near-site retail services are especially important if suburban workers are to be lured out of their cars. Where such activities are absent, many workers find it necessary to drive in order to have a car handy for running midday errands, meeting a colleague for lunch, or going to the bank. Mixed-use environments also allow parking to be reduced through shared-parking arrangements. Reductions in surface parking, in turn, can shrink the dimensions of a project so as to make walking more attractive.

Many suburban office projects were found to be insensitive to the needs of pedestrians, cyclists, and transit users. Site layouts that segregate buildings and land parcels manytimes create prohibitively long walking distances. Most corridors of unrelated office projects have disconnected series of sidewalks surrounded by indistinguishable spaces. The combination of wide setbacks and separate access roads, moreover, discourage the entry of transit vehicles into these properties. Where foot travel and transit usage are relegated to a second-class status, to no surprise, solo-commuting is most prevalent. While spacious site designs enable vehicles to circulate freely once they are inside an office compound, thoroughfares which serve these developments are all too often saturated by vehicles hauling a single occupant. Many office complexes with the best on-site circulation suffer the worst off-site congestion.

Two other sources of worsening suburban congestion have been the abundence of free parking and widening jobs-housing mismatches. The provision of free, convenient parking zoned at more or less one space per employee is an open invitation for most suburban workers to drive to work. Those centers where parking is restricted and prices are charged consistently achieve the highest rates of vehicle-pooling and transit usage. The jobs-housing imbalance problem has been a significant source of the freeway congestion encountered upstream and downstream from major suburban job centers. Growing numbers of non-professional workers are being forced to live distances farther than they might otherwise because of the relatively high cost of housing near many suburban centers. In general, SECs with the most expensive nearby housing average the highest shares of moderate-salaried service workers. The farther away these workers live, the greater the likelihood that suburban freeways will become congested since more miles are logged by more people on the same few beltloops and thoroughfares.

All of these influences, it should be emphasized, do not operate independently of one another. Most suburban workplaces with low densities, for instance, also tend to have a single dominant use and an abundance of free parking. Increasing densities while retaining a surfeit of parking will likely only worsen congestion as more workers descend upon the same work area each morning. Higher densities, alone, will normally heighten congestion around suburban workplaces in the near term. In tandem with market-rate parking fees and mixed-use development, however, densification is apt to make transit and ridesharing attractive enough so as to eventually bring about a net reduction in ambient levels of congestion.

In light of these findings, the sections which follow suggest various institutional, legislative, and land use policy initiatives that offer promise for creating suburban workplaces that enhance mobility. Examples where some of these recommended initiatives are taking form are also discussed.

8.2 Institutional Responses

One of the major obstacles to forging an consensus on land use issues in suburbia is the multitude of government bodies. Most of the metropolitan areas studied in this work have a tradition of strong local control in all matters of land use planning. Unfortunately, all of the local choices made by independent bodies do not always add up to what is best for an entire region. A community's decision to convert residentially zoned land to office use in a setting where jobs far exceed housing might be in the interest of that community's balance sheet, however the increase in cross-town commuting is likely to run counter to the interests of the region at-large. Each community's land use choices might make sense at the time, but over time, they can cumulatively create problems for neighboring communities and the region as a whole. A regional focus, some argue, is necessary if spillover problems like countywide traffic jams are to be successfully dealt with.

While regional governance makes sense in theory, in reality local governments are unlikely to ever give up their control of land use decisions. Two legislative initiatives, however, could accomplish many of the objectives of regional governance by reducing fiscal disparities and competition among communities and promoting jobs-housing integration:

(1) Tax-Base Sharing. Regional sharing of municipal tax revenues could remove much of the fiscal incentive communities have to zone for commercial growth at the expense of residential development. Under tax-base sharing, certain tax revenues would be pooled at the regional level and redistributed according to a community's ratio of workers to employed residents. In principle, tax-base sharing would result in municipalities made up predominantly of industrial and commercial uses to reimburse those communities that end up housing their workers. The only U.S. metropolitan area practicing tax-sharing is Minneapolis-St. Paul, Minnesota, where local jurisdictions share about 28 percent of the region's property tax base. Under this program, local jurisdictions share tax bases, not tax dollars. Each community in the Twin Cities area must contribute 40 percent of the increase in its commercial and industrial property tax base into a metropolitan pool, which is then redistributed according to population and tax base. As a result, many more affluent communities have stopped zoning out low tax generators such as small houses [Fulton, 1987; Reschovsky and Knaff, 1977].

(2) Fair-Share Housing Requirements. Statewide requirements imposed on communities to provide a fair share of a state's affordable housing needs could narrow the gap between where suburban employees work and live. The model for affordable housing programs is the state of New Jersey's. There, a Council of Affordable Housing was formed in response to the Mount Laurel II court decision which found that most municipal zoning ordinances discriminated against low and moderate income families, de facto, by precluding affordable housing. The Council has subsequently set an affordable housing quota for each municipality based on a formula that fairly distributes the responsibility of meeting the State's need of 145,000 new affordable units by 1993. If other states were to follow New Jersey's lead, major progress could be made in ensuring that the housing being built around suburban employment centers is targeted to the earnings levels of most clerical and service-industry workers.

