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Mapping the landscape of urban work: Home-based businesses and the built environment

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Abstract

Home-based businesses represent a large and growing portion of the economy, though little is known beyond limited surveys. This paper describes a novel method of identifying businesses located within residences using parcel-level land use data across 15 counties in California and analyzes their evolution from 1997 to 2014, focusing on their distribution across neighborhoods. Home-based business represented nearly one in six businesses in 2014, and employment in home-based businesses outpaced overall employment growth 37 to 24% from 1997 to 2014. While home-based businesses are associated with both middle-income and wealthy neighborhoods, only in southern California were they associated with growing shares of single-family housing, low population density, and homeownership rates. While prior research emphasizes the importance of technologically and knowledge-intensive services across a variety of home working arrangements, this study reveals that the industrial composition of home-based businesses is roughly equally comprised of knowledge-intensive services and basic economic activity.

Keywords

Home-based businesses, urban spatial structure, built environment, knowledge-intensive services, parcel-level data, GIS

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Introduction

Historically, urban regions have changed as evolutions in urban transportation allowed work and residence to become decoupled. Work and residence were once relatively closely linked, even as recently as the turn of the 19th/20th centuries when the garment industry for example relied on a close connection of the many "work at home" piece work operators who fabricated pieces or whole garments in close proximity to, or even in, their residences. The following 100 years completely unhinged that relationship and work and residence were separated into a work-centered central city and a surrounding ring of suburban residential dwellings. This trend became especially prominent during the half-century from the end of the Second World War until the Global Financial Crisis (GFC) as US metropolitan areas decentralized both in population and employment (Anas et al., 1998; Mieszkowski and Mills, 1993). As Levy (2000) showed, rising per capita income, the continuing shift from a small town to metropolitan society and the dominance of the automobile all worked to change the urban structure from a largely renter-based central city to one characterized by extensive suburbanization, a decline of central business districts (CBD) and the emergence of employment concentrations outside the CBD. Contributing to this decentralization were industrial shifts as the workforce changed its focus from the manufacturing to the services sector. More recently, additional economic and workplace changes have led to an increase in non-standard employment including telecommuting and home-based businesses (HBBs) which are causing workplace linkages to change yet again (Ahn et al., 2012; Giuliano, 1998; Schmid, 2010).

It is the question about these changes in the urban fabric which stimulated this paper and in particular how the emergent but growing role of homework and working from home in the modern city are related to urban spatial structure. Urban planners have viewed trends and policy initiatives such as smart growth and transit-oriented development as means to address urban transportation and environmental problems (Cervero and Duncan, 2006; Handy, 2005; Knaap and Talen, 2005; Levine, 2005; Talen, 2011). However, these solutions do not directly address changes in the nature of urban work. In our view, both technological and social components of the "new urban economy" contribute to the rise of HBBs and their role in shaping urban spatial structure. On the one hand, much of the literature on HBBs and telecommuting focuses on the tech and knowledge-based orientation of work that connectivity improvements have facilitated. This contrasts with the perspective of industrial restructuring which underpins a rise in non-standard work (NSW) arrangements, such as more routine service work, which is often seen as a driver of economic inequality as individuals are driven to NSW out of necessity rather than entrepreneurial opportunity.

This paper argues that social and technological advance will have spatial outcomes on the organization of urban work. Where once workers travelled to specific sites to engage in work, that connection is now more attenuated and work can occur in different forms and different urban contexts. The empirical focus is on HBBs, which are defined here as business establishments principally registered at a residential dwelling unit. Unlike a company, a business establishment is an individual location at which business takes place and is an officially registered entity engaging in private, public, government, or non-profit activity (Walls, 2007). HBBs are a subset of a larger universe of work activity that takes place in the home, which includes telecommuting, working from home, and unofficial self-employment. A small body of empirical work has emerged on HBBs (Jain and Courvisanos, 2013; Mason et al., 2011; Reuschke and Houston, 2016), most of it survey-oriented and focused on the UK and commonwealth countries. Mason et al. (2011) refer to HBBs as "invisible businesses" suggesting their economic significance may be overlooked especially outside of core

regions. We expand upon this literature by developing a new method of identifying HBBs that relies on GIS and urban "big data" and by analyzing the neighborhood socioeconomic and built environments surrounding HBBs. We also add the United States HBB context which has to date been little explored despite being the world's largest economy and featuring a distinctively free-market orientation toward regional development policy.

This paper's first goal is to analyze *what* type of economic activity is home-based, with a focus on the distinction between information and computing technology (ICT) and high-skill opportunities which likely benefit wealthier individuals and neighborhoods versus routine or basic activities. The second goal is to analyze *where* HBBs are principally found across California neighborhoods based largely on neighborhood characteristics including wealth and socioeconomic indicators, the level of density and suburbanization, and the growth of employment overall.

This study analyzes the growth of HBBs from 1997 to 2014 across the northern and southern California metropolitan regions of San Francisco and Los Angeles, an area which covers 15 counties and houses roughly 9% of the United States population (28.1m). Because of the size of counties across the American West, the study area covers 118,000 km^2 including dense urban cores, suburban areas, and vast quantities of rural land, the latter of which is mostly found in Riverside and San Bernardino Counties. This study's high-resolution, GIS approach takes advantage of the evolving city data landscape (Arribas-Bel, 2014) in order to facilitate a novel and comprehensive view of HBBs—using a commercially provided point-level dataset of business establishments and comprehensive parcel-level land use data from municipal planning agencies to identify businesses actually located within residential land parcels. In contrast, previous research was limited to metropolitan-level statistics, small samples of census microdata, or narrowly tailored firm-based surveys which can rely on self-reporting.

This paper then uses six-digit North American Industry Classification System (NAICS) codes are used to examine which types of establishments make up the landscape of HBBs, distinguishing by economic sector with a focus on understanding differences between knowledge- or technology-intensive services and other forms of employment. Third, we examine employment in HBBs by neighborhood income levels to evaluate the hypothesis that HBBs are largely the purview of wealthier areas. Finally, we use census tract-level spatial regressions to relate HBB growth to a neighborhood's socioeconomic and built environment characteristics with a particular focus on the role of suburbanization and the urban density gradient.

Literature and background

NSW, social and technological change, and urban form

Recent aggregate-level statistics have demonstrated a substantial rise in the proportion of individuals who work from home at least some of the time (Clark, 2015; Mateyka et al., 2012). At a regional level, this increase has been aired as a potential explanation for the relative stability of commute times despite population increases, as a self-correction mechanism so to speak, whereby working from home is one possible response to urban congestion and long commutes (Anas, 2015). At the neighborhood level, non-residential activity increasingly occurs in residential areas, with myriad implications for land use mixing, changing urban densities, or potentially for crime and conflict between users.

