Determinacy in Urban Form: Fixed Investment & Path Dependence in Urban Areas

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Abstract

Currently the economics of agglomeration receives a great deal of research attention, focusing on a variety of externalities to explain the evolution of cities. Much of this research is ahistorical, with little attention paid to the cumulative history of investment decisions that are manifested in the urban form that researchers seek to understand. This paper presents evidence that the spatial distribution of employment within the Los Angeles metropolitan area remains broadly unchanged during a remarkably dynamic period in terms of the growth and transformation of its population and employment, as well as other of the fundamental variables of urban models such as transportation and communication costs. Over the twenty-year sample period, the number of employment centers and their share of total employment is quite stable, as is the rank of employment density on a tract-by-tract basis. This stability appears to have its origins in the large fixed investment in structures and highways made decades earlier. Where employment concentrations are not situated astride one of the arteries in the current highway network (largely established by 1960), their location can be attributed to the freeway system as it stood prior to WWII. Indeed, the spatial distribution of current employment centers appears to be explained in no small part by a path dependence that links these centers within the metropolitan area to their distinct antecedents at the turn of the last century.

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1 Introduction

While there is continued inquiry into the causes of idiosyncratic growth and decline of cities within a system of cities, there is a distinct absence of research into why inefficient cities are never abandoned for newer, "optimal" organizations of economic activity. This is not surprising: given the large fixed investment in infrastructure, commercial and industrial real estate, and residential dwellings – not to mention the value of the social and business networks in place – the option to adapt existing investment within cities generally dominates any option that would involve wholesale abandonment or demolition of still-productive assets. The same logic of adaption over other options can be applied equally well to the internal location of economic activity within a metropolitan area. Though it is common to model cities as moving in response to marginal changes in fundamental variables from one unconstrained maximum to another, the problems facing agents are very much constrained – taking the investment choices made by generations of previous households, firms, developers and governments as given. This fact leads to a path dependence within urban areas in which starting points determine the current location of economic activity. Even where the basic building blocks of urban models – transportation costs, communication costs, production technology, etc. – have changed dramatically, the spatial distribution of employment within a metropolitan area may persist for very long periods of time.

This paper provides evidence that the path dependence exhibited in the system of American cities may be echoed in the organization of economic activity within cities themselves. In particular, it demonstrates the marked stability of the hierarchy of employment centers and the spatial distribution of employment within the Los Angeles metropolitan area. The apparent stability of the these centers and of overall employment is especially remarkable in light of the growth and changing nature of both the employment base and the population in the region. Over the twenty-year sample period, the Los Angeles metropolitan area has added a net of approximately 1.4 million jobs – slightly less than the current total employment in Boston – while at the same time its composition of employment has moved substantially away from manufacturing toward service industries. Concurrent changes in the population and

its make up are equally significant: the Los Angeles metropolitan area has grown by almost four million residents, while evolving from a white majority to a ethnic/racial plurality.

Against this backdrop of expansion and change, the location of employment centers is generally stable. This is not to suggest stasis. Indeed, there is substantial growth outside the traditional urban core, although it may be better characterized by *reconcentration*. That is, rather than sprawl, employment in the peripheral areas has become more urbanized. For example, employment has grown faster in Orange County than in Los Angeles County. However, rather than spawning countless low-density centers, this asymmetric growth has resulted in employment densities within existing suburban centers that now rival the densities of the employment centers in Los Angeles County (Giuliano and Redfearn forthcoming).

This process of densification within a stable set of employment centers raises the issue of path dependence: economic concentration exists today where economic concentration existed yesterday. Over short periods, or where there is little change in employment or population, this is easily comprehended. That this appears to hold in a such a dynamic region, and over twenty years, strongly suggests that urban form depends less on some of the common variables used to explain the shape of cities than on their investment histories – even when those investment decisions were made under dramatically different social and economic conditions. For example, over the last twenty years – the era in which the Internet has "destroyed space" – the spatial arrangement of employment has remained remarkably similar to that when e-mail was the domain of a nerdy few in the basements of computer science buildings. Moreover, the location of employment centers appears to have persisted though a century of pronounced growth in income and ever-shrinking transportation costs (Glaeser and Kohlhase 2003). The location of the region's employment appears to be better explained by the initial conditions rather than changes in the set of variables usually thought of as urban fundamentals.

Moreover, the path dependence exhibited in the Los Angeles region appears to be driven primarily by investment in place well before the beginning of the 1980-2000 sample period. The large majority of the employment centers in the region are located on portions of the highway system that existed as of 1960. Those centers that appear inconsistent with this

general finding are likely to be older centers which formed around older infrastructure – either the pre-WWII system of freeways or rail lines. In fact, using a simple accounting, the locations of concentrated economic activity in the region by 1905 explains the spatial distribution of employment as well the current freeway system does. These are crude tests of employment location, but strongly suggest that the duration of persistence as being long enough to warrant more serious consideration in urban models. That is, initial conditions, adjustment costs, and short-term dynamics may be more interesting than long-run equilibria.

The descriptive "model" proposed in this paper takes this approach in assuming a fixed set of initial concentrations of economic activity. Over time, these small employment concentrations (small cities or towns) become centers within a larger metropolitan area. Their isolation at the beginning of the process is overcome by improved transportation technology that raises productivity in every networked city. The two dynamics that are relevant to the issue of path dependence are the adaptation of the fixed capital in these cities and the recycling of rights-of-way used to connect them. Where capital can be adjusted, technological change is enhancing; where it cannot, stagnation occurs. The issue of rights-of-way is important because the process of improving transportation often is only possible by reusing existing roads as sites for boulevards, existing boulevards as freeways, and so on. The iterative process of locating transit between productive locations and then recycling these rights-of-way tends to reinforce the advantages of the original sites of economic activity and makes adaptation of the centers' fixed investment a dominant option relative to building anew outside them. The result of this process is a spatial allocation of economic activity that is significantly dependent on investment choices made long ago.

The central empirical challenge faced in addressing path dependence is developing reasonable tests of the relative explanatory power of data from a variety of epochs, across which data quality varies substantially. To the extent that urban models are ahistorical, with the spatial distribution of employment a function only of contemporaneous levels of transit and communication costs, wages, production functions, etc., data from previous epochs should have little to say about where employment is located today. The variable used in this analysis is the location of employment, not rents. Given slow adjustment in the capital stock,

it is likely that rents are more responsive to shocks. But the actual location of economic activity should change in response to changes in rents over the medium term. This is how support for the notion of path dependence is developed, with the construction of several descriptive measures that speak to the stability of employment location over the medium- and long-terms and by assessing the relative explanatory power of the distant past with the present. Of course, there are many mechanisms by which path dependence may be attenuated or enhanced: zoning, the decentralization of control over economic development, local geography, etc. The paper does not test for their individual relevance. Rather, the goal is simply to examine whether or not the past is central to the present. Future research will be needed to speak to these specific points.

The paper is organized as follows. Section 2 discusses a set of mechanisms that results in path dependence. This descriptive model provides several predictions that form the basis for the empirical tests. Section 3 provides an overview of the economics of employment centers, the sub-metropolitan analog to metropolitan areas in the larger system of cities and one unit of analysis in this research. This section defines centers, discusses their formation, and briefly discusses how they are identified. Section 4 documents the dynamic context of employment and population change within the Los Angeles metropolitan area, against which the stability of employment location should be contrasted. The measures of stability are developed and reported in Section 5. The relationship between fixed investment in buildings and transit is explored in Section 6. This section also offers several conjectures that relate the apparent path dependence to large fixed investments made a century ago. Preliminary conclusions and possible extensions are presented in Section 7.

2 Location Choice & Path Dependence

The urban form that is the subject of this paper is defined by the location of employment. The literature is replete with models whose focus is the location choice of firms. Many of these urban models are ahistorical. Many of those with a temporal component involve time as an index, one that exists simply to denote the life stage of a representative agent who lives for two or three periods. These periods are generally not meant to represent particular

calendar years. The reason for these norms is straightforward, resulting from the desire to undertake comparative statics – to look across equilibria for changes in location, rents, welfare, etc. The significant problem with applying these types of models to real cities is that adjustment costs may be sufficiently large that shocks arrive far faster than developers can profitably rearrange the spatial distribution of economic activity.

Another obvious reason for modeling cities using a crude temporal frame is tractability. That is, the addition of space to already-complex models of firm and household behavior is sufficiently vexing that another dimension may add substantial overhead with little insight to show for it. For these reasons, the "model" developed here is largely descriptive – outlining a set of rules for household, firms, developers, and governments. It avoids any attempt to formalize the rules, and simply iterates through them as way of generating several basic hypotheses.

The model begins with a set of distinct concentrations of economic activity. These proto-centers are likely to arise as a function of local agricultural population, but for the purposes of this model, they are simply assumed to exist. Centers are proximal only through the eyes of one with access to modern transportation. In the first cycle of this iterative model, there is no formal transportation network that links these concentrations. Imagine the American West in the second half of the 1800s: certainly transit occurred between centers, but it was along unmaintained roads. The existence of centers presupposes some advantages to agglomeration. The agglomerative economies are assumed to be highly local, extending only within the centers themselves.

It is these local advantages within the centers that leads firms to locate among the set of existing centers. For price-taking firms, location choice is a function of rents, wages, productivity, etc. and trade-offs among them over a set of existing facilities within the existing centers. No point outside a town is as productive as any point within a town. No assumptions as to the relative magnitude of the advantages across centers are needed. Indeed, some centers may grow faster or slower as a result of stronger or weaker agglomerative economies, but even the slower growth centers offer agglomeration benefits that dominate

locating at some point outside a town.[1]

Households do not live within the centers. As they are not engaged in production, they will not outbid firms for locations within the centers. Rather, they will locate outside centers in a manner that minimizes travel to employment and consumption within the centers themselves. Analogous to the firm location choice, households which live away from centers endure longer commutes with an implied lower effective wage and higher costs of consumption. This assumption is paramount to forcing the population to be all urban (or suburban), with the agricultural population ignored.

In addition to firms and households, the key agents are property owners and local governments. Property owners face on-going decisions regarding the construction of new facilities and/or the adaption of existing facilities. Given local agglomeration economies, site location is fairly straightforward. Where adaptation is optimal, existing structures within centers are renovated to best meet market conditions. Where adaptation is too expensive, new structures are built. This can occur either where old structures are or at the periphery of centers.