It is no coincidence that in both of these cases, state government took the initiative to launch these programs. Only states can prod municipalities into coordinating their growth policies. Extraterritorial sharing of tax resources likewise requires state intervention. Any significant step toward subregional land use planning and tax-sharing must clearly begin in our state capitols, be it through the passage of enabling legislation or through strong leadership.

Besides government initiatives, the private sector can help coordinate land use decisions that are in keeping with regional mobility objectives. Many SECs have business associations already in place that could serve as a vehicle for coordinating land use programs. Local chambers of commerce and trade associations could also encourage their members who develop and build offices and housing to coordinate their respective projects. Individual company initiatives can also encourage closer jobs-housing balances. In the San Francisco Bay Area, for instance, several large companies which recently moved to Bishop Ranch have offered employee relocation bonuses to encourage workers to reside close to their job sites. One company grants relocation allowances on a sliding scale, with the largest contribution going to workers who move the closest to their offices.

8.3 Legislative and Regulatory Responses

Among the instruments available to local government for encouraging more integrated land development, those which produce zoning and tax incentives would likely yield the most lasting mobility dividends. Some of the possible tools available for shaping land use changes around suburban employment centers are outlined below.

(1) Traditional Zoning. Zoning allows a jurisdiction to control the densities, uses, and platting of land. Zoning for higher employment densities, mixed-uses, and multi-family residences near suburban employment centers could reduce solo-commuting.

(2) Performance Zoning. Under this arrangement, certain standards governing the density, site characteristics, traffic impacts, and other features of a development can be pre-established. Performance zoning gives the developer considerable flexibility in designing a project as long as he meets agreed-upon standards. To the extent a developer is held accountable for ensuring that his project will not worsen traffic below level of service D, for instance, the likelihood of on-site housing units being built increases.

(3) Inclusionary Zoning. Here, developers are required to include certain activities or improvements as a precondition to project approval. Inclusionary zoning, for instance, could be used to encourage the joint development of offices, housing units, and retail services in all master-planned business parks.

(4) Conditional Use Zoning. This form of zoning sets standards and conditions to allow land uses normally prohibited in a zone. Conditions might include allowing a new office project only if it is located within a specified radius of an existing high-density residential area.

(5) Incentive Zoning. Developers can also receive bonuses, normally in the form of increased FARs, for providing certain amenities and uses. Taller office towers, for example, might be allowed if a certain number of housing units are built within the development.

(6) Transfer Development Credits. This system allows densities to be distributed among multiple projects in such a way that the high density uses are clustered together. A developer, for instance, could increase densities near employment centers by transferring density credits from areas whose densities will be kept below the allowable ceiling.

(7) Zoning Swaps. Here, the zoning classifications of two different parcels are switched to encourage a richer mixing of land. The city of San Jose, California, for instance, recently instituted a zoning swap policy by rezoning an industrial area into residential at the northern

end of the city while rezoning an equivalent residential land parcel to industrial usage. The intent of this zoning swap is to scatter employment growth, promote mixed-use development, and eventually reduce commuting distances.

8.4 Density Initiatives

Higher densities were shown to be crucial in creating suburban work environments conducive to transit and other commute alternatives. A problem encountered in a number of suburban employment areas is that office densities fall in the 0.5 to 2.0 FAR range -- in general, 2.0 is too low to support intensive transit services, yet 0.5 is high enough to create nodes of development that are congestion points [Regional Transportation Authority, 1987]. The effects of density, of course, varies in a number of contexts. In a setting where free parking encourages nearly everyone to driver, bunching workers together in a high-rise structure will only lead to traffic jams on roads leading to the building. Over time, however, if market prices for parking were charged and frequent transit services were operated, the high-rise structure could prove successful at enticing workers into buses and carpools.

This dual nature of density accounts for the varying zoning programs adopted by local decision makers in their attempts to stave off congestion. Along the rapidly developing Route 206 corridor in central New Jersey, for instance, officials of local jurisdictions have agreed to allow a tripling of current office-commercial densities in hopes of stimulating higher transit patronage. In Minnesota, on the other hand, the city of Edina brought court action to enjoin the city of Bloomington from approving a dense office project, alleging that the development would cause congestion in adjoining Edina. In Santa Clara County, California, furthermore, a special task force of elected officials from five office-industrial cities collectively agreed to limit FARs to under 0.35 when approving new developments in hopes of spreading out trip ends.

To the extent that increases in transit usage and vehicle-pooling are desired, SECs should generally aim for FARs above 2.0. This could be done through a combination of zoning strategies cited above. Transfer development credits, for instance, could be used to create a wedding cake pattern of densities, with high rises concentrated in the core of an SEC and building heights tapering off toward the perimeter. Other measures that might be considered for increasing densities include the introduction of: 1) lower right-of-way and pavement width requirements in areas where traffic volumes are modest; 2) zero-lot line developments; 3) reduced parking space dimensions; and 4) shared-use parking arrangements in mixed-use developments.

