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Los Angeles employment concentration in the twenty-first century

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Abstract

This paper is an empirical analysis of employment centers in the Los Angeles region from 1997-2014. Most extant work on employment centers focuses on identification methodology or their dynamics during a period of industrial restructuring from 1980-2000. This timely study examines hypotheses derived from more recent perspectives on urban concentration and dispersion including New Urbanism, Smart Growth, sustainable cities, and the recent Global Financial Crisis. We use point-based, rather than census tract-based employment data to analyze concentration across five key industries: knowledge-intensive business services (KIBS), retail, creative, industrial, and high-tech, emphasizing changes in center composition and boundaries. While using point data necessitates slight changes to the nonparametric identification method typically used, results show far greater change across centers than previous longitudinal studies. Only 43% of the land area that is in an employment center is part of one in both 1997 and 2014. Using a persistence score, centers range from stable to highly fluctuating, but emerging, persisting, and dying centers are found in core and fringe areas alike. KIBS are most associated with stable centers, while high tech employment is attracted toward emerging areas and retail exists throughout. Emerging centers are more likely to have greater accessibility, while industrial employment becomes far more concentrated in centers by 2014.

Keywords

Subcenters, Los Angeles, Smart Growth, industrial structure, land change

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Introduction

The study of what drives concentration and dispersion of economic activities in urban areas is no less important today than it was at any point since Von Thunen's 1826 publication of *The Isolated State* (1966). However, the study of polycentricity and centers of employment concentration by a variety of urban scholars largely remains rooted in 20th century theory making use of 20th century data. Ideas about polycentricity and edge cities, popularized by books like Garreau (1991) and seminal papers like Giuliano and Small (1991) largely flow from late-20th century concepts about the transition to a post-industrial service economy (see, e.g., Scott, 1988), the "death of Geography" that will be brought about by globalization and Information and Computing Technologies (ICT), and the impact of perpetually decreasing transportation costs (see, e.g., Anas et al., 1998). Empirical studies of 20th century employment concentration generally highlight persistence over time (Redfearn, 2009), emphasizing longstanding ideas about the path dependence of economic landscapes (Arthur, 1988). Most employment centers are heavily conditioned by the location of prior hubs of economic activity, particularly within the Los Angeles region (Redfearn, 2009; Forstall and Greene, 1997).

Changing patterns of employment concentration since the 1980s have often been linked to producer services or knowledge-intensive business services (KIBS), given the role that information technology has had on the intraurban spatial distribution of this typically office-based work that became more prevalent following de-industrialization (Coffey, 2000). In addition to KIBS, high-tech growth has been persistently targeted as a local and regional development strategy, often in the form of research parks or technopoles (Link and Scott, 2015). Urban economies have also been acknowledged for their role as sites of consumer activity, with a specific emphasis on the advantages of globally-connected metropolises and within-city districts featuring unique cultural outputs (Scott, 1997; Florida, 2002; Glaeser et al., 2001). Popularized in part by Florida (2002), a related trend emphasizes the importance of a "creative class" of knowledge workers to the local economy. These high-skill individuals prefer more "authentic" urban experiences in addition to shopping, arts, and recreation. A prime example of the interplay between the producer and consumer sides of the urban economy is the increasing tendency of

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3 employers to move headquarter locations to downtown areas in order to recruit the talented members of
4 the knowledge economy who value proximity to transit and other urban amenities not found in dispersed
5 areas or isolated suburban office parks ("Core Values," 2015). In addition to evolutions in the nature of
6 production and consumption, the field of urban planning offers a number of contemporary perspectives
7 regarding intraurban concentration specifically. The New Urbanism and Smart Growth movements both
8 emphasize how multiple, interconnected centers of employment can contribute to reduced commute time,
9 transportation expense, energy use, and an increased sense of place (Duany et al., 2010; Knaap and Talen,
10 2005), while an increased focus on the sustainability of urban areas has raised substantive concerns over
11 environmental degradation – both locally in the form of land change and pollution but also globally in
12 terms of climate change (see, e.g., Alberti, 2005).
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15 This paper presents an examination of employment centers in the Los Angeles area over a 17-year period
16 during the early years of the 21st century in order to observe the impact of contemporary changes in the
17 urban economy on the spatial distribution of employment concentration. An emphasis is placed on the
18 idea of the stability of centers, following from the contention that employment concentration is an
19 extremely durable long-term phenomenon in cities (Redfearn, 2009), and that changes in urban
20 neighborhoods comprise two separate components: boundary change and compositional change (Rey et
21 al., 2011). McMillen and Smith (2003: , p.332) define an employment center in general terms as “an
22 area with significantly higher employment densities than surrounding areas that is large enough to have
23 a significant effect on the overall spatial structure of the urban area.” Methodologically, this paper
24 adopts a two-stage nonparametric approach to employment center identification in the spirit of McMillen
25 and Smith’s definition using a combination of locally-weighted regression and contiguity relationships in
26 a GIS environment. Following Leslie (2010), we sidestep the more common use of census tracts to
27 delineate centers and instead use point-based data on individual business establishments from 1997 to
28 2014 in order to identify areas of concentration that are statistically distinct from surrounding areas. This
29 high-resolution approach is more adept at capturing the location patterns and location choices of
30 individual businesses. We analyze composition based on five key industry types: KIBS, retail, creative,
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3 industrial, and high-tech. The choice of the Los Angeles area follows a long history of the study of
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5 employment concentration here beginning with Giuliano and Small (1991), while the region's status as a
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7 large, car-oriented metropolis with a mild climate is consistent with many drivers of the urban resurgence
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9 that began in the 1990s (Glaeser and Gottlieb, 2006).
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11 Literature review

12 Concentration and Dispersion of Employment

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14 Agglomeration economies have long been considered the key driver of the concentration of economic
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16 activity (Marshall, 1890; Rosenthal and Strange, 2004). While they are used to explain the existence of
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18 cities and urban hierarchy, the benefits of co-location also influence the internal spatial structure of
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20 individual urban regions (Agarwal et al., 2012). The traditional monocentric city model of urban
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22 economics posits high rents at the city center which decrease with distance due to the co-location benefits
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24 accruing to a downtown location, while polycentricity is an extension stating that agglomeration
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26 economies can also accrue to other regional centers of activity, in part to avoid the congestion costs
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28 associated with a single center. Such employment centers can also be functionally specialized, with
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30 certain industries realizing agglomeration benefits in particular centers or particular industries driving
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32 patterns of concentration (Leslie and Ó hUallacháin, 2006; Fujii and Hartshorn, 1995). A contrasting
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34 perspective is that of Gordon and Richardson (1996), who argue that the prevailing forces in the location
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36 of economic activity – namely, decreasing transportation costs and the rise of ICT – contribute to a
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38 dispersion or “scatteration” of activity rather than concentration in multiple nuclei. Coffey and
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40 Shearmur's (2002) study of higher-order business services in Montréal suggests this position may be too
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42 extreme despite trends toward telecommuting and the suburbanization of back office functions, finding
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44 that this key sector continues to agglomerate but in auxiliary centers rather than the region's main
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46 downtown.
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49 While not much attention has been paid to locational shifts of employment centers, some studies have
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51 found them to be very stable over time, suggesting deep agglomerative underpinnings. Redfearn's (2009)
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3 thorough examination of concentration from 1980-2000 shows that present-day center location can be
4 explained accurately based on deeply-lagged indicators of infrastructure and economic activity such as
5 the original interstate highway map from 1942 or the location of significant places from the turn of the
6 20th century. Arthur (1988) distinguishes between proximity to capital-intensive fixed infrastructure and
7 chance historical occurrences in the emergence of industrial concentration; nonetheless, the belief that
8 urban spatial pattern is heavily path-dependent is widely held. Gradual changes in the location of
9 economic activity might result from economic restructuring, as Gordon and Richardson (1996)
10 demonstrate through the impact of ICT on employment centers, but less commonly explored – perhaps
11 since it requires finer resolution data – is the role that land use change and real estate development have
12 on employment concentration. Longcore and Rees' (1996) study of the advertising and financial services
13 industries in Manhattan describe their move from Wall Street to Midtown as a response to demand for
14 new office buildings featuring better tech connectivity and larger floor plates – both seen as essential to
15 modern businesses. Weber's (2015) study of commercial office space in Chicago emphasizes that
16 aggressive leasing brokers and the financialization of the real estate market led to an oversupply of
17 commercial office space (despite increasing vacancy rates), resulting in a spatial shift of Class A office
18 space from the East Loop district toward Wacker Drive. The same concept of obsolescence, whether real
19 or somewhat manufactured, can apply to the land use needs of other sectors too, particularly retail. For
20 example, the rise of big box stores fundamentally changed the demand for older, enclosed shopping malls
21 (Lorch and Hernandez, 2008).
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46 Production and Employment Concentration

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48 Producer services, or knowledge-intensive business services (together referred to as KIBS in this paper
49 for brevity), have long been associated with studies of polycentricity (Coffey, 2000). Since KIBS are
50 higher-order office-based activities that rely on face-to-face contact they were historically located in
51 CBDs, though innovations in IT during the 1990s led to hypotheses of their suburbanization (Gordon and
52 Richardson 1996). Forstall and Greene's (1997) study of Los Angeles indicates a slight deconcentration
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3 of KIBS through the 1980s. More recently KIBS have been studied for their innovative capacity
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5 (Shearmur, 2012; Herstad and Ebersberger, 2014). Shearmur (2012) finds that some KIBS activity like
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7 R&D may be more innovative if dispersed – further reason to postulate their continued suburbanization.
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9 Nonetheless, the high-skill, high-wage, and metropolitan-oriented nature of KIBS has made them
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11 attractive as a component of economic development policy (Coffey and Polèse, 1989; Lundquist et al.,
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13 2008).