Part of this change is technological—the contribution of ICT has accelerated the shift to a services-oriented economy, allowed for innovations like just-in-time production,

and internet accessibility has provided robust business infrastructure in the home. But the changing relationship between home and work location is also heavily social and is the result of global organizational changes in the nature of work including off-shoring and limited-term contracting that have given rise to non-standard employment, including an overall decline in stable, permanent employment with a firm that at least tends to be based outside the home. Salomon (1998) frames telecommuting in this manner, saying "Telecommuting is an application of a technology which modifies social institutions, namely work and home" (19), emphasizing that a narrow view of telecommuting as technological progress tends to overestimate its rate of adoption and its impact on urban form. In her exploration of the connection between ICT and urban form, Audirac (2002) draws a similar distinction between the neoclassical, deconcentration school of thought that saw technological progress as freeing society from place and distance constraints and the restructuring perspective in which political regimes and place entrepreneurs leverage technology to shape the conditions of economic growth.

While technological changes have certainly influenced the opportunity structure for working at and from home, work in general has experienced major structural changes including the move from manufacturing to service activity, a nearly equal split between men and women in the workforce, and now part-time workers make up nearly a quarter of the workforce (Bureau of Labor Statistics, Current Population Survey, 2015). Working at home and HBBs can facilitate the rise of part-time work, temporary work and casual employment, as well as agency-based or consulting work involving the out contracting of work rather than in-house employment. The term NSW has been used to describe any of these less formalized employment relationships (Presser and Ward, 2011).

While households with NSW arrangements are overrepresented at the lower end of the household income distribution, workers might choose this type of employment to achieve a better work–family life balance, higher life satisfaction or, in the case of self-employment, a greater sense of control. Telecommuting and HBBs are two key components of NSW that have been identified in the literature—both allow for worker flexibility but also may be a response to decreases in long-term, stable employment; at once a result of social and technological trends. In their survey-based research, Williams and Williams (2011) contest a common distinction within entrepreneurship research: that business formation is either motivated by necessity or by opportunity. This may be similar to the case of NSW—and home-based employment—whereby it may represent an opportunity for some but a challenge for others in the face of declining traditional opportunities. Giuliano's (1998) similar yet older research on "contingent workers," which are defined similarly to non-standard workers, found that the rise of this arrangement during the 1980s took place in both high- and low-wage contexts, suggesting benefits for some but constraints for others. Self-employed contingent workers reported shorter commute times than full-time contingent workers across the Los Angeles region. She argues that the ICT advances surrounding work organization are enabling, but not a sufficient condition for the spatial restructuring of work.

Many urban scholars have proposed that the spatial restructuring surrounding home working could increase urban sprawl since there is less need for workers to commute to a centralized location, either a downtown or other center (Castells, 1989; Gordon and Richardson, 1997; Mitchell, 1999; Nilles, 1991). A more general view is that of a diversification of households' residential location choices which could lead to suburbanization for those desiring peri-urban living or increased density should home-based workers prefer the cultural amenities afforded by denser central cities (Levine, 1998). Ellen and Hempstead (2002) posit that white-collar or knowledge-oriented professional workers may be in the

latter camp. Moos and Skaburskis (2007) use Canadian data to illustrate a distinction between decentralization of home-based workers in clerical or administrative support roles while there is a preference for centralization by home-based workers in professional or managerial occupations.

The extensive literature on the impact of ICT on urban form suggests that lowering the cost of information flows reduces the importance of physical distance. Office-based service work that does not involve a physical production process, or occupations which rely heavily on telephone and computer-based interactions appear most suitable for moving away first from central cities and subsequently into home locations interaction (Gaspar and Glaeser, 1998; Sassen, 1991). Ellen and Hempstead (2002)'s telecommuting analysis shows a disproportionate representation of management, professional services, and sales, while Moos and Skaburskis (2007) show that the top four occupations for telecommuting include business services and finance, insurance, and real estate (FIRE), but the categories of "other services" and "health and social services" round out the top four. An older study by Masuo et al. (1992) on home-based work finds it to be more prevalent in sales, marketing, contracting, and transportation activities than other white-collar work.

Understanding HBBs

The goals of this research are first to analyze *what* economic activity takes place in the home and second to investigate *where* HBBs are found across income levels and across neighborhoods. HBBs, as a subset of NSW, are labeled by Mason et al. (2011) as "invisible businesses" since their economic significance may be overlooked; however, such a term could also apply to the difficulty in defining and counting them. Sayers (2014) notes that a challenge in analyzing employment in HBBs is that their owners "tend to multitask," engaging in other economic activity inside or outside of the home. She also notes that the principal feature of HBBs is simply that it takes place in the home—which serves as this study's definition as well, while the notion of multitasking suggests that official employment-based data may not be an accurate representation of economic activity in the home since HBB owners could work elsewhere too. In addition, it is likely that some HBB activity goes unregistered or unlicensed, increasing the difficulty in counting it through official sources.

HBB research diverges somewhat when considering the type of industry involved. Reuschke and Houston (2016) find that nearly all small businesses that start in the home or move *to* the home are knowledge-intensive in nature, emphasizing the importance of a broadband internet connection and that creative or knowledge-intensive industries are less likely to need actual commercial premises than service-based occupations. Mason et al. (2011)'s UK-wide survey dating from 2006 ($n = 5675$ HBBs) finds that the highest count of HBBs is in business services (17.4% of the total), followed by construction and building-related activities (16.5%), computer and related activities (10.0%), and retailing (7.0%). Thus, a sizeable proportion is in industries that are not knowledge-intensive. Jain and Courvisanos (2013) conduct a smaller survey in the city of Casey, Australia ($n = 140$ HBBs) which reveals a similar distribution across industries, with 22% of HBBs in building and maintenance, 11% in IT services, 11% in consultancy services, and 11% in massage and other health services. Existing research has used survey data to analyze the metropolitan and neighborhood context of HBBs. Mason, Carter, and Tagg (2011) and Jain and Courvisanos (2013) emphasize the role of HBBs in increasing economic development potential in rural or peripheral regions. Mason, Carter, and Tagg (2011) find disproportionate HBB representation in rural areas, while also noting that detached homes in the suburbs are more suitable for HBBs—in part since multifamily rental housing may contain lease provisions

prohibiting in-home commercial activity. Reuschke and Houston (2016)'s UK-based survey finds that a strong majority (63–67%) of HBB owners live in detached or semi-detached homes. Their survey also finds that HBBs are overwhelmingly found in wealthier neighborhoods. Folmer and Risselada (2013) make important points about local land use regulation and its role: a strict separation of home and work locations could hinder the adaptation of the built environment to the changing needs of entrepreneurs in the regional economy. Folmer (2016) suggests that small business formation in cultural-cognitive industries in residential areas may be more likely in wealthy or gentrified areas; however, lower rents are also attractive.