In some instances, market forces themselves are bringing about higher density suburban workplaces. At the Denver Tech Center, Perimeter Center, Tysons Corner, and several other suburban downtowns, rising land values have resulted in most one and two story offices that were built in the 1970s being replaced by new high-rise structures. In the case of the Tech Center, the original suburban-like densities of 0.25 FAR have risen to nearly 2.0 over the past two decades [Galehouse, 1984]. All future buildings in the Tech Center will range from four to 24 stories, configured into clustered villages.

8.5 Site Design Initiatives

While the affects of factors such as density and land use composition on commute choices are reasonably well understood, less is know about the relationship between site design and travel behavior. Based on this research, several guiding principles can be offered for creating SEC environments that could encourage workers to travel in some manner other than private automobile:

* Suburban office developments should have a well-defined, centralized core that serves as a focus for surrounding development.

* People-oriented activities should be placed in this core, such as restaurants, shops, and banks.

* Buildings should be sited so as to invite access between them. Self-contained, inwardly focused worksites should be discouraged.

* Setbacks between building entrances and sidewalks should be narrowed to shorten walking distances.

* On-site roads and trailpaths should link directly into off-site facilities surrounding the development.

Anderson [1986] and Potter [1984] have suggested a number of design treatments that could encourage different modes of travel to and within employment centers. Borrowing from their work, the following site practices seem appropriate for SECs.

Transit-Sensitive Designs

Mass transit operates best where the circulation network allows vehicles to be routed directly through a development without requiring extensive backtracking. This implies that roadways within SECs should be highly interconnected, avoiding branching access roads and cul-de-sacs which require buses to retrace their path on the way out (see Figure 8.1). Similarly, access to a site should be provided at two or more points to separate entrance and exit locations and improve through routing [Anderson, 1986].

To make transit usage convenient, several other design practices might be considered:

* Transit stops should be positioned to minimize the walking distance for the greatest number of passengers.

* Bus connection points should be provided near the front entrances of major buildings.

* Waiting areas should provide full amenities, including benches, all-weather protection, and passenger information.

Vehicle-Pooling Design Considerations

Carpools and vanpools essentially have the same access and parking requirements as solo-occupant automobiles. Ridesharing can be made more attractive in several ways, nevertheless. Preferential parking for vehicle-pools is important in large complexes where average walking distances from parking lots to building entrances tend to be long. Where decked parking exists, sufficient vanpool parking should be reserved at the main level and adequate overhead clearance should be provided to accommodate vans' added height. As with bus transit, canopied drop-off zones and staging areas near building entrances should be set aside for carpools and vanpools as well.

Pedestrian and Cycling Design Considerations

A separate internal circulation system for pedestrians and cyclists should be provided where possible. At mid-block junctions with major arteries, grade-separated crossings should

