'EDGE' OR 'EDGELESS CITIES'?

URBAN SPATIAL STRUCTURE IN US METROPOLITAN AREAS, 1980 TO 2000*

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ABSTRACT

This paper presents a descriptive analysis of spatial trends in six US metropolitan areas. The results show that jobs continued to decentralize from the metropolitan core to the suburbs and generalized jobs dispersion was more common than subcentering in the 1980s and 1990s. Three distinctive patterns of spatial development were identified: Jobs dispersion was a predominant spatial process in Portland and Philadelphia; the traditional centers remained strong agglomerations in New York and Boston; and progressive employment subcentering occurred in Los Angeles and San Francisco. They seem to have developed unique paths of job dispersion, in light of their histories and circumstances, that limit the growth of mean commute times.

1. INTRODUCTION

There has been a 'qualitative change' in urban spatial structure in recent decades in US metropolitan areas (Anas, Arnott, and Small, 1998; Clark, 2000). While such sentiment is well recognized, much less is known about the specifics -- the form and nature of the spatial change. What are the prominent features of emerging urban forms? What are the primary forces driving spatial changes? Addressing some of these questions, a large body of urban literature in recent decades has focused on the transformation from monocentric to polycentric metropolitan spatial structures. More recent work suggests the case for the 'generalized dispersion' of economic activities 'beyond polycentricity' (Gordon and Richardson, 1996).

The titles of two widely cited books, '*Edge City*' (Garreau, 1991) and '*Edgeless Cities'* (Lang, 2003), depict two competing views of emerging urban spatial structure. "Edge city" is a journalistic interpretation of polycentric spatial structure with multiple urban cores. While diseconomies tend to outweigh the benefits of central location for many business sectors as a metropolis grows, firms may choose to locate in business concentrations on the urban *edge* avoiding congestion and high land prices. More than a decade after Joel Garreau wrote that the rise of these edge cities signals a new era of urban settlement, Lang reported that it is the "edgeless cities" that are the distinguishing feature of the modern metropolitan landscape. As individual mobility and metro-wide accessibility improves dramatically due to the rapid development of transportation and communication technology, economies of clustering may have been diluted or diffused throughout the metropolitan region. If so, 'generalized dispersion' of employment location with fewer subcenters would best describe the metropolitan landscape (Gordon and Richardson, 1996).

This paper presents an empirical analysis of spatial trends in selected US metropolitan areas to address the questions of whether they are becoming more polycentric or more dispersed and what difference may make. The results show that jobs continued to decentralize from the

metropolitan core to the suburbs and generalized jobs dispersion was more common than subcentering in the 1980s and 1990s. Three distinctive patterns of spatial development were identified: Jobs dispersion was a predominant spatial process in Portland and Philadelphia; the traditional center remained strong agglomerations in New York and Boston; and progressive employment subcentering occurred in Los Angeles and San Francisco. These six places vary in population (in 2000) by a factor of 9.3, they vary in ten-year population growth by a factor of 6.4, yet they vary in drive-alone one-way commuting time (in 2000) by a factor of only 1.2. They seem to have developed unique patterns of job dispersion, in light of their histories and circumstances that limit the growth of mean travel times.

The paper begins with a brief literature review. The discussion introduces the debate on the impacts of technological development on urban form between 'deconcentration' and 'restructuring' schools. The following section describes methodology and data. I rely on two descriptive approaches to analyze spatial developments in six US metropolitan areas, indexing and the analysis of employment centers. I use both absolute and relative criteria to identify employment centers in a consistent way. Then major findings are presented, followed by a discussion of the implications.

2. LITERATURE: EMERGING METROPOLITAN SPATIAL STRUCTURE

Suburbanization has been occurring throughout US urban history (Bruegmann, 2005). In recent years, jobs have, for the most part, followed people into the suburbs, yet with a time lag (Glaeser and Kahn, 2001). As recently as in 1960, 63 percent of metropolitan jobs were still concentrated in central cities, while the majority of residents already lived in the suburbs (Mieszkowski and Mills, 1993). Thus, monocentric urban models still presented a reasonable fit to the time (Clark, 2000). However, jobs became almost as decentralized as the population by the turn of the last century as a consequence of the 'second wave of suburbanization' (Stanback,

1991; Glaeser and Kahn, 2001; Wheaton, 2004). Accordingly, monocentric urban models lost much of their explanatory power. Accessibility to the urban center no longer does a good job explaining the distributions of population and employment (Gordon, Richardson, and Wong, 1986; Small and Song, 1994; McMillen and McDonald, 1998); nor does it explain land value profiles (Heikkila et al., 1989). Indeed, "the continued use of monocentric models can best be understood as a function of their tractability rather than their realism (Dowall and Treffeisen, 1991, p.205)."

Whereas the decentralization of people and jobs is widely recognized, much less is known with regard to the nature of emerging urban spatial structure. Do modern metropolises become polycentric or generally dispersed? Do monocentric, polycentric and dispersed forms describe stages of a sequential spatial evolution? Two competing or complementary perspectives addressing these questions are introduced in this section, which are then tested against via empirical analysis in the following sections.

The first and dominant view holds that a fundamental feature of the modern metropolis is the presence of multiple nodes of urban activities. It emphasizes that there are many concentrations of employment and commercial activities outside the traditional CBD in large metropolitan areas. These subcenters are defined in the literature as 'suburban downtowns' (Hartshorn and Muller, 1989), 'edge cities' (Garreau, 1991), or 'technopoles' (Scott, 1990), according to their functions and industrial composition. They presumably undertake diverse economic roles and spatial functions. Some centers are more specialized in specific industries while others perform more general functions (Forstall and Greene, 1997; Anderson and Bogart, 2001). To denote all the employment concentrations outside the CBD, I use the generic term 'employment subcenter' in this paper (Giuliano and Small, 1991). The growth of multiple subcenters reorganizes the urban fabric, land use patterns and commuting flows, which used to be oriented towards the CBD in a monocentric urban place (Fujii and Hartshorn, 1995).

The polycentric structure of US metropolitan areas has been a popular subject in the literature. Beyond the archetypal polycentric regime Los Angeles (Gordon, Richardson, and Wong, 1986; Giuliano and Small, 1991; Song, 1994; Forstall and Greene, 1997), multiple subcenters are identified in many of the largest metropolitan areas such as Chicago (McMillen and McDonald, 1998; McMillen, 2003a), San Francisco (Cervero and Wu, 1998), Dallas-Fort Worth (Waddell and Shukla, 1993), Atlanta (Fujii and Hartshorn, 1995), and Houston (Craig and Ng, 2001). The list has recently been expanded to include medium size metropolises such as Cleveland, Indianapolis, Portland, and St. Louis (Bogart and Ferry, 1999; Anderson and Bogart, 2001).

It is the 'tension between agglomeration economies and diseconomies' that plays a key role in the transition from monocentric to polycentric urban structure (Richardson, 1995). A firm, by locating in suburban centers, benefits from agglomeration economies that used to be available within the CBD, while mitigating diseconomies such as congestion and high land prices that the older employment centers suffer from (Richardson, 1995). Most of non-monocentric urban economic models are built on this trade-off of agglomeration benefits and congestion costs to explain the timing of employment subcenter formation (Helsley and Strange, 1990; Henderson and Mitra, 1996; Fujita, Thisse, and Zenou, 1997) and the equilibrium number of subcenters (Fujita and Ogawa, 1982; Anas and Kim, 1996). In sum, polycentric urban evolution, the combination of metropolitan wide decentralization and local clustering (Anas, Arnott, et al., 1998), is one way that a metropolis manages to accommodate growth, overcoming the negative externalities that go with size.

The generalized dispersion of jobs over clustering, however, would be more of a norm if the benefits from locating in job centers diminish or even subcenter location is too costly as in the CBD (Fulton, 1996). The second perspective emphasizes this dispersed nature of emerging spatial structure. Gordon and Richardson (1996) suggested the rationale for 'generalized dispersion' in the Los Angeles metropolitan area. They found that the share of total employment

in ‘activity centers’ was not only far less than what could be described as polycentric but also had dramatically decreased from twenty to twelve percent over two decades by 1990. They hypothesized that the advantages of location in centers are diminishing as agglomeration economies are increasingly ubiquitous throughout the metropolitan region by virtue of enhanced automobile access.

Several recent studies include empirical evidence consistent with this view. A similar study of Sydney, Australia reports the dispersion trend for the 1980s, but a moderate reversal in the early 1990s (Pfister, Freestone, and Murphy, 2000). Glaeser and Kahn (2001) also document that suburban jobs (of more recent development) are much more diffused than central city jobs in the average US metropolitan area. A more recent study by Lang (2003) provides a fairly comprehensive report on spatial growth patterns of office space in the thirteen largest metropolitan areas, which tended to be one of the most cluster-favoring sectors. He finds that, “*edgeless cities*, a form of sprawling office development that does not have the density or cohesiveness of *edge cities*,” account for two-thirds of non-downtown office in all metros and more office space than that in downtown is dispersed throughout metropolitan areas except for New York and Chicago.

Will metropolitan structure become more clustered or dispersed? Clark and Kuijpers-Linde (1994) position the urban form debate within the context of competing views on technological development, ‘deconcentration’ and ‘restructuring’ schools (for a survey of the literature, see Audirac, 2002). From the deconcentration perspective, declining costs of transporting goods, people, and information by virtue of technological development are primary factors shaping the metropolitan landscape (Cairncross, 1997; Glaeser and Kahn, 2003; Glaeser and Kohlhase, 2004). In particular, it emphasizes substitutability over complementarity between transportation and communication technology. Therefore, the development of (especially information) technology in this view ultimately contributes to enhancing the mobility of households and firms, implying far greater dispersion of urban activities.

The restructuring perspective, on the other hand, pays more attention to organizational changes and economic restructuring entailed by information technology (IT) development. From this view, IT development confers on a firm more organizational and location flexibility than ever, which leads to the decentralization of production and routine functions but reconcentration of higher order activities at the same time (Castells, 1989; Sassen, 1991). Some authors emphasize that the suburbs of large metropolitan areas are being transformed into the home of high technology clusters and nodes in international information flows and economic networks (Scott, 1988; Muller, 1997; Freestone and Murphy, 1998). The spatial implication is a polycentric structure.

Again, an important part of the analysis involves the nature and geographical scope of agglomeration economies. As individual mobility or accessibility dramatically improves due to metropolitan-wide transportation and communication infrastructure improvements, location in employment centers will become much less attractive given the congestion and other diseconomies of concentration. On the other hand, however, a growing body of economic geography literature holds that proximity still matters. In light of emerging knowledge-based economies, density is believed to foster localized learning and innovation due to tacit nature of knowledge (Malmberg and Sölvell, 1997; Maskell and Malmberg, 1999). In particular, the significance of formal and informal face-to-face contacts in creation or exchange of ideas that cannot be simply transmitted (Storper and Venables, 2004) implies that some sort of agglomeration economies will still works over a fairly short spatial range, resulting in continued clustering. It is, therefore, an empirical question which trend now dominates in the modern metropolis.

3. METHODS AND DATA

Methods

This paper relies on descriptive approaches to addressing research questions raised in the previous sections. A simplest descriptor of metropolitan spatial structure is indexing. I measure the degree of decentralization and deconcentration in selected metropolitan areas using various indices suggested in the literature. Changing patterns of estimated indices over time are expected to capture the overall directions of metropolitan wide spatial transition.

Then, the analysis of employment centers follows that are locus of various urban activities such as commuting and commercial trips. In this step, I extend the analytical framework that Gordon and Richardson (1996) used to test the 'beyond polycentricity' hypothesis. Charting the shifts of metropolitan employment shares by location type - CBD, subcenters, and the dispersed - over time will directly address the question whether metropolitan areas are becoming more polycentric or dispersed. In doing so, I use both absolute and relative criteria to systematically identify metropolitan employment centers.

Centralization and concentration indices

Metropolitan structure is conceptualized by two spatial dimensions as in Anas, Arnott, et al. (1998, p.1431), the degree of centralization and concentration. Centralization is the extent to which employment is concentrated near the CBD, whereas concentration measures how disproportionately jobs are clustered in a few locations or dispersed (Galster et al., 2001). The two dimensions are associated but distinctive, not necessarily moving in the same direction. For instance, the polycentric structure is the interaction of metropolitan wide decentralization and local level clustering. If deconcentration concurs with decentralization, the metropolitan area would evolve in a more dispersed form without significant subcentering.

The two spatial dimensions are operationalized by multiple indices selected from the literature, three for centralization and two for concentration (Table 1). Modified Wheaton and area based centralization indices measure how fast metropolitan employment accumulates along the way from the CBD to the urban edge. The former is normalized by the distance from the CBD and the latter by land area. Thus, all census tracts are sorted by the distance from the CBD in increasing order before calibration. Both measures range from -1 to 1, with 1 indicating perfect centralization. Two concentration indices, the Gini Coefficient and the Delta index, measure how unevenly metropolitan employment is distributed. All area census tracts are sorted by employment density in increasing order for calibrating Gini Coefficient.