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16 High-tech employment in both manufacturing and services is also targeted for its potential to foster local
17
18 economic development. The iconic examples of Silicon Valley and Boston’s Route 128 reflect both an
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20 interurban and intraurban component of agglomeration economies accruing to high-tech industry
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22 (Saxenian, 1994). Numerous policy initiatives – many of which explicitly seek “the next Silicon Valley”
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24 – support local science parks, research parks, technopoles, and tech incubators in order to foster job
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26 growth and technology transfer (Tamásy, 2007). A wide body of empirical and theoretical literature has
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28 emerged on the mixed success of such policies (Link and Scott, 2015; Shearmur and Doloreux, 2008).
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30 Spencer (2015) draws a distinction between the intraurban patterns of science-based technologies and
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32 creative-oriented industries across Canadian cities, suggesting that the former are more concentrated in
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34 low-density suburban campuses while the latter are more prevalent in mixed-use areas or urban cores.
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36 Nonetheless, the continuing evolution of high-tech industry merits longitudinal analysis of its intraurban
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38 patterning.
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42 Finally, manufacturing – particularly defense manufacturing – was a major component in the rise of the
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44 Southern California economy during World War II and the Cold War (Levy, 2000) but has seen a
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46 substantial decline since the 1990s. Historically manufacturing has gravitated toward lower-rent locations
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48 along the urban fringe (Kain, 1968). However, modern forms of flexible or just-in-time production are
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50 thought to affect the typical spatial distribution of manufacturing activity (Scott, 1988), while easy access
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52 to transportation infrastructure is increasingly important for logistics operations (Audirac, 2002).
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57 Consumption and Employment Concentration
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3 Cities are increasingly functioning as centers of consumption as well as production. In the United States,
4 the amount of personal consumption expenditures has grown dramatically over the last several decades
5 and currently accounts for over two-thirds of GDP (McCully, 2011). As Glaeser et al. (2001) note, these
6 growing consumption activities are likely to take place in highly urbanized areas where people enjoy a
7 wide array of goods and services, natural amenities, pleasant aesthetics, and high-quality public services.
8 Providing consumer amenities, sometimes in the form of reducing crime or other types of disamenities,
9 has become crucial to the success or resurgence of places and central cities in particular (Glaeser and
10 Gottlieb, 2006). Shopping behavior, measured using retail employment, is considered as a component of
11 polycentric urban development by Fujii and Hartshorn (1995). Chapple and Jacobus (2009) emphasize
12 the role of retail in neighborhood revitalization and thus the possibility that retail concentration might
13 reflect a form of urban infill. Zukin (2004), however, emphasizes the perpetual strength of shopping
14 malls and suburban town centers, following longstanding ideas about comparison shopping in retail
15 geography (Hotelling, 1929; Nelson, 1958). Thus, concentration in retail might reflect Greenfield or infill
16 development.

17
18 Consistent with the consumption-oriented perspective on urban retail, a broader trend of urban
19 amenitization and revitalization is often linked to the locational preferences of so-called “creative class”
20 workers who are seen as key components of a revitalized local economy (Kolenda and Liu, 2012; Florida,
21 2002). As such, creative employment might be expected to cluster in centers (or downtowns in particular)
22 heavy in retail, dining, arts, and entertainment, consistent with Spencer (2015). In addition to the main
23 downtown, relatively dense suburban mixed-use centers and the smaller downtowns of inner-ring suburbs
24 have been locations of attempts at densification for the same reasons (Filion, 2001). Citing such trends, a
25 wide array of corporations have been moving headquarter and branch locations to downtown areas in part
26 to attract and retain talented workers of the knowledge economy. A survey of corporations who recently
27 moved to downtown areas in the United States found that, in addition to brand image, collaborative
28 opportunities, and proximity to other related businesses (i.e. traditional agglomeration economies), these
29 recruitment benefits were increasingly valued in their location choices (Core Values, 2015). Such a trend
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3 reflects mutual reinforcement between densification trends on both consumer and producer sides of the
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5 economy.
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8 9 Perspectives on Planning

10 While the discussion of employment concentration thus far has emphasized the spatial outcomes of
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12 economic sectors' propensity to concentrate, contemporary movements in urban planning can also inform
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14 the understanding of concentration in general, particularly at a fine spatial scale where city planners, real
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16 estate developers, and other stakeholders are involved in the production of suitable space for economic
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18 activity. New Urbanism and Smart Growth are two distinct movements that began in earnest in the mid-
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20 1990s with a common goal of addressing problems created by urban sprawl (Knaap and Talen, 2005).
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23 While New Urbanism's focus on architecture and urban design contrasts with smart growth's emphasis
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25 within planning organizations, both stress the importance of directing growth toward areas with existing
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27 infrastructure and already concentrated activity rather than remote locations. Regions developed with
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29 such principles in mind are thought to enjoy an increased sense of place, a wider variety of housing
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31 choices, less redundant infrastructure, and reduced vehicle miles traveled, while addressing environmental
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33 concerns is a key motivator of both New Urbanism and smart growth (Duany et al., 2010). In addition,
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35 Sustainable Cities movements within planning, landscape ecology, and related fields emphasize the
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37 connections between growing urban footprints and local and global environmental change (Haughton and
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39 Hunter, 2004; Grimm et al., 2008), and advocate directing growth toward existing, more concentrated
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41 areas to reduce ecological disturbance alongside design-related improvements such as reduced surface
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43 impermeability and increased surface reflectivity. To our knowledge, empirical research has not
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45 specifically linked such contemporary movements with employment concentration specifically, nor is
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47 such an undertaking the explicit goal of this study. However, rising concentrations in existing areas
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49 would suggest that recent development patterns are generally consistent with their ideas.
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56 57 Methods and data

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3 This study examines the evolution of employment centers between 1997 and 2014 by applying an
4 identification method to spatially-explicit business establishment data. Recent research has taken up the
5 cause of improving methodological approaches to identifying employment centers within a metropolitan
6 area. We sidestep a thorough review (for a more detailed treatment, see Agarwal et al., 2012), though the
7 most notable difference in approach is whether to use a fixed threshold for density and total employment
8 in a center (i.e. the original approach of Giuliano and Small, 1991) or to use a regression-based approach
9 that offers more flexibility and statistical robustness (Redfearn, 2007; McMillen, 2001). However, due to
10 factors including the delineation and size of census tracts, the importance of a region's central business
11 district (CBD), and disagreement over what is really considered "local," there is no one true method for
12 employment center identification. This paper adopts a two-stage nonparametric regression-based
13 approach most similar to Redfearn (2007) but with some modifications to account for the different data
14 source.

25 Data source

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27 The data used here are Reference USA point-based establishment data covering 1997-2014 (Infogroup,
28 2015), which provide coordinate data, an employee count, and the North American Industry Classification
29 System (NAICS) code for every business establishment region-wide. 4.67% of business establishments
30 could not successfully be geocoded: in these cases, the centroid of the ZIP code in which the business lies
31 was used as a proxy. Given our focus on recent trends in urbanism, we rely on this data's timeliness,
32 contrasting it with other recent studies such as Agarwal (2015) and Arribas-Bel et al. (2015) which use
33 year 2000 data.

34 Employment center identification

35 While point-based establishment-level data are the "gold standard" for avoiding the modifiable areal unit
36 problem, measuring points based on employment density necessitates their aggregation to a two-
37 dimensional unit. We create a 1km x 1km fishnet, or grid of cells covering the urbanized extent of the
38 region and use GIS to spatially join the establishment and employment figures to these cells. Cells have
39 the advantage of being consistent in size and are designed to represent the region's urbanized space that

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3 could theoretically contain an establishment. While most U.S. studies of urban areas use combined
4 metropolitan statistical areas (CMSAs) from the Census Bureau, the L.A. region's counties of Los
5 Angeles, Orange, Riverside, San Bernardino, and Ventura include vast swaths of rural and uninhabited
6 land. To circumvent this problem, we use 30m resolution remotely-sensed imagery from the National
7 Land Cover Database (Homer et al., 2015) to identify cells in the 5-county area which have at least 10%
8 urbanized land cover.ⁱⁱⁱ Figure 1 shows the raw employment density of the 16,144 cells representing land
9 in the area that could in theory contain establishments.