Finally, local governments act to link centers via existing transit technology. Moving from rudimentary paths between centers, roads are established and then maintained. As cars become available, roads are paved, and so forth. Local governments maximize some social welfare function, balancing the benefits of transit access with the taxes required of the infrastructure. Given finite fiscal budgets, priority is given to connecting centers that offer the highest net benefit. The benefit of linking transit to other centers is shared economies of agglomeration. That is, a firm in a networked center (one linked to other centers) enjoys not only local agglomeration economies, but also some fraction of the agglomeration economies across the networked centers. The fraction is determined by the transportation technologies.

The iterative process of metropolitan evolution begins with a scattering of distinct centers with only rudimentary connections. Around each center are households who work and shop in the centers. At some point, the social benefits of networking two centers surpasses the

[1]Centers can grow spatially; firms simply locate at the edge of an existing town. All that is needed to enjoy a town's agglomerative economies is to be inside it or contiguous to it. Centers can fail via negative growth, but this outcome is handled in the extensions below.

costs of building the required infrastructure. At this point in the process, the optimal path is determined within the context of two centers; it is not optimized with other centers in mind. Firms within the two centers now are more productive, households now locate around the centers, as usual, but they can also locate along the transit corridor. Where previously a third center may have viewed the expense of networking as in excess of the benefits, it now has the opportunity to join, not one, but two centers. This dynamic continues until – for a given transit technology – no more centers join the network.

Several types of shocks can cause further changes to the transit network. First, transit technology may improve, and cause all centers to reexamine their networking choices. Second, centers can grow such that joining the transit network may become optimal. Interestingly, the benefit/cost optimization problem is not the same for the two situations. Networked cities have an existing roads which can be improved less expensively than building a new transit links. Where the new transit technology may push unconnected centers to become networked, it is likely that centers already connected will recycle their existing networks at a higher intensity.

The result of the second round of transit investment is a geography of networked centers whose productive advantage is now even greater over non-networked locales. Firms continue to choose centers as their optimal locations. And, as before, households continue to locate around centers, but they can now also locate further from centers along transit corridors.

One further element is needed to complete the "model" of urban evolution: growth. Centers grow and decline with shocks to prices for the goods and services they produce. Centers that produce goods and services in excess demand will hire more workers and pay higher rents to house them. Rent increases are limited by competition in space markets from other centers. The effective competition is a function of the production functions of firms and the relative substitutability of other centers. That is, if a firm's productive advantage is locally specific, it will pay more to house its workers locally. Alternatively, if a firm's productive advantage exists in any center, its response to rent increases will be to relocate.

Expansion of the number of jobs will eventually lead to adjustment in the fixed capital in which production occurs. Adjustment to existing structures can occur anywhere in a center;

new construction can occur within the center or at the periphery. Note that peripheral expansion will be limited by the price of residential land. In smaller centers, outward expansion may be inexpensive as few households are far from the center. In larger centers, outward expansion may become prohibitive relative to densification because of the premium paid to live close to employment and consumption among resident households.

It is at this point in the iterative process that the nature of commercial real estate becomes the central to explaining path dependence. Indeed, its durability, spatial fixity, and relative adaptability make structures and their associated infrastructure the key elements of the "model." Where structures are adaptable, centers can constantly be renovated to meet the needs of firms at any point in time. Structures that cannot may sit idle as production technology changes and cause centers to lag. For example, in the case of the system of cities, the steel mills in Pittsburgh or original car plants in Detroit – once the acme of productivity – had no economic alternative use and remained unused for long periods after they ceased production. As production technology changed, these structures were not adapted, they were abandoned. Office buildings, retail, light manufacturing, and warehouses, on the other hand, are far more adaptable. Housing accountants in one decade, office buildings may then become home to consultants, lawyers, and other white-collar industries as decades roll by. All that is required are tenant improvements to create "new" office space. Mall tenants come and go, but the mall remains productive. Warehouses are similar in that it is relatively simple to reuse large, open structures to store the goods of any particular era. Moreover, they are relatively inexpensive to destroy if alternative types of employment space are required.[2] The producers of these facilities, developers and current owners, face on-going decisions as to build or renovate. In the case of office space and warehouses, their profit maximizing behavior leads them first to adapt rather than build anew. The choice may be the opposite for goods production in which the fixed investment is very costly to adapt or to clear to make room for more productive land uses.

The iterative process rolls forward with firms and households continuing to reevaluate

[2]This is not to say that any of these products types avoid obsolescence. Rather, it is that each are relatively adaptable and lend themselves to regular adaptation that greatly extends their useful lives relative to their original build-outs.

their location choices, property owners continue to reevaluate their land use and land-use intensity, and local governments continue to reevaluate their local transit networks. Shocks enter the process through technology changes in firm production and to transportation. Though both the set of structures and the extent of the transit network represent fixed investment, they play decidedly different roles in determining the location of economic activity.

Transit networks act to connect productive centers. Centers that are not connected are far less productive than centers that are. This is because firms enjoy agglomerative economies directly from their own center as well as some fraction of all centers to which they have access through the transit network. As such, the network is necessary for path dependence – centers that persist will be located on the network. But note that access to the transit network does not generate economic activity, rather it serves to reinforce advantages to existing concentrations of economic activity.

An interesting dynamic that occurs outside centers is the "filling-in" of the spaces between centers. Just as in the case of center expansion becoming more expensive as households locate around centers in order to minimize on their commutes, households also locate along transit networks. This makes adjustments to the transit network more and more expensive. Improved transit technology is then applied to existing rights-of-way, recycling them at higher intensity use. Centers that failed to network may effectively lose the option to become connected as households locate such that land accumulation for transit investment becomes impossible.

This highly descriptive model of urban evolution sketches several self-reinforcing mechanisms that result in several predictions. First, the location of economic activity should be highly persistent within an urban area – both for the complete spatial distribution of employment as well as its significant concentrations, the employment centers. The mechanisms at work reinforce existing advantages and deter "reoptimization." If true, employment density should be a function of past employment density. An exception to this is where fixed investment is not readily adaptable. Here, vacancy cannot be met with relatively low-cost renovations to appeal to a broad spectrum of potential tenants. Second, employment density should be more persistent *outside* centers than within them. This occurs because it is within

centers that adjustment to the aggregate commercial property stock is most likely to occur.

With regard to transit infrastructure, the "model" predicts that transit networks within an urban area should reflect earlier transit networks: as transit technology improves, rights-of-way should be recycled – leaving their locations unchanged. It also suggests that transit access is a necessary but insufficient condition for the existence of a center. If so, highways should have little predictive power as to the location of employment density (either in tracts or centers). The "model" describes the original networks as links between economically distinct locations and thus the location of older freeways and older freeway intersections should have better explanatory power than newer freeway systems, which may have been designed with some other criteria in mind. Lastly, the model suggests that the starting point for the transit networks is the proto-centers from the distant past. This implies that the location of far earlier concentrations of employment should have some predictive power as to the current spatial distribution of employment.

In short, these model predicts that history should play a significant role in the distribution of both the location of centers and the arrangement of the current transit network.

3 Modeling & Measuring Employment Concentration

This is neither the first paper on path dependence in an urban setting nor on the role of long-lived fixed investment in influencing urban outcomes. There are a handful of papers have examined the role of durable capital in urban form (Wheaton 1982) – and, in particular, durable housing (Glaeser and Gyourko 2005, Harrison and Kain 1974, Anas 1978, Arnott 1980). These papers, however, use durability to explain short-run dynamics that are at odds with papers that exclude it. Their focus is not on longer term path dependence. In the small number of papers on path dependence in an urban setting (Arthur 1988), the focus is generally on the dynamics of industry locations – the birth and death of new firms that results in concentrations like that found in Silicon Valley. There are papers that shed light on several mechanisms that support the descriptive model above. Notably, Munneke (1996) and Rosenthal and Helsley (1994) discuss redevelopment, supporting the basic motivation for adjustment of the fixed capital within centers; Braid (1995) addresses the path dependence

of transit systems as housing crowds of rights-of-way making expansion difficult.

The line of inquiry addressed in this paper is agnostic as to the specific forces that led to the initial formation of cities or to their growth and decline over time. Rather, the paper aims to establish the consistency of the system of intra-urban employment centers during a period in which all of the basic variables used in urban modeling varied widely. An excellent summary of these variables and the evolution of the study of the economics of agglomeration can be found in Anas, Arnott, and Small (1998). In their article, they address the forces of concentration and deconcentration in both mono- and polycentric contexts.

Though it plays an important role in this paper, it should be noted that polycentricity that is not the main finding of this paper. The multi-nodal nature of American cities has long been recognized, popularly by Garreau (1991) and by many academics (McMillen and Smith 2003, McMillen 2001, Giuliano and Small 1991, McMillen and McDonald 1998, McDonald and Prather 1994, Anderson and Bogart 2001, Bogart and Ferry 1999, Craig and Ng 2001, Cervero and Wu 1997, Gordon and Richardson 1996). Despite the growing list of papers on polycentricity, there is a dearth of research on the temporal dynamics of the centers within a metropolitan area. Giuliano and Redfearn (forthcoming) add to this line of inquiry by looking at the Los Angeles region using data very similar to that used in this paper, but employing a different approach to identifying centers. They find stability in the location of urban centers while suburban centers grew at a more rapid rate.[3]