All these indices, particularly the centralization indices, are sensitive to the presence of large unpopulated census tracts in outlying areas due to the well known mismatch of administrative boundaries and functional areas. For instance, the Los Angeles Consolidated Metropolitan Statistical Area (CMSA) might be misrepresented as very centralized if one includes its huge unpopulated desert tracts (the Mojave Desert) in San Bernardino County. A compromise is using a virtual boundary containing 95 percent of metropolitan population that exclude mostly unpopulated tracts in outlying locations just as Wheaton (2004) used the 98 percent population area.

Employment center identification

Many authors have proposed and applied various criteria to define metropolitan subcenters. While these criteria included employment size, office and/or retail space, commute flows, job-housing ratio and land use mix (Cervero, 1989; Giuliano and Small, 1991), recent literature increasingly relies on employment density in defining centers. Primary qualities of urban centers are significantly higher employment density than the surrounding areas (McDonald, 1987) and their influences on density profiles of nearby locations (Gordon, Richardson, and Wong, 1986; Giuliano and Small, 1991; McMillen, 2001). Various investigators have developed

two types of procedures in applying this working definition of employment centers: absolute and relative density criteria (Giuliano et al., 2005).

The first approach defines urban centers in a straightforward manner based on an absolute density cutoff as well as an employment threshold. An employment center is defined as a cluster of neighboring zones with higher density than a certain minimum and containing cluster employment above a threshold size (Giuliano and Small, 1991). This minimum density procedure has been widely applied in empirical research (Gordon and Richardson, 1996; Bogart and Ferry, 1999; Pfister, Freestone, and Murphy, 2000; Anderson and Bogart, 2001). A primary flaw and difficulty of the procedure is in setting the minimum density criterion and employment threshold, which is subject to arbitrariness. The criteria can only be evaluated ex post with reference to local knowledge. Furthermore, one cannot take into account different intra and interurban spatial contexts with a single absolute measure. Further guidelines are needed to apply the procedure for a comparative study involving multiple regions.

The second approach applies relative density criteria, relying upon employment density functions of various types, parametric or nonparametric. By estimating employment density surface for each metropolitan area, it takes into account different spatial contexts both within a metropolitan area and across regions. McDonald and Prather (1994) identified subcenters in Chicago based on significant residuals from an estimated monocentric density function. Other research on Los Angeles was based on estimated polycentric models (Gordon, Richardson, and Wong, 1986; Small and Song, 1994). More recent developments involve the estimation of nonparametric density functions. These include spline density curves (Craig and Ng, 2001) and geographically weighted regressions (GWR) (McMillen, 2001). While both procedures condition subcenters identification on both the distance and direction from CBD, the latter provides a more flexible procedure that can be easily applied in many different regions. GWR estimates a smoothed employment density surface using only nearby observations for any data point (census tract), with more weights given to closer observations. The first step of McMillen's (2001)

procedure identifies such zones as center candidates that have significantly higher densities than the estimated surface.

As will be shown in the next section, a procedure using an absolute density cutoff may fail to identify emerging job concentrations in outlying areas while applying relative criteria tends to under bound main center in the metropolitan core. Thus, I apply *both*, minimum density criteria and GWR density surface, to identify center candidates with some modifications to both procedures. I added the principle of setting the density cutoff to Giuliano and Small's (1991) minimum density method: the density cutoff of each metropolitan area is set at the level of its ninety percentile employment density in 2000 (Table 2).

A major modification to McMillen's (2001) GWR procedure is that I compare two estimated density surfaces, one with a smaller window and the other with a larger window, while he identified the differentials (residuals) between actual density and estimated surface with a large window (50 percent). The bigger the window size, that is the more observations used for density estimation for each data point, the more smoothed the surface. I identify such tracts as center candidates whose density estimates by small window GWR (10 neighboring census tracts) is significantly higher than is predicted by large window GWR (100 census tracts).

The small window estimators are preferably used to identify center candidates instead of actual density on three grounds. First, as a GWR estimator contains density information of neighboring zones as well as the estimating point, it provides us with candidates that are closer to the conceptual center definition discussed above. Second, this procedure is more likely to generate clusters of center candidates, while comparing the actual density tends to yield fragmented peaks. Finally, these clusters of high density zones based on small GWR estimators are expected to be more stable over time than the fragmented peaks.

Only the different statistics due to the use of two GWR surfaces are briefly explained here because general descriptions of the GWR procedure are well provided in McMillen (2001). The significance of the differential between two density estimators at each data point is

determined at the 10 percent level: $(\hat{y}_{Si} - \hat{y}_{Li}) / \hat{\sigma}_i \geq 1.64$, where $\hat{y}_{Si}$ is small window GWR estimator and $\hat{y}_{Li}$ is large window estimator at point i. The variance of the differential is the sum of variances of two estimators: $\hat{\sigma}_i^2 = \hat{\sigma}_{Si}^2 + \hat{\sigma}_{Li}^2$. The variance of small window estimator at point 0 is estimated by the expression (1) and one for large window estimator would be obtained by simply replacing the subscript S with L. $\sigma_s^2(0)$ is a heteroscedastic error term that is also estimated from another kernel regression following McMillen (2001). The dependent variable of the GWRs approach is employment density of each census tract and the independent variables are latitude and longitude coordinates of the tract centroid. W(0) is a diagonal matrix where diagonal elements are a function of each tract's distance from the point 0. A tricube weight function is used to construct the weight matrix.

$$\hat{\sigma}_{S0}^2 = \mathrm{var}(\hat{y}_{s0}) = \mathrm{x}_0'[X'W(0)X]^{-1}X'W^2(0)X[X'W(0)X]^{-1}\mathrm{x}_0\sigma_s^2(0) \qquad (1)$$

Once significantly dense census tracts are identified by either procedure, I define clusters of such candidate tracts as employment centers that comprise an employment threshold. I set the threshold at 10,000 jobs for New York and Los Angeles and 7,000 jobs for other metropolitan areas. Zones sharing either edge or point are defined as neighboring one another following the queen contiguity principle. McMillen's (2003b) contiguity matrix algorithm is utilized to save time in the last step of identifying clusters. While each cluster represents an independent center, centers that were contiguous to the CBD or main center in any census year are considered as part of the CBD or main center in other census years. Thus, we may have a multiple number of clusters within the CBD or main center as in Table 4 to 9.

Data and Study Areas

Employment data come from the 1980, 1990, and 2000 Census Transportation Planning Packages (CTPP, Urban Transportation Planning Package in 1980), which are drawn for transportation planners from decennial census journey-to-work surveys. The CTPP is one of very few sources of employment data by place of work for small geographical units such as census tracts or traffic analysis zones (TAZs). One critical problem in using the CTPP data series is that they employed different geographical systems for different years. While census tract level data are provided for all metropolitan areas in the 2000 data, TAZ systems were used for most metropolitan areas in the 1980 and 1990 data. Further, planners keep changing the number and boundary of zones in a metropolitan area over survey years to reflect new developments. Whereas TAZs may be the better geography than census tracts for employment analysis for a region, census tract boundary is drawn in much more consistent way across regions.

Six metropolitan areas are selected for the current study, given these constraints, for which all three years' data can be converted onto 1990 census tracts, minimizing statistical noise. Spatial changes for only 1990s can be analyzed for New York, Los Angeles, Boston, and Portland due to the difficulty in converting the 1980 data while I can trace the changes for recent two decades in San Francisco and Philadelphia. Census tract relationship files from the US Census Bureau are utilized for converting 2000 data. I converted 1980 data based on correspondence tables obtained from metropolitan planning organizations (MPOs) of San Francisco and Philadelphia. Study area boundaries may be slightly smaller than official CMSA or MSA definition because they are delineated to include zones that are covered by all year data. The sample of six metropolitan areas is quite well balanced in terms of population size and geography given the constraints except that metros in the South are missing. The basic descriptors of the six metropolitan areas studied are shown in the Table 2.

4. RESULTS: 'EDGE' VERSUS 'EDGELESS' METROPOLIS

Trends of Decentralization and Deconcentration

Figure 1 presents one of the simplest ways to identify employment deconcentration trends. All census tracts within the 95 percent population area are grouped into five quintiles by employment density and the densest quintile are further split into two deciles. Then, each density group's share of total employment in each year is presented in the bar charts. Apparently employment deconcentration occurred in all six metropolitan areas. They became more dispersed in later period than in any earlier period, with increased job shares in low density tracts and declining shares in higher density zones. The most significant employment gains were at the bottom two quintiles, the lowest density zones. Employment shifts from higher to lower density areas have long been observed, for the last half century in both inter- and intra-metropolitan contexts by Carlino and Chatterjee (2002). They attribute this postwar urban development to congestion costs of density in their equilibrium model.

Nevertheless, there are substantial variations among regions in terms of the degree and speed of deconcentration. It is surprising that employment concentration is higher in Los Angeles and San Francisco than in the other metropolitan areas, with the majority of jobs concentrated in the densest quintile (two densest deciles). These two western metropolises also experienced less dispersion during the periods studied. It will be shown in the next section that the slow dispersion and high degree of concentration in the two metros are due to jobs clustering in the suburbs. Jobs dispersion was much faster in Philadelphia and Portland where subcentering was less significant.

The same trend is also identified by the changes of concentration and centralization indices presented in Table 3. Overall, employment is more centralized and concentrated than population in all metropolitan areas at any point of time. Yet, jobs are decentralizing and diffusing much faster than population. People moved further out to less congested areas in all

cases but Portland in the 1990s. There was no exception, however, in the overall trend towards more decentralized and dispersed employment distribution.

Jobs were diffusing in Portland and Philadelphia faster than in the other metropolitan areas. All the indices in Philadelphia changed by more than ten percent in the 1990s, which is an accelerated continuation of the same patterns in the 1980s. Portland also underwent fast employment dispersion while experiencing explosive metropolitan job growth in the 1990s, by 57 percent over the decade. It is notable that little dispersion occurred in residential patterns for the same period. Perhaps, all planning and policy schemes to promote compact urban development (Ozawa, 2004) may have been effective in containing residential development, but not in checking workplace dispersion.

Similar trends of decentralization and deconcentration but to a significantly less extent are found in New York and Boston. However, spatial transformation in Los Angeles and San Francisco is distinctive in that deconcentration occurred much more slowly than decentralization. It implies that a significant proportion of decentralizing jobs reconcentrate in suburban clusters in the two western metropolises. This result is confirmed via the analyses of employment centers in the next section.

Growth Patterns of Metropolitan Employment Centers

Snapshot and Trends

Figures 2 to 7 chart the identified metropolitan employment centers by both minimum density and GWR procedures and Tables 4 to 9 present changes of employment shares in these centers over time. These tables are an extended version of the table in Gordon and Richardson (1996, p.291), in which they tested the 'beyond polycentricity' hypothesis. Rows in the tables indicate each census year's employment centers defined by job distribution in the corresponding year while columns show each year's number of jobs and shares of total employment. Of main

interest is the change by location type along the main diagonal (in bold font). For example, with reference to New York (Table 4), center employment share identified by the GWR method decreased from 22.8 percent to 21.0 percent in the 1990s. We can also examine employment growth or decline within the fixed centers boundaries by moving along each row. Referring to New York again, employment in zones identified as centers by GWR procedure as of 1990 decreased by 163,544 (7.9 percent) while 2000 centers gained 35,851 jobs (1.9 percent).

The minimum density approach, as explained above, proportionately overstates the size of the main center whereas the GWR method tends to identify more subcenters particularly in suburban areas. On average, the main centers identified by the minimum density method combine the CBD with surrounding areas so as to contain about twice the number of jobs of the CBD when succinctly defined by the GWR method. For instance, New York's CBD defined as strictly lower and midtown Manhattan south of the Central Park accounted for about 1.2 million jobs as of 2000 whereas the main center describes an eight-mile long area ranging from the Wall Street to Columbia University accommodating about two million jobs. Los Angeles is an extreme case. Whereas its CBD accounts for only about three percent of metropolitan employment, the minimum density method delineates a huge main center, which is a more than a 20-mile long corridor, reaching from East Los Angeles to Santa Monica and accounts for nearly a million jobs.

Notwithstanding the presence of these huge agglomerations, the majority of metropolitan jobs are dispersed outside employment centers in all six metropolitan areas. Lang (2003) made the case for *edgeless cities* by emphasizing that they account for twice the office space of *edge cities* in the thirteen largest metropolitan areas. The results of this research present a far stronger case for the generalized dispersion of employment. Dispersed employment outside centers grew to account for between 66 and 88 percent of metropolitan employment by 2000, depending which identifying procedure is used. Only ten percent or less of the jobs outside the CBD are clustered in subcenters in four metropolitan areas except for Los Angeles and San Francisco. It is these

only two western metropolises that are genuinely polycentric, where substantially more jobs are concentrated in subcenters than in the main centers.