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12 The first step in the nonparametric identification of employment centers, following McMillen (2001), is
13 to estimate a locally-weighted regression which uses nearby employment densities to create a surface of
14 predicted employment for each cell. Local maxima are identified as observations whose actual
15 employment is significantly higher (using a $p < 0.01$ standard) than that predicted by the locally-weighted
16 regression. A kernel is used to smooth the sample over a certain proportion of the observations:

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McMillen (2001) chooses to smooth employment using 50% of the observations in the urban area, while
Redfearn (2007) uses the nearest 1% of the observations. We take advantage of the gridded nature of our
observations to use a single concept of proximity: 120 nearest neighbors. This amounts to a smaller
neighborhood definition of about 0.7% of the sample and should result in local maxima that are more
regularly spaced – consistent with the notion of centers as “areas of higher density than areas nearby.”

On the inside of a 1km^2 grid, 120 nearest neighbors represents 5 cells in each direction and results in cells
within 6.08km being considered as neighbors. The median cell in this study area has neighbors spanning
7.28km, with the higher figure reflecting the impact of the urban grid's edges. In some extreme outlying
areas neighbor distances exceed 80km. Since each neighborhood may contain more than one local
maximum, the final selection of local maxima only includes cells whose employment density is higher
than all of its 120 nearest neighbors.

The second step is to identify the cells surrounding each local maximum which will form the boundaries
of each distinct employment center. We diverge slightly from Redfearn (2007) and adopt a spatial
weights matrix approach similar to McMillen (2003). Using the 120 nearest neighbor definition, we

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3 define an employment center as a contiguous region surrounding each local maximum where each
4 member (1-km² cell) has a higher employment density than its neighbors. A contiguity weights matrix is
5 then used to loop through all cells contiguous to each local maximum and add to the employment center
6 any cells with higher than the neighborhood's average employment. The process is repeated for cells
7 contiguous to those just identified until all possible cells within the local maximum's 120-neighbor
8 neighborhood are evaluated. Of the 16,144 cells encompassing the Los Angeles region, 445 (2.76%)
9 were part of an employment center in 1997 and 530 (3.29%) were part of an employment center in 2014
10 (Figure 2). A robustness test using 4km² and 0.25km² grid cells was also conducted and is detailed in
11 Appendix A. We also replicate the analysis using census tracts; however, substantial overdispersion in the
12 distribution of their sizes makes comparison difficult. Furthermore, we believe a grid cell approach
13 which treats all urban area equally is most consistent with McMillen and Smith's definition that centers
14 should reflect areas with significantly higher density than their surroundings.

25 Exploratory analysis

26
27 After identifying employment centers, we perform exploratory spatial and statistical methods to
28 understand employment concentration dynamics. While this paper identifies centers based on the
29 concentration of total employment, employment is subsequently analyzed across five separate industries.
30 We use a slightly broader version of Shearmur and Alvergne's (2002) definition of KIBS, covering
31 Professional, Scientific and Technical Services (NAICS 54), Information (NAICS 51), Finance and
32 Insurance (NAICS 52), and Educational Services (NAICS 61, excluding primary and secondary
33 education, 61111). Following Kolenda and Liu's (2012) analysis of intrametropolitan creative industries,
34 we employ a simple definition of creative class employment as Information (NAICS 51) and Arts,
35 Entertainment, and Recreation (NAICS 71). While this is a fairly crude definition of creative
36 employment, it reflects components of an innovative workforce and consumption-based employment,
37 both thought to be a component of vibrant cities. Retail (NAICS 44 and 45) is combined with
38 Accommodation and Food Services (NAICS 72) to capture employment in consumption and consumer-
39 facing industries. High-tech employment is defined by Cortright and Mayer (2001) as Computer and
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Electronic Product Manufacturing (NAICS 334), Software Publishing (NAICS 5112), Data Processing and Hosting (NAICS 518), and Computer Systems Design (NAICS 5415). Finally, industrial employment consists of Manufacturing (NAICS 31-33), Utilities (NAICS 22), and Mining, Quarrying, and Oil and Gas Extraction (NAICS 21). Net of overlap, these five categories cover 52.4% of the region's total employment in 1997 and 50.7% in 2014.

First, we will examine employment trends within versus outside of centers. Compositional change overall and in centers will be analyzed using location quotients following Leslie (2010), which compare a center's share of an industry type with that industry's share region-wide. Formally, the location quotient for sector i at location j is given by:

$$(1) LQ_i = \frac{E_{ij} / \sum_i E_i}{E / \sum E}$$

where E_{ij} is the employment in sector i at location j and E_i is the total employment in sector i region-wide.

Location quotients can be compared across individual centers, and between centers and noncenters.

Next, we will analyze boundary and compositional change treating employment centers as discrete entities. Centers are given names based on the US Census-designated place in which their local maximum lies, using local knowledge in cases where a place name repeats or is otherwise unclear. A persistence score is used to analyze the level to which a center's boundaries remain consistent or change over time. Adapting a measure of persistence from Pontius et al. (2004) commonly used in ecological land change analysis, persistence for center i is given by

$$(2) \text{persist}_i = \frac{\text{center}_{t-1} \cap \text{center}_t}{\text{center}_{t-1} \cup \text{center}_t}$$

where the numerator represents cells that are common to the center i in time t and time $t - 1$ and the denominator represents all cells in center i at either time.

We also explore some region-wide trends using cells as observations to improve causal inference. Using ANOVA, cells' membership in an employment center is compared to their proximity to the region's core, proximity to transportation infrastructure, distance to the Pacific Ocean, county, and propensity to specialize in any of the five employment categories.

Results

Overall employment concentration

Using 1km² cells, we identified 46 employment centers in 1997 and 53 employment centers in 2014, with fourteen new centers emerging (30%) against seven dropping out of the set (15%). This is fairly consistent with previous work such as Giuliano et al. (2007) who find 48 centers in the region in 2000. As Table 1a indicates, centers represent a fairly small proportion of total employment though this share grew from 17.4% in 1997 to 19.6% in 2014. However, growth in centers outpaced overall employment growth in this period 45.4% versus 29.3%.

Results appear somewhat sensitive to cell size, and a full discussion is provided in Appendix A.

Replication of the analysis using 4km² cells results in fewer, less dense centers which cover more land area and a larger portion of total employment, while 0.25km² cells result in fewer, denser centers covering less land area. 1km² cells appear most comparable to previous regression-based center identification studies, which have generally been tailored to ensure a fairly consistent number of centers in the region – approximately 40 to 50 (Agarwal et al., 2012). Since the use of 1km² grid cells maintains this consistency and is at approximately the 30th percentile of the size distribution of the region's tracts, the remaining analysis focuses on this resolution alone.

Overall industrial structure

Certain industries also exhibit a changing propensity to exist in centers versus non-centers (Table 2).

One-fourth of KIBS employment, which increases region-wide and in centers, is located in centers in both 1997 and 2014. While KIBS (business services) are more likely to exist in employment centers, their propensity for concentration decreases over the study period from a location quotient of 1.437 to 1.278.

This supports the contention that agglomeration economies such as face-to-face communication are decreasingly important for business services, consistent with theories of the scatteration of back-office components of business operations. However, they are still far more likely to exist in centers than non-centers. High-tech employment actually decreases across the region, but most of this is in the NAICS 334

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3 subcategory comprising tech manufacturing. High tech employment in centers and the high tech location
4 quotient in centers both increase; the latter rising from 0.973 to 1.311. While region-wide industrial
5 employment decreases substantially, the amount of industrial employment in centers stays nearly identical
6 and its location quotient increases from 0.896 to 1.017 – concentration is increasingly important for
7 industrial employment despite historic expectations of suburbanization.
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10 The portion of employment that exists in centers increases from 17.4% to 20.3% and retail's location
11 quotient increases slightly from 1.001 to 1.033. This suggests a slight increase in retail concentration
12 though it does not indicate whether this increase takes place in existing or new centers. Contrary to
13 expectations of creative employment's urban-centric nature, creative employment is less likely than
14 average to exist in centers, with a location quotient of 0.939 that decreases to 0.889 by 2014. While
15 creative employment increases substantially region-wide, the bulk of this growth does not appear to be in
16 centers. It may be that creative amenities, consumption spaces, and creative output are not best measured
17 by employment. Lower-rent areas with less concentrated employment, neighborhoods in transition, or
18 agglomeration shadows may be advantageous for businesses that characterize the creative class; however,
19 the use of 2-digit NAICS codes is admittedly coarse.
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35 Boundary change