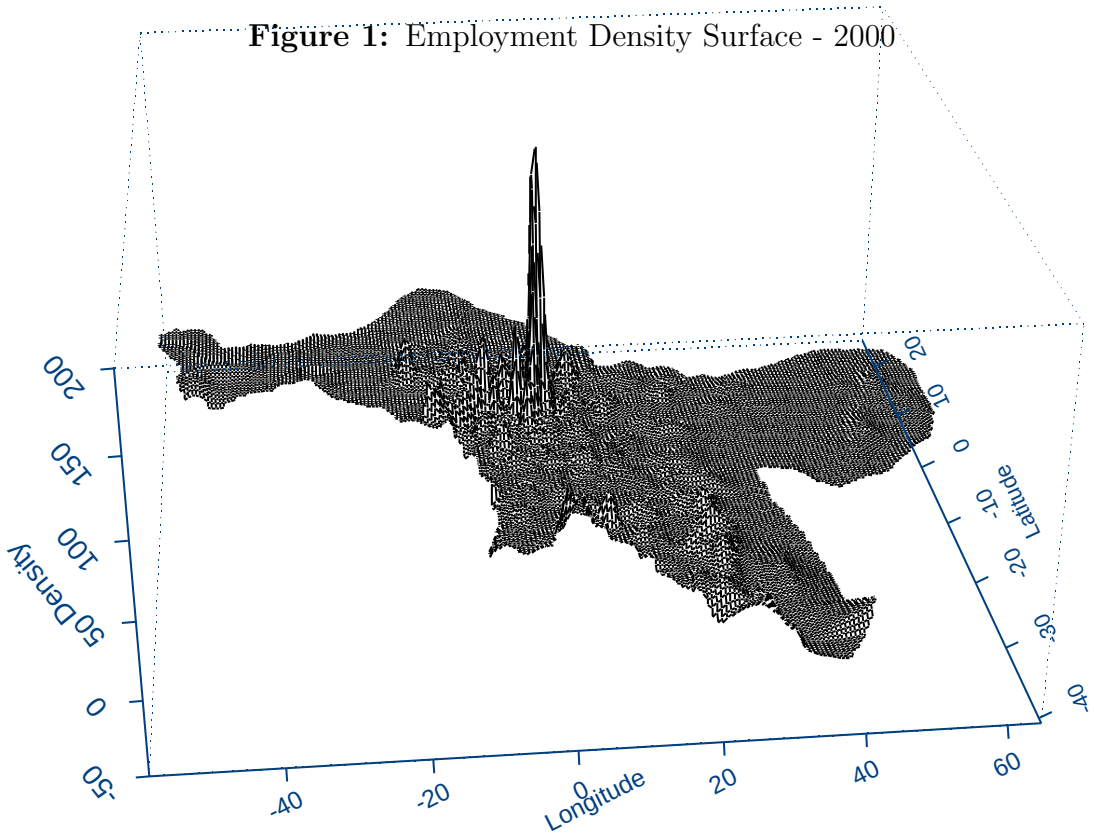
The definition of an employment center used in this research follows Redfearn (forthcoming), it is a contiguous set of census tracts that are significantly more dense (with regards to employment) than their surrounding tracts. Centers in this definition are therefore a function of relative density – not absolute. In this way, Riverside and Oxnard – clearly local centers of economic activity – can be identified despited their low absolute level of employment density. (For reference, the center of downtown Los Angeles has six Census tracts in

[3]They also find the birth of centers, although the method they employ may be responsible for this finding. They use an approach developed by Giuliano and Small (1991), that asserts employment density and total jobs cutoffs in defining employment centers. For example, they define two broad categories of centers: "10-10" and "20-20." A "10-10" center has at least ten jobs per acre and a total of 10,000 jobs; "20-20" centers are defined analogously, with at least 20 jobs per acre and 20,000 total jobs. Using these definitions, "new" centers can appear as the thresholds are crossed, even though they functioned as centers prior to being identified as such.

excess of 100 jobs per acre with a total employment of almost 200,000. In contrast, Ventura County contains only seven tracts with greater of 10 jobs per acre. The total employment in these seven tracts is just over 30,000.)

The intuition behind the use of relative employment densities to define centers can be seen in Figure 1, which plots employment density by location for the Los Angeles region.[4] Here the dominance of the downtown is clear, but so too is a north-south line of centers in the

Figure 1: Employment Density Surface - 2000

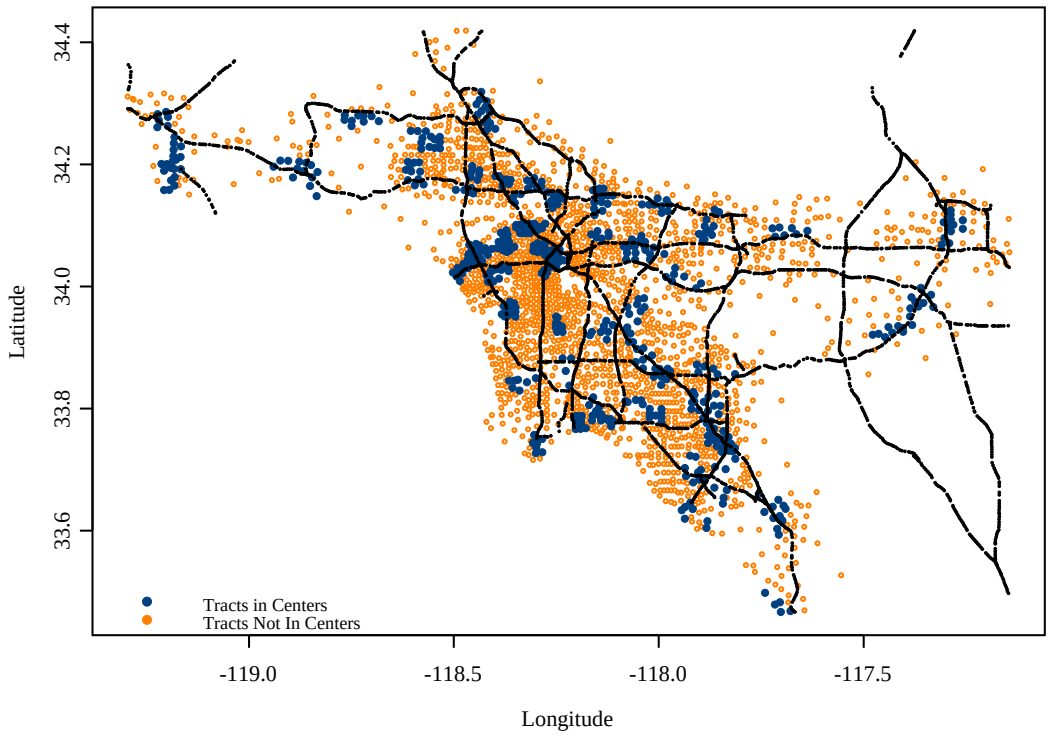


south-eastern portion of the map. These are the densifying centers of Orange County. Also prominent is the ridge of high-density employment running west from the downtown area of Los Angeles. This is the corridor of employment along Wilshire and Santa Monica Boulevards. In addition to these features, there are "peaks" of employment density throughout the metropolitan area – each a potential employment center.

Figure 2 shows the statistically significant of these peaks. The dots on the figure represent Census tracts. The universe of Census tracts is partitioned into those tracts in employment

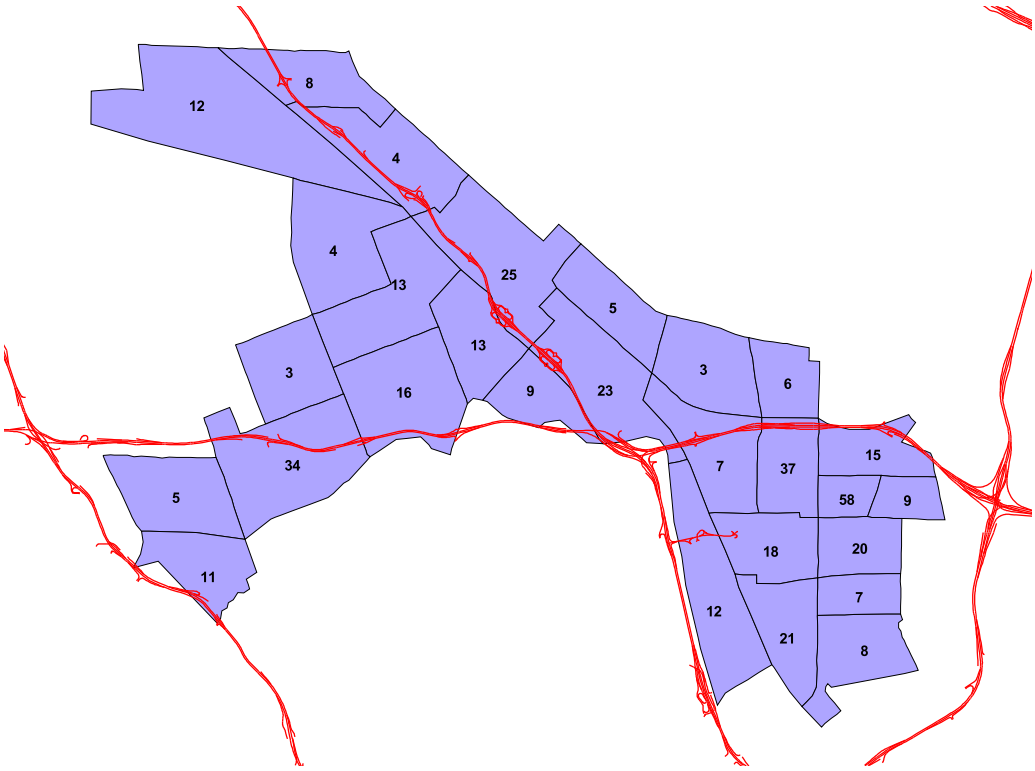
[4]This is a fitted surface, using a locally-weighted regression. See Redfearn (forthcoming) for more details.

Figure 2: Tract Inventory: In and Out of Centers - 2000



centers (the solid dark circles) and those tracts outside centers (the hollow lighter circles). Many of the peaks from the previous figure are present here as statistically significant employment centers. A close look at one of these centers is shown in Figure 3. Together, these two figures hint at the one of the conjectures that will be more rigorously examined below: the role of fixed investment in explaining the stability of the employment centers over time. The highways that run through Figure 3 are Interstate 5 (diagonally from northwest to southeast) and state route 134 (the east-west artery); highways 2 and 170 form the eastern and western borders. These highways represent enormous fixed investments that are essentially permanent. The commercial structures in Glendale and Burbank are certainly not permanent, but very long-lived; they are routinely renovated and expanded as are new structures added to the skyline. That said, the evolution of the Glendale/Burbank center is – like all the others – marginal, with only small changes taking place at any one time. This is the source of the path dependence: no small change in the fundamental variables used in urban modeling will result in any wholesale change in a center's aggregate fixed investment.

Figure 3: Employment Center Example: Glendale/Burbank - 2000



Land prices and rents, may change, but the land use and, therefore, the broader "urban form" will not.