Data and methods

While survey-based research on HBBs can lead to rich, local insights, a main contribution of this paper is the technique for combining micro-level data in order to identify them. HBBs are businesses defined by the built structures in which they exist: they are found in homes rather than in places dedicated to work. In addition to using built environment data to identify HBBs, we seek to understand where they are situated in neighborhoods based on their socioeconomic and built environment characteristics.

Business establishments

We use business establishment data from 1997 and 2014 from *Reference USA* (Infogroup, 2015), which provide XY coordinate data, employment counts, and the NAICS code for every business establishment region-wide. This is a commercial database compiled by Infogroup since 1997 with its roots in public record listings and verified annually by telephone by Infogroup's research staff.[1] An important distinction between establishment-level data and official statistics is that the latter tend to undercount small businesses and individuals who work multiple jobs—both features of NSW and HBB. Neumark et al. (2005) compare business establishment data with the Bureau of Labor Statistics' Quarterly Census of Employment and Wages (QCEW) and find 17–22% more employment and 38–63% more business establishments, with an overcount of 184% for businesses with 1–4 employees. Comparing Reference USA data against QCEW for 2014 across the study area, we find an overall overcount of 11.76% for employment and 25.75% for establishments, roughly in-line with Neumark, Zhang, and Wall's (2005) findings (see Appendix 1 for details). A possible explanation they offer is that self-employed or independent contractors having multiple businesses are counted once *per business* in establishment data, suggesting they are actually more comprehensive datasets that are better at identifying the small businesses that are likely to be home-based.

Parcel-level land use data

In addition to the increasing use of spatially explicit commercial business data in employment research, municipal agency data are now provided to citizens free of charge, partly in response to calls for more local government transparency (Arribas-Bel, 2014). Parcel-level land use data in particular have been used by economists and geographers to understand the role of zoning in land development, particularly at the urban fringe, since as discrete units of land, parcels allow for improved econometric identification of behavioral drivers of land change (Irwin and Geoghegan, 2001; Kane et al., 2014; Newburn and Berck, 2006). Many county tax assessors in the United States maintain property-level records that are well-suited for this purpose; however, data structures and coverage can vary substantially by county.

In addition, many municipal planning organizations (MPOs) maintain spatially disaggregated land use data for urbanized regions which is usually rooted in tax data but integrates satellite imagery and expert analysis in areas where county records are incomplete. These databases are mostly used for regional growth projections and transportation planning. Records were assembled from three MPOs covering 15 counties across California: the Southern California Association of Governments (SCAG), the San Diego Association of Governments (SANDAG), and the Association of Bay Area Governments (ABAG). In order to match the temporal extent of the business establishment data, the closest possible year to 1997 and 2014 for each MPO was used. 1993 and 2012 data are used for SCAG, while 1995 and 2013 data are used from SANDAG. ABAG relies on 2005 for both years: unfortunately prior data availability is hampered by low quality, while funding shortfalls have prevented this MPO from producing an updated version. Appendix 2 provides a breakdown of the residential land use categories present in these data.

Using ArcPython scripting and ArcGIS 10.2.2, a Spatial Join procedure was used which flagged business establishments if they existed inside the polygon boundaries of residentially coded land parcels. These are then called "HBBs." Figures 1 to 3 provide a visual depiction of the HBB identification method with business establishments overlaid on land use. Figure 1 shows an area in central Orange County. While visually, most business establishments tend to cluster around arterial streets and in certain areas with nonresidential land uses, the quantity and distribution of business establishments in residential areas—HBBs—is notable. Figure 2 shows the Cambrian Park neighborhood of San Jose, which is in Silicon Valley. While retail areas and commercial corridors are clearly identifiable, this largely residential area stands out for its prevalence of business establishments within single-family residential parcels. Figure 3 depicts a portion of Riverside, in inland southern

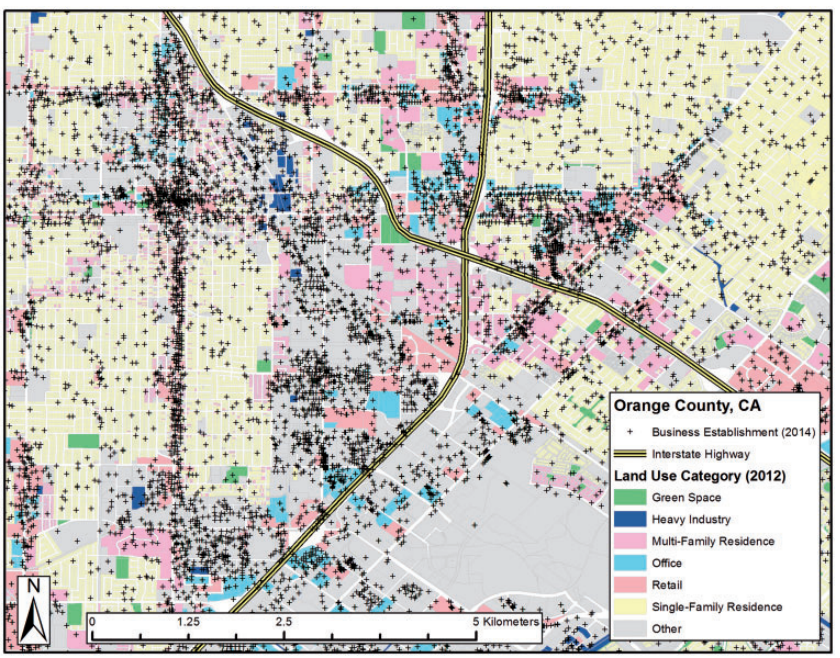

Figure 1. Home-based businesses in a section of Orange County in southern California.

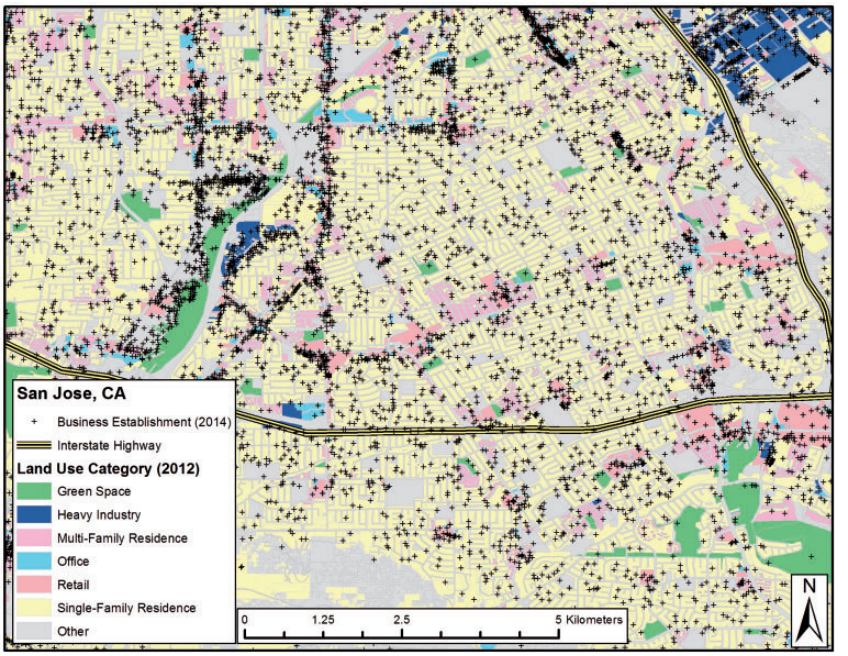

Figure 2. Home-based businesses in a section of Santa Clara County in the Silicon Valley region of northern California.

