NETWORK ACCESSIBILITY & THE EVOLUATION OF URBAN EMPLOYMENT

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FINAL REPORT

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Disclaimer

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Abstract

This research examines the impact of accessibility on the growth of employment centers in the Los Angeles Region between 1980 and 2000. There is extensive empirical documentation of polycentricity – the presence of multiple concentrations of employment – in large metropolitan areas. However, there is limited understanding of the determinants of growth of employment centers. It has long been held that transportation investments influence urban structure, particularly freeways and airports. Using data on 48 employment centers, we test the effects of various measures of accessibility on center employment growth: network accessibility and two measures of labor force accessibility. We also test the relevance of access to airports. We find that after controlling for center size, density, industry mix, and location within the region, only labor force accessibility is significantly related to center growth.

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1 INTRODUCTION

1.1 Project Objective/ Summary Problem Statement

It is becoming increasingly clear that major cities in the U.S. have become polycentric (McMillen, 2003). What is less clear are the determinants of growth in these nodes of concentrated employment outside the traditional city center. Recent research by Giuliano and Redfearn (Giuliano et al, 2007; Redfearn, 2007) inventories an extensive set of employment centers within the five-county region that makes up the Los Angeles Consolidated Metropolitan Statistical Area and tracks their growth over three time-periods: 1980, 1990, and 2000. Giuliano et al find that the locations of these employment concentrations have remained remarkably stable over this twenty-year sample period. During this period, however, the amount and density of employment has changed substantially. Employment and employment density have grown more rapidly in the suburban and exurban centers – but at an uneven rate among them. The importance of the region's highway system is made clear by the fact that essentially every center is located adjacent to at least one major freeway, with many centers located at the intersection of two or more. The question we address is the extent to which differential employment growth across centers can be explained by the quality of local access to Los Angeles' extensive transportation network.

1.2 Background and Motivation for Research

It has been understood for some time that cities are the engines of economic activity in developed countries. What is less well understood is the location and growth of economic activity within cities themselves. Theoretically, the same factors that are initially responsible for the formation and growth of Central Business Districts (CBD) now contribute to the growth of employment concentrations outside downtown. These include accessibility to qualified workforce, transport networks, local infrastructure, favorable government policies, and the investment decisions of private developers, among others.

There is an extensive literature documenting the polycentricity of large U.S. metropolitan areas such as Los Angeles (Giuliano and Small, 1991, 1993; Small and Song 1994; Forestall and Greene 1997; Giuliano et al, 2007; Redfearn, 2007) and Chicago (McMillen and MacDonald 1998, 2000), among others. There are, however, relatively few systematic studies investigating the determinants of growth of employment centers at certain locations within metropolitan areas.

Forstall and Greene (1997) argue that employment centers in the Los Angeles CMSA have evolved from long established activity centers that have grown or expanded over time and are not necessarily new developments (Irvine being the only exception). Their conclusion implies that there is historical path dependence in the formation of employment centers. Giuliano and Small (1999) investigate a series of hypotheses concerning growth of employment within subcenters, including labor force accessibility and accessibility to the freeway system. They do not however find statistical evidence in favor of either. They concede that "good accessibility to labor force and good highway access were so prevalent" across the Los Angeles metropolitan area that these forces "did not exert any discernible effects on differential growth rates of subcenters" (p 190). Their conclusion is that "unique location factors, including zoning and fiscal policies as well as airport access and land availability may be more relevant" in explaining intra-metropolitan spatial trends (p 199).

There are four reasons to revisit the connection between network accessibility and intra-metropolitan employment growth. First, there is reason to believe that previous metrics of accessibility insufficiently captured the variation in access across locations. Second, recent research has provided a new inventory of employment subcenters that is both more complete and covers a longer period of time. Third, this new panel data spans what some consider two distinct economic epochs in Southern California with the first – from 1980 to 1990 – representing the last of an era of manufacturing – and the second – from 1990 forward – being characterized by recovery and adjustment and the emergence of the service sector as a mainstay in the economy. Differential demand for access to transportation networks may vary substantially over these two epochs. Lastly, with so much evidence that transportation networks matter for location choice, the Giuliano and Small results seem counter-intuitive and beg for a second look – either to further support the thesis that the ubiquity of highways implies little spatial difference in access across a major metropolitan area or to find new evidence that access does, in fact, matter for economic growth.

1.3 Organization of Report

The remainder of this report is organized as follows. Section 2 presents a literature review on employment centers, growth, and accessibility. Section 3 presents our research approach, methodology, and data. Section 4 describes trends in employment center growth and transport access, and presents our empirical analysis. The last section summarizes results and discusses remaining questions for further research.

2 LITERATURE REVIEW: Employment Centers, Growth, Accessibility

2.1 Theories Regarding Accessibility and Urban Form

There is extensive literature explaining the evolution of metropolitan spatial structure in economic terms (for example, Mills, 1967; Fujita 1989). Existence of an employment center, such as the central business district (CBD), is explained on the basis of economies of scale in production (agglomeration economies) and diseconomies in transportation and congestion. It is argued that firms locate inside employment centers to benefit from external economies of scale, both pecuniary and technological, of locating in spatial proximity to other businesses, for example access to a large skilled labor pool, knowledge spillovers, and input sharing.

2.1.1 The Standard Model

The standard urban model assumes a single employment center, and distributes households based on trade-offs between housing and commute costs (see Anas, Arnott and Small, 1998 for a summary; Fujita, 1989 for a comprehensive synthesis). The model predicts declining and constantly decreasing population density with distance from the city center. Population density declines with distance, because unit housing costs decline, and therefore households consume more housing. The model also predicts commuting patterns: the average commute trip distance is equal to the mean distance of total population to the center. If housing demand elasticity varies across households, those with stronger preferences for housing will locate further away from the center. And if these preferences are related to income, lower income households would locate closer to the center while higher income households would consume more housing and locate further away. If transport costs decline, more housing is consumed, the city expands, and the density gradient declines.

Empirical evidence tends to support standard theory. Population density does decline with distance from the city center, and the population density gradient has declined over time (Anas, Arnott and Small, 1998; see section 3.2 below). Lower income households tend to live near the city center and have shorter commutes, while higher income households are more likely to live in the suburbs (Mieskowski and Mills, 1993).

2.1.2 Employment Centers

One of the major criticisms of the standard model is that metropolitan areas are no longer monocentric. Some argue that contemporary metropolitan areas are polycentric; others argue that they are best described as dispersed, or without significant employment concentrations. Whether or not employment concentrations exist depends on the extent of agglomeration economies and the scale at which they work. If agglomeration economies exist at the sub-metropolitan level, we should observe one or more clusters of employment, which we will call employment centers.

What are the factors that lead to multiple employment center formation? To the extent that agglomeration benefits outweigh agglomeration diseconomies, such as traffic congestion, high land rents, etc., firms would continue to locate inside the existing centers. Over time, however, an existing center may grow to a point where the negative externalities of locating inside it outweigh the benefits, at least for some firms. As firms seek locations outside the existing centers, agglomeration benefits could lead to the emergence of employment centers at other locations. Indeed formation and growth of employment centers can be expressed as an outcome of the interplay between the centrifugal forces of decentralization and the centripetal forces of agglomeration (Anas et al 1998). Indeed these forces may vary widely by industry and function. London and New York may concentrate as globalization progresses and more headquarters seek to locate near other headquarters. At the same time, second tier metropolitan areas may experience declining concentration as both manufacturing and front-office activities relocate to other areas.

Researchers have suggested several theories regarding emergence and growth of employment centers subsequent to the CBD. One set of theories is based on traditional arguments of economies of scale in production and diseconomies in transportation and congestion (Helseley and Sullivan, 1991). Chen (1996) proposes that an exogenous change in transportation technology that lowers transport cost, and a drop in agglomeration economies that loosens ties to the CBD may lead to the formation of an employment center.

Another view is that employment centers emerge as a result of the decision making of local governments, including tax policy and land-use policy (Fujita, 1989; Sullivan, 1986; Zhang and Sasaki, 1997, 2000). A competing view is that private developers facilitate migration of firms, and hence play an important role in the creation of employment centers (Henderson and Mitra, 1996). Private developers may enlist the support of the city (Wieand, 1987), or their independent decisions may lead to center formation (Brasington, 2001).

Some theorists ascribe center formation to location decisions of large firms. According to Fujita and Thisse (2002) an employment center may emerge when a large firm moves to a distant location away from the CBD. The large firm moves far enough to take advantage of lower land rents and cheaper labor, but close enough to the CBD to take advantage of information flows and other urbanization economies. Additionally, location of a firm may also depend on idiosyncratic preferences of entrepreneurs, knowledge-workers, chief executive officers, or others involved in decision making (Anas et. al. 1998).

In sum, the central tension in determining urban structure is the relative strength of economies and diseconomies of agglomeration. Although much else has been introduced in the literature in terms of factors influencing employment center growth, access to labor force remains one of the key theoretical determinants of emergence of employment centers.

One way of measuring the effects of "access to labor force" on employment center growth is in terms of its "accessibility." Accessibility is a measure of how easily a spatial object or activity at location *i* can be reached by another object at location *j*. Giuliano (1995, p3) notes that "as contact between two places becomes cheaper in time and money, accessibility increases. The propensity for people to interact with others at a distance increase as the cost of access decreases." Hence, higher accessibility should translate into higher agglomeration benefits, thereby facilitating employment center growth.