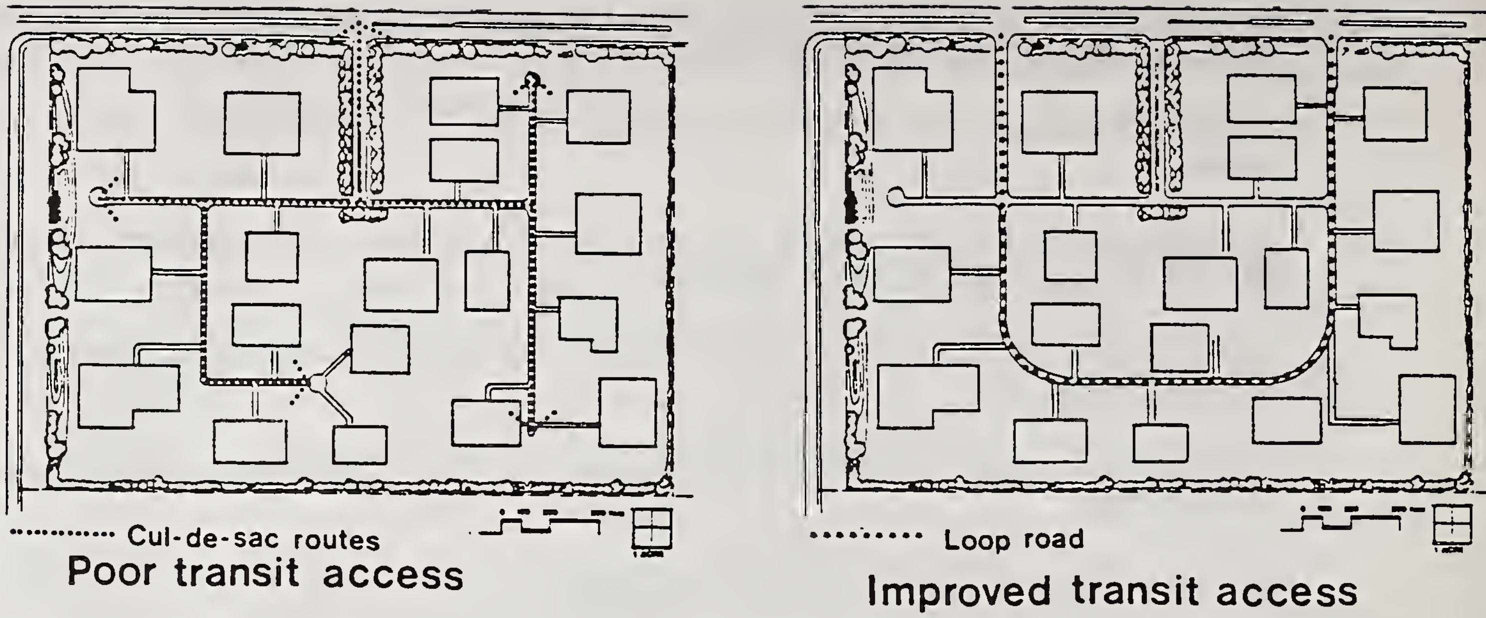


Figure 8.1 **Alternative Road Layouts Within an Office Development.**
Source: Anderson [1986].

be provided (see Figure 8.2). Paths should also be efficiently routed through adjacent parcels and between major trip origins and destinations rather than along the perimeter of a site. Attractive landscaping, adequate lighting, and assorted pedestrian amenities such as benches, shade trees, and public art can invite suburban workers to walk when they might otherwise drive.

Bikepaths are generally most appealing to cyclists when they follow curvilinear alignments and are bordered by berms, trees, and other plantings. There should also be a clear connection of an internal bikeway to the network beyond the boundaries of a site. Other on-site amenities that can encourage workers to cycle to work include secure bicycle lockers and storage areas and facilities for showering and changing into work clothes. In many mixed-use developments, health clubs offer such services.

8.6 Parking Considerations

Parking supplies have been shown to be a critical factor influencing the travel choices of workers in suburban and urban settings alike. A number of studies show that the likelihood of workers commuting via transit or some other alternative is far more sensitive to parking supply and costs than to such incentives as lower fares or improved transit connections [Meyer and Gomez-Ibanez, 1981]. While there is tremendous resistence to reducing parking supplies in most suburban settings, a number of communities have taken bold steps to do exactly that. Besides the case of downtown Bellevue, programs to contain parking are currently under way at the Denver Tech Center, the North Dallas Parkway, Warner Center, and a number of communities in central New Jersey along the Route 1 corridor, among other places. The Denver Tech Center has encouraged the retrofit of parking lots where feasible. The Center's Design Criteria manual notes that "consideration should be given to designing parking structures for future alternative uses in the event parking demand diminishes".

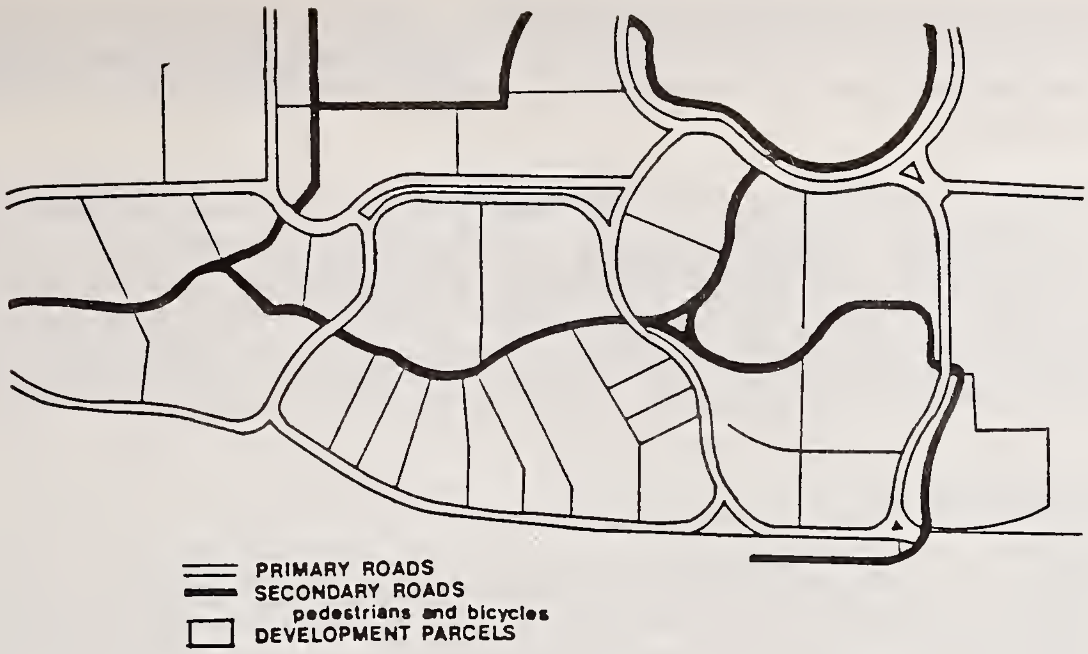


Figure 8.2 Separate Pedestrian and Cyclist Path System. Source: Anderson [1986].