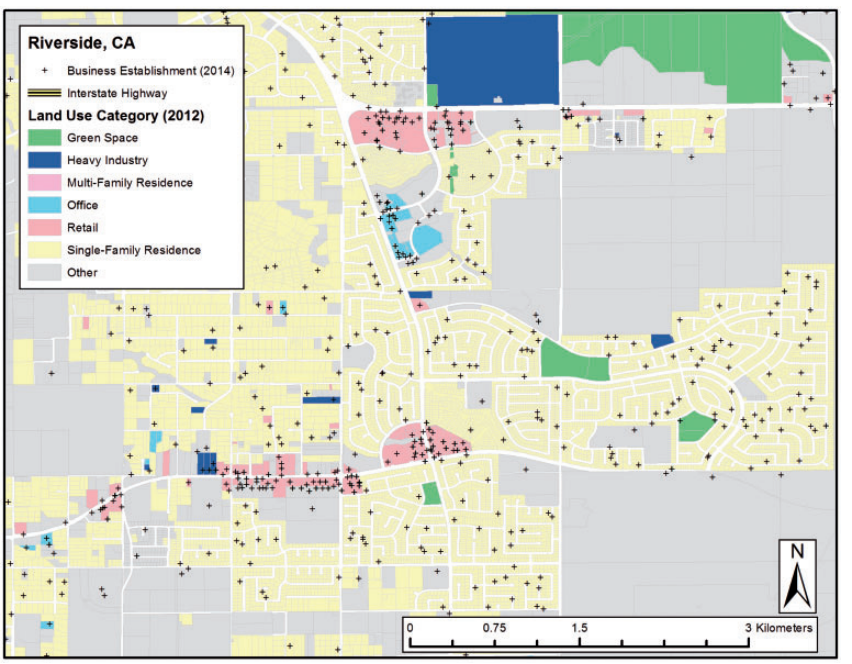

Figure 3. Home-based businesses in a section of Riverside County in southern California.

California adjacent to a military installation. This larger-scale map shows fewer home businesses, though the contrast between the retail and office centers is visually clear.

Analytical methods

After identifying HBBs, we tabulate their counts, growth, and employment across counties and economic sectors, using six-digit NAICS codes to segment knowledge-oriented from routine services. HBBs are then joined to census tract-level shape files and demographic information from the US Census and American Community Survey (Neighborhood Change Database, 2016). Tracts are split into quintiles by household income level employment in HBBs is analyzed overall, by knowledge-oriented and basic services, and separately for northern and southern California in order to test the contention that HBB employment is the purview of wealthier areas as opposed to a necessity for those in lower-resourced neighborhoods.

Finally, a census tract-level regression is used to model of the rate of HBB growth from t to $t+1$ is as follows (equation (1))

$$ln(HBB_t) - ln(HBB_{t+1}) = \alpha + \rho Wy + \beta\left(GROWTH_{t,t+1}\right) + \gamma(SES_t) + \varepsilon$$

where $GROWTH_{t,t+1}$ is a matrix of growth rates used to control for overall population and employment growth and better identify causes of HBB growth above and beyond growth between 1997 and 2014 generally. SES_t is a matrix which captures initial socioeconomic conditions using year 2000 census data to approximate the 1997 starting point. Given Mason et al.'s (2011) emphasis on potential for HBB to provide economic development potential to targeted areas, we are interested in whether HBB growth is greater in areas that are otherwise growing in population or employment. Previous research has also emphasized the propensity for HBB owners to live in detached, single-family homes in lower density areas, therefore also included in this term is the growth rate of single-family homes using Census data to gauge whether, as prior studies suggest, areas increasing in their quantity of suburban-style housing are most suitable for HBB growth. Since land use data in northern California was not longitudinal, this measure uses year 2000 US Census and 2006–2010 American Community Survey figures to gauge the increase in the share of *housing* (rather than land use) that was detached, single-family. Population density is included in SES_t as an indicator of intraurban location, as California's largely polycentric urban areas preclude a crisp delineation of urban, suburban, exurban, and rural. Homeownership in the initial year is also investigated. Other socioeconomic measures in the initial year include the vacancy rate, the rate of resident unemployment, and the share of population that is over 65 years of age, foreign-born, white (non-Hispanic), or that holds at least a Bachelor's degree. The share of households in a tract with a broadband internet connection (defined as 200 kbps of service or better) is provided by the Federal Communications Commission (FCC) as of 2008 and is also included to investigate whether provision of broadband as business infrastructure impacts HBB growth.

Results

HBBs totals by county

Table 1 presents totals for HBBs and home-based employment by county. In 1997, 15.3% of businesses were based in single-family residences; increasing to 16.6% by 2014. The share of

Table 1. Business establishment and employment by home status.

County	Home-based businesses (HBBs)		Employment in HBBs		Growth in employment in HBBs	Total employment Growth	Share of total emp. growth that is in HBBs	ACS[a]: Pct. Who work from home (2014)
	Pct. 1997	Pct. 2014	Pct. 1997	Pct. 2014				
Alameda	16.3%	19.1%	6.4%	7.4%	29.1%	12.7%	14.7%	5.6%
Contra Costa	18.8%	21.9%	8.6%	8.3%	40.3%	45.0%	7.7%	5.9%
Los Angeles	13.8%	11.6%	5.6%	4.8%	2.3%	18.9%	0.7%	5.1%
Marin	20.1%	23.2%	8.9%	10.8%	38.2%	13.3%	25.4%	9.9%
Napa	18.3%	20.6%	9.0%	12.3%	99.2%	45.8%	19.5%	5.6%
Orange	14.3%	19.8%	5.2%	6.7%	75.1%	34.2%	11.3%	5.1%
Riverside	17.6%	17.3%	6.6%	7.9%	109.6%	74.7%	9.7%	5.0%
San Francisco	13.5%	15.3%	5.6%	5.4%	2.9%	6.2%	2.6%	4.1%
San Bernardino	15.3%	16.4%	5.4%	5.8%	62.9%	53.3%	6.4%	6.5%
San Diego	14.5%	20.1%	4.6%	6.6%	73.9%	21.4%	15.8%	7.1%
San Mateo	16.1%	18.3%	6.2%	6.8%	24.4%	12.2%	12.3%	5.0%
Santa Clara	16.8%	20.3%	5.4%	7.1%	46.0%	10.1%	24.5%	4.6%
Solano	21.7%	21.6%	11.7%	10.5%	35.4%	51.0%	8.1%	3.9%
Sonoma	20.8%	23.5%	9.8%	11.5%	39.2%	18.9%	20.3%	6.9%
Ventura	20.4%	17.8%	8.4%	10.4%	71.4%	37.5%	16.0%	5.6%
Northern	16.9%	19.7%	6.6%	7.6%	33.1%	15.8%	13.9%	5.7%
Southern	14.6%	15.5%	5.5%	6.0%	39.0%	27.9%	7.7%	5.2%
Total	15.3%	16.6%	5.9%	6.5%	36.9%	24.2%	8.9%	5.34%