2.2 Employment Center Growth

The empirical literature on employment center growth is surprisingly limited, mainly due to data limitations. The primary source for historical employment data is the Bureau of Economic Analysis (BEA), which has collected county level data since 1969. Counties are too large for analysis of intra-metropolitan spatial trends. Commuting data was collected by the US Census starting in 1960 as part of the long form survey. The Census Transportation Planning Package (CTPP) uses the commuting data to generate estimates of jobs by local area (transportation analysis zones or census tracts). However, these data are subject to several sources of error: the long-form sample is based on population characteristics, not employment; place of work responses may be unclear or incomplete; reported travel times or distances may be inconsistent, methods for aggregating the sample to the regional population may have problems, etc. Nevertheless, most studies of intra-metropolitan employment utilize the CTPP data.

2.2.1 Intra-metropolitan spatial trends

Lee, Seo and Webster (2006) examine employment trends, specialization and commuting patterns of 12 US CMSAs to investigate historical changes in metropolitan spatial structure, 1980 – 1990 using US Census data. They compared growth trends inside and outside of the central city. Employment shares in the central city vs outside the central city differed across the sample, but in all cases the total central city share declined. For example, in all CMSAs where manufacturing jobs declined, the decline was greater in the central city than outside. Other studies have examined commuting patterns to compare changes in the distributions of population and employment (recent studies include Horner, 2007; Yang, 2008).

Far more numerous are studies of population distributions over time. Because of the wide availability of population data across metropolitan areas and time intervals, estimates of the population density gradient have been the most common approach for examining the evolution of urban spatial structure. The consistent result of these studies – conducted for cities around the world and for time periods dating back to the 19^{th} century – is lower average density and flatter gradients over time, consistent with reduced transport costs and rising per capita income (see McDonald, 1989, for a summary).

2.2.2 Employment centers

Empirical study of employment centers requires that they be defined and identified. In economic terms, an employment center is a cluster of activity of sufficient magnitude to influence land prices and hence spatial form. In the case of a single center, identifying the center is trivial (the zone with highest land value per unit, or highest density). In theory, identifying centers in a polycentric area is also straightforward: any cluster that *independently* influences land values constitutes a center. The reality of metropolitan areas is far more complicated. Metropolitan areas have many clusters of employment, from isolated suburban office parks to the downtown. These clusters follow a variety of topographies – including natural and economic geography; neither of which is readily parameterized into circles or ellipses. In some cases major freeways define linear concentrations, in others a cluster might be broken up by a river or canyon. It is therefore not surprising that in empirical research employment centers have been defined in many different ways.

In one of the earliest works on employment centers, Cervero (1989) described “subcities” as “like downtowns in their densities and land-use mixtures,” “secondary office and retail centers within their respective metropolitan markets” (page 80). Cervero’s subcities included locations like Post Oak Galleria in Texas and South Coast Plaza in California. Garreau (1991) names the emerging new centers that are far from the CBD ‘edge cities.’ To qualify as an edge city, a settlement must satisfy five conditions: 1) at least 5 million square feet of rental office/commercial space; 2) at least 600,000 square feet of rental retail space; 3) more jobs than bedrooms; 4) perceived by people as one place (has a distinct single identity); and 5) was nothing like a city 30 years ago. Garraeu describes Tysons Corner, Virginia as an archetypal edge city.

Others have taken an urban economics approach and developed various methods based on employment density and related factors. Giuliano and Small (1991), identify an employment center as a set of contiguous analysis zones[1] such that each have a certain minimum employment density ***D*** and together have a certain minimum total employment ***E***. In the same study they used values of 10 jobs per acre and 10,000 jobs for ***D*** and ***E*** in a case study of Los Angeles.

McMillen and McDonald (1997) adopt a nonparametric procedure, using locally weighted regression (LWR) estimates of employment density. McMillen (2001) proposes a two-stage non-parametric procedure. McMillen and Smith (2003) combine the McMillen (2001) and Giuliano and Small (1991) methods described above. The McMillen (2001) method provides a list of potential employment center sites, which includes all tracts with significantly positive residuals. An employment center is then defined as a group of sites from this list that are contiguous and for which total employment exceeds 10,000. Using TAZ level employment data from the 1990 CTPP, they produce an exhaustive list of employment centers for 62 metropolitan areas. Lee (2007) used a modified McMillen and Smith method, as well as the Giuliano and Small method to identify centers in 1980, 1990, and 2000 for selected metropolitan areas, also using CTPP data.

Finally, Redfearn (2007) utilizes spatial econometric techniques to generate a smooth employment density surface, identify local maxima on the density surface (which are potential center candidates), and then utilizes an iterative procedure to cluster Census tracts, maximizing the mean average density differences between the clusters and the tracts that surround them. He then uses several statistical tests to confirm that the centers are significantly more dense (with regard to employment) from their surroundings. Presence of employment centers, however defined, is demonstrated across varying metropolitan area size, age, location, and growth rates.

Just two employment center studies examine trends over time. Lee (2007) used CTPP data for New York, Los Angeles, Boston, Portland, San Francisco and Philadelphia. He identified centers using a combination non-parametric and parametric method, and then compared shares of employment inside and outside the CBD and all centers. Comparing 1990 and 2000, CBDs lost employment share, and centers outside the CBD lost employment share in all metro areas except Los Angeles. Lee's study does not examine factors associated with growth or decline of centers.

Using 1970 and 1980 data, Giuliano and Small (1999) empirically investigate a series of hypothesis to explain the determinants of growth of employment centers (between 1970 and 1980) in the Los Angeles region. Their hypotheses are related to 1) economic productivity; 2) labor force accessibility; and 3) access to the region's transportation facilities. As noted earlier, they found no significant relationship between center growth and accessibility to labor force or access to the highway system. They did, however, find evidence that proximity to large airports influences urban center formation.

In his doctoral dissertation, Agarwal (2008) empirically examines the determinants of employment center growth. Using 1990-2000 data from the Los Angeles region, he tests a series of hypotheses re the role of local governments in employment center growth. He uses the Giuliano and Small (1999) measures as his control variables. Using measures of both growth

[1] Analysis zones are spatial units approximately the size of census tracts.

controls and growth promotion, he finds no significant relationship between local government policies and employment center growth. However, in contrast to the Giuliano and Small (1999) study, Agarwal finds economic factors including agglomeration economies, labor force accessibility, and proximity to a major airport are all significantly associated with employment center growth. He suggests that the emergence and growth of employment centers appears to be a part of the larger decentralization phenomenon. Firms value access to the labor force and hence jobs follow people. As population decentralizes, so do jobs.

Our understanding of how and why employment centers emerge, grow and decline remains limited. The few studies conducted to date provide conflicting evidence.

2.3 Accessibility

The focus of this research is the role of accessibility in employment center growth. What does "accessibility" mean, and how might it be measured? Most generally, accessibility refers to the ease of movement between places. Accessibility measures how close one location is to another, and what opportunities exist at these locations. As movement between places becomes less costly, either in terms of money or time, more interaction will occur. Hence the capacity and structure of the transportation system affects accessibility.

Accessibility also includes the concept of attractiveness, meaning the opportunities or activities located in a given place. Giuliano (2004) states, "…..we can define accessibility as the attractiveness of a place as an origin (how easy is it to get *from* there to all other destinations) and as a destination (how easy is it to get *to* there from all other destinations)." (p. 240). Thus spatial interaction is a function of both the transport system and the geographic distribution of activities. "Opportunities" is an amorphous term; it could include access to labor force, goods and services, jobs, amenities, transportation nodes (e.g. airports, train stations), etc.

In its simplest specification, accessibility between two locations *i* and *j* can be expressed as a function of the Euclidean distance between location *i* and location *j*:

$$A_i = \sum_j f(d_{ij}) = \sum_j e^{-\beta * d_{ij}} \qquad (1)$$

Empirical studies show that the distribution of interactions between a given location *i* and other locations *j* follows a negative power function, in which an impedance parameter β is usually calibrated using observed data. The sum of the negative power functions from location *i* to all or one set of other locations *j* is the accessibility for location *i*. The shorter the distance from *i* to *j*, the higher the accessibility of *i*.

This base specification could be modified for measuring different types of accessibility, which can be categorized into four broad groups: 1) network accessibility, 2) place accessibility, 3) individual accessibility, and 4) comprehensive accessibility. Comprehensive accessibility is a combination of two or more of the first three categories (Table 1).

2.3.1 Network Accessibility

Transport network accessibility measures the ease of accessing all other points (*j*) on the transport network from location *i*. Network accessibility measures do not take into account activities or opportunities – the generators of travel. To measure network accessibility, in the base specification (1) described above, travel distance *d* (the impedance measure) could be replaced with travel time, or generalized travel cost, or even the number of nodes between *i* and *j* in the network.