What type of location has gained jobs for the recent periods? There are three important findings from the trend analysis. First, jobs continued to decentralize from the metropolitan core to suburbs in the 1980s and 1990s. The employment share in the core, whether defined as the CBD or the main center, shrank in all six metropolitan areas for any studied period. In particular, the CBDs of New York, Los Angeles, and Philadelphia experienced absolute job losses. By 2000, the CBDs' employment shares had decreased to 3 percent in Los Angeles and 12.6 percent in New York. Even the main centers including surrounding areas house less than a quarter of metropolitan employment, ranging from 13 percent in Los Angeles to 22 percent in Boston.

Secondly, jobs dispersion was a more common phenomenon than subcentering. Dispersed job locations performed better than employment centers in almost all cases, with the only exception being the 1990s in San Francisco. However, dynamic employment subcentering was typical of the two western metropolises, Los Angeles and San Francisco, rather than being a norm. New clustering of jobs in surburban areas nearly offsets the jobs loss from older centers in the two polycentric regimes. In other metropolitan areas, employment growth in subcenters neither kept pace with the metropolitan average nor compensated for employment share losses in the core.

Finally and most importantly, the trend analysis of six metropolitan forms shows that spatial structures did not evolve in one direction. Overall, three different patterns of spatial transformation were identified when examining decentralization and clustering patterns. Each type consists of a pair of cases. The remainder of this paper will explore each of the spatial evolution patterns.

Three patterns of spatial evolution

Portland and Philadelphia represent the first type where jobs dispersion was predominant without significant suburban clustering. Both decentralization and deconcentration occurred to the greatest extent. The employment share in the urban core shrank relatively quickly, but the subcenters were not strong enough to be a magnet for the decentralizing jobs. As a result, center employment shares defined by any measure fell substantially.

The CBD of Philadelphia and its surrounding areas underwent remarkable job losses in absolute terms and hence the employment density fell down in the central location. The size of the main center that passes a minimum density shrank substantially, with its employment share decreased from 26.2 percent in 1980 to 15.9 percent in 2000. The subcenters also experienced job losses in the 1990s while the employment shares in the subcenters combined were stable in the 1980s. Virtually all metropolitan employment growth for the recent two decades occurred outside employment centers. Philadelphia became, as Lang (2003) describes, "the edgeless metropolis of the north."

In Portland, the proportion of dispersed jobs exploded. The Portland metropolitan area added more than four-hundred thousand jobs in the 1990s, which is a 57 percent increase from 1990. Thus, most areas within the region benefited from the fast employment growth, but with a disproportionate growth share directed to lower density zones. Fully 88 percent to 98 percent of metropolitan employment growth, depending centers definition, occurred at dispersed locations. Accordingly, the center employment share diminished substantially. The employment share of the CBD dropped from 12.9 percent to 7.9 percent and from 26.8 percent to 19.2 percent in the main center. With regard to subcenters growth, the two different center identification procedures show mixed outlooks. Densification in the suburbs especially along State Highway 217, about ten miles southwest of Portland's downtown, resulted in some new centers when identified via the minimum density method. Yet, the GWR method fails in identifying these peaks. In sum, the Portland metropolitan area became denser but flatter in the 1990s.

Contrary to the first pattern, the urban cores performed better than the suburban centers and remained strong employment agglomerations throughout the 1990s in Boston and New York. Even the small job loss in the CBDs was mostly offset by the growth in adjacent areas. Thus, the main centers' share remained stable. The spatial process in the two northeastern metropolises can be summarized as little decentralization and moderate deconcentration. Overall loss of center employment share was smaller than in the first two metropolises.

The centralized structure of Boston did not diminish in the last decade. In Table 6, the employment share in the CBD defined by the GWR method appears to have fallen from 12.2 to 10.3 percent. It fell because job centers in Cambridge that were parts of the 1990 CBD became disqualified as centers in 2000. But, this was not due to job losses in Cambridge but because of densification of the surrounding areas. To put it more technically, the small window GWR surface in Cambridge area is not significantly higher than the large window GWR surface in 2000 not because the former fell but because the latter arose. Vitality of the CBD can also be confirmed by employment growth rates in the CBDs by each year's definition, 4.9 percent and 8 percent, which are similar to or higher than the metropolitan average. The more broadly defined main center also maintained its employment share at around 22 percent. On the contrary, job concentrations in surburban Boston were trivial in 1990 and shrank even further by 2000.

Manhattan, the largest employment agglomeration in the country also maintained its predominance throughout the 1990s, containing about two million jobs. Although the downtown in the lower Manhattan experienced some job loss, it was replenished in the lower density parts of the island. Thus, employment share in the main center was stable above 21 percent throughout the period. Unlike in Boston, the suburban employment centers particularly in New Jersey and Long Island also performed well. As a result, there was only a minor loss of center employment share in the New York metropolitan area in the last decade.

Two polycentric regimes in the west, Los Angeles and San Francisco, have taken a quite different path from the two previous development patterns; call it decentralized concentration.

Whereas employment agglomeration in the regional core shrank, absolutely in Los Angeles and relatively in San Francisco, a significant proportion of decentralizing jobs reconcentrated in suburban centers. The share of clustered employment remained the most stable in this polycentric structure for the last decade.

The dynamics of subcentering in the two metros call for lengthy explanation because the two center identification procedures provide different results. In Los Angeles, suburban employment centers defined by the GWR method added about two hundred thousand new jobs in all while the minimum density method captures the employment loss of the similar size. In other words, the more flexible nonparametric method captures the rise of new clusters in the outer ring suburbs. Ten new subcenters emerged while seven disappeared and five became merged into others in the metropolitan region. Most new clustering occurred around border areas of Los Angeles and Orange and Riverside counties, while many of inner ring subcenters in Los Angeles County disappeared perhaps as a result of the industrial restructuring in the region. The net effect was about a three percentage point increase in the subcenters employment share. Yet, those emerging small peaks in outer ring suburbs were not dense enough to pass the minimum density test. Thus, the minimum density method accounts for only 34 subcenters in 2000 and a decreased employment share by three percentage point from 1990.

In San Francisco, to the contrary, the nonparametric method appears to represent less clustering in the 1990s while minimum density method identifies more subcenters in 2000 than in 1990. The GWR results suggest that subcenters' employment share fell from 20 to 13 percent in the 1990s. This extraordinary drop, however, is a statistical construct due to the imperfect data conversion between census years. Whereas I converted all three year's data onto 1990 census tracts as mentioned above, the 1990 tract boundaries do not well reflect new developments in the 1990s. This mismatch problem is especially notable in relatively new and fast growing areas such as Silicon Valley, where the older tracts were typically very large and have been split in the later surveys. Thus, there was substantial noise in converting 2000 data back onto 1990 census

tracts and this resulted in the failure to identify the densification of high tech jobs in Silicon Valley by the GWR method.

This reasoning can be confirmed by the fact that a huge Silicon Valley subcenter is found when using 2000 data and 2000 census tracts without the data conversion. This subcenter amalgamates high tech clusters from Mountain View, CA in the westerly direction to Milpitas, CA to the east, containing 283,850 jobs. When using 2000 census tracts, the total centers employment share by the GWR method is as large as 30.5 percent (1,070,799 jobs), combining shares in the CBD and subcenters, 6.3 percent (220,528) and 24.2 percent (850,271), respectively. The minimum density method also offers the substantial expansion of the Silicon Valley subcenter and the overall growth of clustered jobs. In sum, the results of both procedures present about a four percentage point increase in subcenters employment share in the San Francisco metropolitan area in the 1990s.

It was the clustering of high technology firms that led to the rise and growth of employment subcenters in the both polycentric regimes. The world renowned clusters of semiconductor and IT firms in Silicon Valley and the computer and biotechnology complex in Irvine/Santa Ana/Costa Mesa have grown to be even larger regional employment centers than each region's CBD by the recent turn of the century. These new employment centers are very different from either traditional downtowns or old industrial space in their functions, infrastructure, and urban form, bearing different policy implications. For instance, they have much lower density, less congestion, and higher amenities often in the form of industrial and office parks. They are better accessed by car than by public transit. The impacts and policy implications of these spatial transformations should provide good research opportunities in the future.

4. CONCLUSIONS

This paper has presented results from a descriptive analysis of spatial structure and its changing patterns in six US metropolitan areas in order to address the question whether emerging urban forms can be characterized as increasingly *edgy* or *edgeless*. For many years, most researchers thought in terms of monocentric cities; only recently has polycentricity been embraced but it too may already be dated. Findings from this research parallel the results of Gordon and Richardson (1996) and Lang (2003) -- that workplace locations are far more dispersed than are expected by most analysts. Jobs continued to decentralize from the metropolitan core to the suburbs in the 1980s and 1990s and jobs dispersion was a more common phenomenon than subcentering for the periods studied.

Nevertheless, there were remarkable variations in spatial trends among the six metropolitan areas. Three patterns of spatial development were distinguished in the paper (Figure 8). Jobs dispersion was the predominant spatial process in Portland and Philadelphia, where rapid decentralization and deconcentration occurred. In New York and Boston, the main centers in the core remained a strong agglomeration while subcenters' employment share further diminished. In contrast, progressive employment subcentering occurred in two polycentric regions, Los Angeles and San Francisco.

To the extent that the results for six metropolitan areas can be generalized, the results imply that metropolitan spatial evolution may not be a linear process from monocentric through polycentric and to dispersed structure. A more plausible scenario is that some metropolitan structures are undergoing the transition to a polycentric structure while others are more apt to diffuse. In other words, agglomeration economies are realized differently in different regions. Although more thorough examinations are needed to explain the sources of the different spatial manifestations, the results of this research provide important clues for future research.

First, the geographical and historical contexts of an individual metropolis strongly affect the path by which it responds to general trends such as ever decreasing transportation costs and IT development. For instance, the decentralized structure of Los Angeles has often been associated with its substantial land resources and highway and boulevard networks whereas San Francisco's polycentricity is largely configured by the topography of the region including the presence of the bay (Lang, 2003). Spatial development patterns of a metropolitan area are also *path dependent* (Giuliano et al., 2005) as are technology adoption and industrial development (Nelson and Winter, 1982). The apparent reason is the durability of the built environment. New York and Boston with big and long established CBDs were less subject to decentralization while polycentricity of Los Angeles and San Francisco was reinforced in the last decade.

Second, economic restructuring and the resulting industrial structure is an important factor in the spatial development of an individual metropolis. Different industrial sectors benefit from different sources of agglomeration economies with varied geographical ambits and distance decay functions (Dekle and Eaton, 1999; Rosenthal and Strange, 2001). For instance, the benefits of CBD location are greater for the finance sectors than the manufacturing sectors. Thus, the strong and relatively stable agglomerations in the CBDs of New York and Boston can be associated with their strong industrial shares of jobs in the finance and business services sectors. It remains to be seen whether or not the terrorist attack on Manhattan in 2001 has brought about any significant change on these spatial trends.

On the other hand, research and development or production in high technology sectors has a tendency to cluster in the suburbs of large metropolitan areas. The advantage of local proximity in these sectors involves the intensive creation and exchange of tacit knowledge, ultimately contributing to innovation and growth of firms in the clusters. While the internal dynamics of the two high tech clusters in Santa Clara and Orange Counties are discussed in the economic geography literature (Scott, 1988; Scott, 1990; Saxenian, 1994), this paper shows that

the spatial logic works as an important agglomerating force at the sub-metropolitan scale, creating and fostering new employment subcenters.

Other aspects of economic restructuring, however, contribute to the deconcentration of employment locations. Proximity to consumers is a more important location factor in personal services and retail industries. Thus, the continuing tertiarization of metropolitan economies will result in further employment dispersion given the extensive suburbanization of population in US metropolitan areas. It may also entail the decline of some older subcenters.

The dominant trend in recent decades involved jobs dispersion. However, there was significant variation in spatial decentralization trends among metropolitan areas studied. The six places studied vary in population (in 2000) by a factor of 9.3, they vary in ten-year population growth by a factor of 6.4, yet they vary in drive-alone one-way commuting time (in 2000) by a factor of only 1.2. They seem to have developed unique patterns of decentralization, in light of their histories and circumstances, that limit the growth of mean travel times. Policy makers have, for the most part, avoided peak-load pricing of road use. Yet, it appears that land markets allow unique land use pattern adaptations that limit the effects that metropolitan growth or size have on commuting cost increases.