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37 While comparing centers versus non-centers is informative, analyzing individual employment centers
38 based on their stability over time helps us to understand the changing forces of concentration and
39 dispersion. Figure 2 shows the location of centers across the region in 1997 and 2014. While the land
40 area of employment centers increased from 445km² to 530km², only 294km² was common to both
41 periods, yielding an overall persistence score of 0.4317 (Table 1). This finding illustrates how
42 employment centers emerged, died, grew, and contracted at a finer scale, contrasting with previous tract-
43 level studies such as Redfean (2009) which found high levels of stability over time. Table 1 demonstrates
44 that persistence scores vary by spatial scale as well, ranging from 0.288 using 0.25km² grid cells to
45 0.6154 using 4km² grid cells, while persistence using 1km² cells is fairly comparable to tract-level
46 persistence (0.5019). This also contrasts with Leslie's (2010) fine-scale, establishment-level findings,
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3 which concluded that point-derived employment centers in Phoenix, Arizona were largely stable from
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5 1995 to 2004 but does not use a persistence score.
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7
8 Table 3 shows persistence scores for all 60 individual employment centers. Five centers do not
9
10 experience any boundary change and have the maximum persistence score of 1. These include downtown
11
12 Los Angeles and downtown Glendale – two historically-embedded and stable core areas. Some smaller
13
14 centers also experience full persistence including Malibu, a 27-mile long corridor along the Pacific coast
15
16 to the northwest of Los Angeles. It is identified as a center mostly because its densest 5km² is denser than
17
18 the rest of Malibu. Blythe, a small town near the Arizona border, is similar in that its status as a center is
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20 largely due to its location far from other centers while its full persistence makes sense in the context of
21
22 the town's age and stability. Montclair also exhibits full persistence and is a three-city employment
23
24 center spanning the Los Angeles – San Bernardino county line, though its persistence is not readily
25
26 explained by its history or location.
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29 What may be more unexpected is the prevalence of low-persistence centers. The minimum persistence
30
31 score of zero is displayed by the fourteen new centers in 2014, as well as the seven centers that ceased to
32
33 exist – no area was in common to both years. Furthermore, 30 of the 60 centers at any time have a
34
35 persistence score at or below 0.5. Torrance, one of the region's larger centers, has the lowest (nonzero)
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37 persistence score, with only 2km² out of 28 remaining the same. Whereas in 1997 employment in
38
39 Torrance was concentrated farther east along a major arterial road, employment density has crept farther
40
41 east toward the junction of two freeways (I-405 and I-110). The Covina, Corona, San Fernando Valley,
42
43 and Burbank/LA employment centers show similar processes of directional shifting. In fact, San
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45 Fernando Valley and Burbank/LA are each two distinct centers since their extents in 1997 and 2014 are
46
47 not contiguous. In 1997, the 4km² center labeled Burbank/LA 1 represented the local employment
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49 density peak and consisted mainly of strip retail and other establishments. By 2014 the local peak in
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51 employment density was a strip along Interstate 5 stretching from Burbank's commercial airport to its
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53 historic downtown core.
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3 Two employment centers in Orange County provide a contrast between persisting and shifting
4 employment centers (Figure 3). The northern center extends from John Wayne Airport (SNA) to include
5 parts of Irvine, Santa Ana, Costa Mesa, and Tustin and is widely known as a business headquarter
6 location, housing firms such as Western Digital and Taco Bell. The 1997 and 2014 versions of this
7 employment center overlapped by 95% – a 1km² addition in Santa Ana was the only change for 2014.
8 The center further south surrounds the former El Toro Marine Air Corps Station and only has 2km² of
9 overlap between its 1997 and 2014 versions. In 1997 this employment center was characterized by a
10 variety of light industry and small businesses surrounding two major arterial roads. However, the
11 opening of the Irvine Spectrum Center shopping mall in the late nineties shifted the concentration of local
12 employment eastward to the junction of interstates 5 and 405. The local employment density maximum is
13 now the mall area rather than the commercial corridor. Dynamism in a center's boundaries can be
14 experienced by small, medium, and large centers alike.

15 Compositional change

16 While the previous section demonstrates fluctuating employment center boundaries, this section
17 investigates changes in the industrial composition of individual centers. The rightmost two columns of
18 Table 3 indicate for each center the industrial sector (KIBS, retail, creative, industrial, or high tech) with
19 the highest location quotient in order to gauge which of these key industries is most specialized there. For
20 most centers, retail displays the highest location quotient, indicating its prevalence in centers region-wide.
21 Twenty-three employment centers in 1997 (50%) and twenty-eight centers in 2014 (53%) can be
22 considered “retail-driven.” This label is fairly persistent as well – only five such centers become more
23 specialized in something else. These include the well-diversified Long Beach center whose industrial and
24 tech LQs increase substantially, the destination towns of Lake Arrowhead and Palm Springs who shift
25 toward creative employment, and a slight industrial uptick in Temecula. Poignantly, City of Industry
26 shifts from an industrially-dominated employment to retail. Seven of the fourteen “emerging” centers
27 were retail-dominated.

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3 The increasing tendency of industrial employment to concentrate is also reflected in center-level location
4 quotients. Three new employment centers (Chino, Rancho Cucamonga, and Santa Fe Springs) are
5
6 industrially-dominant, while Temecula's focus shifts from retail to industrial and Torrance's focus shifts
7
8 from high tech to industrial. Similar to the region-wide results presented earlier, KIBS tend to show a
9
10 decrease in prevalence in employment centers. Six centers are principally characterized by KIBS
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12 employment in 1997, though San Bernardino and Beverley Hills/West Hollywood see their focus switch
13
14 to creative by 2014. While some of this can be attributed to the overlap between the KIBS and creative
15
16 employment categories, only three centers display both an increase in KIBS location quotient and a value
17
18 above 1: Irvine/SNA Airport, Irvine-Lake Forest, and Torrance. Note that these results comment on a
19
20 center's location quotient across the five categories considered, not its total employment in any industry.
21
22 Creative class employment has the highest location quotient in three decidedly non-central employment
23
24 centers in 1997: Victorville, Banning, and Covina. In contrast, by 2014 six distinctive centers are
25
26 characterized principally by creative employment in 2014: Anaheim, the weekend retreats of Palm
27
28 Springs and Lake Arrowhead, Beverley Hills/West Hollywood, San Bernardino, and Burbank. Consistent
29
30 with the decline in high-tech manufacturing employment discussed earlier, the high-tech concentration
31
32 across the seven tech-dominant centers in 1997 appears to have dissipated: only Irvine/SNA and
33
34 Irvine/Lake Forest remain tech-dominant in 2014. Both the old and new San Fernando Valley centers are
35
36 tech-dominated, airport-adjacent El Segundo and Camarillo emerge as tech centers, and Long Beach
37
38 shifts from a retail to a tech focus.

39
40 Furthermore, these compositional changes at the center-level implicitly take boundary change into
41
42 account. For example, while Torrance's dominant employment category shifts from tech to industrial, its
43
44 footprint changed dramatically too (with persistence score of 0.07). The 1997 boundaries of the Torrance
45
46 center were characterized by retail, industrial, and high tech employment which declined. The area
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48 extending eastward from the 1997 center boundaries experienced similar industrial and tech declines but
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50 in contrast made up for them with substantial increases in KIBS and retail employment, meriting
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1 inclusion as part of the employment center in 2014. While still characterized by heavy industry, Torrance

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5 is an example of a center whose locus of employment shifts both spatially and compositionally.

6
7 Region-wide patterns

8
9 While analyzing individual employment centers provides rich detail about the evolving economic
10 geography of the region, using sixty observations which vary dramatically in size and importance is not
11 conducive to statistical inference. This section analyzes the 681 1km² grid cells that were part of an
12 employment center in either 1997 or 2014. Only 294 cells were part of a center in both years. A simple
13 ANOVA test is conducted to compare emerging, persisting, and dying cells based on their proximity to
14 the Los Angeles' downtown, freeways, passenger rail, airports, and the Pacific coast (Table 4a)ⁱⁱⁱ.

15
16 Proximity to downtown provides a crude measure gauging whether cells are located centrally or nearer
17 the urban fringe, while proximity to the Pacific Coast is a strong determinant of land price and indicates a
18 major regional amenity. Cells comprising emerging employment centers are about 20km closer to the
19 CBD than either persisting or dying cells – a significant difference. Emerging areas are also significantly
20 closer to freeways, airports, rail lines, and the Pacific coast. This collinearity is unsurprising since
21 airports, freeways, and rail lines tend to co-locate. There are no significant locational differences between
22 persisting areas and dying areas. Overall, these results suggest that new, growing places of employment
23 concentration are more discerning with their location choices and are significantly nearer to existing
24 infrastructure, region-wide amenities, and less toward the urban fringe.