Since parking facilities tend to be land-hungry, efforts to reduce their size and dimensions should be pursued where possible. Shared-parking programs are one way to shrink parking lots. In Portland, Oregon, for instance, a shared-parking ordinance offers density bonuses to uses in MXDs that are able to share parking. Another way to reduce parking's affects on site density is to put it underground. In most instances, land prices have to be fairly high to do this. Density bonuses, however, can make underground parking more attractive. As noted in the previous chapter, the city of Bellevue grants an additional one square foot of office space for every two square feet of parking placed underground. Some firms appear willing to incur the higher expense of below-surface parking on aesthetic grounds, moreover. For example, at the headquarters of a computer firm in Redmond northeast of downtown Bellevue, 1,680 parking spaces have been built beneath seven main buildings, even though all buildings are only two stories in height. As a result, a considerable volume of foot traffic flows between buildings.

8.7 Mixed-Use and Jobs-Housing Initiatives

A central finding of this research is that suburban work settings with mixtures of uses are essential if workers are to be lured out of their private automobiles. Synchronization of jobs and housing growth near suburban centers, moreover, could relieve suburban congestion by internalizing more travel within well-defined subregions.

Mixed-Use Development

Many of the zoning instruments already discussed could encourage multi-use development. Tax concessions could likewise induce such projects. Performance standards might also be introduced to create heterogeneous work environments. In Cupertino, California, for instance, a program has been instituted that encourages developers to diversify their projects. Prior to formal permit application, a developer is informed how many trip ends his project is allotted at a given time in the future. The developer can then propose whatever mixture of land uses will contain trip-making within the allotted ceiling. Since the trip generation rates applied in making the projections are considerably lower for multi-use than single-use projects of comparable size, developers have a built-in incentive to add retail, restaurants, and housing into their proposals.

Fortunately, a growing number of developers no longer need to be pushed to build mixed-use suburban projects. The market itself is encouraging this. At the Denver Tech Center, for instance, developers have decided to sell land below market price for on-site housing, child-care services, and selected retail functions in order to create a more integrated mixture of complementary uses. While losses are being sustained in the near term, developers are convinced that a more lively mixed-use work setting will prove more profitable in the long run.

Jobs-Housing Balances

Closer coordination of suburban job and housing growth can be encouraged in a number of ways. State legislation, such as New Jersey's, can require all communities to zone for some multi-family housing. State funds can also be tied to local housing policies. In the Commonwealth of Massachusetts, for instance, Executive Order 215 denies state development assistance to any community found to be unduly restrictive of housing growth. Some state initiatives, however, have been less peremptory. Connecticut distributes handbooks explaining the benefits of affordable housing to local officials. California, moreover, has passed enabling legislation which allows local governments to create zones where accessory units can be developed in existing single-family sites.

Localities can take a number of initiatives themselves to promote multi-family and moderate-income housing. Inclusionary zoning and density bonuses, for instance, could encourage new apartment construction. Tax-exempt municipal bonds could also be issued to finance housing additions. In Orange County, California, developers are required to provide 25 percent of all new units in unincorporated areas of the county at prices affordable to low and moderate-income families. Density bonuses and below-market financing raised through revenue bonds have been introduced to encourage low-cost housing production. In the communities of Costa Mesa and Santa Ana within Orange County, moreover, building permits are regulated to ensure that jobs and housing growth occur at the same pace. In both communities, the amount of commercial and industrial floorspace for which building permits are issued in any one year is set according to how much housing was built the prior year. In addition, both places require large office developers to build or contribute to the production of residential units within city limits that will house at least 20 percent of their tenants' employees. Similar office-housing linkage programs have been created in San Francisco and Boston [Porter, 1985].

Finally, as part of the development review process, localities are in a position to bargain for jobs-housing linkages. Credits against impact fee obligations, for instance, could be granted in exchange for developers agreeing to build affordable housing units within office complexes. Where no impact fee ordinances exist, jurisdictions could negotiate for such linkages as part of the permit approval process. Several California communities have taken noteworthy steps in this direction. The cities of Novato and San Rafael in Marin County, for instance, not only require that all developers of large-scale office projects build on-site housing; developers must also give employees who work in these projects the "right of first refusal" -- i.e., the chance to purchase market-rate units before they are opened to the general public. In Burlingame and Menlo Park in San Mateo County, moreover, city officials routinely negotiate with developers and employers during the project review process to give hiring preference to local residents as a means of both shortening commutes and increasing local employment. Several other California communities, in addition, sponsor skill training and referral programs to match residents to jobs.

8.8 Closing Remarks

Land use and transportation have historically shown how closely related they are to one another. The reason why most European cities are so compact, with many residents living near their workplaces, is that they evolved in an era when walking was the primary means of travel. Cities like Los Angeles and Houston, on the other hand, grew most rapidly during a period when the auto-highway system was gaining ascendancy, producing a sprawling settlement pattern. There is no reason to believe that the same kind of relationships between land use and transportation will not hold for suburban work settings as well. To the extent suburban workplaces are built primarily to accommodate the automobile, the prevalence of solo-commuting will simply reinforce the low-density, single-use character of these places. An environment where appreciable numbers of workers spend considerable time in traffic jams each morning and evening will be firmly set into place. While it is unlikely that the private automobile ever will, and perhaps ever should, fall from its reign as the dominant mode of commuting, at the same time steps need to be taken to make ridesharing, mass transit, walking, and cycling respectable alternatives. As suburbia continues to become the destination of more and more travel, it is essential that the joint influences of land use and transportation be carefully weighed when designing workplaces of the future.