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TABLES AND FIGURES

Table 1. List of centralization and concentration indices

Centralization indices	
Modified Wheaton index (Wheaton, 2004)	$MWI = (\sum_{i=1}^{n} E_{i-1} DCBD_i - \sum_{i=1}^{n} E_i DCBD_{i-1}) \Big/ DCBD^*$
Area based centralization index (Massey and Denton, 1988)	$ACI = \sum_{i=1}^{n} E_{i-1} A_i - \sum_{i=1}^{n} E_i A_{i-1}$
Weighted average distance from CBD (Galster et al., 2001)	$ADC = \sum_{i=1}^{n} e_i DCBD_i / E$
Concentration indices	
Gini Coefficient (Gordon, Richardson, and Wong, 1986; Small and Song, 1994)	$GINI = \sum_{i=1}^{n} E_i A_{i-1} - \sum_{i=1}^{n} E_{i-1} A_i$
Delta index (Massey and Denton, 1988; Galster et al., 2001)	$DELTA = \frac{1}{2} \sum_{i=1}^{N} \left\| \frac{e_i}{E} - \frac{a_i}{A} \right\|$

e_i: number of employment at zone i; E_i: cumulative proportion of employment at zone i;
E: total metropolitan employment; e_i/E: share of employment at zone i;
a_i: land area at zone i; A_i: cumulative proportion of land area at zone i;
A: total metropolitan land area; a_i/A: share of land area at zone i;
$DCBD_i$: the distance of zone i from CBD; DCBD*: metropolitan radius;
n: number of zones.

Table 2. Characteristics of six metropolitan areas

	New York			Los Angeles			Boston			Portland		
	1990	2000	'90-'00	1990	2000	'90-'00	1990	2000	'90-'00	1990	2000	'90-'00
Metropolitan area												
Employment (000) [1]	9,039	9,409	4.1%	6,751	6,717	-0.5%	2,189	2,311	5.6%	704	1,106	57.1%
REIS Employment (000) [1]	9,668	10,268	6.2%	6,944	7,314	5.3%	2,913	3,271	12.3%	771	1,028	33.3%
Population (000)	19,502	21,134	8.4%	14,521	16,370	12.7%	4,056	4,307	6.2%	1,793	2,265	26.3%
Mean commute (min) [2]	30.8	34.4	11.7%	26.4	29.0	9.8%	25.4	28.4	11.8%	22.0	24.5	11.4%
Commute by drive alone	25.3	28.5	12.6%	25.6	27.8	8.6%	24.3	27.1	11.5%	21.0	23.2	10.5%
Area (sq. mile)	9,841	9,841		33,822	33,822		2,743	2,743		6,950	6,950	
Number of zones	5,053	5,053		2,546	2,546		867	867		395	395	
95% population area [3]												
Employment (000)	8,623	8,953		6,552	6,444		2,130	2,247		697	1,073	
Population (000)	18,503	20,074		13,899	15,549		3,863	4,090		1,698	2,146	
Area (sq. mile)	8,099	8,099		9,003	9,003		2,335	2,335		5,426	5,426	
Number of zones	4,810	4,810		2,467	2,467		833	833		379	379	
Urban radius (mile)	67.3	67.3		69.2	69.2		32.8	32.8		46.4	46.4	
Mean zone size (acre)	1,078	1,078		2,336	2,336		1,794	1,794		9,163	9,163	
Region-wide density	1.7	1.7		1.1	1.1		1.4	1.5		0.2	0.3	
Mean density	18.4	18.3		6.2	5.4		7.7	8.1		4.3	4.9	
Median density	4.1	4.3		3.1	2.9		2.3	2.4		1.2	1.7	
90 percentile density	26.8	25.8		12.3	10.7		16.9	15.2		7.4	8.4	
CBD peak density	1,668.5	1,577.5		170.8	190.5		350.8	339.6		250.5	274.5	

	San Francisco				Philadelphia			
	1980	1990	2000	'90-'00	1980	1990	2000	'90-'00
Metropolitan area								
Employment (000) [1]	2,316	3,051	3,405	11.6%	1,902	2,300	2,440	6.1%
REIS Employment (000) [1]		3,343	3,919	17.2%		2,700	2,927	8.4%
Population (000)	5,027	6,014	6,784	12.8%	4,881	5,174	5,387	4.1%
Mean commute (min) [2]		26.2	30.5	16.4%		24.5	27.7	13.1%
Commute by drive alone		24.2	28.4	17.4%		23.1	26.1	13.0%
Area (sq. mile)	6,922	6,922	6,922		3,743	3,743	3,743	
Number of zones	1,284	1,284	1,284		1,308	1,308	1,308	
95% population area [3]								
Employment (000)	2,279	2,956	3,272		1,853	2,190	2,313	
Population (000)	4,836	5,735	6,443		4,693	4,946	5,116	
Area (sq. mile)	4,316	4,316	4,316		2,833	2,833	2,833	
Number of zones	1,216	1,216	1,216		1,243	1,243	1,243	
Urban radius (mile)	49.6	49.6	49.6		34.4	34.4	34.4	
Mean zone size (acre)	2,272	2,272	2,272		1,458	1,458	1,458	
Region-wide density	0.8	1.1	1.2		1.0	1.2	1.3	
Mean density	7.2	7.8	8.2		6.4	6.4	5.5	
Median density	1.6	2.3	2.3		1.6	2.1	2.1	
90 percentile density	11.9	13.9	13.6		11.1	10.4	8.2	
CBD peak density	650.9	584.4	686.0		446.0	576.6	590.8	

1) Total employment excludes members of the armed forces. The wage and salary employment data from the Regional Economic Information System (REIS) are also presented for comparison. Although the CTPP data generally underestimate the number of employment, this does not seem to affect the analysis of spatial distribution of employment.

2) Mean commute times shown are of workers who work in each metropolitan area. Thus, they may be slightly longer than residence-based census figures, depending on how many workers a metropolis draws from the outside.

3) The area that houses 95% of the total metropolitan population excludes mostly unpopulated tracts in outlying locations. All centralization and concentration indices are measured for this area.

Table 3. Centralization and concentration indices

		New York			Los Angeles			Boston			Portland		
		1990	2000	%Ch. 90s	1990	2000	%Ch. 90s	1990	2000	%Ch. 90s	1990	2000	%Ch. 90s
Centralization													
MWI	Emp	0.46	0.43	-7.8	0.39	0.35	-11.5	0.25	0.23	-8.9	0.57	0.49	-15.1
MWI	Pop	0.37	0.37	-0.7	0.33	0.3	-8.9	0.13	0.12	-12.3	0.39	0.38	-2.7
ACI	Emp	0.69	0.65	-5.6	0.64	0.6	-6.5	0.53	0.5	-5.2	0.76	0.72	-5.9
ACI	Pop	0.61	0.61	-0.4	0.58	0.55	-4.7	0.43	0.42	-4.2	0.66	0.66	0
ADC	Emp	18.07	19.29	6.7	21.09	22.65	7.4	12.35	12.71	2.9	9.92	11.94	20.4
ADC	Pop	21.24	21.33	0.4	23.18	24.2	4.4	14.25	14.52	1.9	14.11	14.36	1.7
Concentration													
GINI	Emp	0.86	0.82	-5.3	0.88	0.85	-2.8	0.73	0.71	-3.8	0.95	0.9	-5.3
GINI	Pop	0.78	0.77	-0.9	0.81	0.8	-1.6	0.62	0.6	-3.5	0.84	0.83	-0.2
DELTA	Emp	0.7	0.65	-7	0.75	0.71	-4.6	0.57	0.54	-4	0.88	0.79	-10.2
DELTA	Pop	0.62	0.61	-1.4	0.68	0.67	-2.5	0.48	0.46	-4.1	0.71	0.71	0.3

		San Francisco						Philadelphia					
		1980	1990	2000	%Ch. 80s	%Ch. 90s	%Ch. 80-00	1980	1990	2000	%Ch. 80s	%Ch. 90s	%Ch. 80-00
Centralization													
MWI	Emp	0.2	0.12	0.09	-38.1	-26.2	-54.3	0.35	0.3	0.23	-15.4	-23.8	-35.5
MWI	Pop	0.07	0.02	0	-65.6	-78.6	-92.7	0.27	0.22	0.19	-15.5	-13.9	-27.3
ACI	Emp	0.49	0.42	0.39	-13.2	-6.9	-19.2	0.59	0.55	0.49	-7.3	-11.3	-17.8
ACI	Pop	0.38	0.34	0.32	-11.6	-5.3	-16.3	0.53	0.49	0.46	-7	-5.9	-12.6
ADC	Emp	19.94	21.79	22.58	9.3	3.6	13.2	11.13	12.07	13.29	8.4	10.2	19.4
ADC	Pop	23.14	24.23	24.67	4.7	1.8	6.6	12.65	13.36	13.89	5.6	4	9.9
Concentration													
GINI	Emp	0.9	0.87	0.85	-3.2	-3.2	-6.3	0.85	0.81	0.72	-5.2	-10.9	-15.5
GINI	Pop	0.83	0.81	0.8	-2.4	-1.4	-3.8	0.75	0.69	0.66	-7.3	-4.6	-11.6
DELTA	Emp	0.77	0.73	0.69	-5.1	-5.3	-10.1	0.69	0.64	0.56	-7.4	-13.5	-19.8
DELTA	Pop	0.7	0.67	0.66	-3.5	-2.1	-5.5	0.6	0.54	0.5	-9.9	-6.4	-15.6

1) MWI: Modified Wheaton index; ACI: Area-based centralization index; ADC: Weighted average distance from CBD; GINI: Gini coefficient; DELTA: delta index.
2) Extremely low modified Wheaton index in San Francisco and its fast decline are due to the presence of San Francisco Bay. Note this index is normalized by the distance from the CBD.
3) Comparison of indices across metropolitan areas should be done with caution because the difference may due to the presence of unpopulated large tracts rather than built-up settlement variations.

Table 4. Centers employment trends in New York, 1990 to 2000

a) GWR method

	# centers	1990 Employment	Share	2000 Employment	Share	Job Growth	% Growth	Growth Share
1990 Centers		**2,061,564**	**22.8%**	1,898,020	20.2%	-163,544	-7.9%	-44.2%
CBD[1)]	3	1,268,196	14.0%	1,207,518	12.8%	-60,678	-4.8%	-16.4%
Subcenters	31	793,368	8.8%	690,502	7.3%	-102,866	-13.0%	-27.8%
Dispersed		6,977,680	77.2%	7,511,439	79.8%	533,759	7.6%	144.2%
2000 Centers		1,935,694	21.4%	**1,971,545**	**21.0%**	35,851	1.9%	9.7%
CBD[1)]	2	1,194,991	13.2%	1,190,025	12.6%	-4,966	-0.4%	-1.3%
Subcenters	33	740,703	8.2%	781,520	8.3%	40,817	5.5%	11.0%
Dispersed		7,103,550	78.6%	7,437,914	79.0%	334,364	4.7%	90.3%
Total		9,039,244	100%	9,409,459	100%	370,215	4.1%	100%

b) Minimum density method

	# centers	1990 Employment	Share	2000 Employment	Share	Job Growth	% Growth	Growth Share
1990 Centers		**2,741,243**	**30.3%**	2,675,354	28.4%	-65,889	-2.4%	-17.8%
Main center	1	1,973,355	21.8%	1,984,192	21.1%	10,837	0.5%	2.9%
Subcenters	29	767,888	8.5%	691,162	7.3%	-76,726	-10.0%	-20.7%
Dispersed		6,298,001	69.7%	6,734,105	71.6%	436,104	6.9%	117.8%
2000 Centers		2,595,091	28.7%	**2,701,316**	**28.7%**	106,225	4.1%	28.7%
Main center	1	1,975,972	21.9%	1,996,657	21.2%	20,685	1.0%	5.6%
Subcenters	26	619,119	6.8%	704,659	7.5%	85,540	13.8%	23.1%
Dispersed		6,444,153	71.3%	6,708,143	71.3%	263,990	4.1%	71.3%
Total		9,039,244	100%	9,409,459	100%	370,215	4.1%	100%

1) All employment centers identified south of Central Park in Manhattan are defined as CBD.

Table 5. Centers employment trends in Los Angeles, 1990 to 2000

a) GWR method

	# centers	1990 Employment	Share	2000 Employment	Share	Job Growth	% Growth	Growth Share
1990 Centers		**1,797,308**	**26.6%**	1,583,703	23.6%	-213,605	-11.9%	629.3%
CBD	1	219,948	3.3%	171,566	2.6%	-48,382	-22.0%	142.5%
Subcenters	43	1,577,360	23.4%	1,412,137	21.0%	-165,223	-10.5%	486.8%
Dispersed		4,953,400	73.4%	5,133,064	76.4%	179,664	3.6%	-529.3%
2000 Centers		1,987,947	29.4%	**1,957,555**	**29.1%**	-30,392	-1.5%	89.5%
CBD	1	230,893	3.4%	196,695	2.9%	-34,198	-14.8%	100.8%
Subcenters	41	1,757,054	26.0%	1,760,860	26.2%	3,806	0.2%	-11.2%
Dispersed		4,762,761	70.6%	4,759,212	70.9%	-3,549	-0.1%	10.5%
Total		6,750,708	100%	6,716,767	100%	-33,941	-0.5%	100%

b) Minimum density method

	# centers	1990 Employment	Share	2000 Employment	Share	Job Growth	% Growth	Growth Share
1990 Centers		**2,540,357**	**37.6%**	2,241,297	33.4%	-299,060	-11.8%	881.1%
Main center	2	1,032,457	15.3%	916,374	13.6%	-116,083	-11.2%	342.0%
Subcenters	40	1,507,900	22.3%	1,324,923	19.7%	-182,977	-12.1%	539.1%
Dispersed		4,210,351	62.4%	4,475,470	66.6%	265,119	6.3%	-781.1%
2000 Centers		2,276,391	33.7%	**2,169,966**	**32.3%**	-106,425	-4.7%	313.6%
Main center	2	948,608	14.1%	875,531	13.0%	-73,077	-7.7%	215.3%
Subcenters	34	1,327,783	19.7%	1,294,435	19.3%	-33,348	-2.5%	98.3%
Dispersed		4,474,317	66.3%	4,546,801	67.7%	72,484	1.6%	-213.6%
Total		6,750,708	100%	6,716,767	100%	-33,941	-0.5%	100%

1) Centers which were contiguous to the CBD or main center in any single census year are considered as parts of the CBD or main center. This is why the entry in number of centers for CBD or main center is sometimes larger than one.