2.4.2 Place/Activity Accessibility

Place, activity, or individual accessibility can be measured by assigning appropriate weights to $f(*)$ in the base specification (1) described above.

$$A_i = \sum_j f(d_{ij}) \times w_j \tag{2}$$

The assigned weight is a relevant attribute of j, e.g. labor force accessibility is often measured by the sum of $f(*)$ weighted by the population of each j.

$$A_i = \sum_j f(d_{ij}) \times P_j \tag{3}$$

For certain types of accessibility, the effects of competing opportunities or destinations need to be considered as well. The idea of competing effects came as early as the 1940s when Stouffer first coined “intervening opportunities, “ a set of k locations between i and j, that might divert an individual at origin i to destination k from his/her planned destination j (Stouffer 1940, 1960). Fotheringham (1983a, b) expanded the concept to include competition from both alternative origins and destinations. Because of the cost of transport, nearby destinations are discounted less than destinations further away. Taking the example of shopping, an individual might choose to shop at a less preferred but closer shopping center. When competing destinations are considered, the accessibility of i is weighted not just by the attributes of w_j, but also by D_i, the inverse of the sum of accessibility of i for all k, yielding the familiar “spatial interaction” model:

$$A_i = \sum_j \frac{f(d_{ij}) * w_j}{D_i}$$

$$D_i = \sum_k P_k * f(d_{ik}) \tag{4}$$

A further refinement of accessibility takes into account different travel modes, for example private vehicle and public transport (Wachs and Kumagai 1973). Travel time and cost varies greatly between these modes, so an access measure based on private vehicle travel will be quite different from the same measure based on public transport. Shen (1998) generated car and transit-based measures of job accessibility in Boston. He computed a weighted accessibility measure, with the weights being the proportion of population at location i traveling by that particular mode v:

$$A_i^G = \sum_v (P_i^v / P_i) A_i^v \tag{5}$$

where A_i^G is the general accessibility for all groups of people living in zone i, P_i^v is the number of people living in zone i and travelling by mode v, P_i is the total number of people in zone I, and A_i^v is the accessibility for people living zone i and travelling by mode v.

Shen’s study demonstrated that job seekers dependent upon public transit had much lower levels of job accessibility.

Accessibility measures based on places are not necessarily good measures of accessibility for specific individuals. A given individual might live in a highly accessible place, but may not have the capacity (income, ability to drive) to take advantage of the accessibility. In addition, variations in preferences may make one type of accessibility more valuable to some people than to others. When considering accessibility for individuals, time as well as space is relevant: if an individual's daily schedule leaves her no time to stop at the cleaners after work, the availability of the cleaners is not relevant. The concept of a space-time prism has been used as a measure of accessibility since the late 1970s. Accessibility is defined by the resources of the individual as well as the spatial distribution of opportunities and their time-dependent characteristics (Lenntorp 1978, Burns 1979, Ashiru et al. 2003, Recker et al. 2001).

Table 1 summarizes the different types of accessibility measures and gives some examples of applications. Comprehensive measures are those that combine two or more types of measures. Since our research seeks to examine determinants of employment center growth, we will use place-based accessibility measures.

Table 1: Types of Accessibility and Applications

Type of Accessibility	Definition	Perspective	Application	Model	Measures
Network accessibility	The degree of connectivity between a location and other location(s) in the studied area	Network system	Freight transport networks accessibility (Thomas et al., 2003), social network accessibility (Barabasi 2002)	Gravity model	$A_i = \sum_j f(d_{ij}) = \sum_j e^{-\beta * d_{ij}}$
Place/activity accessibility	How easily a place/opportunity can be reached by individuals	Place	Job accessibility (Wang & Minor 2002, van Wee et al. 2001), dwelling sites accessibility (Geertman et al. 1995); Spatial technology accessibility (Shen 1998)	Weighted gravity model	$A_i = \sum_j f(d_{ij}) * w_j$
				Spatial interaction model	$A_i = \sum_j \frac{f(d_{ij}) * w_j}{D_i}$ $D_i = \sum_k P_k * f(d_{ik})$
Individual accessibility	How much a geographic area and how many opportunities an individual can reach given his/her space time constraints	Individual	Urban opportunity accessibility/choice set (Kwan and Hong 1998), facility accessibility (Weber and Kwan 2002)	Space-Time model; Weighted gravity model	Space time prism, PPA; $A_i = \sum_j f(d_{ij}) * w_j$
Comprehensive accessibility	The combination of two or more measures of accessibility	Whole system	Transit route accessibility (Murray & Wu, 2003)	Varies	Varies

3 RESEARCH APPROACH, METHDOLOGY AND DATA

The purpose of this research is to examine the growth of employment centers, and to determine the role of accessibility in explaining variation in growth across them. Building on prior research we have conducted, we use the Los Angeles region as our empirical case study. In this chapter we present our research approach, methodology and data.

3.1 RESEARCH APPROACH AND METHODOLOGY

As described in Chapter 2, emergence, growth and decline of employment centers is the result of agglomeration economies and diseconomies. Agglomeration economies promote co-location; the benefits from co-location offset higher land prices. Diseconomies – congestion, land scarcity – are deterrents to co-location. Diseconomies associated with very large centers are associated with the emergence of subcenters. Other factors associated with subcenter emergence and growth include population suburbanization and location of important inter-regional transport nodes. Employment centers emerge, grow or decline as a result of location choices made by employers. These choices are influenced by access to labor markets, proximity to customers, as well as the costs of inputs across locations. All of these factors are dependent on their spatial distribution and the transportation network that connects these locations. Our interest is in accessibility, so we want to control other relevant factors and develop appropriate measures of accessibility.

3.1.1 Basic Model

We start with a simple model of employment center growth as a function of accessibility and a set of control variables:

$$\Delta E = f(X, Z)$$

where $\boldsymbol{X}$ = vector of access measures
$\boldsymbol{Z}$ = vector of control measures

Building on the earlier Giuliano and Small (1998) work, we start with control factors associated with economic productivity: size, density, industry composition, and location within the region. Large centers might grow faster because of the benefits of agglomeration economies, or might grow slower or decline as a result of congestion, land scarcity, pressures on public facilities, and other diseconomies of agglomeration. Employment density more directly reflects land availability and capacity for the center to grow. All else equal, less dense centers may grow more quickly because lower density may indicate more land availability and lower land prices.

The third economic productivity control is industry composition. Center growth will be influenced by regional growth across industry sectors. Centers with larger shares of fast growing industries should fare better than centers with larger shares of slow growing or declining industries. For each center we compute the amount of growth that would have occurred if each industry sector had grown at its growth rate for the entire region:

$$\Delta E_m^P = \sum_i E_i \overline{g_i} \tag{6}$$

where E^P is the predicted growth of center *m*, E_i is the base period employment in sector *i,* and g_i is the regional growth rate of sector *i*.

Location within the region may matter with respect to urbanization economies: employment centers located closer to the core may enjoy greater urbanization economies and overall access to the labor force. On the other hand, proximity to the core implies higher land prices and more congestion, raising the cost of doing business, as well as more competition from the main center. We measure distance to the core as the straight line distance to the peak tract of the CBD.

Another set of potential control factors is the influence of local land use policy. Market conditions may be favorable to employment center growth, but local zoning or other controls may prevent it. Conversely, entrepreneurial local governments may promote employment center growth through infrastructure investments, tax exemptions or other policies. Agarwal's recent work found no significant relationship between measures of local government activity and employment growth either inside employment centers or across cities more generally. We therefore do not include land use control proxies in our analysis.

3.1.2 Measuring Accessibility

As described in Chapter 2, there are many possible measures of accessibility. Our main interest is with the transport network: does the access provided by the highway network, or by the region's major airports explain employment center growth? From theory, we should expect both highways and airports to have a significant effect. Higher levels of accessibility increases the attractiveness of certain locations, enticing firms and household to choose such locations over others. Casual observation (and some qualitative studies) suggests that employment centers tend to locate near major highway interchanges. Of course, not all highway interchanges have nearby employment centers.

The earlier Giuliano and Small work found no significant relationship between center growth and access to highways. They concluded that highway access was ubiquitous; there was not enough variation in access across centers to make it a differentiating factor. However, their measure was simply the distance to the nearest freeway entrance. Given the extent of the freeway network in Los Angeles, their results are not surprising. A simple measure of distance to the nearest freeway entrance does not capture the value of relative location within the network. We hypothesize that relative location matters: locations closer to the core of the network should have more attractiveness than locations near the edges. Our first highway accessibility measure is network accessibility,

$$A_i = \sum_j e^{-\beta d_{ij}}$$

where d_{ij} is the travel cost (in distance or time) between nodes *i* and *j*, and β is the impedance function. In our case d_{ij} is the shortest path free-flow travel time (see Section 3.2

below). The value of β is typically determined by using the observed trip distance (time) distribution to estimate the best fit value for that distribution. In earlier studies, researchers (e.g. Fotheringham 1983a) have found the value of β to range between 0.01 and 3.0.

Given the integration of the world economy, we would expect access to airports to matter, as airports provide access to the inter-regional and international transport network. The largest airport should have the greatest effect, because it offers the most frequent and diverse number of potential destinations. Airport proximity was consistently significant in the earlier G&S study. We use the following measures for airport proximity: distance to LAX, distance to the nearest of the region's 4 major airports (LAX, Santa Ana, Burbank, Ontario), and distance to the nearest of the three smaller airports.[2]

Networks provide a set of potential origins and destinations, but it is the activities at these origins and destinations that generate spatial interaction. From the perspective of the firm, location considerations include access to potential workers, consumers, and production inputs. In some sense the spatial distribution of these activities [wrong word] is a representation of the indirect effects of network accessibility: the underlying network-based access influenced the form of these distributions. Population distribution is a widely used and accepted proxy for both labor force access and consumer market access, and we use it in this research.