In close, the reason why the planning and design of suburban workplaces is of such paramount importance is that many employment centers around the country are just beginning to take form. It is imperative that developers and planning professionals seize the opportunity to coordinate transportation and land use while many projects are at a fairly embroyonic stage and there is still time to take steps which will enhance future mobility. For once the vast majority of projects in an area are on the ground, the stage is already set for how workers will commute for years to come and the opportunities to build environments which induce workers to choose certain commuting options will become quite limited. The physical design characteristics of workplaces, it must be remembered, is one of the few areas where the public sector has direct control of through the development review process. Unlike other traffic mitigation strategies, such as staggered work hour initiatives and vanpool programs, which fall almost totally under the purview of local developers and employers, public officials can directly influence the size, scale, densities, and tenant mixes of future workplaces when plans are being designed and negotiated. To the extent that public policy-makers exercise their perogatives and work toward creating suburban environments that feature a lively mix of activities and are sensitive to the needs of pedestrians, cyclists, bus riders, and vehicle-poolers, lasting mobility dividends will accrue to those who live, work, and do business in the suburbs.

APPENDIX I

NATIONAL SURVEY ON
LAND USE AND TRAVEL CHARACTERISTICS
OF MAJOR SUBURBAN EMPLOYMENT CENTERS

Please answer all questions as fully as possible. If you are unsure about your response, please make your best estimate and indicate that it is an estimate by placing an (E) after the response.

Name of Project or Development:______________________________________

1. Land Use, Employment, and Site Characteristics of Development

1.A. Please provide information on the following **scale** and **locational** characteristics of the development:

Total land acreage ____________________

Approximate number of miles to the primary and largest downtown (central business district) in the metropolitan area ____________________

Current total square footage of floorspace for entire development ________________

Future total square footage of floorspace at build-out (final completion) of development ____________________

Expected year of project build-out (completion) ____________________

1.B. Please provide information on the following **employment** characteristics of the development:

Current number of employees in the entire development ____________________

Expected number of employees at build-out (final completion) of development ____________________

Approximate percent of workforce in the development currently employed in the following occupations:

Management	_______________
Administration and Accounting	_______________
Professional and Technical (e.g., R&D, engineering, etc.)	_______________
Clerical and Secretarial	_______________
Sales	_______________
Assembly and Manufacturing	_______________
Other (_______________)	_______________
	Total: 100 %

1.C. Please provide information on the following density and design characteristics of the development:

Average floor area ratio (i.e., ratio of floorspace to land area -- for instance, 2:1 means twice as much floor area as land area) ____________

Maximum allowable floor area ratio under current zoning ____________

Percent of land covered by buildings, on average (i.e., footprint of buildings to total land area of sites -- for example, a 33% coverage rate means one-third of land is taken up by buildings) ____________

Average front lot setback of buildings from property or site lines ____________

Average side lot set-back of buildings from property or site lines ____________

For the entire development, what are the number of stories of:
Typical or "average" building ____________
Lowest building ____________
Tallest building ____________

Please describe the "typical" building in the development (in terms of size, scale, length, depth, and general design features):
____
____
____
____
____

For the entire development, what are the approximate dimensions (in feet) of:
Typical or "average" lot ____________
Smallest lot ____________
Largest lot ____________

Please describe the general lot pattern and propinquity of buildings in the development (e.g., large, rectangular lots with buildings perpendicular and far apart; lots of varying shapes and sizes with buildings relatively nearby; etc.) :
____
____
____
____
____

Has the evolution of the development: (please check most appropriate response)
Been according to the original master plan ______
Been according to annual or periodic revisions to the master plan ______
Occurred incrementally or in a step-by-step fashion ______
Other (____________) ______

Number of different conditions, covenants, and restrictions (CC&Rs) that are affixed to the land in the entire development ____________

1.C. (cont.)

Describe the development by checking as many of the following categories that apply:

Master-planned project ____________
Campus-style ____________
Urban village ____________
Suburban downtown ____________
Business park ____________
Office park ____________
Executive park ____________
Industrial park ____________
Technology park ____________
Mixed-Use complex ____________
Speculative buildings ____________

Describe the overall design philosophy, if any, behind the project:

____
____
____
____
____
____

1.D. Please provide information on the following **land use** characteristics of the development:

Percent of total floorspace in project devoted to:

Offices ____________
Retail and Commercial ____________
Industrial/Manufacturing ____________
Warehousing ____________
Residential housing ____________
Other (______________) ____________
Total: 100%

Number of housing dwelling units currently in the development ____________________
-- Number of detached single-family units ____________________
-- Number of attached multi-family units ____________________

Expected number of dwelling units at project build-out (completion) ________________

Number of restaurants currently in the development ____________________

Number of banks currently in the development ____________________

Number of shopping clusters, retail centers,
or shopping malls in the development ____________________

1.D. (cont.)