Table 6. Centers employment trends in Boston, 1990 to 2000

a) GWR method

	# centers	1990 Employment	Share	2000 Employment	Share	Job Growth	% Growth	Growth Share
1990 Centers		**423,626**	**19.4%**	412,571	17.8%	-11,055	-2.6%	-9.0%
CBD	1	267,616	12.2%	280,837	12.2%	13,221	4.9%	10.8%
Subcenters	9	156,010	7.1%	131,734	5.7%	-24,276	-15.6%	-19.8%
Dispersed		1,764,972	80.6%	1,898,815	82.2%	133,843	7.6%	109.0%
2000 Centers		341,885	15.6%	**356,366**	**15.4%**	14,481	4.2%	11.8%
CBD	1	220,556	10.1%	238,101	10.3%	17,545	8.0%	14.3%
Subcenters	7	121,329	5.5%	118,265	5.1%	-3,064	-2.5%	-2.5%
Dispersed		1,846,713	84.4%	1,955,020	84.6%	108,307	5.9%	88.2%
Total		2,188,598	100%	2,311,386	100%	122,788	5.6%	100%

b) Minimum density method

	# centers	1990 Employment	Share	2000 Employment	Share	Job Growth	% Growth	Growth Share
1990 Centers		**591,727**	**27.0%**	570,591	24.7%	-21,136	-3.6%	-17.2%
Main center	2	480,894	22.0%	502,857	21.8%	21,963	4.6%	17.9%
Subcenters	8	110,833	5.1%	67,734	2.9%	-43,099	-38.9%	-35.1%
Dispersed		1,596,871	73.0%	1,740,795	75.3%	143,924	9.0%	117.2%
2000 Centers		483,972	22.1%	**549,006**	**23.8%**	65,034	13.4%	53.0%
Main center	2	453,186	20.7%	502,915	21.8%	49,729	11.0%	40.5%
Subcenters	5	30,786	1.4%	46,091	2.0%	15,305	49.7%	12.5%
Dispersed		1,704,626	77.9%	1,762,380	76.2%	57,754	3.4%	47.0%
Total		2,188,598	100%	2,311,386	100%	122,788	5.6%	100%

1) Centers which were contiguous to the CBD or main center in any single census year are considered as parts of the CBD or main center. This is why the entry in number of centers for CBD or main center is sometimes larger than one.

Table 7. Centers employment trends in Portland, 1990 to 2000

a) GWR method

	# centers	1990 Employment	Share	2000 Employment	Share	Job Growth	% Growth	Growth Share
1990 Centers		**134,785**	**19.2%**	143,557	13.0%	8,772	6.5%	2.2%
CBD	1	90,887	12.9%	97,750	8.8%	6,863	7.6%	1.7%
Subcenters	2	43,898	6.2%	45,807	4.1%	1,909	4.3%	0.5%
Dispersed		569,045	80.8%	962,218	87.0%	393,173	69.1%	97.8%
2000 Centers		121,127	17.2%	**129,385**	**11.7%**	8,258	6.8%	2.1%
CBD	1	81,021	11.5%	87,310	7.9%	6,289	7.8%	1.6%
Subcenters	2	40,106	5.7%	42,075	3.8%	1,969	4.9%	0.5%
Dispersed		582,703	82.8%	976,390	88.3%	393,687	67.6%	97.9%
Total		703,830	100%	1,105,775	100%	401,945	57.1%	100%

b) Minimum density method

	# centers	1990 Employment	Share	2000 Employment	Share	Job Growth	% Growth	Growth Share
1990 Centers		**243,573**	**34.6%**	257,182	23.3%	13,609	5.6%	3.4%
Main center	1	188,426	26.8%	208,926	18.9%	20,500	10.9%	5.1%
Subcenters	3	55,147	7.8%	48,256	4.4%	-6,891	-12.5%	-1.7%
Dispersed		460,257	65.4%	848,593	76.7%	388,336	84.4%	96.6%
2000 Centers		266,045	37.8%	**315,947**	**28.6%**	49,902	18.8%	12.4%
Main center	1	191,210	27.2%	212,732	19.2%	21,522	11.3%	5.4%
Subcenters	6	74,835	10.6%	103,215	9.3%	28,380	37.9%	7.1%
Dispersed		437,785	62.2%	789,828	71.4%	352,043	80.4%	87.6%
Total		703,830	100%	1,105,775	100%	401,945	57.1%	100%

Table 8. Centers employment trends in San Francisco, 1980 to 2000

a) GWR method

	#	1980 Employment	Share	1990 Employment	Share	2000 Employment	Share	Job Growth	% Growth	Growth Share
1980 Centers		**624,676**	**27.0%**	632,654	20.7%	645,409	19.0%	20,733	3.3%	1.9%
CBD	2	186,175	8.0%	172,081	5.6%	187,102	5.5%	927	0.5%	0.1%
Subcenters	17	438,501	18.9%	460,573	15.1%	458,307	13.5%	19,806	4.5%	1.8%
Dispersed		1,691,562	73.0%	2,418,196	79.3%	2,759,738	81.0%	1,068,176	63.1%	98.1%
1990 Centers		653,741	28.2%	**807,396**	**26.5%**	771,235	22.6%	117,494	18.0%	10.8%
CBD	1	217,139	9.4%	204,524	6.7%	224,535	6.6%	7,396	3.4%	0.7%
Subcenters	21	436,602	18.8%	602,872	19.8%	546,700	16.1%	110,098	25.2%	10.1%
Dispersed		1,662,497	71.8%	2,243,454	73.5%	2,633,912	77.4%	971,415	58.4%	89.2%
2000 Centers[2)]		484,995	20.9%	558,336	18.3%	**652,661**	**19.2%**	167,666	34.6%	15.4%
CBD	2	204,169	8.8%	188,960	6.2%	211,195	6.2%	7,026	3.4%	0.6%
Subcenters	16	280,826	12.1%	369,376	12.1%	441,466	13.0%	160,640	57.2%	14.8%
Dispersed		1,831,243	79.1%	2,492,514	81.7%	2,752,486	80.8%	921,243	50.3%	84.6%
Total Jobs		2,316,238	100%	3,050,850	100%	3,405,147	100%	1,088,909	47%	100%

b) Minimum density method

	#	1980 Employment	Share	1990 Employment	Share	2000 Employment	Share	Job Growth	% Growth	Growth Share
1980 Centers		**749,987**	**32.4%**	767,373	25.2%	763,643	22.4%	13,656	1.8%	1.3%
Main center	1	400,154	17.3%	407,344	13.4%	443,454	13.0%	43,300	10.8%	4.0%
Subcenters	13	349,833	15.1%	360,029	11.8%	320,189	9.4%	-29,644	-8.5%	-2.7%
Dispersed		1,566,251	67.6%	2,283,477	74.8%	2,641,504	77.6%	1,075,253	68.7%	98.7%
1990 Centers		801,095	34.6%	**926,021**	**30.4%**	886,695	26.0%	85,600	10.7%	7.9%
Main center	1	417,952	18.0%	447,956	14.7%	482,996	14.2%	65,044	15.6%	6.0%
Subcenters	18	383,143	16.5%	478,065	15.7%	403,699	11.9%	20,556	5.4%	1.9%
Dispersed		1,515,143	65.4%	2,124,829	69.6%	2,518,452	74.0%	1,003,309	66.2%	92.1%
2000 Centers		809,095	34.9%	946,210	31.0%	**1,151,744**	**33.8%**	342,649	42.3%	31.5%
Main center	1	416,317	18.0%	444,962	14.6%	482,246	14.2%	65,929	15.8%	6.1%
Subcenters	20	392,778	17.0%	501,248	16.4%	669,498	19.7%	276,720	70.5%	25.4%
Dispersed		1,507,143	65.1%	2,104,640	69.0%	2,253,403	66.2%	746,260	49.5%	68.5%
Total Jobs		2,316,238	100%	3,050,850	100%	3,405,147	100%	1,088,909	47%	100%

1) Centers which were contiguous to the CBD or main center in any single census year are considered as parts of the CBD or main center. This is why the entry in number of centers for CBD or main center is sometimes larger than one.

2) When using 2000 data by 2000 census tracts without converting it to 1990 census tracts, centers employment share by the GWR method is 30.5% (1,070,799), combining shares in CBD and subcenters, 6.3% (220,528) and 24.2% (850,271), respectively.

Table 9. Centers employment trends in Philadelphia, 1980 to 2000

a) GWR method

	#	1980 Employment	Share	1990 Employment	Share	2000 Employment	Share	Job Growth	% Growth	Growth Share
1980 Centers		**400,215**	**21.0%**	403,319	17.5%	359,736	14.7%	-40,479	-10.1%	-7.5%
CBD	1	261,514	13.8%	260,959	11.3%	242,980	10.0%	-18,534	-7.1%	-3.4%
Subcenters	12	138,701	7.3%	142,360	6.2%	116,756	4.8%	-21,945	-15.8%	-4.1%
Dispersed		1,501,429	79.0%	1,897,137	82.5%	2,080,619	85.3%	579,190	38.6%	107.5%
1990 Centers		370,028	19.5%	**400,809**	**17.4%**	331,451	13.6%	-38,577	-10.4%	-7.2%
CBD	1	239,804	12.6%	247,803	10.8%	228,425	9.4%	-11,379	-4.7%	-2.1%
Subcenters	13	130,224	6.8%	153,006	6.7%	103,026	4.2%	-27,198	-20.9%	-5.0%
Dispersed		1,531,616	80.5%	1,899,647	82.6%	2,108,904	86.4%	577,288	37.7%	107.2%
2000 Centers		359,415	18.9%	374,046	16.3%	**360,556**	**14.8%**	1,141	0.3%	0.2%
CBD	1	239,804	12.6%	247,803	10.8%	228,425	9.4%	-11,379	-4.7%	-2.1%
Subcenters	10	119,611	6.3%	126,243	5.5%	132,131	5.4%	12,520	10.5%	2.3%
Dispersed		1,542,229	81.1%	1,926,410	83.7%	2,079,799	85.2%	537,570	34.9%	99.8%
Total Jobs		1,901,644	100%	2,300,456	100%	2,440,355	100%	538,711	28%	100%

b) Minimum density method

	#	1980 Employment	Share	1990 Employment	Share	2000 Employment	Share	Job Growth	% Growth	Growth Share
1980 Centers		**681,348**	**35.8%**	646,320	28.1%	547,278	22.4%	-134,070	-19.7%	-24.9%
Main center	2	497,467	26.2%	477,390	20.8%	419,952	17.2%	-77,515	-15.6%	-14.4%
Subcenters	13	183,881	9.7%	168,930	7.3%	127,326	5.2%	-56,555	-30.8%	-10.5%
Dispersed		1,220,296	64.2%	1,654,136	71.9%	1,893,077	77.6%	672,781	55.1%	124.9%
1990 Centers		648,009	34.1%	**726,650**	**31.6%**	582,820	23.9%	-65,189	-10.1%	-12.1%
Main center	3	461,648	24.3%	480,752	20.9%	417,574	17.1%	-44,074	-9.5%	-8.2%
Subcenters	18	186,361	9.8%	245,898	10.7%	165,246	6.8%	-21,115	-11.3%	-3.9%
Dispersed		1,253,635	65.9%	1,573,806	68.4%	1,857,535	76.1%	603,900	48.2%	112.1%
2000 Centers		535,526	28.2%	584,623	25.4%	**553,168**	**22.7%**	17,642	3.3%	3.3%
Main center	4	397,500	20.9%	421,275	18.3%	389,134	15.9%	-8,366	-2.1%	-1.6%
Subcenters	12	138,026	7.3%	163,348	7.1%	164,034	6.7%	26,008	18.8%	4.8%
Dispersed		1,366,118	71.8%	1,715,833	74.6%	1,887,187	77.3%	521,069	38.1%	96.7%
Total Jobs		1,901,644	100%	2,300,456	100%	2,440,355	100%	538,711	28%	100%

1) Centers which were contiguous to the CBD or main center in any single census year are considered as parts of the CBD or main center. This is why the entry in number of centers for CBD or main center is sometimes larger than one.