[a]American Community Survey Data (2010–2014) for "Work at home" status, provided as a comparison.

employment is far smaller—5.9% of employees work in a HBB in 1997 and 6.5% in 2014. This share is slightly above the count of individuals who worked at home in 2010 found in Mateyka et al. (2012) and Clark (2015), who reported 5.0% of the Los Angeles area and 6.2% for the San Francisco area. However, this figure is conceptually very different in that it includes telecommuters and others whose primary business is physically based elsewhere. This measure of HBBs gauges the level of employment generated by businesses based in home locations; however, it is true that employees of a HBB do not necessarily complete work in that home.

While the percentage share of HBBs increased modestly, the bottom row of Table 1 indicates that growth in employment from HBBs outpaced overall employment growth 37 to 24%. Importantly, 8.9% of *new* jobs over this period were in HBBs. This varies notably by county. In three suburban counties of northern California—Marin, Sonoma, and Santa Clara, which includes Silicon Valley—the share of new jobs that were in HBBs was above 20%. Growth in HBB employment was comparatively modest in Los Angeles and San Francisco counties (the latter of which is far more urban and is coterminous with the city)—with growth rates of 2.3 and 2.9% actually reflecting a lower share of workers in HBBs by 2014. Despite greater overall employment growth in southern California, a higher share of that growth was in HBBs in the northern counties.

HBBs by economic sector

Table 2 shows HBBs by economic sector, sorted by those with the highest 2014 employment in HBBs. While occupation-based studies of home working and telecommuting in particular (e.g. Ellen and Hempstead, 2002) find an overrepresentation in professional, technical, and managerial employment, the top spots on this list are a mix of knowledge-intensive, tech-oriented services as well as many fairly routine, basic industries. This is roughly in concert with Mason et al.'s (2011) and Jain and Courvisanos' (2013) surveys of HBB in the UK and Australia. The top five generators of home-based employment are construction (NAICS 23), healthcare and social assistance (62), professional, scientific, and technical services (54), retail trade (44–45), and real estate rental and leasing (53). This finding is also consistent with Masuo et al. (1992) who reported that contrary to the notion of an increase in home-based work by white-collar workers, in fact home-based workers were likely to be in sales, marketing, contracting, and transportation activities.

Construction (NAICS 23), Health Care and Social Assistance (62), and Professional, Scientific, and Technical Services (54) are the top three generators of employment in HBBs in 2014, each with over 100,000 such employees. While construction has the highest employee count in 2014, the top spot was occupied by health care and social assistance in 1997. The professional services category had the most HBB establishments in both years by a small margin.

A closer examination of individual establishments in construction demonstrates that this category largely consists of small building contractors and tradespeople such as masons, roofers, electricians, and plumbers. While it is likely that much of the work in these trades takes place outside the home, the home clearly remains a key business resource for administrative tasks, entrepreneurial activity, and even as a resource for local job opportunities if HBBs have employees. NAICS 54, Professional, Scientific, and Technical Services encompasses a variety of knowledge-oriented services such as consultancies, architects, attorneys, computer systems designers, accountants, and firms engaging in accounting, graphic design, advertising, and scientific research services. Health Care and Social Assistance (NAICS 62) showed a very high representation (about 28% of its employment) in sub-codes 6244: Child

Table 2. Home-based businesses (HBBs) and employment in home-based businesses by industry.

NAICS 2-digit industry code		Employment in HBBs		Home-based businesses			Pct. of total emp. in HBBs		Employment growth	
		2014[a]	1997	2014	1997	*Increase*	2014	1997	Total	in HBBs
23	Construction	113,851	47,288	32,789	13,943	57.5%	18.8%	17.4%	123.2%	140.8%
62	Health Care and Social Assistance	111,992	63,479	16,586	7890	52.4%	6.3%	7.3%	105.2%	76.4%
54	Professional, Scientific, and Technical Services	107,479	43,741	34,834	15,363	55.9%	9.4%	8.0%	108.7%	145.7%
44	Retail Trade	76,248	34,290	23,522	11,539	50.9%	4.2%	3.5%	85.2%	122.4%
53	Real Estate and Rental and Leasing	67,898	37,111	19,536	10,063	48.5%	15.4%	17.7%	110.2%	83.0%
81	Other Services (except Public Administration)	60,965	37,507	16,804	10,218	39.2%	8.7%	9.1%	70.2%	62.5%
56	Admin. and Support and Waste Mgmt. and Remediation	52,899	26,215	15,508	7170	53.8%	11.7%	9.8%	70.2%	101.8%
61	Educational Services	47,475	25,250	3972	1651	58.4%	5.0%	5.0%	89.4%	88.0%
72	Accommodation and Food Services	37,746	15,484	4743	1945	59.0%	3.2%	2.5%	92.5%	143.8%
42	Wholesale Trade	34,423	26,625	6723	6850	−1.9%	5.4%	4.5%	6.9%	29.3%
31	Manufacturing	27,271	17,079	5210	3231	38.0%	2.2%	1.7%	28.2%	59.7%
0	No Category	25,501	222,176	15,481	51,797	−234.6%	27.0%	6.6%	−97.2%	−88.5%
52	Finance and Insurance	23,181	10,875	7495	3075	59.0%	4.2%	3.1%	55.4%	113.2%
48	Transportation and Warehousing	22,671	8318	5539	1615	70.8%	7.3%	4.4%	62.6%	172.6%
51	Information	21,356	9151	4990	2555	48.8%	5.2%	4.4%	95.9%	133.4%
71	Arts, Entertainment, and Recreation	18,271	7196	4488	1607	64.2%	5.0%	5.5%	176.7%	153.9%
92	Public Administration	16,274	2914	819	204	75.1%	2.4%	0.9%	108.0%	458.5%
11	Agriculture, Forestry, Fishing and Hunting	3827	1157	813	296	63.6%	13.4%	7.1%	74.8%	230.8%
22	Utilities	1586	577	144	71	50.7%	2.6%	3.4%	257.1%	174.9%
55	Management of Companies and Enterprises	543	97	188	45	76.1%	3.1%	2.3%	310.6%	459.8%
21	Mining, Quarrying, and Oil and Gas Extraction	413	209	93	43	53.8%	3.5%	3.1%	75.1%	97.6%

NAICS: North American Industry Classification System.