25
26 County-level locational trends are also easily examined and help to parse between core and fringe areas
27 (Table 4b). While Los Angeles County is clearly the region's core, Orange County is considered to be
28 fairly well-established. While the cities of San Bernardino and Riverside are long-standing, the counties
29 which bear their names are archetypical urban fringe areas and are referred to as the "Inland Empire,"
30 while Ventura County is far smaller in population. A chi-squared test on the first three columns of Table
31 4b yields a significant value of 18.13, indicating that there is variation in the level of persistence by
32 county. While San Bernardino County has the lowest persistence at 0.37, Los Angeles County is not far
33 behind at 0.38. Orange and Riverside Counties are notable higher in terms of persistence with values of
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3 0.52 and 0.49. These results do not correspond to the general perceptions of counties as core or
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5 peripheral – flux appears to exist throughout the region.
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7 Table 4c contains the final analysis of cells by persistence, investigating whether cells that emerge,
8
9 persist, or die tend to specialize. Location quotients are calculated relative to total employment in the
10
11 sector rather than center-only employment. The substantially higher LQ for KIBS in persisting areas
12
13 again highlights this sector's relationship with stability. Trends in retail, creative, and industrial
14
15 employment mirror previous results: all are more specialized in emerging areas, though retail is more
16
17 weakly specialized in emerging areas and creative employment shows low specialization in any kind of
18
19 employment center. The high tech sector continues to demonstrate a strong propensity toward emerging
20
21 locales (LQ of 2.24) versus 0.78 for persisting and 1.61 for dying areas, indicating high churn.
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25 26 27 Discussion and conclusions

28
29 The purpose of this study was to examine changes in the composition and spatial distribution of
30
31 employment centers across the Los Angeles region based on 21st century changes in the urban economy.
32

33
34 The employment center identification method used is particularly reflective of local instances of high
35
36 density, while the use of point-based data to provide a more realistic view of individual businesses'
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38 location decisions as well as changes in the boundaries of centers. The use of a nonparametric
39
40 identification technique is adept at distinguishing local peaks in employment density, defined as areas
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42 within about 7km.
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44
45 First, the dominant feature of employment concentration over 1997-2014 is change rather than core-area
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47 stability, especially when investigated using a cell-based method that treats all urban space equally. Not
48
49 only do centers emerge and die region-wide, the boundaries of employment centers change substantially
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51 in core and fringe areas alike which contrasts markedly with prior longitudinal studies. The economic
52
53 landscape is not characterized by core areas gradually expanding and increasing in density. There are
54
55 clearly some persistent centers that remain vibrant such as downtown Los Angeles, Irvine/SNA, Glendale,
56
57 and Beverly Hills/West Hollywood. However most areas are more in-flux. Places like Irvine/Lake
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1 Forest, Torrance, and Burbank highlight the gradual spatial shifts that accompany the interplay between
4
5 economic shifts and the real estate cycle. In Irvine/Lake Forest a new shopping mall shifted the locus of
6
7 regional employment away from a more producer-oriented corridor, while in Torrance industrial increases
8
9 overshadowed nearby losses in tech concentration. In Burbank, employment concentration gravitated
10
11 toward the city's historic downtown. Future research could isolate the role of both policy and individual
12
13 real estate developments in some of these concentration shifts. We find some evidence that emerging
14
15 areas of employment concentration are closer to L.A.'s downtown, freeways, airports, rail lines, and the
16
17 Pacific coast when compared to persisting or dying areas of concentrated employment. Fixed
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19 infrastructure, centrality, and this regional amenity clearly play a role in where employment grows. Since
20
21 these are long-term, fixed components of the urban landscape, this result suggests strong path-dependence
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23 despite changes since 1997 – a reassurance for proponents of smart growth.
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27 In terms of industrial structure, KIBS employment remains an important component of stable
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29 employment centers, though overall KIBS are decreasingly found in concentrated areas, consistent with
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31 theories surrounding the role of IT or innovation surrounding KIBS dispersion. However, KIBS' strong
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33 association with persisting centers and persisting cells suggests somewhat of a resilience to locational
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35 economic changes, which could justify the policymakers' focus on attracting business services due to
36
37 their more lasting nature. High-tech employment is now most concentrated in centers and particularly in
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39 newly emerging parts of centers – this even though employment in tech manufacturing has been
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41 decreasing. This provides some evidence that growth in employment concentration is heavily related to
42
43 high-tech activity in new and established centers alike. However, high-tech employment exhibits more
44
45 locational dynamism, suggesting that while investments in science parks or technopoles could promote
46
47 increased job concentration, high-tech may not always be the best target for long-term, stable local
48
49 economic development. Industrial employment demonstrates an increasing propensity to agglomerate in
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51 centers despite its overall decline, which may speak to the resilience of the manufacturing employment
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53 that does remain: flexible or just-in-time production modes may benefit more from agglomeration, and in
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55 particular from proximity to fixed infrastructure. Alternatively, the most economically competitive (thus,
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2
3 remaining) industry could have location advantages by being in centers. Given the shuttering of much of
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5 the region's defense and aerospace manufacturing industries after the Cold War, this makes sense but
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7 might be specific to the Los Angeles area.
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10 Like high-tech, retail employment and retail location represent an increasing share of what drives regional
11
12 employment concentration. This is consistent with the idea of consumption-focused cities – more than
13
14 half of the region's new centers are more specialized in retail than anything else. This speaks to the
15
16 power of “emerging town centers” – which in the Irvine/Lake Forest example shown is in fact a large
17
18 shopping mall and its hinterland. Creative employment is fairly loosely defined in this study but is not
19
20 primarily found in centers and is in fact decreasingly concentrated in centers. The distinctiveness of some
21
22 of the region's creative-oriented centers (Disneyland is in the Anaheim center, while the Burbank and
23
24 Beverley Hills/West Hollywood centers house major movie studios) may be a reflection of the
25
26 idiosyncrasies of Southern California's creative employment base – i.e. television, film, and a globally-
27
28 known recreation destination – making any conclusions regarding creative employment regionally-
29
30 specific. At a minimum, it's clear that employment counts in creative industries are not the same thing as
31
32 the class of amenity-seeking “knowledge workers” described by Florida and can vary across regions.
33
34 Much of the thinking on creative employment and the amenitization favored by knowledge workers is
35
36 associated with downtown revitalization. While some loft conversions and arts districts have been noted
37
38 in Los Angeles' downtown, if anything distinctive about it stands out in this study it is its persistent
39
40 boundaries and persistent KIBS-orientation. It is the largest center by only a narrow margin, and the
41
42 region is known for housing cultural amenities elsewhere. Government employment, unexplored in this
43
44 study, is known to be high in downtown L.A. and could be an important consideration here and in other
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46 regions, especially if job creation policies are at all oriented toward the public sector.
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50 By following the simple logic that “centers are areas of employment density greater than their
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52 surroundings”, we find substantial changes hidden behind the overall increase in centers: of the 445km² of
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54 land in centers in 1997, only 294km² remains in a center by 2014. Previous tract-level research on the
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56 same region covering the 1980s and 1990s found far more employment center stability, but did not
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1
2
3 explicitly consider changing boundaries or persistence. While our robustness check suggests that the
4 resolution at which analysis is conducted matters, all grid cell sizes in this study – as well as census tracts
5 – exhibited substantial boundary change. Future studies should be careful to use geographies that treat all
6 urban space equally. An added benefit of this approach is that it avoids the pitfalls of using fairly few
7 individual employment centers as observations, which does not offer adequate statistical robustness.
8
9 Finally, this study suggests some caution against the contention that future growth will necessarily favor
10 existing concentrated areas. Employment concentration continually fluctuates and while growth in
11 employment centers outpaces growth overall, the vast majority of new jobs lie outside centers despite
12 increasing emphasis on smart growth policy and urban sustainability. Policymakers should be keenly
13 aware of leveraging local strengths and locational advantages, while also paying attention to what kind of
14 employment may be most lasting.
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Tables

Table 1: Employment in/out of subcenters

	1997	2014	Percent growth
Number of centers	46	53	15.2%
Size of centers (km ²)	445	530	19.1%
Center employment	1,092,461	1,588,345	45.4%
Total employment	6,261,171	8,095,136	29.3%
Percent in center	17.4%	19.6%	12.5%

Overall Persistence Score: 0.4317

Table 2: Sectoral employment by subcenter

	1997			2014		
	Employment	Center Employment	Center Percent	Employment	Center Employment	Center Percent
KIBS	1,054,885	264,454	25.1%	1,440,656	361,208	25.1%
Retail	1,323,133	230,986	17.5%	1,840,616	373,226	20.3%
Creative	285,030	46,718	16.4%	479,256	83,566	17.4%
Industrial	889,489	138,991	15.6%	687,580	137,252	20.0%
High Tech	178,821	30,374	17.0%	138,576	35,637	25.7%
TOTAL	6,261,171	1,092,461	17.4%	8,095,136	1,588,345	19.6%
	Percent of Employment in Centers	Percent of Total Employment	Location Quotient	Percent of Employment in Centers	Percent of Total Employment	Location Quotient
KIBS	24.2%	16.8%	1.437	22.7%	17.8%	1.278
Retail	21.1%	21.1%	1.001	23.5%	22.7%	1.033
Creative	4.3%	4.6%	0.939	5.3%	5.9%	0.889
Industrial	12.7%	14.2%	0.896	8.6%	8.5%	1.017
High Tech	2.8%	2.9%	0.973	2.2%	1.7%	1.311