We use two different measures of labor force access. The first measures "total" labor force access, a weighted sum of population discounted by distance,

$$A_m = \sum_j L_j^{-\beta d_{jm}} \tag{7}$$

where L_j is labor force residing in tract j, d_{jm} is the distance between j and m, the peak tract of center m, and β is the impedance parameter. Note that labor force accessibility for each center is calculated as the accessibility of the peak tract, and takes into account the resident labor force in all tracts within the region.

The second measures "relative" labor force access, and takes into account competition for labor from other employment locations,

$$B_m = \sum_j L_j \left(E_m e^{-\beta d_{jm}} / \sum_k E_k e^{-\beta d_{km}} \right) \tag{8}$$

where E_m and E_k are total employment in centers m and k respectively. B_m may be viewed as attaching to each member of the labor force a probability, based solely on commuting distance, of choosing to work in the employment center in question. The parameter $1/\beta$ measures the commuting distance over which the attractiveness declines to a fraction e^{-1} of its peak value. Following Giuliano and Small (1999), the value of $1/\beta$ is set equal to the regional average

[2] The region's other primary airport – Long Beach Airport – had significantly lower enplanements than each of the four airports included in analysis. During the calendar year 2000, Long Beach Airport had only 335,225 enplanements, where LAX had more than 32 million, Burbank had more than 2 million, Ontario had more than 3 million, and Santa Ana had almost 4 million enplanements (Source: Federal Aviation Administration's official website http://www.faa.gov/airports_airtraffic/airports/planning_capacity/passenger_allcargo_stats/passenger/index.cfm?year=2000 Visited on November 2, 2008)

commuting distance of 9.81 miles in 1990. We expect all access measures to be positively associated with employment center growth.

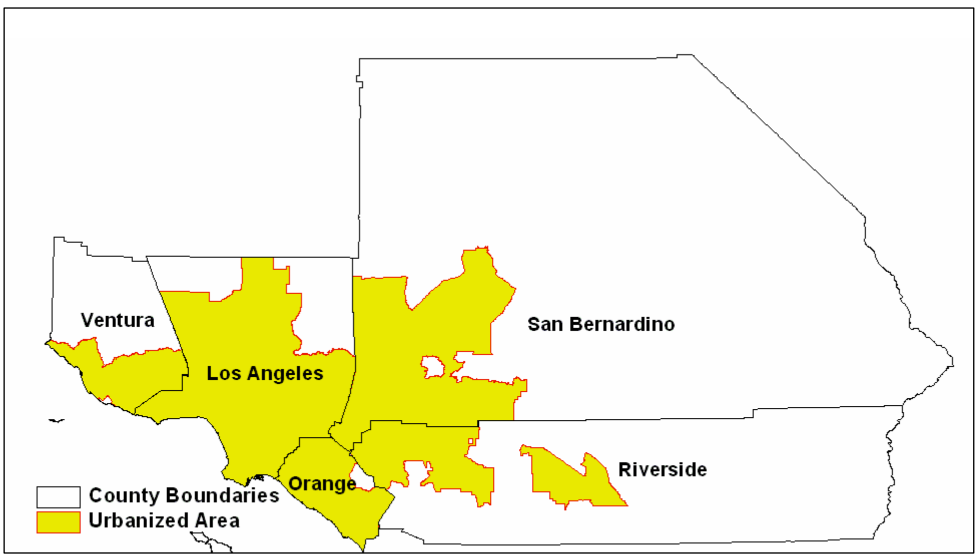
3.2 DATA

Our analysis requires population and employment data as well as transport network. We describe our data and sources in this section.

3.2.1 Population and Employment Data

Our analysis area is the 2000 urbanized area portion of the five county Los Angeles CMSA, which includes the counties of Los Angeles, Orange, Riverside, San Bernardino and Ventura (see Figure 1). We use the urbanized area as defined by the US Census and exclude the vast tracts of mountains and deserts with little or no employment or population. These large but almost empty tracts contain a small fraction of the region's population and employment, and could not reasonably be expected to include employment centers.

Figure 1: Urbanized Area in the Los Angeles CMSA



Census tract level employment and population data for 1980, 1990 and 2000, as well as shape files for each year, were provided by the Southern California Association of Governments (SCAG). The employment data are developed by SCAG from wage and compensation data reported to the State Economic Development Department (EDD) of the California Labor and Workforce Development Agency. Maintaining a consistent geography across the three analysis years - 1980, 1990, and 2000 - is essential for valid comparison. We chose 1990 census tracts as our unit of analysis, and converted all the data to 1990 census tract geography. There are 2,474 tracts covering a total area of about 5 million acres (just under 8,000 square miles).

A brief summary of regional employment and population trends will help to place our results in context. Table 2 gives employment and population, by county, for the Urbanized Area. Over the entire period, employment increased from about 5.4 million to about 7.3 million (35%), and population increased from 11.2 to 15.8 million (41%). Growth was uneven both across the decades and across counties. Population and employment growth was more rapid 1980 – 1990 than 1990 – 2000, and while employment increased more than population 1980 – 1990, the reverse was true 1990 – 2000. In relative terms growth was slowest in Los Angeles County, but in terms of absolute numbers, Los Angeles County added the greatest number of jobs and people. Los Angeles County stands out also as the only county that lost employment, 1990 – 2000. The fastest growth in both jobs and population took place in Riverside County, with a more than doubling of jobs between 1980 and 1990. Jobs increased more than population 1980 – 1990 in Orange County, but the trend reversed 1990 – 2000. In San Bernardino and Riverside counties, jobs increased faster than population, an indication of transformation from bedroom suburb to urbanized area.

Table 2: Employment and Population by County, Urbanized Area

	1980		**1990**				**2000**			
County	Emp	Pop	Emp	Change (%)	Pop	Change (%)	Emp	Change (%)	Pop	Change (%)
LA	3.93	7.46	4.60	17.0	8.82	18.2	4.44	-3.5	9.54	8.2
Orange	0.92	1.93	1.30	41.3	2.41	24.9	1.51	16.2	2.87	19.1
Riverside	0.13	0.54	0.29	123.1	0.91	68.5	0.43	48.3	1.13	24.2
SB	0.24	0.79	0.43	79.2	1.28	62.0	0.55	27.9	1.56	21.9
Ventura	0.17	0.47	0.25	47.1	0.60	27.7	0.31	24.0	0.68	13.3
Total	5.39	11.19	6.87	27.5	14.01	25.2	7.24	5.4	15.78	12.6

We use the simple but robust Giuliano and Small (1991) method to identify employment centers. Giuliano and Small define a center as a cluster of contiguous zone having a minimum employment density of ***D,*** and together containing total employment of at least ***E***. For the purpose of this study we have chosen to use the employment centers identified in an earlier study by Giuliano et al (2007) who identify 48 employment centers in the region in 2000 using D=10 jobs per acre and E=10,000.

Table 3 presents selected characteristics of the 48 employment centers in the region 2000. The centers are ranked in the order of their size, i.e. Center 1 had the largest number of jobs in 2000 whereas Center 42 had the lowest. There is a "rank size" effect, i.e. a few very large and many smaller centers. The largest center had a 2000 employment of more than half million jobs, the next four largest centers had more than 100,000 jobs each, and the subsequent smaller centers had less than 70,000 jobs each. The smallest center had just a little over 10,000 jobs.

Other center characteristics are also quite varied. The largest center in terms of area, Los Angeles Downtown, was spread over nearly 18,000 acres while the smallest, Newport Beach, was spread across just over 600 acres. There was also a large variation in employment density. The densest center, Los Angeles Downtown, had an employment density of approximately 30 jobs per acre in 2000 whereas each of the least dense centers (centers 6, 30, and 37) had employment density of 10 jobs per acre, just above the cutoff.