Within a three mile radius of the development:
- Approximate square footage of retail development ____________
- Number of shopping centers or shopping malls with over 100,000 square feet of floorspace ____________
- Number of residential dwelling units ____________
  - -- Number of single-family units ____________
  - -- Number of multi-family units ____________
- Approximate purchase price of "average" or typical single-family home ____________
- Approximate monthly rental of "average" or typical apartment unit ____________

1.E. Please provide information on the following **land ownership** characteristics of the development:

Of the development's total land area, what share is:
- Owned by the developer or developers ____________
- Owned by private firms and companies ____________

Number of different property owners in the development ____________

2. Transportation Characteristics of Development

2.A. Please provide information on the following **travel characteristics of workers** in the development.

Average home-to-work travel time of employees (in minutes) ____________

Average home-to-work one-way travel distance of employees (in miles) ____________

Percent of total workforce that commutes to work by:
- Driving alone ____________
- Carpool ____________
- Vanpool ____________
- Mass transit ____________
- Walk ____________
- Other (__________) ____________

Total: 100%

Percent of workforce that participates in:
- Flexitime program ____________
- Staggered work hours program ____________
- Work-at-home program ____________

Average time of arrival of workforce in morning ____________ (a.m.)

Average time of departure of workforce in evening ____________ (p.m.)

2.B. Please provide information on the following transportation facilities and service characteristics at or near the development:

Number of freeway miles (in one direction) within
a five mile radius of the development ____________________

Number of roadway miles (in one direction) within
the development itself ____________________

Number of freeway interchanges within
a three mile radius of the development ____________________

Daily traffic volume (in one direction) of the principal freeway or
arterial that serves or leads into the development ____________________

Average level-of-service on principal freeway or arterial that serves
or leads into the development on typical weekday ____________________
(where traffic volumes as a percent of capacity are:
A = < 60%; B = 60-69%; C = 70-79%;
D = 80-89%; E = 90-99%; F = 100% or >)

Average level-of-service on major surface streets
within a three mile radius of the development ____________________

Designated or generally accepted peak hour (e.g., 7:30-8:30 a.m.):
-- For morning peak ____________________
-- For afternoon peak ____________________

Percent of daily trips by workforce in the development that occur during:
-- Morning peak hour ____________________
-- Afternoon peak hour ____________________

Typical or "average" number of parking spaces in the development:
-- Per 1,000 gross square feet of floorspace ____________________
-- Per employee ____________________

The current parking ratios in the development are: (check whichever apply)
-- Below the ratios found at comparable developments in the area __________
-- At or above the ratios found at comparable developments __________
-- Below maximum zoning requirements ____________________
-- Above minimum zoning requirements ____________________

Number of mass transit bus runs that operate during the main peak hour:
-- Within the development ____________________
-- Within a three mile radius of the development ____________________

Average daily ridership of bus service(s) that
operate(s) within the development ____________________

2.B. (cont.)

Do the owners of the development operate or support: Yes No
-- A shuttle or circulator within the complex ___ ___
-- Commuter bus runs outside the complex ___ ___
(If yes to either, please describe: ____________________
____
____
____)

Number of privately owned and operated subscription or commuter buses that serve the development daily ____________

Number of companies in the development that provide vans for their employees as part of a formal vanpool program ____________

Current number of company-sponsored vans that serve employees in the development ____________

Within the development, is there: Yes No
A designated rideshare coordinator ___ ___
A special office for rideshare coordination ___ ___
A separate, internal bikepath system ___ ___