Table 3: Employment centers, sorted by total employment

Name	1997 Employment	2014 Employment	1997 km ²	2014 km ²	Total km ²	Persistence Score	Status	1997 - Highest LQ	2014 - Highest LQ
Downtown LA	163,118	161,850	8	8	8	1	Persists	KIBS	KIBS
Beverly Hills/W. Hollywood	113,030	158,930	13	15	16	0.75	Persists	KIBS	Creative
Irvine/SNA Airport	126,321	139,972	21	22	22	0.955	Persists	High Tech	High Tech
Glendale	51,647	86,457	11	11	11	1	Persists	Retail	KIBS
Pasadena	58,916	83,518	12	11	12	0.917	Persists	KIBS	KIBS
El Segundo	Non-center	69,540	0	14	14	0	Emerges		High Tech
Irvine/Lake Forest	27,840	65,638	11	12	21	0.095	Persists	High Tech	High Tech
Torrance	51,760	53,841	13	17	28	0.071	Persists	High Tech	Industrial
San Fernando Valley 2	Non-center	52,690	0	16	16	0	Emerges		High Tech
Santa Fe Springs	Non-center	41,334	0	13	13	0	Emerges		Industrial
Riverside	35,226	36,676	16	15	16	0.938	Persists	KIBS	KIBS
Temecula	19,731	36,539	13	14	15	0.8	Persists	Retail	Industrial
Corona	16,606	36,166	13	13	20	0.3	Persists	Industrial	Industrial
Doney	Non-center	35,782	0	11	11	0	Emerges		Retail
Anaheim	20,587	34,506	8	7	10	0.5	Persists	High Tech	Creative
Long Beach	23,326	33,614	10	12	13	0.692	Persists	Retail	High Tech
Burbank/LA 2	Non-center	29,603	0	9	9	0	Emerges		Creative
Montclair	24,862	28,731	13	13	13	1	Persists	Retail	Retail
City of Industry	17,492	27,989	8	7	8	0.875	Persists	Industrial	Retail
Rancho Cucamonga	Non-center	26,680	0	11	11	0	Emerges		Industrial
Ventura	11,193	25,312	6	10	10	0.6	Persists	Retail	Retail
Chino	Non-center	22,745	0	12	12	0	Emerges		Industrial
Riverside SW	Non-center	20,601	0	7	7	0	Emerges		Retail
Lancaster	15,780	20,070	13	14	15	0.8	Persists	Retail	Retail
Palm Springs	13,589	19,936	11	14	17	0.471	Persists	Retail	Creative
Palm Desert	20,149	19,852	11	9	12	0.667	Persists	Retail	Retail
Thousand Oaks	12,225	19,205	11	10	13	0.615	Persists	Retail	Retail
Simi Valley	14,846	18,699	11	10	13	0.615	Persists	High Tech	Retail
Camarillo	Non-center	17,510	0	10	10	0	Emerges		High Tech
Covina	6,641	17,231	4	8	11	0.091	Persists	Creative	Retail
Santa Clarita	10,074	15,086	7	6	7	0.857	Persists	Retail	Retail
Hemet	13,831	14,833	16	16	17	0.882	Persists	Retail	Retail
Moreno Valley	Non-center	13,928	0	14	14	0	Emerges		Retail
Victorville	14,151	13,605	11	12	15	0.533	Persists	Creative	Retail
Palmdale	4,256	11,773	6	10	10	0.6	Persists	Retail	Retail
Dana Point	6,289	9,101	7	7	9	0.556	Persists	Retail	Retail
Menifee	Non-center	6,712	0	11	11	0	Emerges		Retail
Barstow	4,838	6,149	8	9	9	0.889	Persists	Retail	Retail
San Bernardino	25,631	6,060	11	3	14	0	Persists	KIBS	Creative
Lake Elsinore	3,191	5,825	9	11	13	0.538	Persists	Retail	Retail
Big Bear Lake	3,356	5,797	12	11	14	0.643	Persists	Retail	Retail
Yucaipa	Non-center	4,778	0	8	8	0	Emerges		Retail
Santa Paula	5,805	4,719	9	8	11	0.545	Persists	Industrial	Industrial
Banning	2,182	4,685	8	6	9	0.556	Persists	Creative	Retail
Ojai	3,551	4,278	8	7	8	0.875	Persists	Retail	Retail

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45	Malibu	3,133	4,150	5	5	5	1	Persists	KIBS	KIBS
46	Blythe	3,760	3,586	8	8	8	1	Persists	Retail	Retail
47	Fillmore	2,139	2,732	6	7	7	0.857	Persists	Retail	Retail
48	Adelanto	1,380	2,640	6	3	6	0.5	Persists	Industrial	Industrial
49	Lake Elsinore SE	Non-center	1,808	0	3	3	0	Emerges		Retail
50	Lake Arrow head	1,284	1,758	3	4	5	0.4	Persists	Retail	Creative
51	Yucca Valley	1,906	1,725	4	4	5	0.6	Persists	Retail	Retail
52	Pinon Hills	Non-center	1,400	0	2	2	0	Emerges		Retail
52	San Fernando Valley 1	57,946	Non-center	9	0	9	0	Dies	High Tech	
53	Oxnard	26,885	Non-center	18	0	18	0	Dies	Retail	
54	South El Monte	23,706	Non-center	12	0	12	0	Dies	Industrial	
55	Haw thorne	11,325	Non-center	5	0	5	0	Dies	High Tech	
56	Burbank/LA 1	10,097	Non-center	4	0	4	0	Dies	Industrial	
57	Perris	4,768	Non-center	9	0	9	0	Dies	Industrial	
57	Needles	2,092	Non-center	7	0	7	0	Dies	Retail	

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Table 4: Analysis by Individual Cells (n = 681)

a. ANOVA by Location					
	Mean - dying cells	Mean - emerging cells	Mean - persisting cells	ANOVA p-val	Significant Pairs
km to L.A. CBD	80.54	60.94	80.97	0.0001	emerges-dies,persists-emerges
km to Freeway	2.90	1.94	4.34	0.0001	persists-emerges
km to Airport	24.50	11.59	26.64	0.0001	emerges-dies,persists-emerges
km to Coast	51.05	39.22	53.90	0.0025	persists-emerges
km to Rail	40.63	25.53	36.96	0.0000	emerges-dies,persists-emerges
b. Persistence Scores by County					
County	Dying	Emerging	Persisting	Total Cells	Persistence Score*
Orange	14	15	31	60	0.52
Riverside	30	57	84	171	0.49
Ventura	28	21	41	90	0.46
Los Angeles	50	97	92	239	0.38
San Bernardino	29	46	44	119	0.37
*Chi-square value of 18.13 with 8 degrees of freedom is significant at p=0.0203					
c. Location Quotients by Persistence					
	KIBS	Retail	Creative	Industrial	High Tech
Dying cells (n=151)	1.01	1.00	0.62	1.12	1.61
Emerging cells (n=236)	0.91	1.10	1.01	1.43	2.24
Persisting cells (n=294)	1.49	1.00	0.82	0.78	0.78

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ⁱ While studies such as Redfearn (2007) use census-defined Urban Areas (UAs) to exclude uninhabited land, we found numerous instances of clearly urban business establishments outside UA boundaries. Since the definition of UAs relies on residential census block population, certain establishments were missed. This was most prevalent in coastal and inland recreational areas such as Malibu and Lake Matthews.

ⁱⁱ NLCD land cover categories 21, 22, 23, and 24 as of 2011 were considered urban in this analysis. See Homer et al. (2015).

ⁱⁱⁱ Los Angeles city hall is used to define the region's CBD and is at 34C03'11"N, 118C14'27"W. Passenger rail consists of Los Angeles Metro and Metrolink commuter rail stations.