Figure 2 suggests the same interaction on a broader scale. As this illustration suggests, it would not be an inappropriate generalization to state that centers are a function of access to the transportation network. This is both obvious and a direct prediction of basic urban models. What is interesting is that most of the current centers formed decades ago, on a freeway system that pre-dated WWII. Another way of viewing this is to look for where there are no centers on current highways (and, in particular, on the intersections of these highways). The region is full of "transit advantaged" locales that reveal no employment centers. In fact, many of these locales are on the newer freeway segments with no antecedent in the older freeway systems and offer no original employment concentration from which a current one might have evolved. These points are discussed more completely below.

4 The Dynamics of Metropolitan Employment

As discussed previously, a finding of stability in the location of an urban area's employment centers would be less compelling if the urban area itself were relatively static. The empirical results presented in this section are intended to suggest that Los Angeles and its surrounding cities form a highly dynamic metropolitan area – perhaps one of the most dynamic urban areas in the United States over the two decades from 1980 to 2000. It should be noted that dynamism and growth are not synonymous. Certainly the Los Angeles metropolitan area has grown, adding 1.4 million jobs and 3.7 million residents.[5] But, as large as these numbers are, they understate the transformation of region's economy and demographics. Like the rest of the country, the region's economy has experienced a broad trend toward services and away from manufacturing employment. And though it retains more manufacturing than many other major metropolitan areas, the period from 1980 to 2000 represents an upheaval in the composition of manufacturing. Heavily concentrated in defense industries, Los Angeles experienced major dislocation within the manufacturing sector with the end of the Cold War and its associated cuts in defense spending. In fact, a significant portion of the generally small changes we do find in the system of centers may be attributable to the decline of employment in these particular industries.

The "churning" of the population is no less remarkable than the change in the cross section of employment. While adding 3.7 million residents, the white population lost its status as the majority racial/ethnic group, with Hispanics reaching a plurality. The Los Angeles region is now home to large communities of immigrants from around the globe. It has been the rapid growth of these groups that has fueled the overall growth in the region's population. Tables 1 and 2 offer a glimpse into these dynamics, but focus on the spatial and temporal variation in employment and population growth.

[5]To be specific, the five-county region is not fully represented in data used in this paper. Riverside, San Bernardino, and Ventura Counties are large and sparsely populated geographies – with the first two stretching from Los Angeles County to the Arizona border. The five-county data have been culled to include a "compact urban" set of Census tracts. This was done to make possible the nonparametric procedure used to identify the employment centers. As a rough guide, the cities that bound the "compact urban" set of tracts are Oxnard to the west, Santa Clarita to the north, Redlands to the east, Corona along the 15 freeway, and Dana Point to the south. More on the selection criteria can be found in Redfearn (forthcoming).

Table 1: Employment & Employment Growth by County

	Employment			Percent Change	
Area	**1980**	**1990**	**2000**	**1980-1990**	**1990-2000**
Los Angeles	3,891	4,478	4,278	15.1	−4.5
Orange County	911	1,290	1,492	41.6	15.7
Riverside	103	139	199	35.0	43.2
San Bernardino	230	362	464	57.4	28.2
Ventura	160	251	299	56.9	19.1
Metro Area	5,295	6,520	6,732	23.1	3.3

Table 1 reports that the 1980s were a period of robust growth, with the region's employment base growing from 5.2 million to 6.5 million. Growth moderated substantially in the first half of the 1990s, yielding a net addition of only 200,000 jobs over the full decade. These broad trends mask the rise of the suburban counties of Orange, Riverside, San Bernardino, and Ventura – all of which maintained a brisk rate of growth even after the region's economy slowed. Note that while Los Angeles County actually lost significant employment, it remained the dominant employer within the region throughout the 1990s.

To a great extent, population shifted in concert with the trends in employment, underscoring the transformation of the outer counties from bedroom communities of commuters to employment centers in their own right. Table 2 echoes Table 1, reporting broad and rapid

Table 2: Population & Population Growth by County

	Population			Percent Change	
Area	**1980**	**1990**	**2000**	**1980-1990**	**1990-2000**
Los Angeles	7,303	8,497	9,125	16.3	7.4
Orange County	1,907	2,366	2,797	24.1	18.2
Riverside	277	413	494	49.1	19.6
San Bernardino	660	1,019	1,232	54.4	20.9
Ventura	456	584	666	28.1	14.0
Metro Area	10,604	12,879	14,316	21.5	11.2

population growth during the 1980s; growth moderated during the 1990s. Unlike the case of employment, Los Angeles County did not lose population after the job cuts in the defense

industries.

Because the working definition of a center rests on the relative density of employment, it may be useful to revisit the employment figures in terms of job density. Table 3 reports the employment densities for the Los Angeles metropolitan area and its five component

Table 3: Employment Density & Growth by County

	Density (jobs/acre)			Percent Change	
Area	**1980**	**1990**	**2000**	**1980-1990**	**1990-2000**
Los Angeles	3.7	4.3	4.1	15.5	−4.9
Orange County	2.2	3.1	3.5	40.2	15.3
Riverside	0.7	0.9	1.3	35.4	43.2
San Bernardino	0.8	1.2	1.6	57.0	28.2
Ventura	0.7	1.0	1.2	56.9	18.6
Metro Area	2.5	3.0	3.1	23.2	3.0

counties.[6] The table makes comparisons between the counties easier by removing variation in their geographic size. Again, Los Angeles is the most dense, but Orange County shows a marked densification over the twenty-year sample period. The other three counties have – to a lesser extent – also become relatively more dense: growing from a relative density ratio of five to one in 1980 to three to one by 2000.

Finally, because we focus on stability, it might be useful to examine stability of the

Table 4: Employment & Population Shares by County

	Shares of Employment			Shares of Population		
Area	**1980**	**1990**	**2000**	**1980**	**1990**	**2000**
Los Angeles	73.5	68.7	63.5	68.9	66.0	63.7
Orange County	17.2	19.8	22.2	18.0	18.4	19.5
Riverside	1.9	2.1	3.0	2.6	3.2	3.5
San Bernardino	4.3	5.6	6.9	6.2	7.9	8.6
Ventura	3.0	3.8	4.4	4.3	4.5	4.7
Metro Area	100.0	100.0	100.0	100.0	100.0	100.0

[6] Again, keep in mind that for all five counties the sparse rural regions have been removed from the data. Our focus in on intra-urban area employment.

shares of both employment and population over our sample period. Table 4 does not suggest stability; instead it reports consistent migratory trends away from the center. Indeed, each of the outer four counties account for a growing share of the metropolitan area's jobs and residents at the expense of the region's traditional center, Los Angeles County. Making sense of these trends while arguing for general stability in the spatial distribution of employment is the subject of the next section.

5 Stability in the Hierarchy of Employment Centers

The dynamism documented in the previous section underscores a significant shortcoming in examining agglomeration at a high level of aggregation. The statistics in the tables above point to rapid and marked change at the county-level, but they failed to account for the actual location of employment growth or loss within these relatively large geographic units of analysis. The centers defined in Redfearn (forthcoming) can be used to refine the question of employment location. Table 5 reports analogous statistics by using employment centers

Table 5: Employment, Density, & Employment Shares by County

	Census Year			Percent Change	
Area	**1980**	**1990**	**2000**	**1980-1990**	**1990-2000**
Employment (millions)					
Total	5.3	6.5	6.7	23.1	3.2
In Centers	2.7	2.9	3.2	9.7	8.2
Not in Centers	2.6	3.6	3.6	36.8	−0.8
Density (jobs/acre)					
Total	2.5	3.0	3.1	23.1	3.0
In Centers	11.3	11.4	11.6	1.3	1.6
Not in Centers	1.4	1.9	1.9	38.2	−0.2
Employment Shares					
In Centers	50.5	45.0	47.2	−10.9	4.8

as the unit of analysis. These figures suggest that marked changes in aggregate employment mask a stable share of employment in centers. Certainly the rate of growth in employment outside centers grew more rapidly in the 1980s than in the 1990s, but the overall process

left broadly unchanged the shares of employment in and out of centers. Alone, these figures do not speak to path dependence in the spatial distribution of employment, as the location of centers can evolve over time. Indeed, it is entirely possible that centers themselves come and go over time, undermining any relevance of stable employment shares as evidence of stability.

To examine the stability of the location of employment over time, a series of simple regressions can be estimated that simply ask how past employment in a tract predicts subsequent employment. Clearly from day to day these regressions would be uninteresting. However, the dates of the Census cross-sections fit well with a pronounced business cycle in the metropolitan area. The 1980s represented a boom in the region, especially for defense manufacturing. With a rapid build up of armed forces toward the end of the Cold War, the region's traditionally large share of employment dedicated to defense industries (dating back to WWII) experienced significant growth. These were high-multiple jobs, with many other jobs created to support and serve them. The 1990s, by contrast, saw the end of the Cold War and a shock significant enough to reduce the labor force by almost a million jobs, dropping from 12.6M at the end of 1990 to 11.8M just three years later. Much of the decade was spent restructuring and recovering from the shock to defense spending and its repercussions around the Los Angeles Basin. Regressions across these two decidedly different periods should capture spatial reallocation to the extent that there is any.

Table 6 reports four regressions of tract employment density in 2000 on tract employment density in 1980 and 1990. Surprisingly, the coefficients on the employment density of the most recent decade's employment density are close to one in all four regressions, while the coefficient on the decade prior is irrelevant. That is, when tract-level employment density in 1980 is the sole explanatory variable, it is highly significant – close to one – and explains a large majority of variation in the dependent variable. However, when 1990 and 1980 data are included in the same regression, 1980 is not significantly related to current employment density. Note that the fraction of variation in the 2000 tract-level employment density explained by these fully-historic models is quite high. In other words, the starting point of employment density ten or twenty years ago – *exogenous to any current or intervening*

Table 6: Employment Density = f(past Employment Density)

	ln(ED00)	ln(ED90)	ln(ED00)	ln(ED00)
ln(ED90)	0.909	–	–	0.813
	(0.01)			(0.01)
ln(ED80)	–	0.874	0.821	0.111
		(0.01)	(0.01)	(0.01)
r^2	0.894	0.756	0.722	0.897
Subsample Results: Tracts In Centers				
r^2	0.854	0.674	0.622	0.861
Subsample Results: Tracts Not In Centers				
r^2	0.941	0.881	0.873	0.946

(Note: standard deviations in parentheses)

fundamentals – is almost sufficient to explain the most recent cross section of employment density.