Figure 1. Changes in employment shares by density quintile (decile)

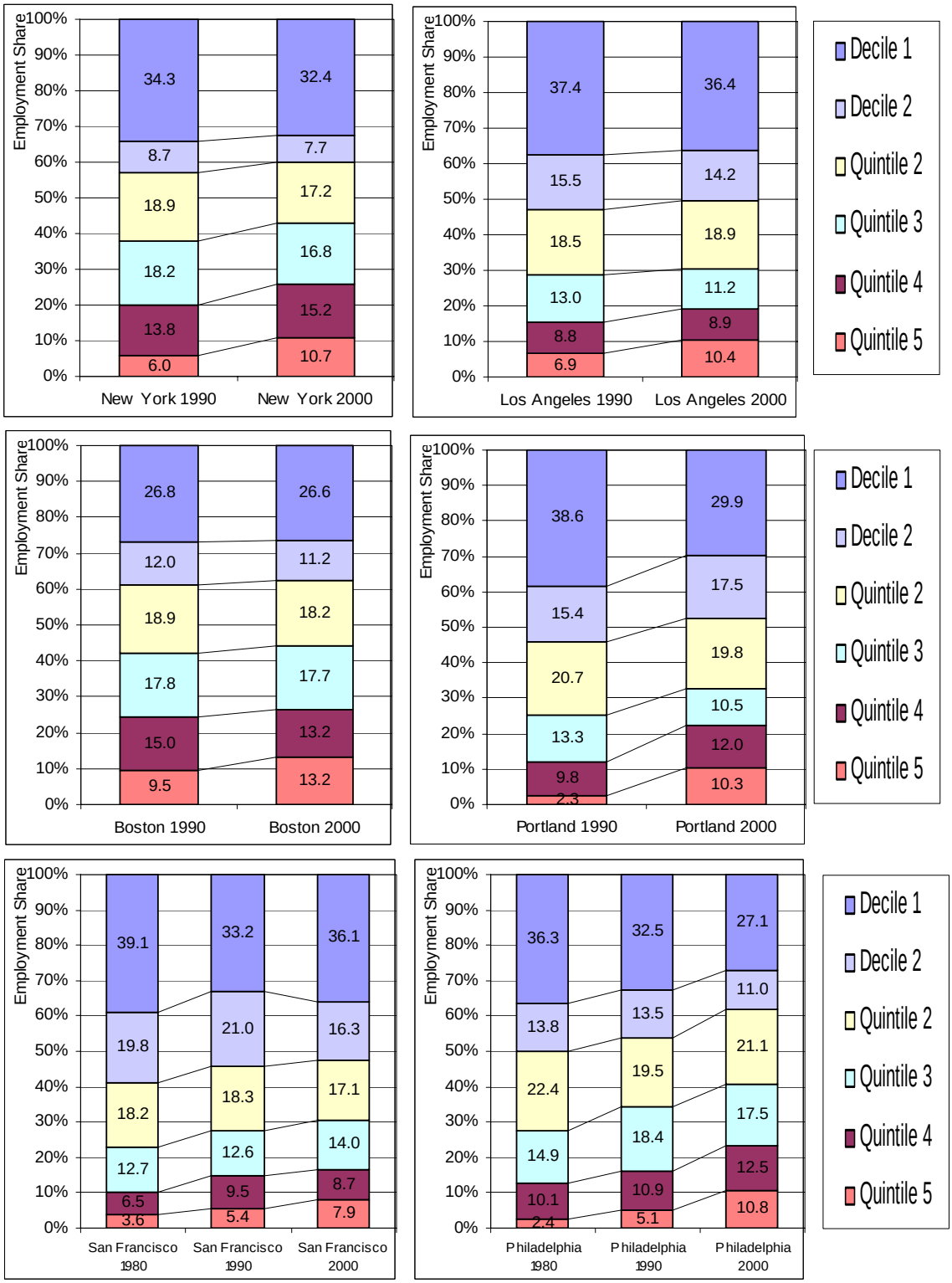
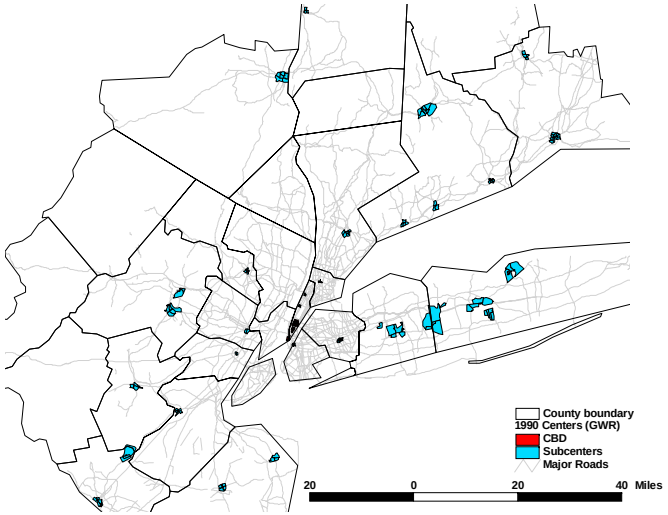
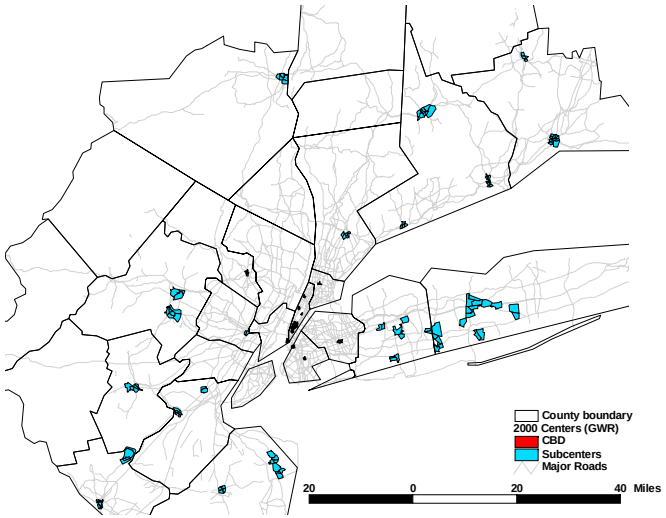


Figure 2. Employment centers in the New York metropolitan area, 1990 to 2000

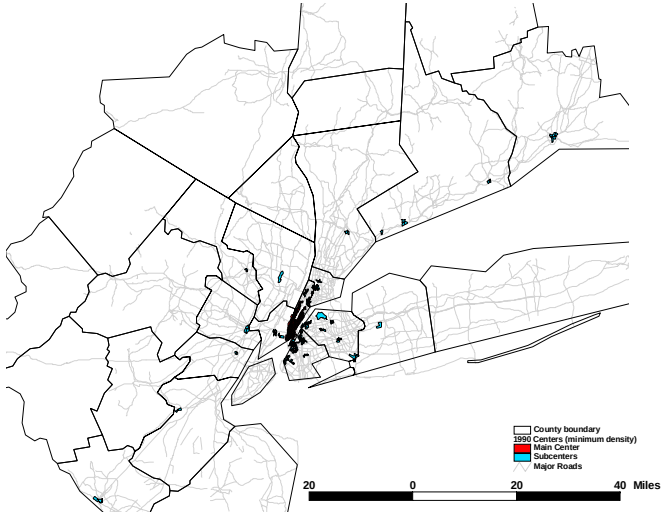
a) 1990 centers by GWR method



b) 2000 centers by GWR method



c) 1990 centers by minimum density method



d) 2000 centers by minimum density method

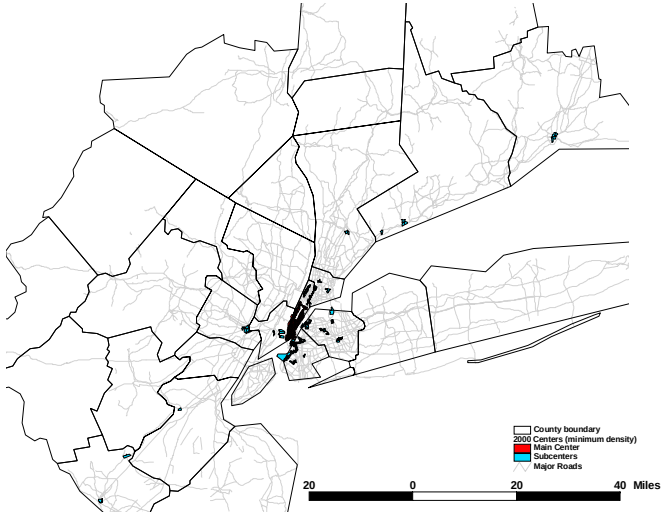
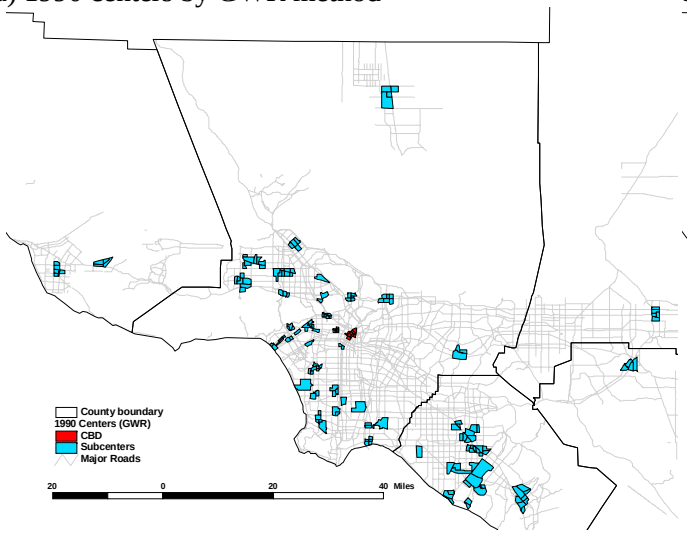
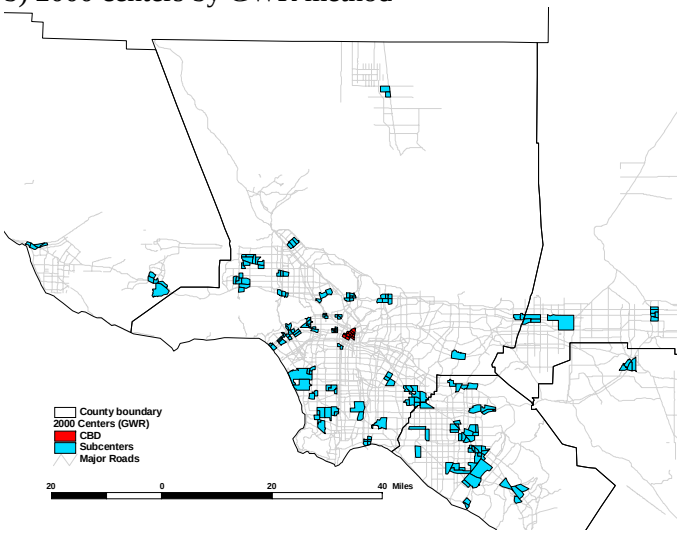