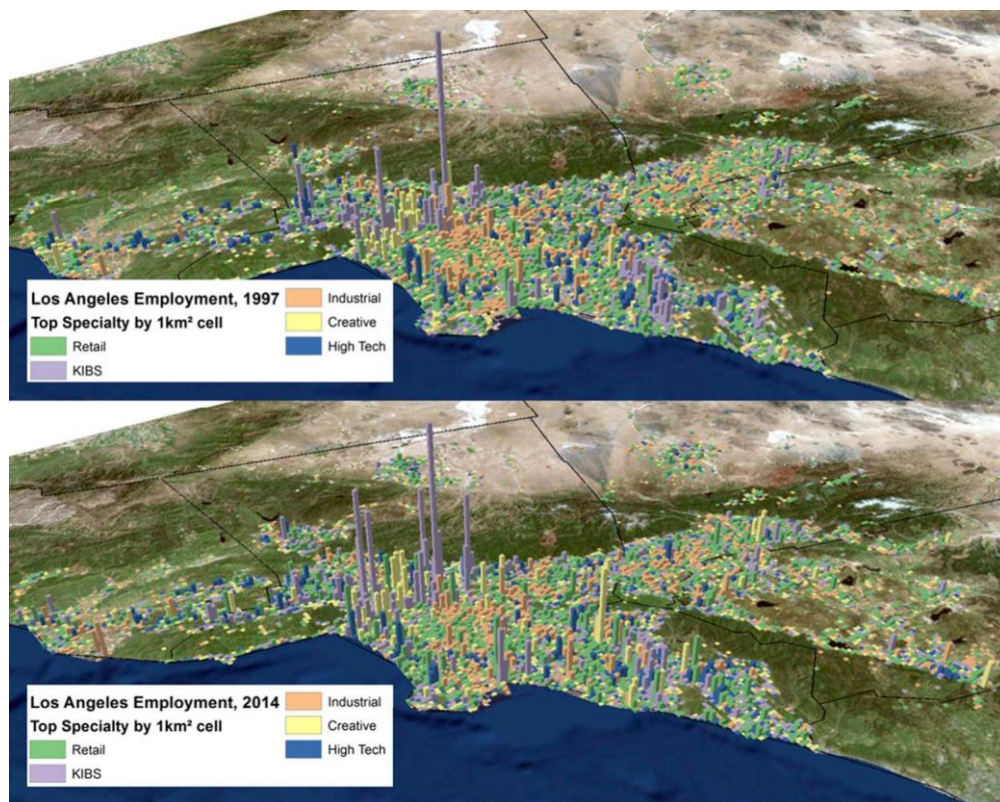


Figure 1: Los Angeles Region Employment Density, 1997-2014

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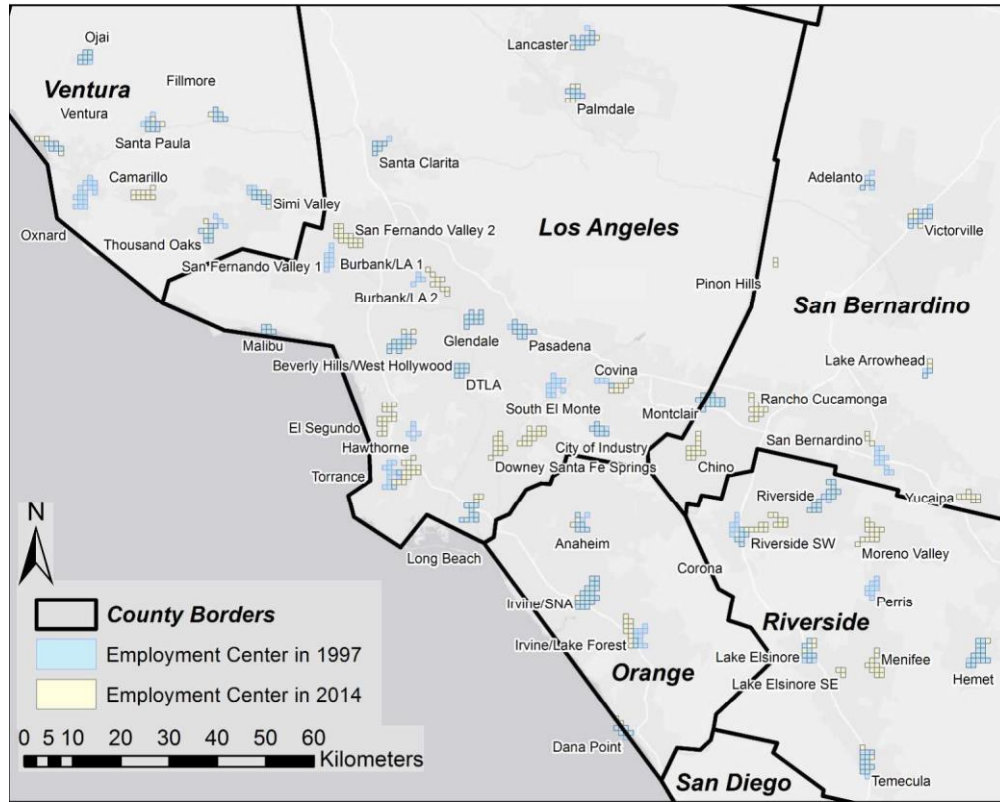


Figure 2: Los Angeles region employment centers, 1997-2014

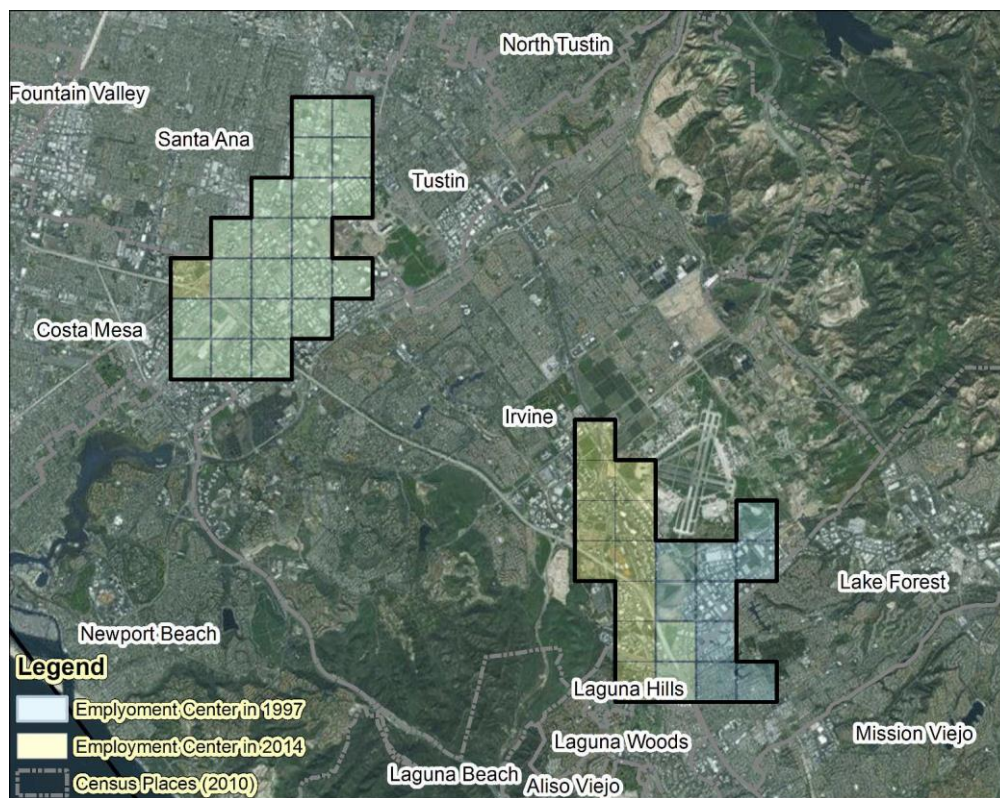


Figure 3: Contrasting employment center boundary changes in Orange County

Appendix A: Employment Center Sensitivity to Spatial Scale

In order to provide a measure of robustness and justify the selection of 1km² grid cells for this analysis, we replicated the analysis using 4km² cells, 0.25km² cells, and census tracts. First, in order to maintain a roughly consistent concept of proximity analogous to the 6-7km threshold used for 1km² cells, it was necessary to modify the 120 nearest neighbor criterion. Using 36 nearest neighbors for 4 km² cells and 484 nearest neighbors for 0.25km² cells roughly mirrors the range used for identification of local maxima and center boundaries.

We also replicated the analysis using census tracts; however, substantial overdispersion in the distribution of census tract sizes ($\mu = 14.5\text{km}^2$, $\sigma = 174\text{km}^2$) makes generating a consistent proximity concept impossible. Additionally, the NLCD-based urban area identification procedure is incompatible with tracts since many tracts with businesses also contain large natural areas and would have urban land coverages below 10%. We follow through with the analysis but instead use tracts within the 5 county area's US Census urbanized area boundaries. Results for all resolutions and tracts can be found in Table A1.

Results appear somewhat sensitive to cell size. Replication of the analysis using 4km² cells results in fewer centers which cover more land area and a larger portion of total employment, while 0.25km² cells result in fewer centers covering far less land area. At this fine resolution the number of centers actually decreases between 1997 and 2014; however total employment in centers rises, suggesting that smaller grid cells detect a much denser form of employment concentration. Thus, it's clear that each cell size represents a distinctly different concept of "employment concentration." This is a component of employment centers that could not be realized in previous tract-level studies.

employment concentration; for example, a suburban corporate campus is likely larger than this but could record all its employees at a single point. Furthermore, an identified local maximum could be a single office building with high employment. A somewhat smaller office building across a wide arterial road might not even be in a contiguous cell at this resolution, opening up the possibility of missing key auxiliary portions of employment centers.