The adaptability of fixed investment plays a significant role in the descriptive model laid out earlier. This process may actually mean that the results in Table 6 may understate the extent of path dependence. Where asymmetric growth in the spatial distribution of employment occurs, it reduces the explanatory power of the models of density level on earlier density levels, even where differential growth may not change the rank of employment density of one tract relative to others. For example, the central business district of Los Angeles has lagged in terms of growth over the entire twenty-year sample period, but remains by far the largest and most dense center of employment in the region. This relationship is explored in Table 7, which regresses the rank of a tract's employment density on its rank in earlier decades. The table is striking in its similarity to the employment density regressions reported in Table 6, but is even more striking for the levels of persistence it reveals. The coefficients on the single regressor models are even closer to one than the previous models, and each explains a higher fraction of variation. The one difference is in the coefficients on the two-regressor model in the fourth columns. In Table 7, even the earlier decade's rank remains significant, though not as relevant.

In both tables, the explanatory power of the various models is reported for two subsets of

Table 7: Rank(Emp. Density) = f(past Rank(Emp. Density))

	rk(ED00)	rk(ED90)	rk(ED00)	rk(ED00)
rk(ED90)	0.971	–	–	0.692
	(0.00)			(0.02)
rk(ED80)	–	0.964	0.956	0.289
		(0.01)	(0.01)	(0.02)
r^2	0.942	0.929	0.914	0.948
Subsample Results: In Centers				
r^2	0.925	0.915	0.897	0.934
Subsample Results: Not In Centers				
r^2	0.967	0.951	0.942	0.970

(Note: standard deviations in parentheses)

the data. In each, the r^2's for tracts in employment centers and outside employment centers are reported. The models reveal greater persistence outside centers than within them. This is consistent with the hypothesis that adjustment to the stock of capital that houses employees of all sorts is more likely to occur in existing centers than outside them. Where adjustment occurs, both the levels of employment density and the rank of employment density changes, reducing the explanatory of the models.

With regard to the persistence of centers – the spatial clustering of census tracts by employment density – there are several interesting statistics. There are 538 tracts that are members of centers in 2000. This number is 555 in 1990 and 535 in 1980. This regularity belies two types of changes: changes in center boundaries and changes in the centers themselves. The majority of the change in tract membership comes from boundary changes, although there are several new centers in each decade as well as several that disappear.[7] On the issue of stability of centers, 383 of the 538 tracts that were in centers in 2000 were in centers in 1990. This number is 351 when the comparison is 1980. Speaking to issue of stability in the location of employment, the tracts common to centers in each of three

[7]Recall that a center is defined by its density of employment relative to the density of employment in the surrounding tracts. As such, centers can be "born" or "die" even if their employment remains unchanged. This process is most clear in urbanizing Orange County, which during the 1980s saw several centers disappear against a backdrop of rising general density, only to reappear as they too densified in the 1990s. This speaks to the process of urbanization that will be left to future research.

cross-sections comprise 85 percent of center employment in 2000.

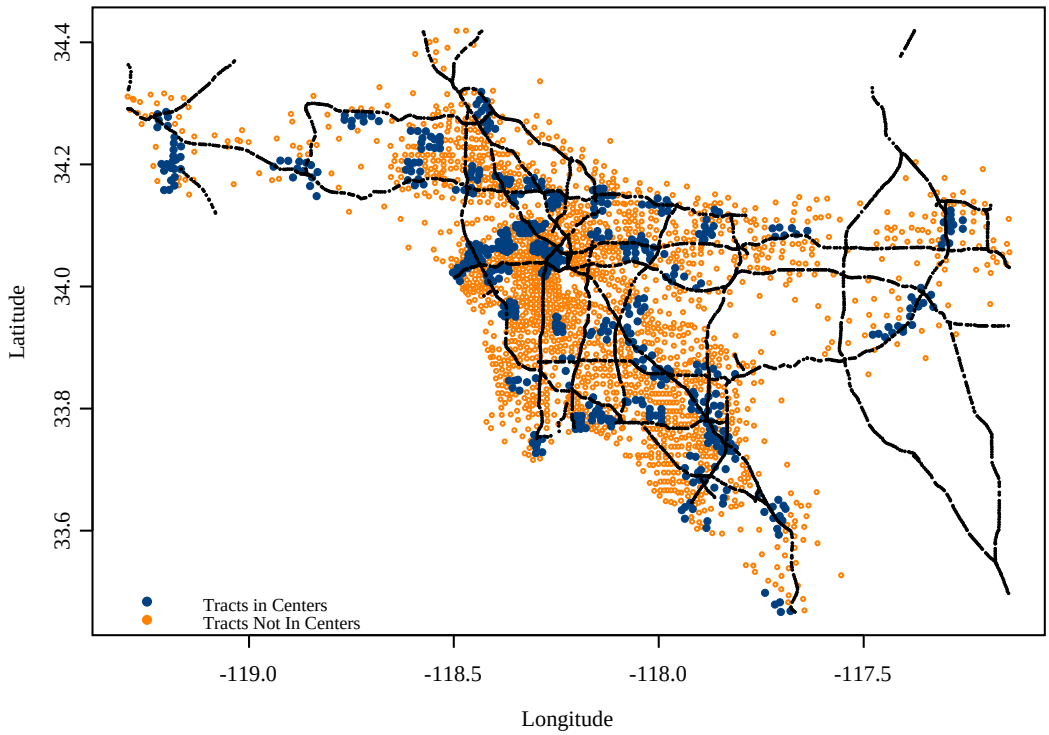
Taken together, the tract-level and center-level statistics suggest a marked path dependence in the spatial distribution of employment. Without appealing to any contemporaneous variables, the explanatory power of fully historic models is approximately 90 percent. Furthermore, the difference in the models supports the hypothesis that adjustment to the location of employment is more likely to occur within employment centers. Having established some measures of path dependence, the question then becomes what drives it and if it is consistent with the descriptive model of adaptable fixed investment and relatively fixed transit networks.

6 Path Dependence & Fixed Investment

The descriptive model told a story of reinforcing mechanisms. First, distinct economic places (i.e. not contiguous) become connected via simple transit technology, enhancing the productivity of all centers which become connected. This further favors these locales over undeveloped sites as optimal choices for incoming or expanding firms. As growth occurs, residents – who locate on the periphery of the distinct economic places – fill in the areas between them and effectively preclude truly new transit networks and force employment densification. This results, not in ongoing re-optimization in an unconditional sense, but rather in adjustments to existing transit networks along established rights-of-way. The result is an ossification of employment locations and the pathways the transit networks follow (even if modes along them or their intensity of usage may change over time). Following this logic, new highways should have little predictive power relative to older ones, and, in fact, the first economic concentrations tied together by the transit networks should explain current employment's location as well.

To test these conjectures, two fairly simple calculations are made that compare the explanatory power of transit networks over time and specific locations over time. The first approach asks whether a tract close to a transportation network is more likely to be densely populated with jobs. It does this for three configurations of the region's highway networks: 2000, 1960, and 1942. Figure 4 shows the 2000 centers and with the highway system (at the

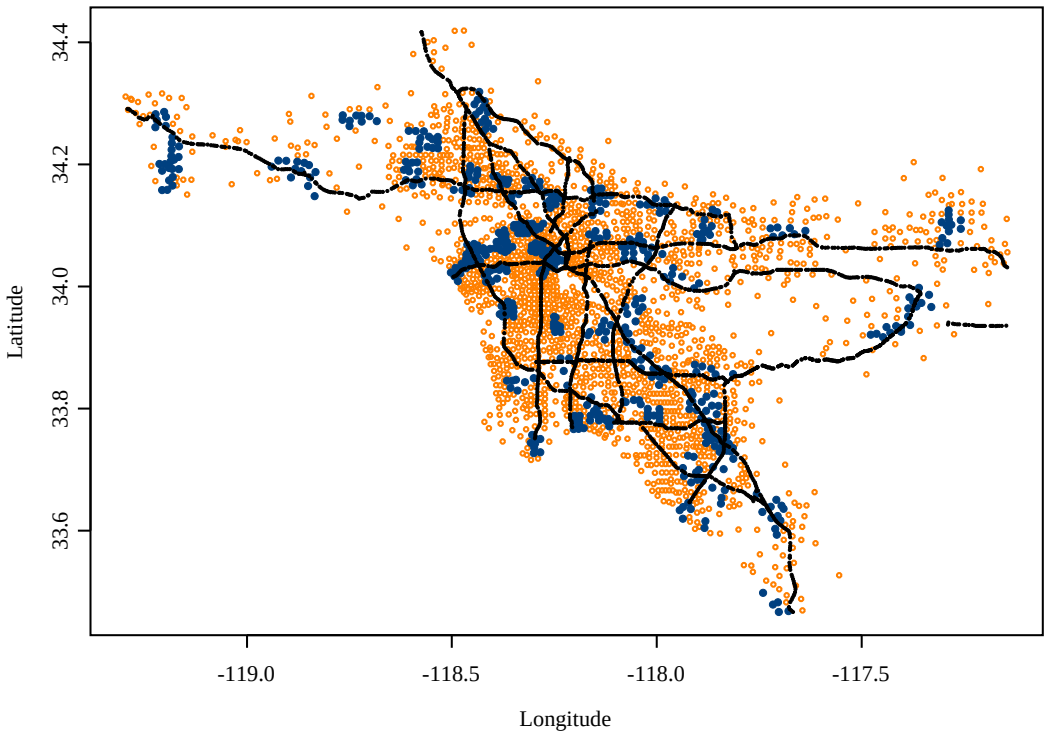
Figure 4: 2000 Employment Centers and 2000 Highways



time) superimposed on top. It might be tempting to claim that centers are fundamentally about highways. But to do so would be to ignore the hundreds of miles of highways that have no significant employment or employment centers. Moreover, a look back forty years reveals that current highways are worse at explaining the current distribution of employment than the highway system as of 1960. Figure 5 shows exactly this. The difference in the two highway systems is essentially the addition of segments that run through areas of sparse employment. Along these routes there appear to be at most one center that might be attributable to the "new" route – all other centers explained by the 2000 network are also explained by the 1960 era network.