Figure 2: Employment Centers in Los Angeles Region, 2000

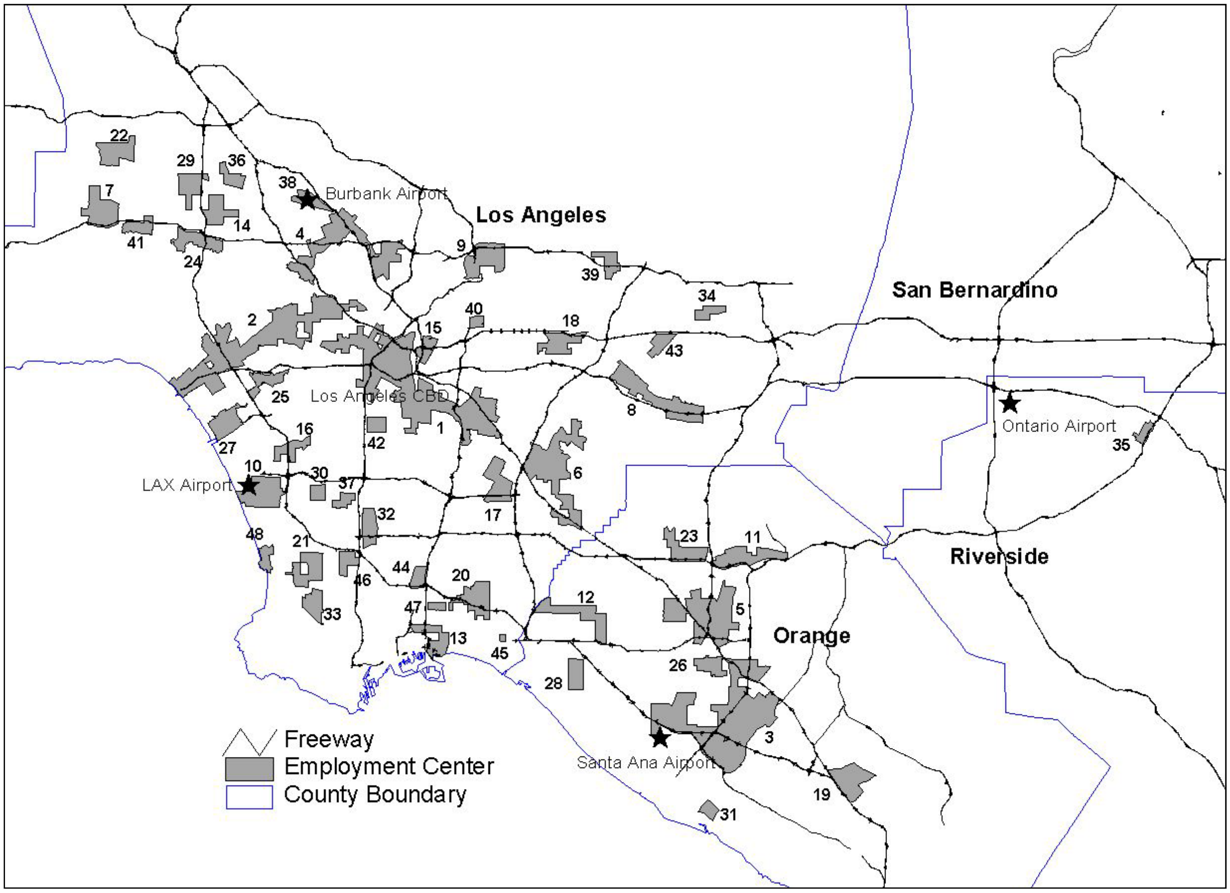


Table 3: Growth of Employment Centers, 1990-2000

Number of Centers with Positive Growth	27
Number of Centers with Negative Growth	21
Average Growth	2,487
Median Growth	850

Between 1990 and 2000, not all centers grew, some also lost employment (see Table 3). Note that we use the boundaries of the 2000 centers and compare employment within these boundaries for 1990. The average employment growth, between 1990 and 2000, inside the employment centers was 2,487 while the median growth was 850. There is a good mix of centers that lost jobs and the ones that gained jobs to test the hypotheses regarding the determinants of employment center growth. Center 3 (Santa Ana-Costa Mesa-Irvine) was the biggest gainer, whereas Center 19 (Long Beach) was the biggest loser in terms of total number of jobs (see Table 4). Center 36 (Burbank) had the highest negative growth rate whereas Center 19 (Irvine Spectrum) had the highest positive growth rate.

Table 4: Selected Characteristics of Employment Centers

Center ID	Name	Area (acres)	Emp 2000	Emp 1990	Emp Growth 90-00	Percent Growth 90-00
1	LA Downtown-LA East	17949	539,645	563,717	-24072	-4.27
2	Santa Monica-Wilshire-Hollywood	13773	421,049	394,691	26358	6.68
3	Santa Ana/Irvine/South Coast Plaza	16648	291,673	249,354	42319	16.97
4	Burbank/Glendale/Universal City	6786	132,149	105,578	26571	25.17
5	Anaheim	7202	123,462	108,840	14622	13.43
6	Whitter-Norwalk-Santa Fe Springs	7060	69,891	69,053	838	1.21
7	Hidden Hills	2781	70,896	50,403	20493	40.66
8	City of Industry	4505	61,092	49,382	11709	23.71
9	Pasadena	2823	58,424	59,687	-1263	-2.12
10	LAX	2993	53,432	45,707	7725	16.90
11	City of Orange	2671	40,114	34,693	5421	15.63
12	Garden Grove	2662	37,687	28,608	9079	31.74
13	Long Beach	1726	37,125	45,524	-8399	-18.45
14	Van Nuys Airport	1695	34,267	24,549	9718	39.59
15	USC Health Center	967	31,674	19,463	12211	62.74
16	Inglewood	1257	32,865	34,932	-2067	-5.92
17	Downey	2299	31,262	32,099	-837	-2.61
18	Rosemead/El Monte	1936	30,622	29,563	1059	3.58
19	Irvine Spectrum	2606	29,382	16,546	12,835	77.57
20	Long Beach Airport	2475	30,312	59,428	-29,116	-48.99
21	Torrance North	2123	29,817	28,808	1,009	3.50
22	Northridge	2110	28,507	31,243	-2,736	-8.76
23	Fullerton	1964	23,934	25,683	-1,749	-6.81
24	Sherman Oaks	1915	25,440	32,958	-7,518	-22.81
25	Culver City	1269	23,934	32,451	-8,517	-26.25
26	Santa Ana	1262	25,232	21,040	4,192	19.92
27	Marina Del Ray	1926	21,074	21,428	-354	-1.65
28	Hungtington Beach	1317	20,623	24,637	-4,014	-16.29
29	Van Nuys West	1657	17772.0	26,224	-8,452	-32.23
30	Hawthone/Lawndale	647	15,535	4,403	11,132	252.82
31	New Port Beach	610	15,492	9,100	6,392	70.24
32	Compton	1488	14,707	20,323	-5,616	-27.63
33	Torrance South	1356	14,262	17,340	-3,078	-17.75
34	Covina	807	13,842	8,770	5,072	57.83
35	Riverside	658	14,604	15,322	-718	-4.69
36	Van Nuys City	947	13,471	13,389	82	0.61
37	Gardena	687	12,867	12,005	862	7.18
38	Burbank Airport	1055	12,938	26,790	-13,852	-51.71
39	Monrovia	1162	11,378	12,624	-1,246	-9.87
40	South Pasadena	433	10,674	8,175	2,499	30.57
41	Woodland Hills	1053	11,607	13,190	-1,583	-12.00
42	Huntington Park	801	10,696	8,670	2,026	23.37
43	West Covina	953	11,390	10,738	652	6.07
44	710/405	863	11,177	3,930	7,247	184.39
45	Cal State Long Beach	105	10,948	7,774	3,174	40.83

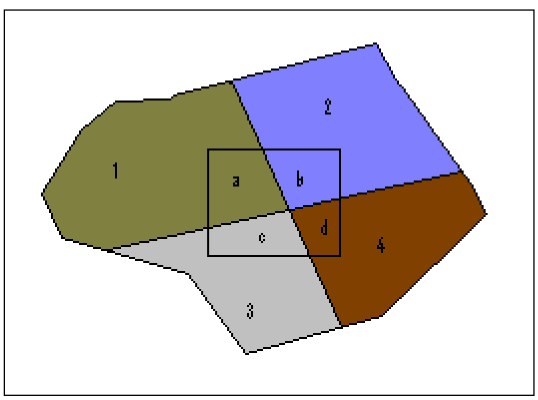
46	Torrance East	969	10,020	10,206	-186	-1.82
47	Long Beach North	375	10,096	12,793	-2,697	-21.08
48	Redondo Beach	773	9,854	7,725	2,129	27.56
Totals		**134,099**	**2,608,914**	**2,489,556**	**119,356**	**4.79**

3.2.2 Network Data

Generation of network-based accessibility measures requires data on the highway network. We obtained 1990 network data from SCAG. These are network files compiled in the TransCAD software package. Since we are interested in how accessibility affected center growth of 2000, we use the 1990 network as the basis for our calculations. Figure 3 shows the 1990 network; it consists of 11,115 links and 7,453 nodes.

The network data are geographically located in terms of Traffic Analysis Zones (TAZs), spatial units approximately the size of census tracts, but with different boundaries. For the urbanized area, there are 1,527 TAZs, compared to 2,474 census tracts. It was therefore necessary to locate the 48 centers in the 1990 TAZ geography. We used an area-weighted method to obtain the network access for the peak tract of employment centers. In TransCAD, the layer of peak tract was superimposed onto the layer of network access.[3] The overlay function enables us to obtain network access of the peak tract of employment centers based on the network access associated with TAZs within each employment center. Figure 3 provides an illustration.