Table A1: Employment in/out of subcenters

a. 1km ² grid cells			
	1997	2014	Percent growth
Number of centers	46	53	15.2%
Size of centers (km ²)	445	530	19.1%
Center employment	1,092,461	1,588,345	45.4%
Total employment	6,261,171	8,095,136	29.3%
Percent in center	17.4%	19.6%	12.5%
Overall Persistence Score: 0.4317			
b. 4km ² grid cells			
	1997	2014	Percent growth
Number of centers	31	33	6.5%
Size of centers (km ²)	924	1,008	9.1%
Center employment	1,870,206	2,484,263	32.8%
Percent in center	29.9%	30.7%	2.7%
Overall Persistence Score: 0.6154			
c. 0.25km ² grid cells			
	1997	2014	Percent growth
Number of centers	46	39	-15.2%
Size of centers (km ²)	111	107	-3.6%
Center employment	336,637	450,347	33.8%
Percent in center	5.4%	5.6%	3.5%
Overall Persistence Score: 0.2880			
d. 2010 Census tract boundaries			
	1997	2014	Percent growth
Number of centers	54	64	18.5%
Size of centers (km ²)	1961	2799	42.7%
Center employment	2,405,380	3,465,000	44.1%
Percent in center	38.4%	42.8%	11.4%
Overall Persistence Score: 0.5019			

Since the region's street grid is comprised mainly of arterial roads spaced at half-mile increments (which

Tract boundaries induce other problems because their sizes and shapes are inconsistent. Their far lower employment density, shown in Table A1, reflects the non-urbanized areas contained within tract boundaries. However, while tract-level centers include a higher percent of regional employment than 1km² centers, it is worth noting that both the growth in center employment and the growth in center percent of employment are nearly identical.

would divide the urban space into 0.65km^2 units), 0.25km^2 resolution appears too small to capture

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employment concentration; for example, a suburban corporate campus is likely larger than this but could record all its employees at a single point. Furthermore, an identified local maximum could be a single office building with high employment. A somewhat smaller office building across a wide arterial road might not even be in a contiguous cell at this resolution, opening up the possibility of missing key auxiliary portions of employment centers.

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3 Figure A1 and Table A2 show the Ventura employment center, which illustrates the region-wide patterns
4 found in Table A1, i.e. the existence of fewer, smaller, denser centers at finer resolution and the existence
5 of fewer, larger, less dense centers at coarse resolution. Only the highest-density “core” of the center
6 appears at 0.25km² scale. At 1km², the region identified as a center has a footprint four times as large,
7 while at 4km² a large portion of land to the south meets the criteria for having a “higher density of jobs”
8 than its surroundings and is therefore included as part of the center. At this resolution, the center is six
9 times larger. Since the 36km² area to the south is more suburban in nature than the core of downtown
10 Ventura, it is likely to consist of a different industry mix than the subcenter as conceived at 0.25km² or 1
11 km² resolutions.
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25 FIGURE A1: VENTURA EMPLOYMENT CENTER (2014)
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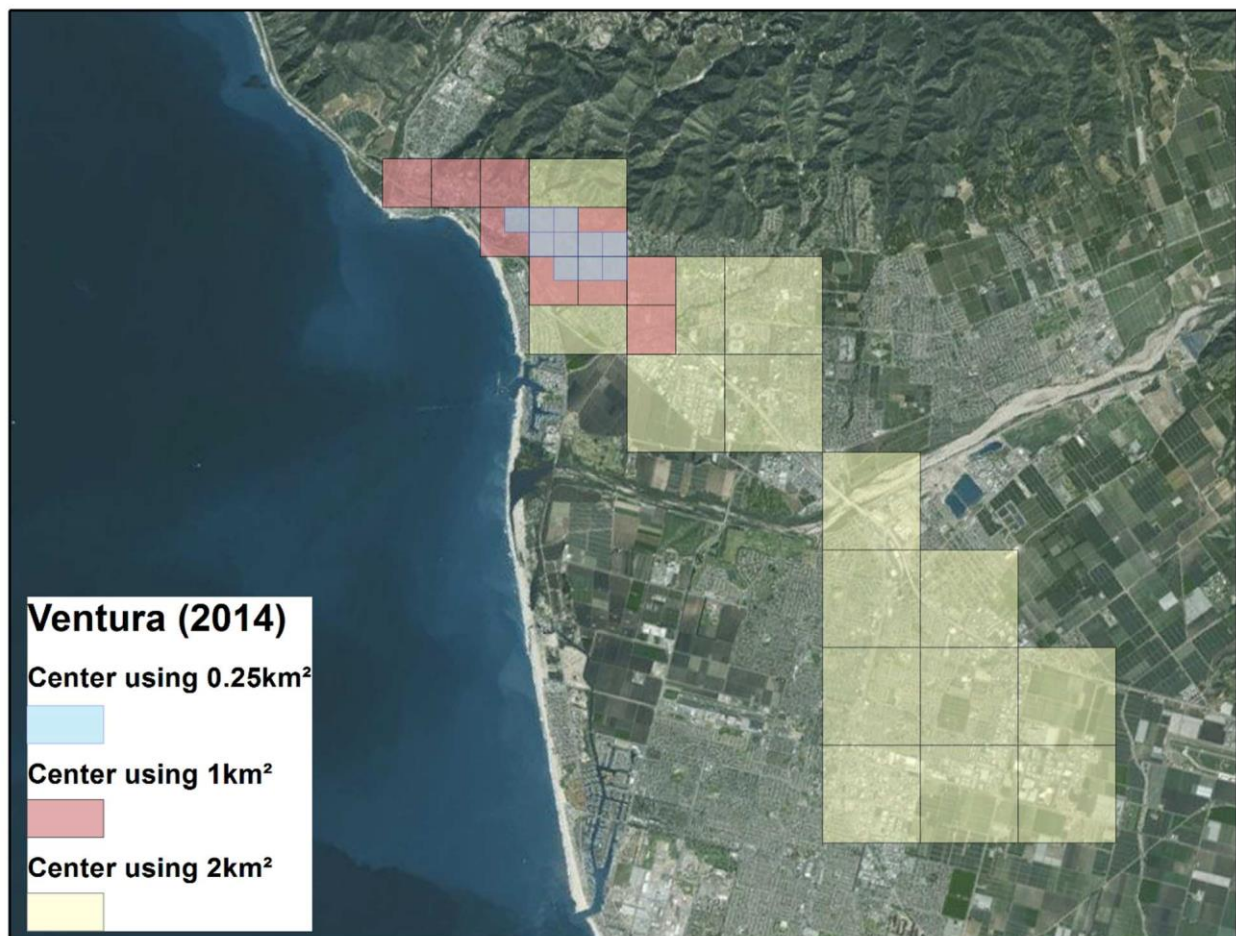


Table A2: Ventura Employment Center (2014)

	0.25km ²	1km ²	4km ²
Number of cells	10	10	15
Total land area (km ²)	2.5	10	60
Center employment	9,308	25,312	98,875
Ctr. emp. dens. (jobs/km ²)	3,723	2,531	1,648

Anas, Arnott, and Small (1998) remark that subcenter boundaries are quite sensitive to definition, saying “the urban landscape is highly irregular when viewed at a fine scale... It may be that the patterns that occur at different distance scales are influenced by different types of agglomeration economies, each based on interaction mechanisms with particular requirements for spatial proximity.” (p. 1440). In the context of the present study, this suggests that KIBS, industrial, tech, or other individual sectors may have a propensity to agglomerate that exists most acutely at a particular scale. The present study identifies subcenters based on total employment, not on sector employment and comments more directly on urbanization economies of scale rather than localization economies of scale. A future study which identifies KIBS centers, tech centers, and industrial sectors based on employment in the sector alone and irrespective of other employment may be better at finding the scales of the different types of agglomeration economies proposed by Anas, Arnott, and Small.

Nonetheless, Table A3 attempts a crude measure of distinguishing the scale at which sector-specific agglomeration economies might operate. For each scale, the sectoral employment that is in subcenters is displayed, as well as the share of total subcenter employment each sector represents. Shares appear mostly robust across scales. An exception is creative employment, which represents a higher share of center employment at a coarser resolution. However, the idiosyncratic nature of creative employment in Los Angeles, driven by the television and film industries as well as regional-level attractions like Disneyland, might limit the applicability of this result to other regions.

Table A3: Sectoral Center Employment and Share by Scale (2014)

	0.25km ²		1km ²		4km ²	
	Emp. in Centers	% of Emp. in Centers	Emp. in Centers	% of Emp. in Centers	Emp. in Centers	% of Emp. in Centers
KIBS	108,236	24.03%	361,208	22.74%	526,297	21.19%
Retail	108,257	24.04%	373,226	23.50%	525,831	21.17%
Creative	15,755	3.50%	83,566	5.26%	183,757	7.40%
Industrial	34,769	7.72%	137,252	8.64%	222,390	8.95%
High Tech	6,100	1.35%	35,637	2.24%	44,358	1.79%
TOTAL	450,347		1,588,345		2,484,263	

In summary, 1km² cells appear most comparable to previous regression-based center identification studies. Studies of Southern California have generally been tailored to ensure a fairly consistent number of centers in the region – approximately 40 to 50 (Agarwal, Giuliano, and Redfearn 2012). Since the use of 1km² grid cells maintains this consistency, and is at approximately the 30th percentile of the size distribution of the region's tracts, the remaining analysis focuses on this resolution alone. A Monte Carlo approach using a simulated spatial distribution of employment might be the most appropriate method for future research to analyze the scale at which employment concentration occurs.