There a handful of significant exceptions to the rule that centers are located on highways. They are not glaring in the sense that none of them are truly far from the current highway network, but they do not appear to be organized with the current system in mind. These include the Wilshire/Santa Monica Boulevards center as well as the Hollywood center adjacent to it. Both of these centers are oriented in a distinctly east-west manner, while

Figure 5: 2000 Employment Centers and 1960 Highways



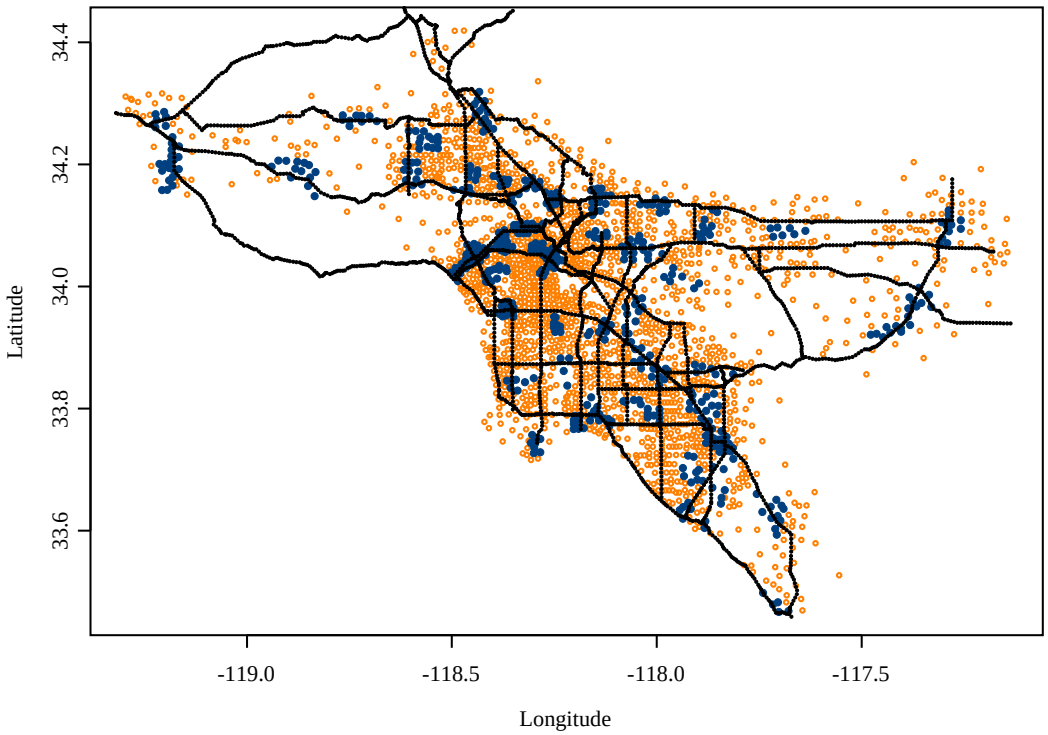
the highways they abut run approximately north-south. Also, in the San Fernando Valley, there is a center that runs diagonally and is unattached to any freeway; the same is true of a center directly south of the CBD.

Once more, the iterative, reinforcing mechanisms described in the "model" predict that looking to an earlier network may be informative. Indeed, Figure 6 reveals that the highway system as of 1942 explains, not only the same centers explained by the 2000 highway system, but all the anomalies save the diagonal center in the San Fernando Valley. In this instance, it is a rail network that predates any of the highways which provides the logic for this center's existence and its geographic orientation.

These relationships can be formally assessed in a manner analogous to the previous regressions. Table 8 reports the regressions of employment density on proximity to various highway network configurations, while Table 9 reports the regressions of tract membership in centers on the same variables.

The regressions reported in Table 8 compare models of the log of employment density

Figure 6: 2000 Employment Centers and 1942 Highways



in 2000 on different specifications of the distance to the nearest freeway – as of 2000 and 1942. Unlike the previous regressions, these are only marginally successful at explaining the existence of employment density. However, even at this marginal level of success, the highway system of 1942 is significantly more informative than are today's freeways. A comparison of Figures 4 and 6 explains the differences. First, the earlier network is more oriented toward directly tying together places of economic activity. Moreover, all the relevant parts of the current system are captured by the older system. Clearly, much of the current system uses the rights-of-way established in the older system. The drop in explanatory power is due to the fact that significant portions of the earlier network have not been recycled into more intense uses – staying boulevards rather than becoming freeways. Furthermore, the new portions of the highway system are mostly peripheral, passing through the region but serving more to link San Diego and Las Vegas than to tie new locations of economic activity to the existing network. These results are echoed in Table 9, which reports logistic regressions of center membership on the same proximity measures. Again, the 1942 highways dominate the 2000

Table 8: Employment Density & Highway Access

	ln(ED00)	ln(ED00)	ln(ED00)	ln(ED00)	ln(ED00)
Intercept	1.122	1.298	0.970	1.168	1.041
	(0.02)	(0.04)	(0.03)	(0.03)	(0.05)
$\ln(d^1_{00}))$	−0.309	−0.219	−		−0.061
	(0.03)	(0.03)			(0.04)
$\ln(d^2_{00}))$	−	−0.219	−		−0.156
		(0.04)			(0.05)
$\ln(d^1_{42}))$	−	−	−0.479	−0.342	−0.360
			(0.03)	(0.03)	(0.04)
$\ln(d^2_{42}))$	−	−	−	−0.298	−0.478
				(0.04)	(0.05)
r^2	0.059	0.072	0.134	0.158	0.204

(Note: standard deviations in parentheses)

highways in terms of explanatory power, although neither do all that well at predicting which tracts are in centers. In this sense, highways should be seen as necessary but not sufficient conditions for the existence of employment centers.

There is one further prediction of the descriptive model that can be explored. The starting point for the iterative process is the existence of distinct concentrations of economic activity. These dictate the original transit networks, and the two in turn then persist for periods of time longer than secular changes in the fundamentals typically used in urban models. To examine this aspect of the model, the spatial organization of current employment can be viewed as organized around significant points in space, rather than along the networks that connect them – those used in the previous tests.

The question is: what is a "distinct concentration of economic activity"? Again trying to disentangle the role of transit networks from original distribution of economic activity, two types of points were used. The first are highway intersections, because it is possible that each point on the network is not as relevant as others. For example, the analogous calculation in a national context might find the interstate system of freeways as equally irrelevant due to the vast expanses of low-density farm land that lies between Seattle and Chicago. So, the more relevant points on the transit network may be the intersections which favor firms there

Table 9: Employment Density & Center Membership

	SC00	SC00	SC00	SC00	SC00
Intercept	−1.312	−1.167	−1.522	1.168	1.356
	(0.05)	(0.08)	(0.06)	(0.03)	(0.10)
$\ln(d^1_{00}))$	−0.357	−0.283	−		−0.136
	(0.05)	(0.06)			(0.07)
$\ln(d^2_{00}))$	−	−0.185	−		−0.116
		(0.08)			(0.08)
$\ln(d^1_{42}))$	−	−	−0.551	−0.461	−0.423
			(0.06)	(0.07)	(0.07)
$\ln(d^2_{42}))$	−	−	−	−0.210	−0.142
				(0.08)	(0.08)
pseudo r^2	0.018	0.021	0.039	0.042	0.047

(Note: standard deviations in parentheses)

over places not on intersections, e.g. Chicago and Seattle, but not the length of Route 94 that connects them. Therefore three sets of highway intersections are used as origins around which the share of total current (2000) employment is calculated; these are intersections of the highway systems as of 2000, 1960, and 1942.

In addition to the intersections, a different type of location is also used as the basis for analogous calculations. Here, places that were either incorporated as cities or contained proven significant economic activity as of a particular year are included. The goal is to find economically significant and distinct places that existed earlier than any highway system. If the model holds, it is these places that should be tied together in the early years by rudimentary transportation networks which will in turn establish the rights-of-way that are still used today as transit corridors. These "significant places" are defined as such if one of two criteria were met. The first is incorporation. If a place was legally incorporated as a city by the cutoff year, the centroid of the current city was used as a significant place.

Incorporation meant several things in the early 1900s and is therefore an imperfect measure of economic distinctiveness. That is, incorporation was often the first step taken by business leaders engaged in economic development – part of the the adaption process described in the model. That said, incorporation was also used defensively by residents to

ward off annexation by neighboring cities. This defensive incorporation appeared to be just getting underway between 1905 and 1910 and so both years are included in the analysis, though it appears that the two purposes of incorporation will result in some noise in this measure.

The second manner of being designated a significant place is if, in fact, there is evidence of a material concentration of economic activity. This definition was necessitated by the large number of cities which – while economically relevant for decades by the early 1900s – did not incorporate until much later. Thousand Oaks, for example, was long the site of the stage coach stop on the route connecting Los Angeles and Santa Barbara. It had a major inn and supporting services well before many of the incorporations in the late 1880s but did not itself incorporate until 1956. Other places, such as Hollywood, incorporated relatively early – in 1903 – but then acceded to annexation to Los Angeles within a decade, leaving it then (as it currently is) as a district of the city of Los Angeles.

Figures 7 through 11 display the different sets of significant points used in the last calculations. The intersections are both fairly intuitive and readily seen as relevant in the first two figures.

The second set of figures (Figures 9 through 11) display the progression in the number of "significant" places starting in 1895.[8] Even as this early date, it's clear that this set of historic locales is related to the current spatial distribution of employment. Certainly, being incorporated or having a significant concentration is not deterministic, as there are several older locales that do not include significant concentrations of employment as of 2000. That said, the large majority of the historic set of locales is found within the boundaries of a current employment center.

The number of significant places in 1895 is 33. This rises to 57 by 1905 and 63 in 1910. These points are plotted in Figures 10 and 11. The new points that appear by 1905 appear to spaced further apart than the new arrivals over the following five years through 1910. This is

[8]It is possible, in fact, to move even further back to the original ranchos with divided the land in the regions. It is along the boundaries of these parcels that the great boulevards were established. In fact, it's possible to see the rough outlines of spatial organization of land use prior to statehood through careful selection of current major surface streets. This is another way to see the long persistence of infrastructure investments. This is left for future research.