Figure 3. Employment centers in the Los Angeles metropolitan area, 1990 to 2000

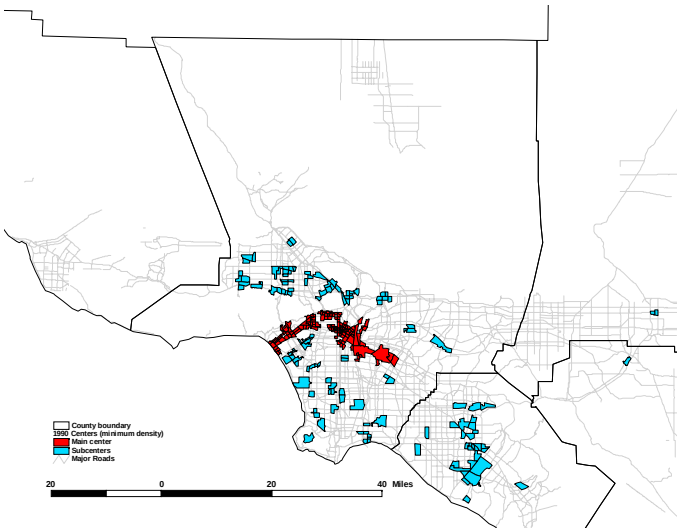
a) 1990 centers by GWR method



b) 2000 centers by GWR method



c) 1990 centers by minimum density method



d) 2000 centers by minimum density method

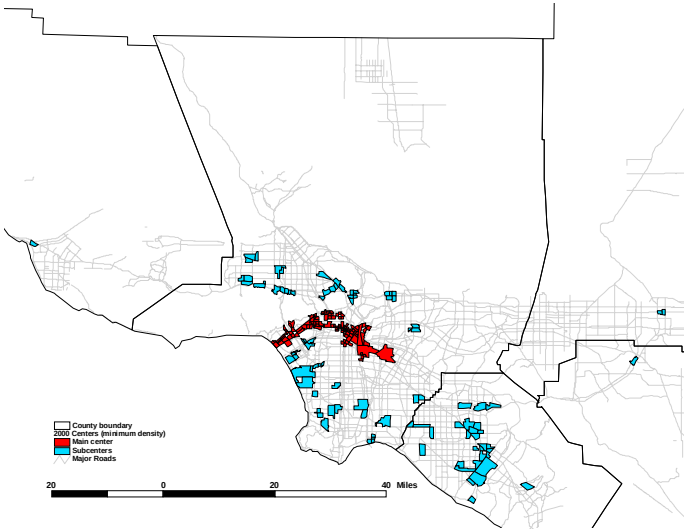
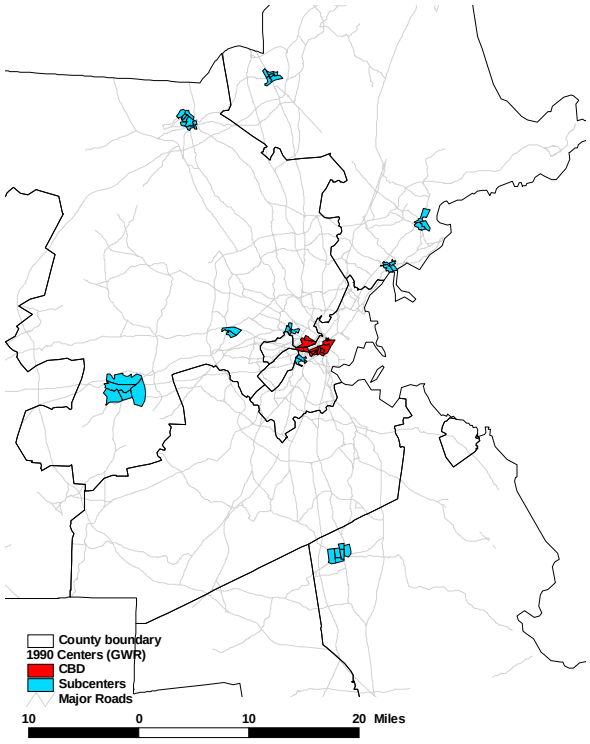
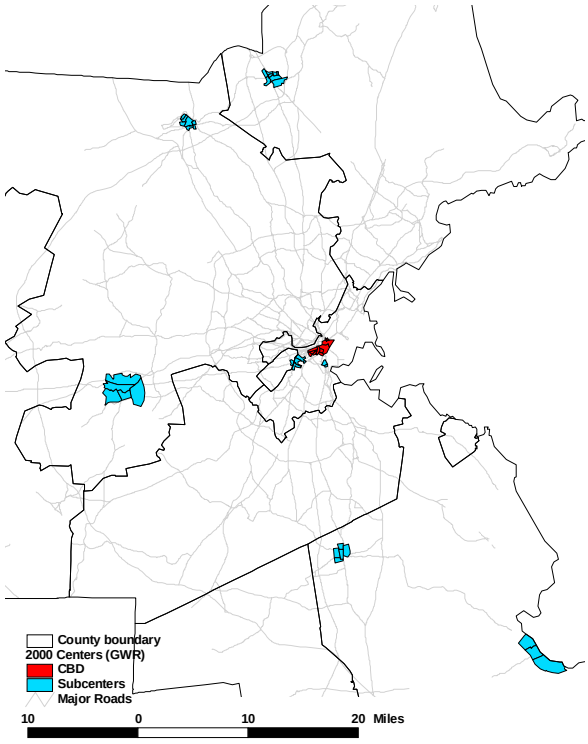


Figure 4. Employment centers in the Boston metropolitan area, 1990 to 2000

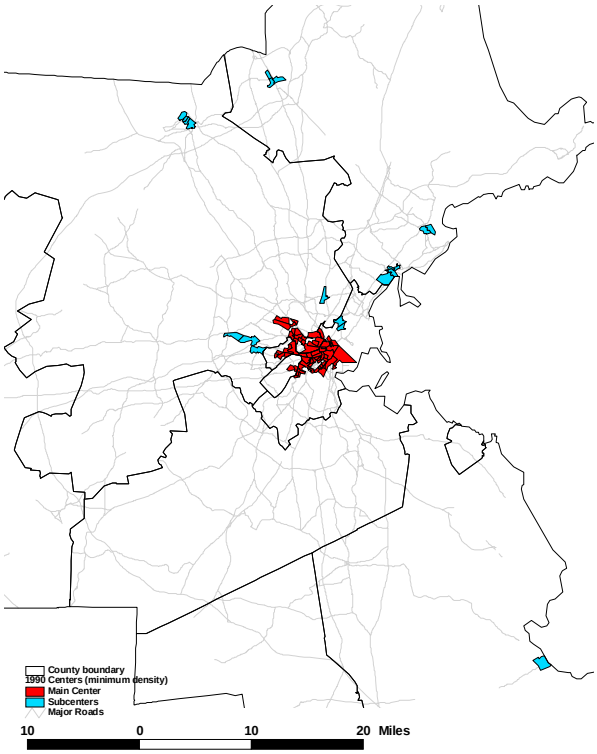
a) 1990 centers by GWR method



b) 2000 centers by GWR method



c) 1990 centers by minimum density method



d) 2000 centers by minimum density method

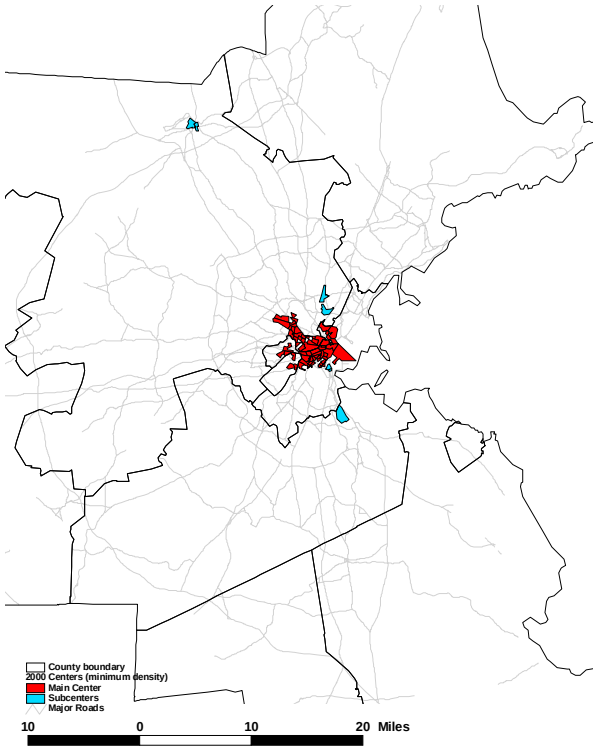
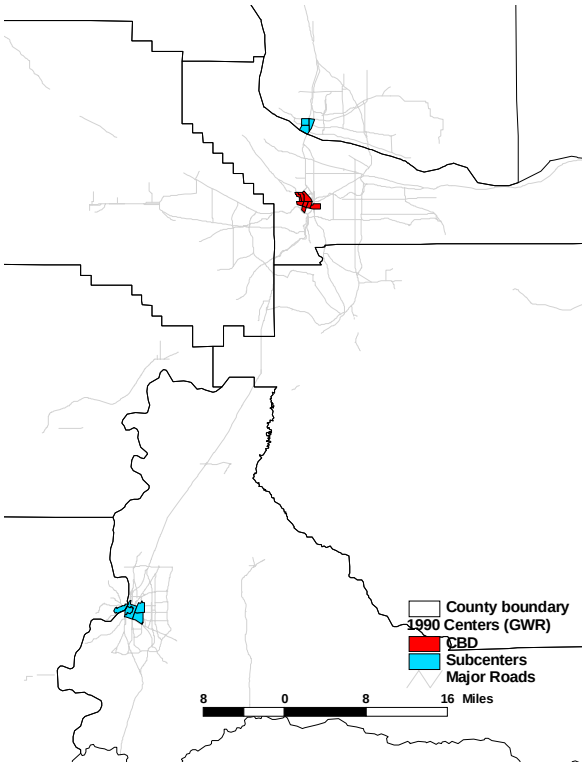
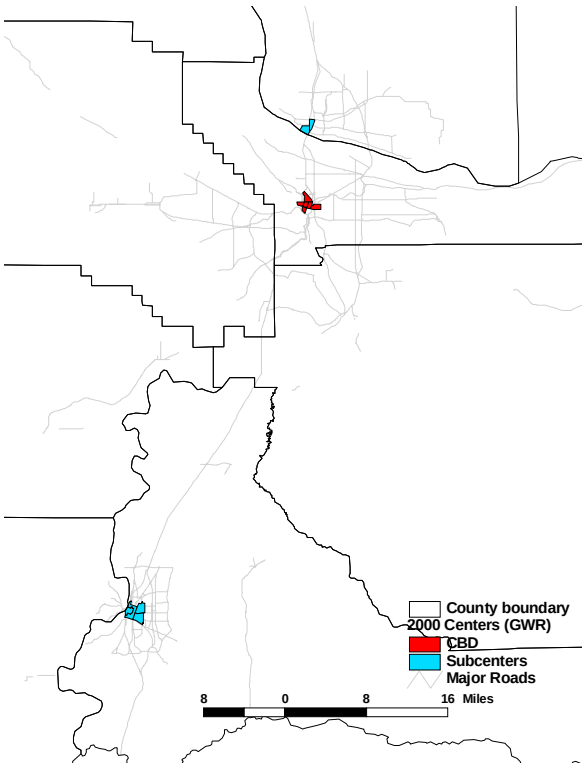