Figure 3: An employment center's peak tract consisting of area a, b, c, and d overlaid onto TAZs 1, 2, 3, and 4



3.3 Descriptive Results on Accessibility

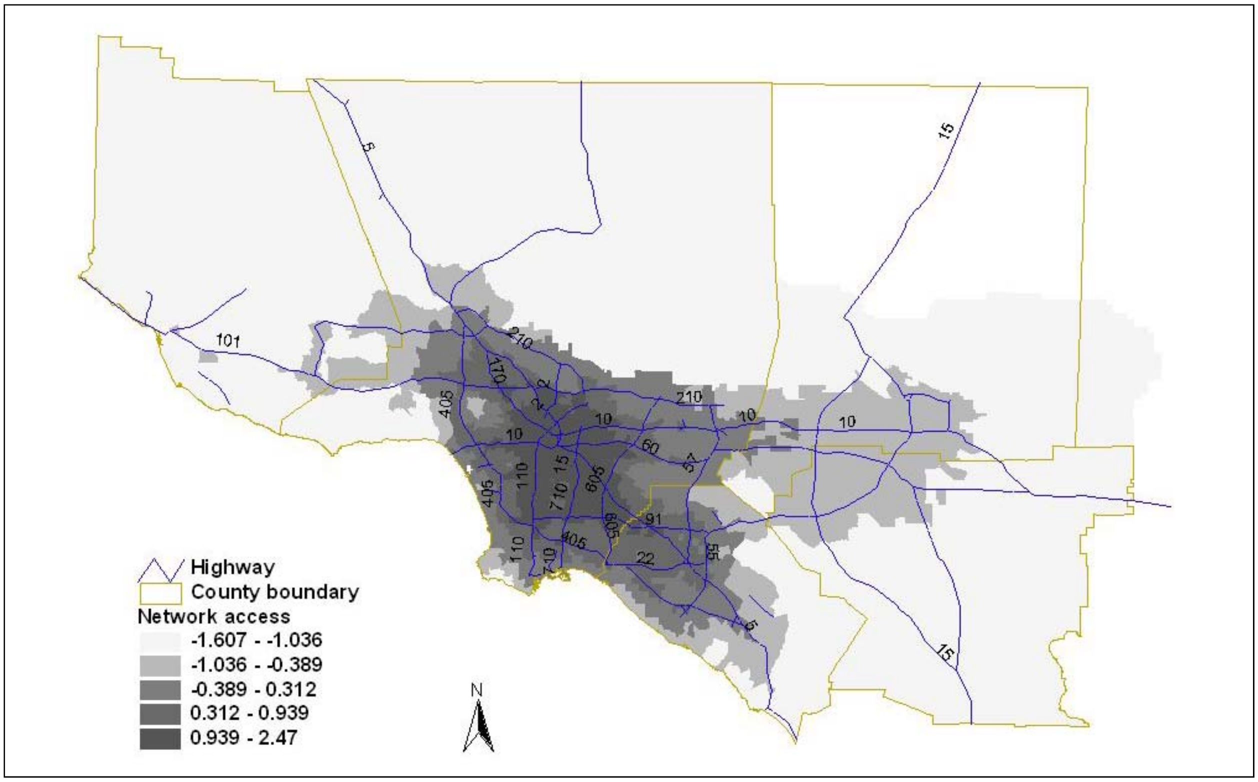
The network data include free flow speed on each link, link and node capacity characteristics, and geographic location via centroid connectors that link each TAZ to the network. Using a shortest path algorithm, we generate free flow travel times for every centroid to centroid pair. In calculating network accessibility, we normalize travel times to mean = 0 and variance = 1. One issue is whether free flow speeds are a reasonable proxy for network access; the Los Angeles is well-known for its congestion, and is it quite possible that travel times with congestion are more relevant in firm location decisions. Generating congested travel times

[3] All shapefiles have been converted to UTM 11N projection system in TransCAD.

requires a trip origin-destination (O-D) matrix that represents total travel demand for the target period, and the O-D matrix is itself a function of the employment and population distributions. A congested network captures the effects of these distributions. It was not possible to obtain a 1990 O-D matrix, so we use only the free-flow network accessibility measure.

Figure 4 shows the network accessibility of the region. As expected, the highest level of accessibility is in the central core of the network and extends east and southeast along the major freeway corridors. It may be noted that the "core area" encompasses a large area: much of the southern half of Los Angeles County, and a portion of Orange County. From the perspective of the locating firm, there are many choices for which network accessibility is comparable.

Figure 4: Network Access of TAZs in 1990 (Free Flow)



Note: The categories are based on quintiles of normalized network access values

We calculate the network accessibility of the peak tract of employment center *m* as:

$$A_m = \sum_j \frac{Area_j}{Area_m} \times Access_{TAZ_i | j \subset i}$$

Referring to Figure 3, for an employment center's peak tract *m* that consists of area *j* (e.g., a, b, c, and d) overlaid onto TAZ *i* (e.g., 1, 2, 3, and 4), its network access would be an aerial proportionate share of TAZ i's network access. The network access for the peak tract of each employment center is then used as a proxy for the network access of each employment center.

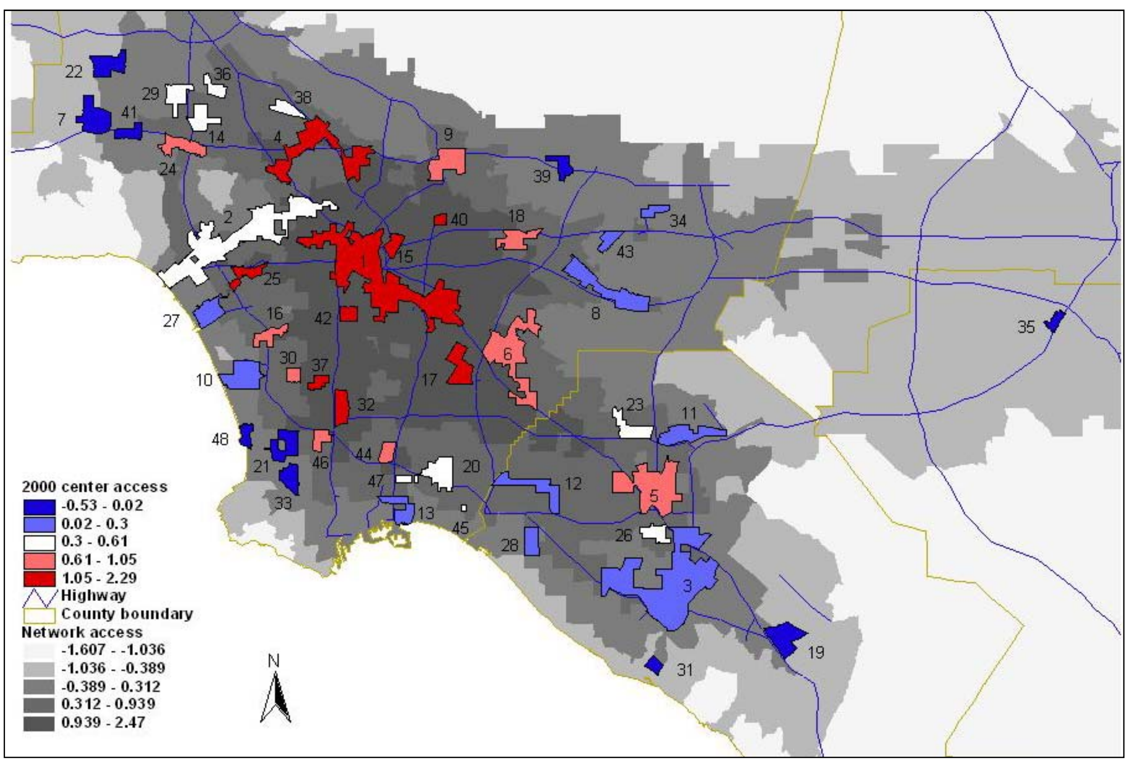
Table 5 gives network access values for the entire region, and for all the centers. It shows that centers have higher levels of mean network accessibility than the region as a whole. The maximum is higher for the region because the region calculation is on the basis of TAZ centroid and hence is capturing the highest density TAZ, while the center calculation reflects the weighted sum of the entire center. The standard deviation is much smaller for the centers; few centers are located in areas of low network accessibility.

Table 5: Network access, total region and employment centers

	Mean	Median	Min	Max	Std Dvn
Total region	72.07	71.74	1.13	181.09	44.14
Centers	94.94	93.30	48.88	173.29	27.87

Figure 5 overlays the centers on the network accessibility map of Figure 4. Center accessibility is divided into quintiles, from lowest (dark blue) to highest (dark red). There are two observations to be drawn. First, there is a distinct concentric pattern of center accessibility. The LA CBD, along with other centers along the I-5 have the highest accessibility. Next come a ring of centers located primarily along the I-405, SR-101, and I-10/SR-60. The outermost centers include Irvine Spectrum (#19), Newport Beach (#31), and Riverside (#35). Second, most centers are located within the two highest quintiles of regional network accessibility, and no centers are located within the two lowest quintiles of network accessibility.

Figure 5: 2000 Center Network Accessibility, 1990 Network



Note: The categories are based on quintiles of normalized network access values

4 RESULTS AND CONCLUSIONS

Our hypotheses focus on the relationship between employment center growth and various measures of accessibility. First we present some descriptive analysis of center growth and accessibility, and then discuss results of our regression models.

4.1 DESCRIPTIVE ANALYSIS

Employment growth for the region from 1990 to 2000 was much lower than in the previous decade (5.4% vs 27.5%), and Los Angeles County lost employment (decline of 3.5%). For the 48 centers identified in 2000, the average growth was about 16%, but the median was 3.5%, slightly less than the region as a whole. As noted in Chapter 3, 21 of the 48 centers lost employment over the decade. Figure 6 shows the centers with respect to the Los Angeles CBD and the four major airports, coded as having either gained or lost employment. The figure does not reveal any clear relationship between airports and employment center growth/decline. Some employment centers in close proximity of airports have lost employment (e.g. 16, 24, 29, and 38) while others have gained (e.g. 3, 4, 10, 14, and 36). Similarly, some centers in close proximity of LA CBD have lost employment (e.g. 25, 27) while others have gained (e.g. 15, 42).