Figure 7: 2000 Employment Centers and 1942 Highway Intersections

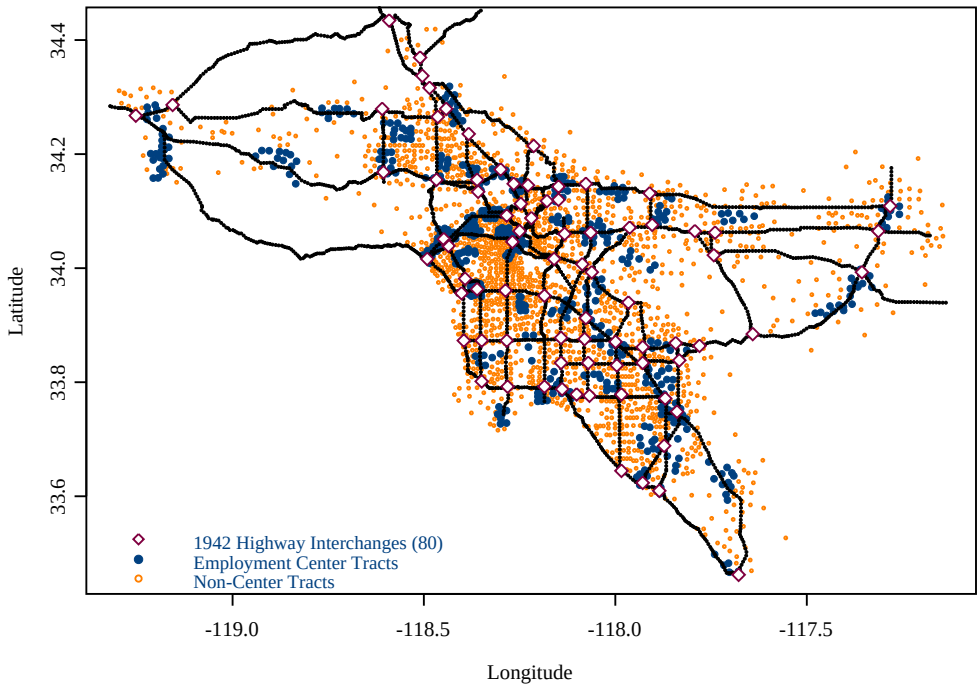


Figure 8: 2000 Employment Centers and 2000 Highway Intersections

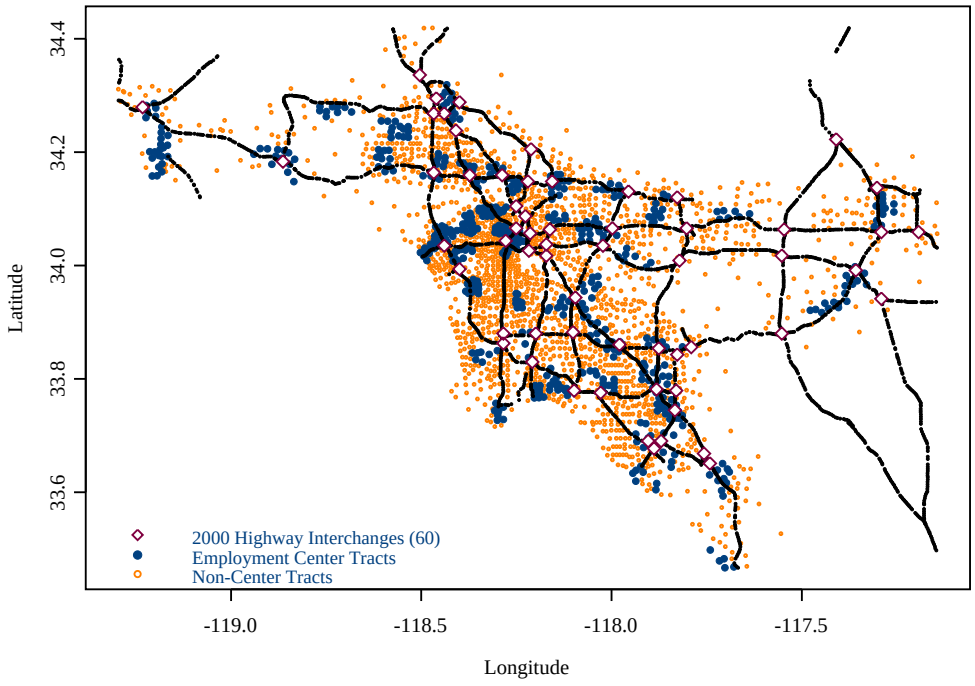
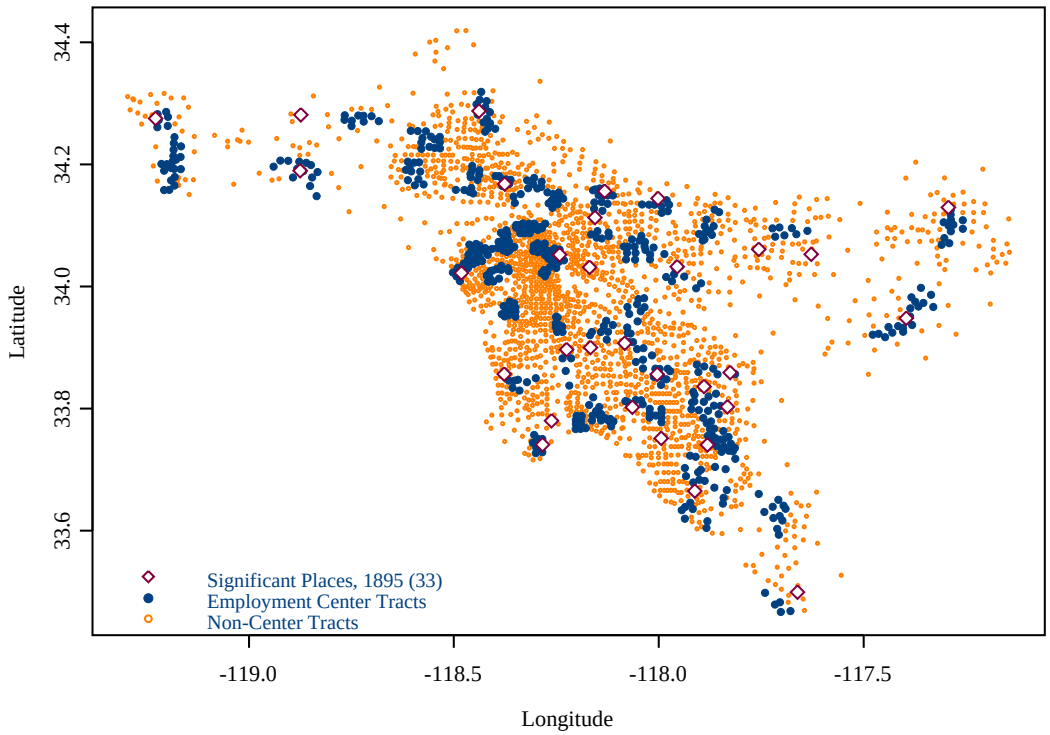


Figure 9: 2000 Employment Centers and 1895 Significant Places



likely to reflect the beginning of the defensive incorporation, with many new incorporations occurring very close to others – effectively precluding annexation.

Having defined these sets of "significant places," it is possible to see which set of points best explains the current distribution of employment. This is done by calculating the cumulative share of employment within concentric rings around the five sets of points.[9] Clearly, these are crude measures of economic distinctiveness. But they do proxy for the spatial distribution of employment well prior to any modern transit network. (This is not to say that there wasn't mass transit of a sort. But while Hollywood and downtown Los Angeles are today a short drive from each other, the carriage ride available at the turn of the century was scheduled to be the better part of two hours long.)

[9]In fact, many dates were examined for dates earlier than the Great Depression. Specifically, for various dates ranging from 1880 to 1930, sets of significant points were defined. In addition to the rise of defensive incorporation, a second reason for picking 1905 and 1910 from among them is that the total number of "significant places" is 57 and 63, respectively. These numbers bracket the the 60 intersections in the 2000 highway system. By 1920 there are 75 such places and mechanically more of the total employment could be closer to the larger set of points.

Figure 10: 2000 Employment Centers and 1905 Significant Places

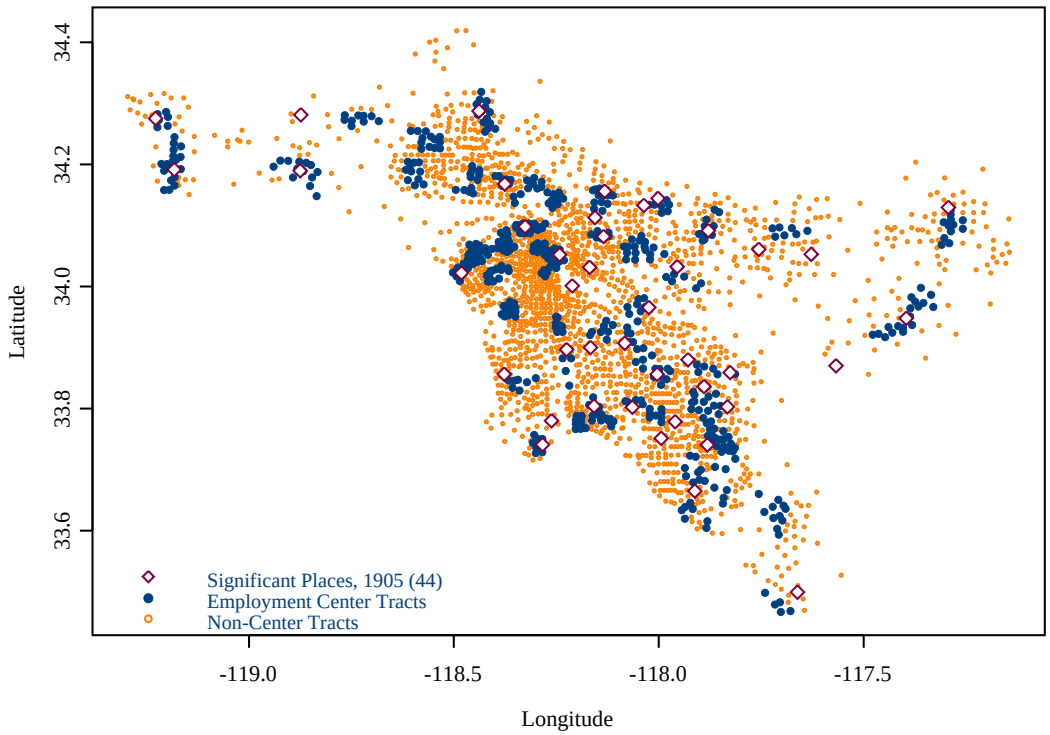
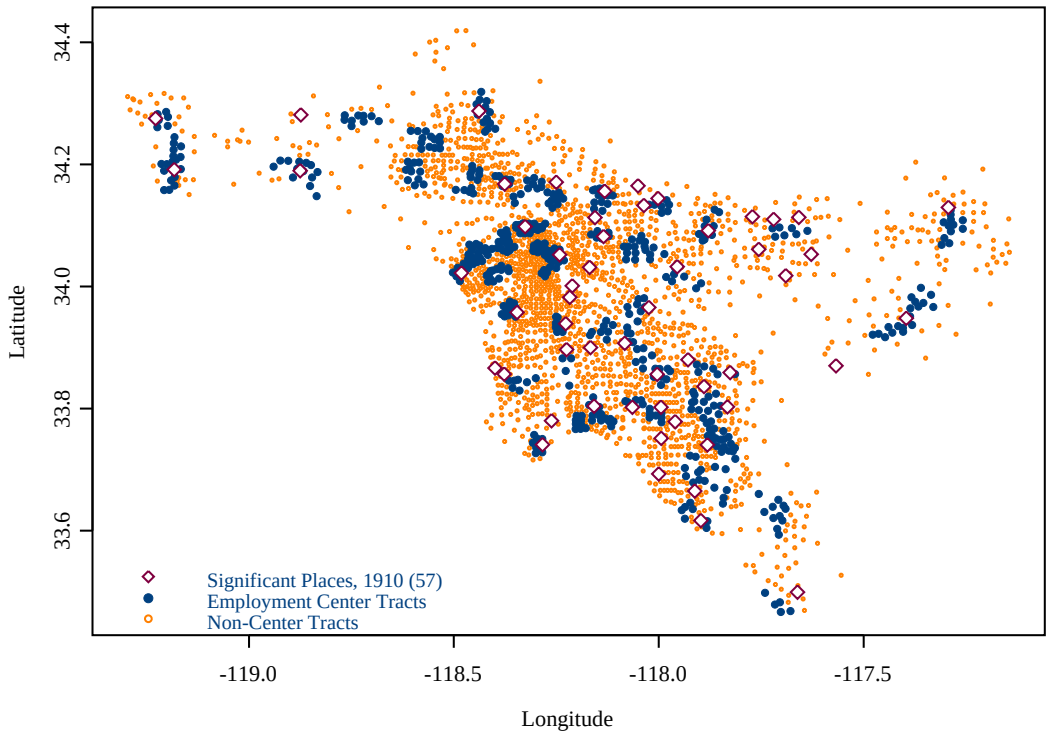