Figure 5. Employment centers in the Portland metropolitan area, 1990 to 2000

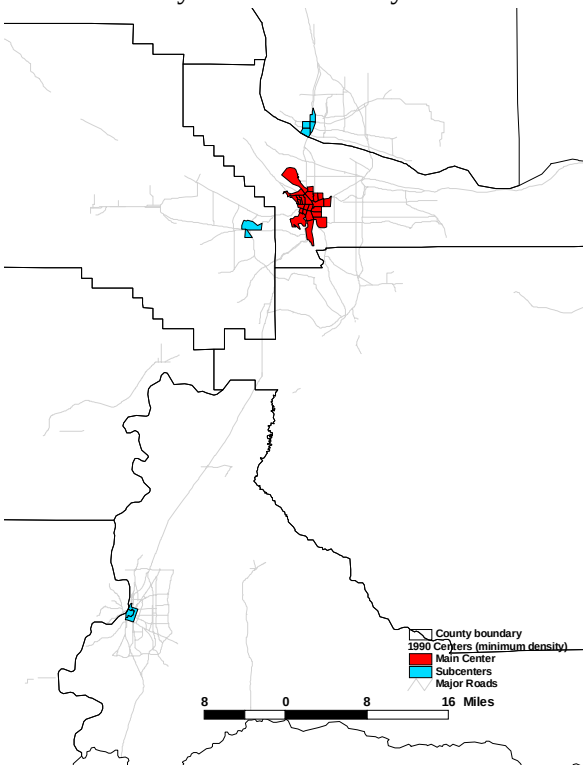
a) 1990 centers by GWR method



b) 2000 centers by GWR method



c) 1990 centers by minimum density method



d) 2000 centers by minimum density method

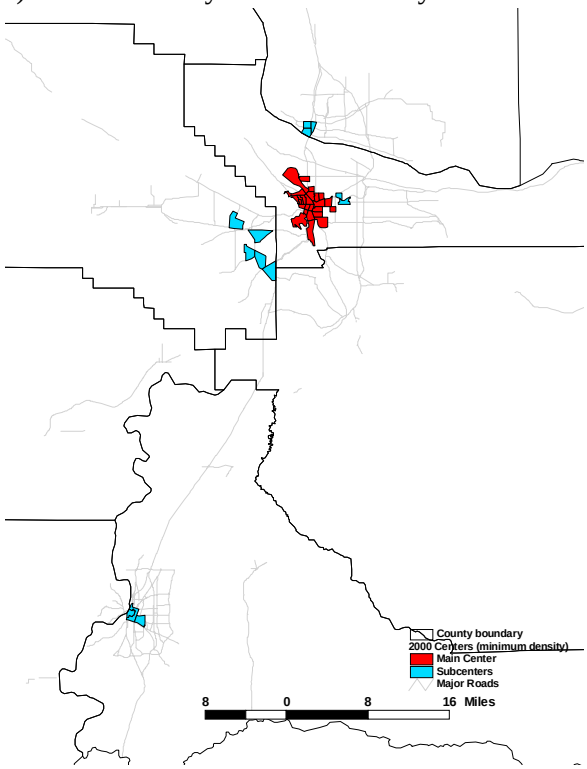
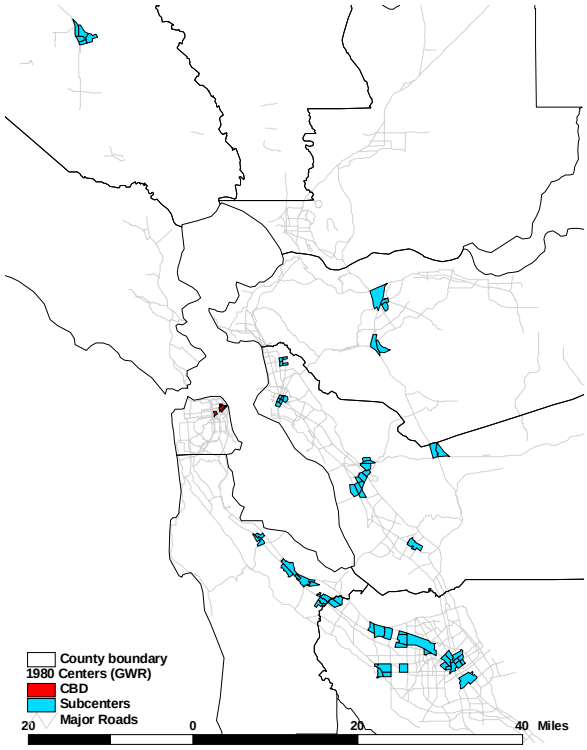
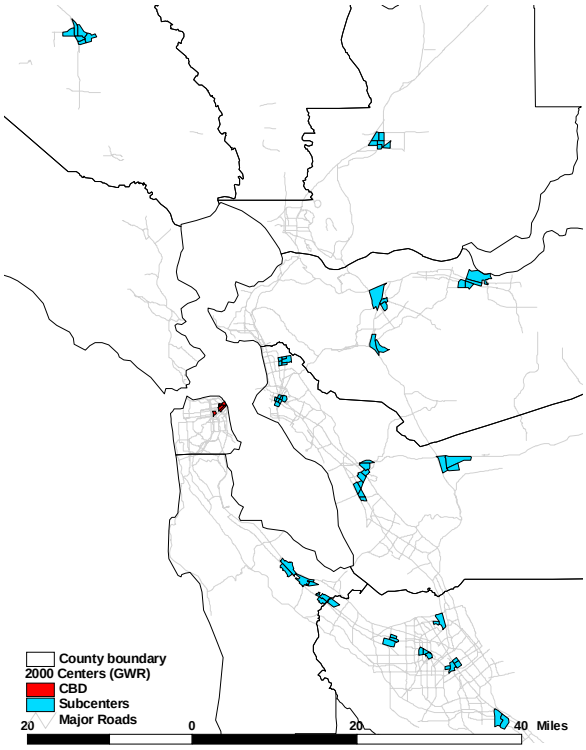


Figure 6. Employment centers in the San Francisco metropolitan area, 1980 to 2000

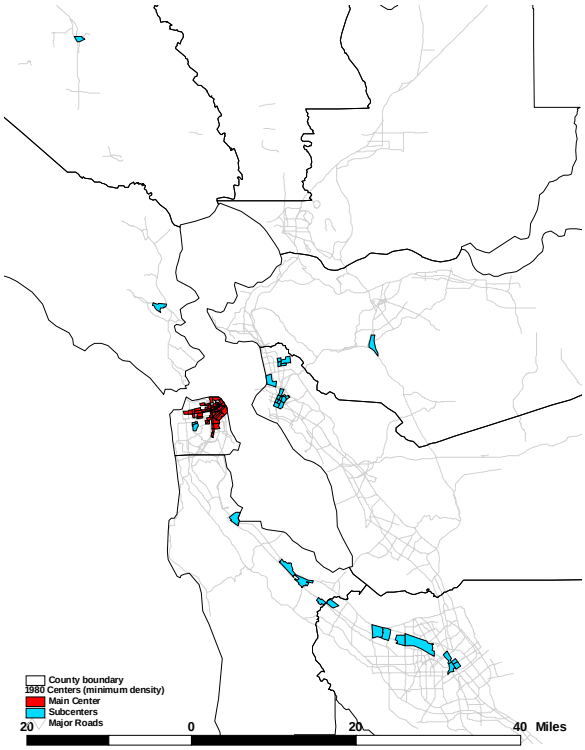
a) 1980 centers by GWR method



b) 2000 centers by GWR method



c) 1980 centers by minimum density method



d) 2000 centers by minimum density method

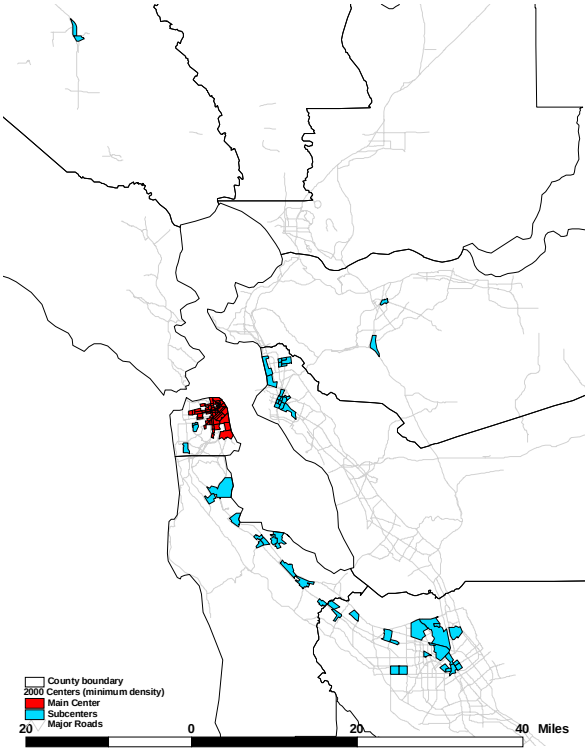
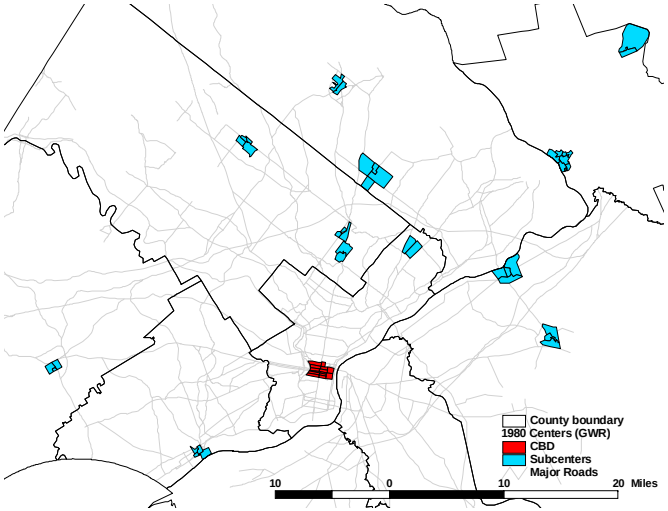
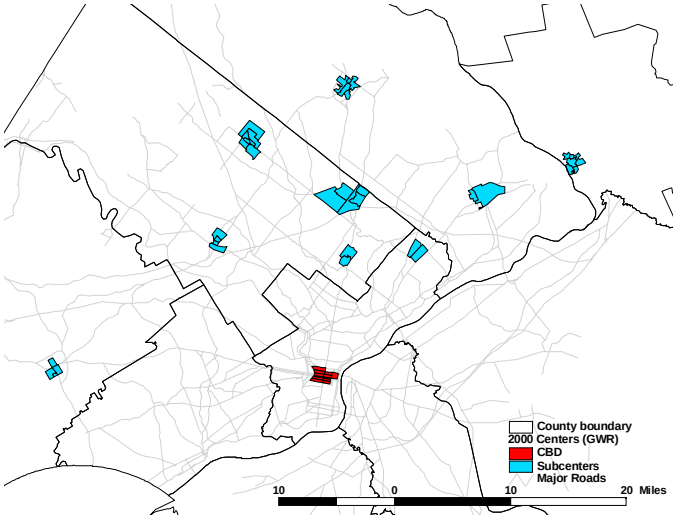


Figure 7. Employment centers in the Philadelphia metropolitan area, 1980 to 2000

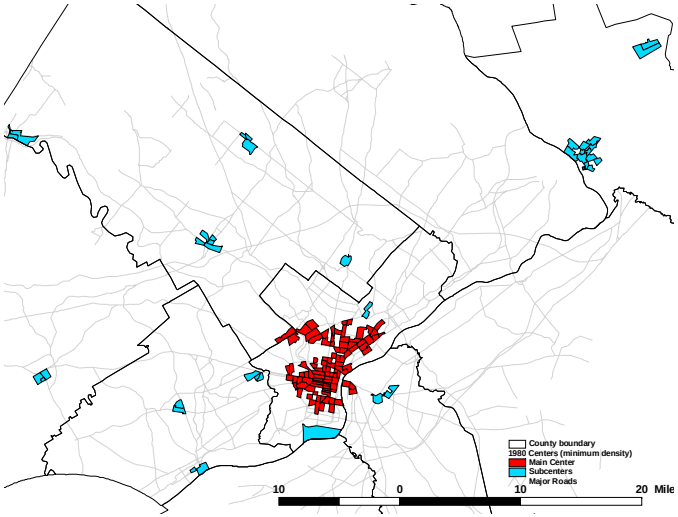
a) 1980 centers by GWR method



b) 2000 centers by GWR method



c) 1980 centers by minimum density method



d) 2000 centers by minimum density method

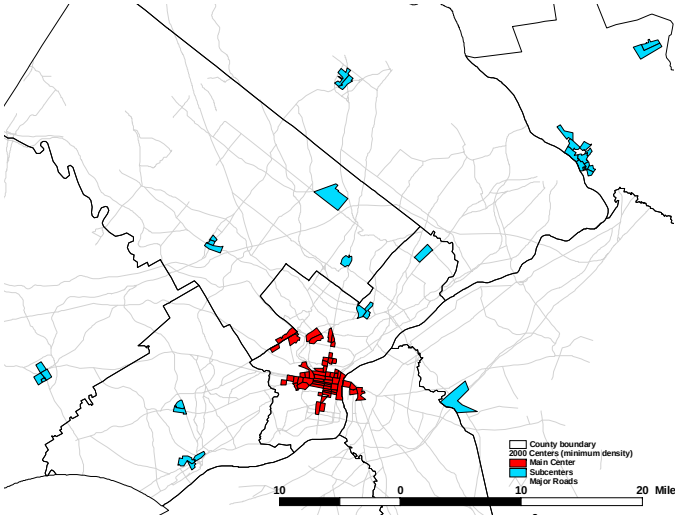
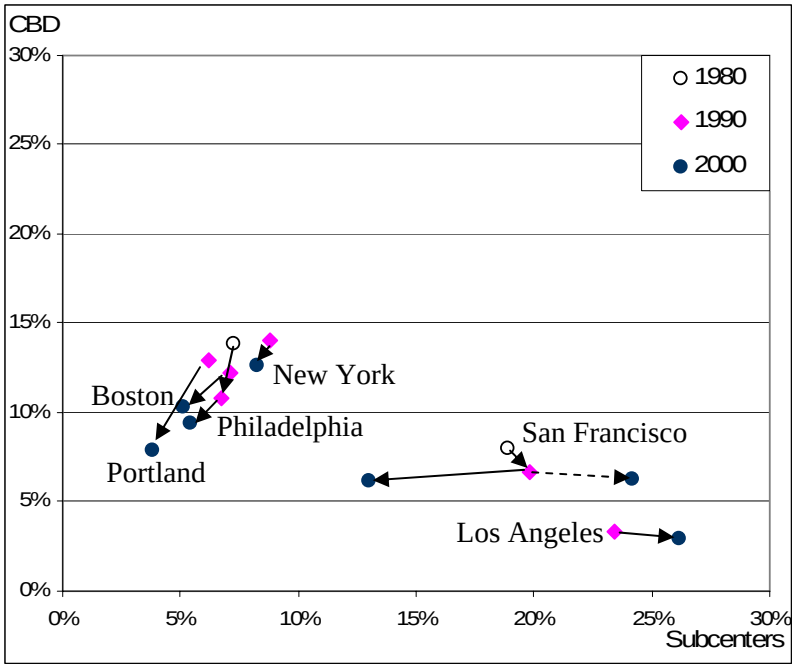


Figure 8. Changes of employment shares for both definitions of centers, 1980 to 2000

a) GWR method results



1) Dotted line for San Francisco indicates the 2000 result when using 2000 census tracts without data conversion.

b) Minimum density method results