Figure 6: Employment Center Growth in Los Angeles

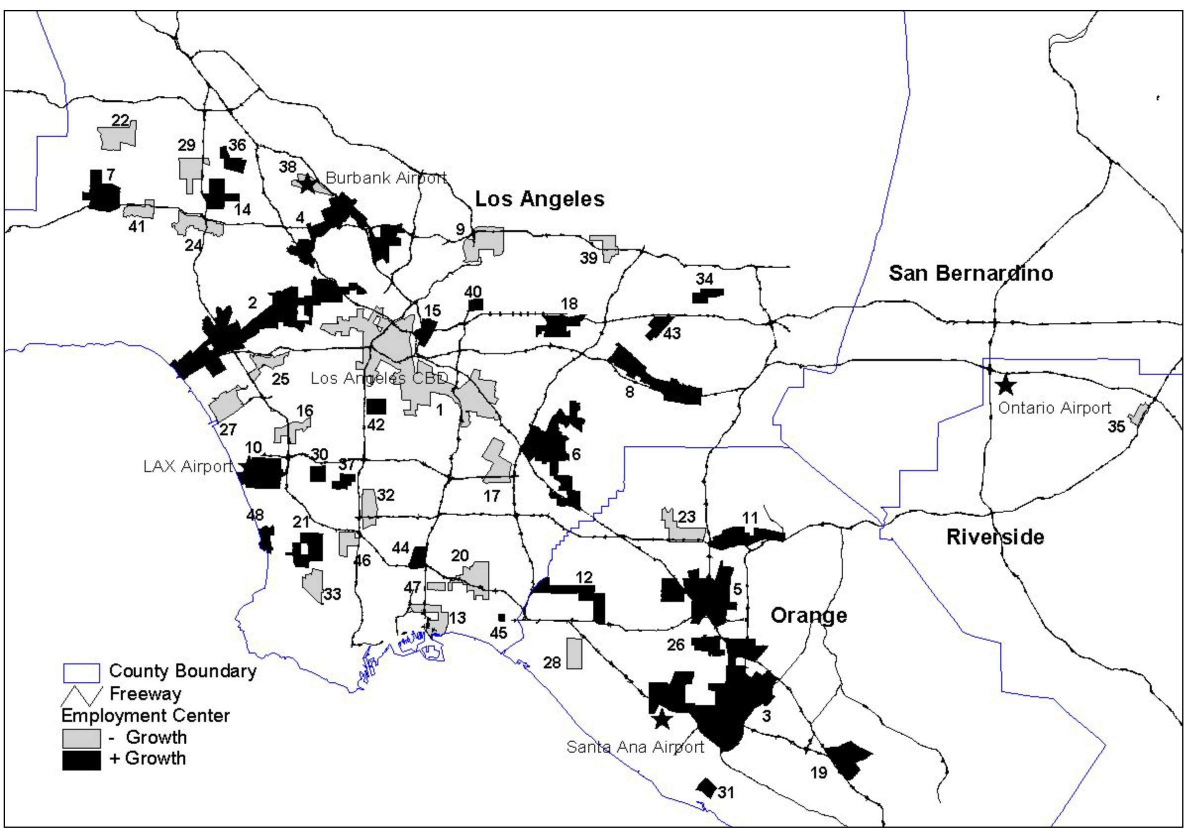
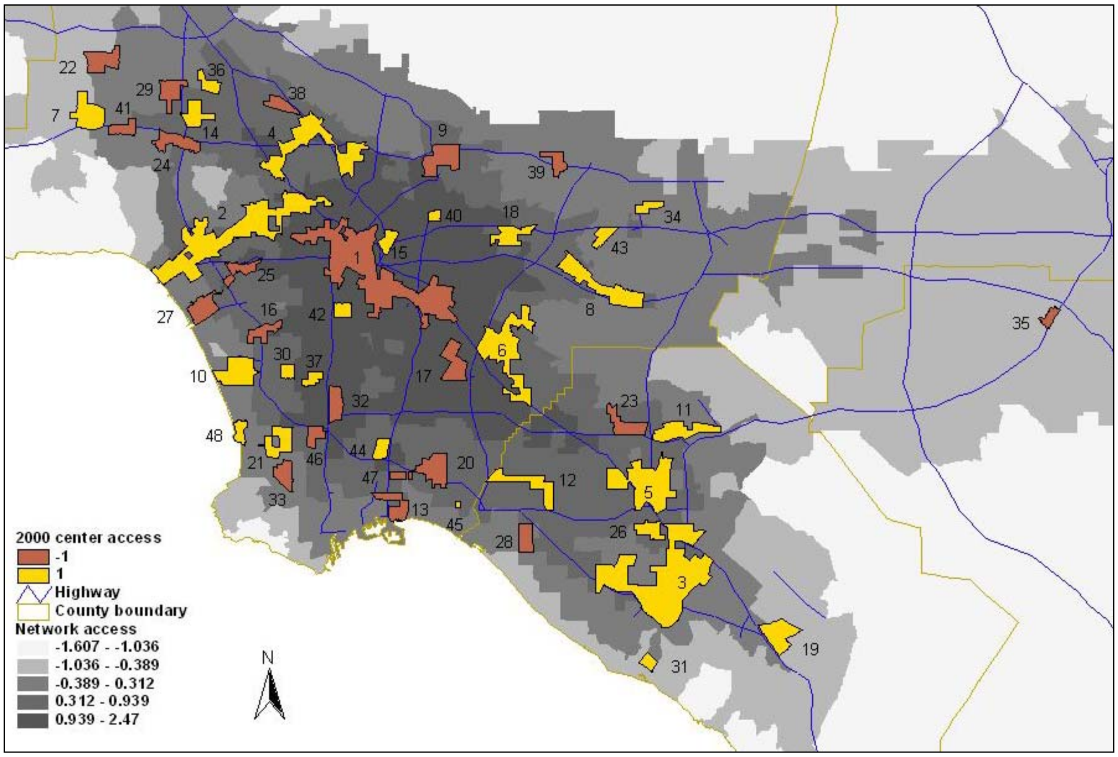


Figure 7: Employment Center Growth and Network Access



Note: -1 implies negative employment growth and 1 implies positive employment growth between 1990 and 2000

Tables 6a and 6b present cross-tabulation of employment center growth with quintiles of absolute labor force accessibility and relative labor force accessibility, respectively. There is no association between absolute labor force accessibility and employment center growth. However, relative labor force accessibility clearly influences employment center growth. A higher proportion of centers with high relative labor force accessibility tends to gain employment while the opposite is true fro centers with lower relative labor force accessibility.

Table 6a. Employment Center Growth and Absolute Labor Force Accessibility

	1 quintile 783 – 1,788*	2 quintile 1,788 – 1,991	3 quintile 1,991 – 2,275	4 quintile 2,275 – 2,645	5 quintile 2,645 - 3,126
Negative Growth	3	5	4	5	4
Positive Growth	6	5	6	5	5

* in 1,000s

Table 6b. Employment Center Growth and Relative Labor Force Accessibility

	I quintile 2,572 – 10,611	2 quintile 10,611 – 17,808	3 quintile 17,808 – 25,566	4 quintile 25,566 – 33,374	5 quintile 33,374 – 105,876
Negative Growth	6	5	4	3	3

Positive Growth	3	5	6	7	6

4.2 REGRESSION RESULTS

We use the variables described in the previous chapter and estimate regression models to test the impacts of accessibility on employment center growth. Table 7 gives variable names and descriptive statistics, and Table 4.2 gives pairwise correlations for the same set of variables. Some variables have very large standard deviations ($E_{00} – E_{90}$, 1990 employment, predicted growth), all related to the mixed growth experience of the centers over this decade. The skewed distribution of centers (a few very large, very dense centers) is evident from the means and medians of 1990 employment and 1990 density. The geographic distribution of centers is evident in the average distance of 17.4 miles from the LACBD. It may be noted that our centers include the CBD. Centers are on average close to at least one major airport; average distance is about 11 miles.

Table 7: Variables and Descriptive Statistics

Variable	Description	Mean	Median	Std Dvn
$E_{00} – E_{90}$	Absolute change in employment (dep var)	2486	849	11,770
E_{00}/E_{90}	Ratio change in employment (dep var)	1.16	1.03	0.52
Emp 90	1990 employment	51,866	42,876	99,678
Den 90	1990 density (emp/mi^2)	17.43	14.94	10.61
DistLA	Distance to CBD (miles)	17.21	15.67	9.76
Shiftshr	Predicted growth rate based on average regional industry sector growth	2.07	2.60	8.74
DistLAX	Distance to LAX (miles)	19.27	18.00	11.61
DNrstAir	Distance to the nearest airport (miles)	10.66	10.50	5.39
DnrstnotLAX	Distance to nearest airport excluding LAX	14.34	14.45	6.50
NetwkACC	Free-flow network accessibility	94.94	93.29	27.86
LFACC	Absolute labor force accessibility	2,149,044	2,146,125	530,300
RLFACC	Relative labor force accessibility	26,944	23,668	21,631

Table 8 shows that neither of the dependent variables is strongly correlated with any of the independent variables. Distance to the CBD is highly correlated with distance to LAX, since from a regional standpoint they are relatively close to one another. Network access and absolute labor force access are highly correlated, but neither is correlated with relative labor force access. Network access and absolute labor force access is correlated with distance to CBD, as would be expected, and with 1990 employment.