[a]Sorted in descending order by employment in HBBs 2014.

Day Care Services and 6233: Continuing Care Retirement Communities and Assisted Living Facilities for the Elderly. While it should not be surprising that care for the young and the old is taking place as a business in residential neighborhoods, the prevalence of this activity in an accounting of HBBs runs contrary to the perspective of HBBs as new economy drivers of economic prosperity for regions. In particular, a California state law governing "Residential recovery facilities and group homes" circumscribes local zoning regulations, mandating that cities allow residential care businesses for the young, old, and disabled (serving six or fewer residents) within any residentially zoned area (Kautz, 2011). In this instance, these small businesses which provide basic neighborhood services are supported by state-level policy.[2]

Two categories with a high representation in HBBs represent miscellaneous services. Administration and Support and Waste Management and Remediation Services (NAICS 56) includes exterminators, janitors, landscapers, carpet cleaning services, call centers, document preparation services, collection agencies, travel agents, and employment search services, while Other Services (NAICS 81) includes computer repair, religious organizations (such as small churches that appear to be run out of individuals' homes), social organizations (one such example is a stamp-collecting club), and miscellaneous personal services such as pet sitting and pet grooming. Retail businesses (NAICS 44) operating out of the home include sales of most any product imaginable from specialty auto parts to surfboards to apparel and appear to mostly represent internet sales businesses. Searching home-based retailers by name also yields high counts of brands engaged in so-called multilevel marketing which rely on layered structures of quasi-independent, home-based salespeople (Keep and Vander Nat, 2014) including Mary Kay Cosmetics (80 businesses), Amway Distributors (48 businesses), and Herbalife (42 businesses). Finally, Real Estate and Rental and Leasing (NAICS 53) businesses are a mix of real estate agents or brokers working out of their homes, appraisal or home inspection businesses, and offices for apartment leasing and homeowners' associations.

Despite the knowledge and technological orientation present in NSW research, there appears a sharp distinction amongst the top industry categories of HBBs between those that are knowledge-oriented services and those that are routine or basic services. This is approached first by qualitatively identifying four-digit NAICS codes that are clearly knowledge-oriented or basic using the above descriptions. This accounting covers approximately 53% of home-based establishments (see Appendix 2 for a breakdown). A more exhaustive approach is achieved by using European Labor Force Survey categorizations, which identifies "Knowledge-intensive activities" by industry code (Reuschke and Houston, 2016), using a crosswalk table to convert European industry codes to NAICS. A location quotient was calculated to gauge the level of disproportionate representation of these categories in HBBs, compared to all businesses (details are in Appendix 3). Basic industries were heavily overrepresented in residences, with a location quotient of 1.34 in 1997 and 1.38 in 2014. Knowledge-intensive services were slightly overrepresented in residential locations using our own classifications (1.04 in 1997 and 1.08 in 2014) and slightly underrepresented using the European Labor Force classifications (0.87 in 1997 and 0.79 in 2014).

Income quintiles

Figure 4 splits counts of home-based employment by income quintile, using the 2000 income distribution to separate by census tract and show counts of (a) all home-based employment, (b) home-based employment in basic services, (c) home-based employment in knowledge-intensive services, and (d) home-based employment in knowledge-intensive services using

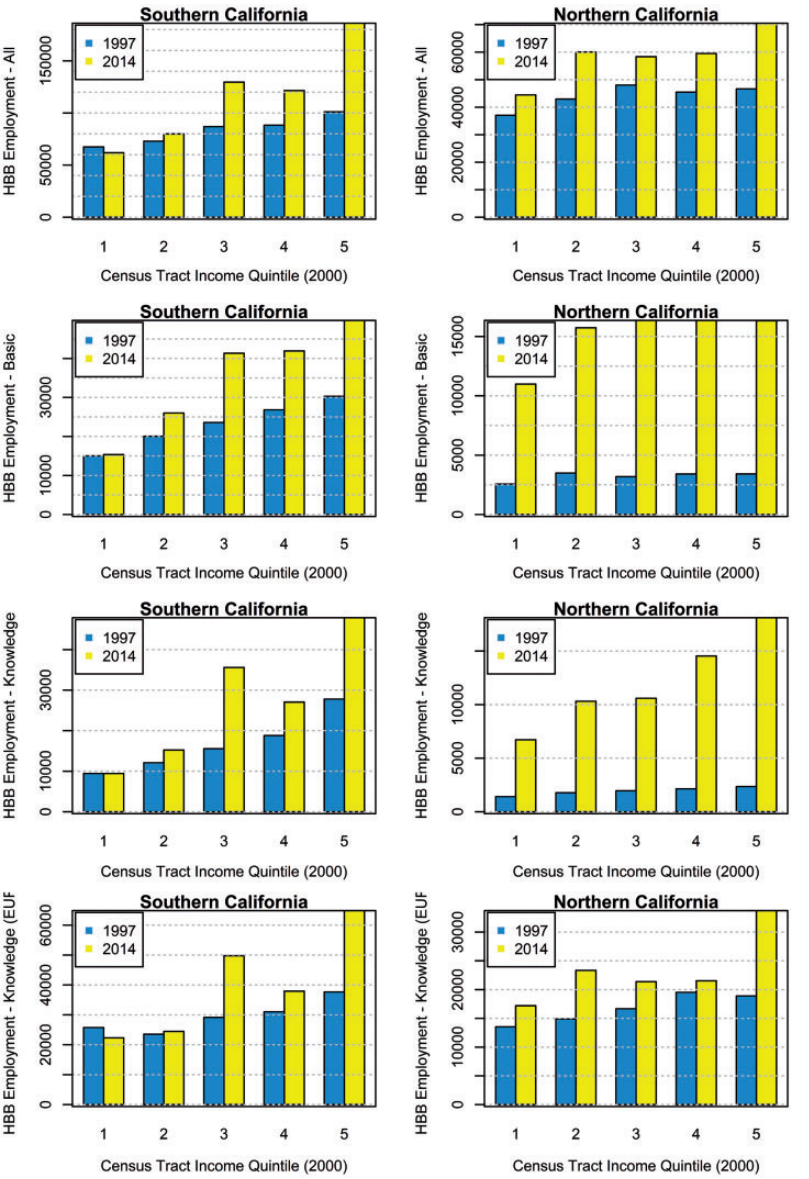

Figure 4. Employment in home-based businesses (HBBs) by neighborhood income. Note that in 1997, a high share of Northern California businesses were not classified by industry type.

the European Labor Force Survey classifications, with analysis conducted separately for the distinct economies of northern and southern California. Consistent with Reuschke and Houston's (2016) finding that HBBs are overwhelmingly found in wealthier neighborhoods, we generally find that higher income quintiles have higher levels of employment in HBBs. However, this is not a universal pattern.