Figure 12 displays the cumulative shares of employment within various concentric rings around the three sets of significant places. The first noteworthy item is the pervasiveness of the highway system even as early as 1942. Fully 95 percent of all 2000 employment in the Los Angeles metropolitan area is within 5.6 miles of what was an intersection between two freeways that were operating as of 1942. 75 percent of employment is within 3.6 miles of the 1942 intersections, but distance to capture the same share of the employment using the 2000 intersections is 4.0 miles.

Across the set of historic locales, there is a natural progression of more employment being organized around the growing number of points. Indeed, any comparison with the 1942 highway intersections may not be fair: there are 80 intersections in this set, substantially more than either of the other two sets. On the other hand, the set of significant points from 1895 is comprised of only 33 locales. Not surprisingly it does not explain the current distribution of employment as well as the other sets. That said, these are a set of points that represent economically distinct points at the end *of the 19th century*, that they have any

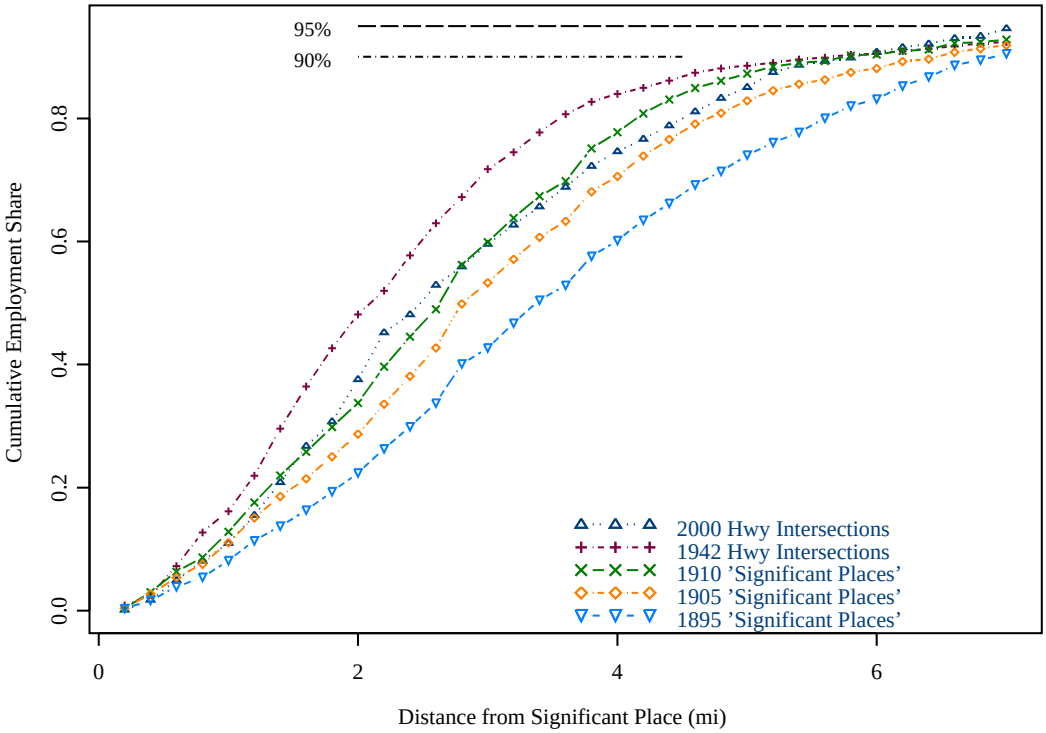
Figure 11: 2000 Employment Centers and 1910 Significant Places



explanatory power is somewhat remarkable. The other two sets of historic points – those from 1905 and 1910 – produce virtually identical cumulative distribution functions as the set of highway intersections in 2000. While crude, these measures suggest that the spatial distribution of employment as of 2000 is explained as well by the distant past as current conditions.

Contemporaneous access to transit is a frequent variable in urban models. This is because these models predict that travel time is a relevant variable in both firms' and households' location choice. Nothing in these figures disputes that hypothesis. Rather, the figures collectively suggest that the minimization problems solved by households and firms in the distant past resulted in investment choices that appear to condition choices made many years later. In other words, starting points appear to matter in a way that is not frequently acknowledged in urban models. Here, an early set of locations remains a significant explanatory factor in the location of employment today – almost 100 years prior to the data being examined.

Figure 12: Cumulative Employment Shares by Distance to Significant Places



7 Conclusion & Extensions

The goal of this research is to examine persistence in the spatial distribution of employment within an urban area. In each of the empirical exercises, the past remains highly relevant. And, in many cases of the simple models of employment and highway networks, the past better explains current conditions than the present. The model developed is largely qualitative and the tests are relatively unsophisticated, but the results are clear nonetheless: the past matters. While every variable in standard urban models has changed dramatically over the last decades, economic activity today is concentrated in the same locations it was concentrated in a century ago.

Certainly, changes in fundamental variables are manifested in modern cities, but often through rents rather than the location of activity. The reason for this persistence – despite changes in rents – is that marginal changes in rent seldom justify wholesale changes in the spatial arrangement of fixed investment. An owner of a fifteen story office building is not

likely to tear it down to rebuild a fourteen story building even if current conditions imply that fourteen stories would be optimal if starting anew. Similarly, the producers of commercial and industrial real estate adjust continually, but raze productive assets only when the land use/land-use intensity is far from optimal.

For the distribution of urban employment, this means that persistence in location is a direct result of the durability of the fixed capital. More specifically, where fixed capital is adjustable, employment centers can constantly be remade. This is especially relevant for Los Angeles, where much of this real estate is readily adaptable. Office space is a direct input of the production function of sales forces in 1950, defense contractors in 1960, lawyers in 1970, consultants in 1980, and programmers in the 1990s. While each require modifications, the basic fixed investment in the structure remains useful and therefore the location of employment at that point dominates the location of the same employment in a new facility at some new location. The same is true of warehousing, which can house whatever items are demanded by American consumers from overseas, etc. This is not to say that these product types don't face functional or physical obsolescence. Rather, is says that even large shocks to demand for a center's structures is unlikely to yield large-scale changes in the actual set of structures, but instead it will lead to adjustments to the structures themselves. At the margin, new buildings may replace the least appropriate of the structures.

Accordingly, the notable exception to the finding of persistence in employment centers in the Los Angeles metropolitan area is where capital was not readily adjustable. A significant center of employment in 1980 and 1990 surrounded the aerospace industries in the southwest of Los Angeles County. The end of the Cold War greatly reduced demand by these industries for production facilities. The fact that they were specialized facilities (with the likelihood of liability problems associated with contamination) made them difficult to adapt to other tenants, and these tracts remain underutilized land today – in fact, they no longer constitute a center since they are no longer significantly more dense that their surrounding tracts. The parallel within the system of American cities might be Detroit, whose fixed capital was heavily invested in facilities not readily adapted to changing technologies and whose resistance to adaptation played a significant role in the city's current stagnation.

There remain several areas of improvement for this research. In particular, the definition of the "significant places" may be refined. The role of railroads has been largely glossed over, though they readily fit into the descriptive model and clearly have had a significant role in the evolution of the region. It is not likely, however, that these shortcomings are driving the results. Persistence is clear in any historical map of the metropolitan area: place names found there can still be found in real estate brokers' descriptions of current office and industrial submarkets. Of course, the link between very old infrastructure and the current arrangement of cities is readily apparent in most older U.S. cities: the street layout in the centers of Boston, Philadelphia, Washington, D.C. and other major cities have never been "reoptimized." With so much fixed and human/social capital organized around existing patterns, the efficiency gains would never cover the adjustment costs. And what's true on the East Coast is true in Los Angeles: the center of Los Angeles remains where it was over a century ago – along the river that bears its name. This true today, with a metropolitan-wide population of over 14 million, just as it was when the city's population first exceeded 100,000 in the 1900 Census. This persistence should be a regular feature of urban models.

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