Table 8: Pairwise Correlations

	E_{00}-E_{90}	E_{00}/E_{90}	Emp 90	Den 90	DistLA	Shiftshr	Dist LAX	Dnrst Air	Dnrst notLAX	Netwk ACC	LFACC	RLF ACC
E_{00}-E_{90}	1.00											
E_{00}/E_{90}	**.436**	1.00										
Emp 90	.096	-.113	1.00									
Den 90	-.186	*-.240*	.221	1.00								
DistLA	.198	.044	-.217	-.074	1.00							
Shiftshr	*.279*	.219	.133	-.009	.087	1.00						
DistLAX	.191	-.007	-.063	-.062	**.815**	.071	1.00					
DNrstAir	-.199	-.104	-.076	.097	.054	-.057	**.306**	1.00				
DnrstnotLAX	*-.241*	.088	*-.239*	-.089	-.184	.070	**-.348**	**.457**	1.00			
NetwkACC	-.153	.063	*.318*	.155	**-.734**	*-.330*	**-.462**	-.079	-.037	1.00		
LFACC	-.158	.037	*.241*	.114	**-.870**	-.053	**-.676**	.014	*.250*	**.874**	1.00	
RLFACC	.170	.109	**.538**	.100	.055	.095	.099	-.083	-.091	.071	-.016	1.00

Our group of 48 centers includes the Los Angeles main center (CBD). Should the main center be included? Urban theory on polycentricity is about why new centers form in the metropolitan area. Implied is that the dynamics of emergence and growth of the "subcenters" is different from that of the main center. We would argue that the fundamentals of agglomeration should be the same for all centers. Hence we include the LA CBD in the regressions. Our group of centers also includes some outliers. Two small centers stand out for unusually large growth (centers 30 (Hawthorne) and 44 (Carson)). Several of the smaller centers include only one census tract, and hence are vulnerable to data errors. We re-checked the data on these centers, and concluded that there was no justification for deleting them from the regression.

Finally, we considered whether to use the absolute change in employment or the ratio change in employment for the dependent variable. We estimated models using both, and we found that the absolute form tends to exaggerate the impact of the largest centers (results not shown). Therefore we use the ratio form of dependent variable. We use natural log forms for the dependent variable, 1990 employment, 1990 density, and distance to the LA CBD.

Table 9 gives results for the base model (we present beta coefficients and t values) and for the airport access measures. Starting with the base model, the coefficients on 1990 employment and 1990 employment density suggest that smaller, lower density centers were associated with higher growth rate. We noted that hypotheses for size and density could go in either direction, depending on whether the negative or positive effects of agglomeration dominate. The coefficient of distance to the LA CBD is not significant, suggesting that location with respect to the CBD has no impact on center growth. The predicted growth variable coefficient is positive, as expected. Overall the base model has a modest level of explanatory value.

Table 9: Base Model and Airport Access Measures

	Base Model		Add dist to LAX		Add dist to nearest airport		All airport measures	
	Beta coeff	T	Beta	T	Beta	T	Beta	T
Const		5.586		5.514		5.611		5.474
lnEMP90	-*.324*	2.411	-*.336*	2.421	-*.329*	2.438	-*.295*	2.142
lnDEN90	**-.421**	3.261	**-.421**	3.227	**-.417**	3.209	**-.396**	2.975
lnLA	-.181	1.401	-.214	1.403	-.179	1.374	-.144	.605
Shiftshr	<u>.217</u>	1.809	<u>.212</u>	1.739	<u>.212</u>	1.756	<u>.222</u>	1.776
DistLAX			.059	.415			.114	.459
Dnrstair					-.094	.780	-.127	.893
Adj R	.325		.311		.318		.277	

Bold = sig at p < .01
Italic = sig at p < .05 > .01
Underline = sig at p < .10 > .05

The three models that include measures of airport access show no significant effect of location with respect to airports. Adding these variables has almost no effect on the base variable coefficients. These results are counter to Giuliano and Small (1999), and to Agarwal (2008). Agarwal used a slightly different group of centers; this may explain the difference. Agarwal dropped 6 employment centers from the 48 we have used. Furthermore, Agarwal measures airport access in two parts: 1) distance to the nearest airport not including Lax and 2) distance to LAX. While he does not find distance to LAX significant, distance to the nearest airport excluding LAX is significant. Some possible explanations for differences from Giuliano and Small include 1) the location of centers is more dispersed in 2000 than 1980, 2) several major aerospace firms were/are located near the region's airports and suffered decline in 1990s.

Table 10 gives results for the accessibility measures. We test each accessibility measure individually, and then as a group in the last model. Only the relative labor force access coefficient is significant. Consistent with the qualitative results of Figures 7 above, network access has no effect on center growth, nor does absolute labor force access. This is not surprising; because of the relatively high population density of much of the urbanized area, labor force access is ubiquitous across a large portion of the region. The relative labor force access measure takes into account the competition for workers from other centers. The positive sign suggests that centers with a high net access of workers had higher growth rates, consistent with theory.

Table 10: Highway and Labor Force Accessibility Models

	Add network access		Add labor force access		Add relative labor force access		All access measures	
	Beta	T	Beta	T	Beta	T	Beta	T
Const		2.273		2.859		4.621		2.566
lnEMP90	-.251	1.867	-.266	1.968	**-.421**	3.174	**-.412**	3.125
lnDEN90	**-.419**	3.281	**-.414**	3.234	**-.397**	3.395	**-.408**	3.491
lnLA	-.048	.241	-.156	.850	-.078	.653	.153	.776
Shiftshr	**.350**	2.952	**.346**	2.884	**.320**	2.937	**.320**	2.939
Netwkacc	-.123	.643					0.323	1.278
Laboracc			-.011	0.063			-.053	.229
labrelacc					**.369**	2.927	**.419**	3.156
Adj R	.342		.336		.448		.455	

Bold = sig at p < .01
Italic = sig at p < .05 > .01
Underline = sig at p < .10 > .05

Finally we estimate the full model (Table 11), including all measures of accessibility. Results do not change; coefficients that were borderline significant drop in significance, but signs and magnitude are consistent with the partial results. Only relative labor force access has a significant relationship with employment center growth.

Table 11: Full Model: All Access Measures

	All airport + all access	
	Beta	T
Const		2.441
lnEMP90	**-.428**	3.124
lnDEN90	**-.399**	3.313
lnLA	.105	.486
Shiftshr	**.317**	2.844
DistLAX	.129	.624
distnrtair	-.058	.414
Netwkacc	.206	.641
Laboracc	.105	.303
labrelacc	**.403**	2.621
Adj R	.432	

Bold = sig at p < .01
Italic = sig at p < .05 > .01
Underline = sig at p < .10 > .05

5 CONCLUSIONS

Our results suggest that employment center growth in the Los Angeles region is a complex process in which traditional forms of accessibility play a limited role. We have some suggestive evidence that smaller centers and less dense centers are likely to grow faster, probably because of greater land availability (lower land prices) and hence more opportunities for new firms to locate and existing firms to expand. Location with respect to the CBD is not a factor. The main core of employment concentration in Los Angeles is a corridor from the traditional downtown area to Santa Monica in the west; it would seem that the peak zone of the CBD is not a robust indicator of employment or activity centrality in Los Angeles. As expected, industry mix plays a role: all else equal, centers with more jobs in high growth industry sectors grew faster than those with a smaller share of such jobs.

Although we developed a good measure of highway network accessibility, we find no relationship between it and center growth. This is counter to conventional wisdom, casual observation, and theory. Development of the freeway network no doubt greatly changed highway accessibility in the region, but by 1990 the freeway building era was long over. We surmise that the impact of the freeway system took place in earlier decades, yielding the broad surface of labor force accessibility we observe here. Our results do not necessarily suggest that highway access does not matter; rather, we observe the indirect effects of highway access through the population and employment distributions. Given the broad spatial distribution of high labor force access, it makes sense that the differentiating feature for center employment growth is its competitive position with respect to labor access. Broadly speaking, centers further from the regional core should be more competitive, because they are located closer to the suburbanizing population (e.g. the jobs following people hypothesis).

There are several avenues to extending this work. We have not fully explored the role of outliers, and we have relied on a method of center identification that employs absolute employment and employment density figures rather than relative. One way to test the robustness of our results is to use centers identified using the relative density measures proposed in Redfearn (2007). His approach identifies smaller centers, especially located in the periphery. These centers also experienced growth, but not enough to be defined as a center in this work. The “right” definition of a center remains an open question, but the work presented here could be extended using other center definitions to see how robust the results are.

Perhaps the more fruitful next step would be to examine the role of industrial concentration within the centers. Certainly accessibility and density interact with broader employment trends occurring differentially across industries. Notions of co-location and external economies of agglomeration are at the heart of urban economics and remain poorly understood. The centers we work with here and the dynamics we have identified are likely to be influenced by background trends in the industries contained within them. We have not compared center growth with employment growth more generally. Therefore we do not know if centers are in fact unique clusters, or if employment growth dynamics are similar everywhere.

Both of these lines of research are beyond the scope of the current paper. But, where work has been undertaken on centers and their industry mixes, it has never -- to our understanding – included the role of accessibility. Our plans are ambitious and we intend to follow both lines to better understand the dynamics of firm location that are manifest in urban form.

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