In southern California in 1997, the level of HBB employment raises linearly with income for all business types, in basic industries, and both definitions of knowledge-based employment, i.e. higher HBB employment at each higher income quintile. By 2014, while this

pattern remains in general, the third (middle) and fifth (top) quintiles experience the largest increases in HBB employment. This increase is very pronounced in knowledge-based employment. In northern California, there is less clarity in the relationship between neighborhood median income and HBB employment. For all industries in 1997, the middle quintile actually has the highest level of HBB employment but by 2014, the second and the top quintiles experienced more substantial increases. This is pronounced in the European classification of knowledge-intensive industries as well: the number employed in HBB at the top income quintile increased by nearly 15,000 and the second quintile by roughly 8500 compared to much smaller gains elsewhere. It is notable that HBB employment levels increased across all quintiles in northern California, while in southern California, the lowest quintile actually decreased slightly. Generally, gains in HBB employment appear to accrue at the top and middle portions of the income distribution, even in knowledge-intensive industries. It may be that, as suggested by Sayers (2014), HBB owners "tend to multitask" and engage in other income-producing activity as well, perhaps those in the middle income quintile.

Which kinds of neighborhoods experience growth in HBBs?. The previous section established a slight difference in the propensity for growth in home-based employment based on whether its nature was knowledge-intensive or comprised largely of routine services. This section uses tract-level regressions to gauge the relationship between various neighborhood-level characteristics and growth in HBBs (equation (1)). The regressions are run separately for southern and northern California to account for (a) fairly substantial differences in HBB dynamics illustrated in Table 1 and (b) the need for contiguous census tracts to estimate spatial models. Chloropleth maps of the dependent variable to be modeled—the natural log of the growth in HBBs from 1997 to 2014—are shown in Figures 5 and 6.

LaGrange multiplier tests on Ordinary Least Squares (OLS) specifications in both northern and southern California models indicate strong ($p < 0.0001$) spatial autocorrelation in the dependent variable and suggest the use of a spatially-lagged dependent variable ρWy (using first-order queen contiguity weights) to correct for the association of HBB growth in neighboring tracts (Anselin, 2002). Base year median household incomes were strongly correlated with a number of other socioeconomic measures (namely, an absolute value above $r = 0.5$ with homeownership, bachelor's degree, percent white, and unemployment), thus it was omitted from the model since multicollinearity affected the ability to detect the impact of these other covariates. Regression results are shown in Table 3.

Southern California

A spatial lag model in southern California provides an improved model fit over an OLS estimation as measured by both (pseudo) R-squared and AIC values. Most coefficient estimates and standard errors are lower in the spatial model and most practical interpretations are the same. Growth in HBB is positively and very strongly related to employment and population growth in the tract, with a higher estimate for employment growth. A positive coefficient estimate on the increase in a tract's share of single-family detached homes—significant but only in the spatial model—provides some evidence that areas in the process of suburbanization experience growth in HBB employment. This is corroborated somewhat by the significant and negative coefficient estimate for population density, which indicates that less dense areas in 2000 experience subsequent HBB growth. Homeownership rate is also significantly positively associated with HBB growth.

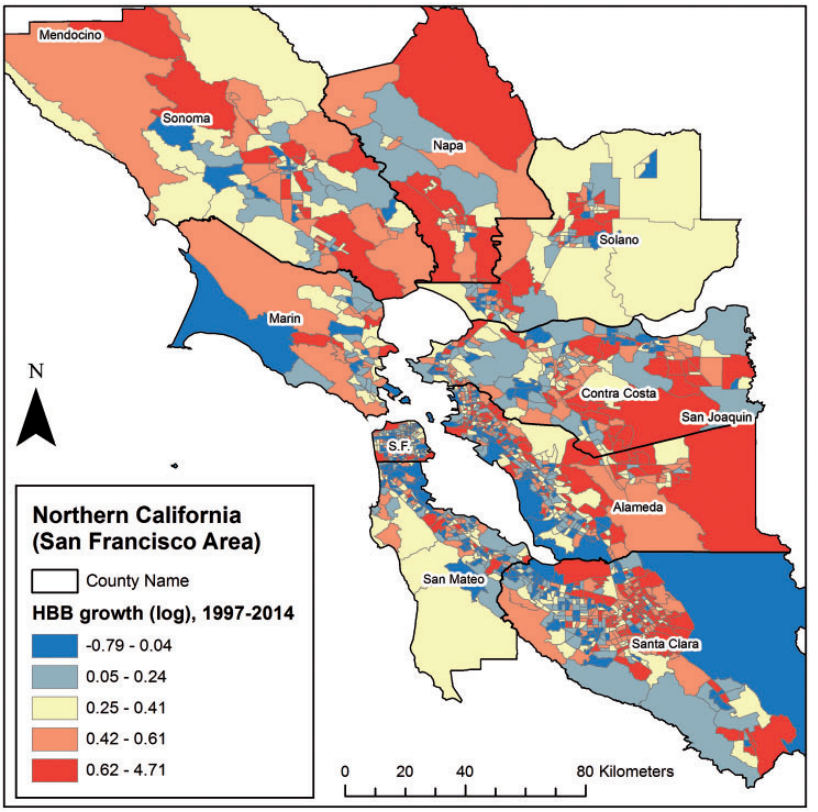

Figure 5. Home-based business ((HBB)) growth in northern California.

A low unemployment rate is the neighborhood characteristic most strongly related to HBB growth, followed by a high share of residents with a bachelor's degree or above, and a low share of foreign-born residents. While the share of the neighborhood population that is White, non-Hispanic is not significantly related to HBB growth in the OLS model, this is a strongly negative predictor of growth in the spatial model. By identifying a significant proportion of home-based workers over 65, previous findings suggested that HBBs may provide continued earnings opportunities to those above a certain age (Mateyka et al., 2012); however, this study finds that neighborhoods with a higher share of retirement age population experience lower HBB growth, though this result is only very weakly significant ($p < 0.10$) in the spatial lag model. Contrary to Reuschke and Houston (2016), who emphasize the importance of networked neighborhoods, tract-level broadband availability bears no significant statistical relationship with HBB growth. It does, however, show a strong bivariate correlation with the level rather than the growth of HBBs ($r = 0.41$ to $r = 0.46$ in 1997 and 2014, respectively).