3. Survey Respondent Information

Title or position of respondent ____________

Name and phone of possible contact person ____________________

THANK YOU FOR YOUR TIME AND ASSISTANCE

**** Please return the questionnaire in the stamped, return envelope ****

APPENDIX II

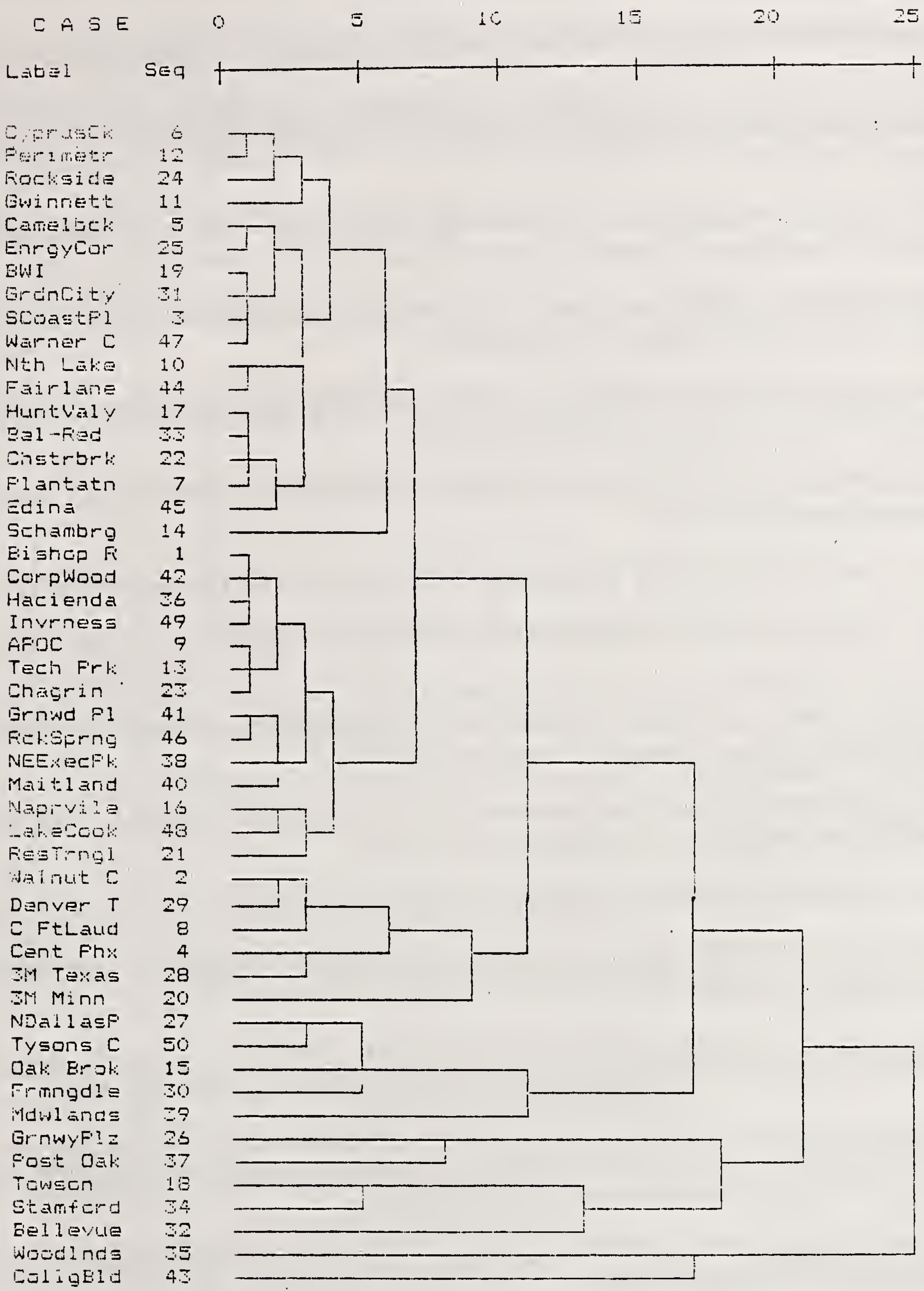
Cluster Analysis Summary

This appendix briefly discusses the empirical results for the cluster analysis of SECs summarized in Chapter Four, section 4.3. Changes in the coefficients (i.e., squared Euclidean distances) from one step of grouping to another formed the basis for deciding at what stage to stop merging clusters. For instance, the two SECs that were paired at the first stage to form the initial cluster were Bishop Ranch and Corporate Woods since they had the lowest distance coefficient -- 0.0875. The second stage involved the grouping of BWI and East Garden City, whose distance coefficient was 0.123. This process continued, with coefficients getting larger at each step. Between the 42nd and 43rd stages, the coefficients rose from 6.69 to 6.88, a modest 2.8 percent increase. Between the 43rd and 44th stages, there was a marked increase in the coefficients from 6.88 to 8.38, a 21.8 percent jump. The sharpest rise, however, was between the 44th and 45th stages, whereby the coefficients rose 32.3 percent, from 8.37 to 11.08. At this stage, the coefficients were getting comparatively high, nearly two-thirds more than what they were just two stages earlier -- an indication that the merging process should cease. This was confirmed by the fact that the coefficients increased by less than one-tenth of one percent between the 45th and 46th stages.

Table A.II presents the dendrogram produced from this analysis. The dendrogram, which is read from left to right, portrays the formation of clusters in sequence, scaled so that distance coefficients fall between 0 and 25. Vertical lines denote joined clusters. The position of the line on the scale indicates the distance at which clusters were joined. Since many of the distances at the beginning stages are similar in magnitude, it is difficult to tell the sequence in which some of the early clusters are formed. (For instance, it is clear that Bishop Ranch, Corporate Woods, Hacienda, and Inverness combined early to form a cluster, however exactly at what stage this occurred is not discernable). More relevant, however, is the the formation of clusters at the later stages (i.e., the right side of the dendogram) since this is where the cut-off is usually set for merging clusters. All clusters formed after the normalized distance score of 15 were ignored. This meant that some of the more idiosyncratic cases (e.g., The Woodlands) that entered in the far late stages had to be judgementally assigned to a cluster. This was generally done so that these cases fell within the ranges of some of the key density and size variables for a group. Additionally, in order to ensure that the final groups had roughly comparable numbers of cases, in several instances large clusters that had merged in fairly early stages were separated, in one case below the normalized coefficient of 8. Thus, as used in this study, cluster analysis, in and of itself, is not an end result. Rather, it is helpful for providing an overall framework for grouping cases. When combined with one's best judgements, it provides a useful foundation for generating interpretable clusters.

Table A.II

Dendrogram of Cluster Analysis of 57 SECs



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