Northern California

Relationships between neighborhood characteristics and the growth in HBBs are far weaker in northern California—even with the spatial lag specification the pseudo R-squared value is only 0.233. While employment growth is a stronger predictor of HBB growth than population growth in both regions, the difference in northern California is an order of magnitude,

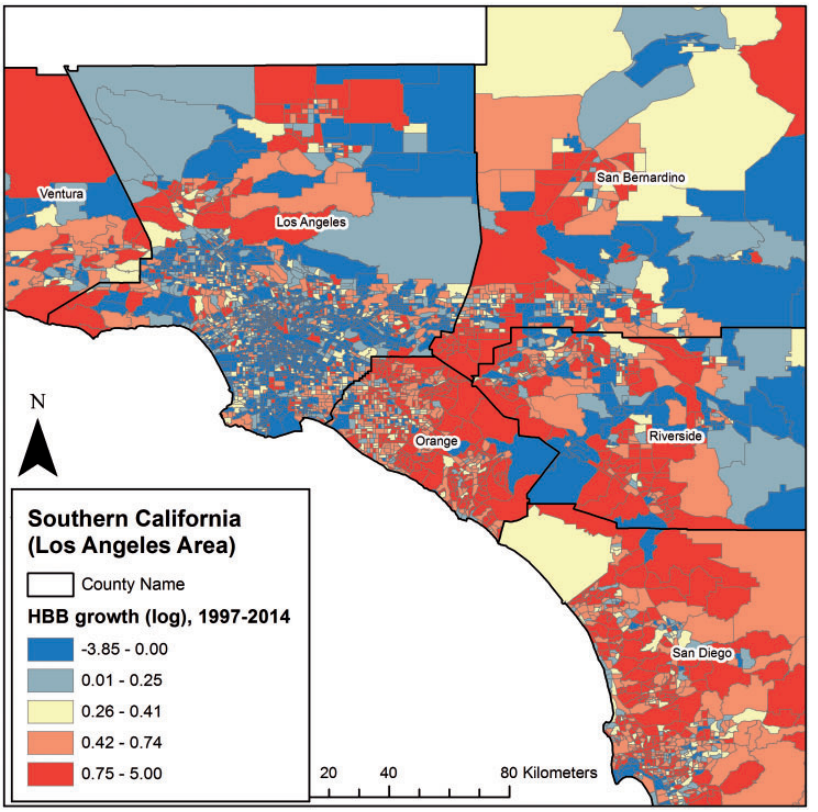

Figure 6. Home-based business (HBB) growth in southern California.

rather than two- or three-fold as in southern California. Suburbanization—measured by the increase in share of single-family homes—is not related to HBB growth, and the negative relationship between population density and growth found in southern California is not significant in the region surrounding San Francisco. In addition, homeownership rate is only significantly related to HBB growth in the OLS model and not in the spatial model, leading us to conclude that low density, suburban areas are not substantively related to HBB growth here as they are in southern California.

As in southern California, the unemployment rate and the share of population that is White, non-Hispanic are significantly negatively related to HBB growth, suggesting that low-unemployment minority areas may be generators of increased HBB activity. We are not able to detect any substantive relationship between retirement age population in this region and HBB growth. A somewhat unexpected finding is that the education levels do not predict HBB growth—in fact, the relationship is weakly negative in the OLS model. Education levels in northern California are far higher (37% college educated versus 25% in southern California). Despite different relationships to HBB growth in the models, in both northern and southern California correlations between the *level* of HBBs in 1997 and the share of the population with a B.A. were strong and positive ($r = 0.36$ and $r = 0.31$, respectively). However, the San Francisco and L.A. metro regions differ greatly in the relationship between HBB growth and education: a strong positive relationship in the south ($r = 0.24$) and virtually no relationship in the north ($r = -0.04$). One possible rationale which can

Table 3. OLS and spatial lag regression results: Growth in HBBs (ln) 1997–2014.

	Southern California 6 Counties, 4553 OLS Regression		Southern California 6 Counties, 4553 Spatial Lag		Northern California 9 Counties, 1588 OLS Regression		Northern California 9 Counties, 1588 Spatial Lag	
	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
Constant	0.0791***	*(0.0809)*	0.0332	*(0.0843)*	0.4457***	*(0.1014)*	0.3381**	*(0.0989)*
rho			0.5332***	*(0.0168)*			0.2912***	*(0.0352)*
Growth								
Population growth (log)	0.1113***	*(0.0145)*	0.0769***	*(0.0128)*	0.0481**	*(0.0144)*	0.0377**	*(0.0139)*
Employment growth (log)	0.3518***	*(0.0162)*	0.2637***	*(0.0144)*	0.2535***	*(0.0173)*	0.2269***	*(0.0169)*
Incr. in % of HH detached	0.1386	*(0.1004)*	0.1839*	*(0.0886)*	0.0707	*(0.1061)*	0.0836	*(0.1026)*
Initial conditions								
Pop. density (log)	−0.0461***	*(0.0096)*	−0.0203*	*(0.0085)*	−0.0129	*(0.0093)*	−0.0084	*(0.0091)*
Homeownership rate	0.2052**	*(0.0550)*	0.1641**	*(0.0489)*	0.1171*	*(0.0568)*	0.0692	*(0.0553)*
Vacancy rate	−0.3054·	*(0.1757)*	0.0475	*(0.1550)*	0.1666	*(0.2818)*	0.1641	*(0.2726)*
Unemployment rate	−1.4977***	*(0.2649)*	−0.9321***	*(0.2341)*	−1.1218**	*(0.3749)*	−0.8912*	*(0.3628)*
Percent > 65 yrs old	−0.5926***	*(0.1517)*	−0.2164·	*(0.1338)*	−0.1028	*(0.1538)*	−0.2539	*(0.1489)*
Percent foreign born	−0.5726***	*(0.0928)*	−0.2118**	*(0.0824)*	−0.0718	*(0.1077)*	−0.0479	*(0.1041)*
Percent w/B.A.	0.3882***	*(0.0774)*	0.2719***	*(0.0686)*	−0.1148·	*(0.0632)*	−0.0699	*(0.0613)*
Percent White, non-Hisp.	−.0556	*(0.0729)*	−0.1847**	*(0.0644)*	−0.1057·	*(0.0792)*	−0.1498*	*(0.0766)*
Broadband coverage	−0.0056	*(0.0082)*	−0.0024	*(0.0073)*	−0.0221**	*(0.0080)*	−0.0159*	*(0.0078)*
R-squared/psuedo R-sq.	0.2599		0.4222		0.1864		0.233	
Akaike Information Criterion (AIC)	9283.26		8400.55		1578.5		1508.7	

***$p < 0.0001$.
**$p < 0.01$.
*$p < 0.05$.
·$p < 0.10$.

explain the stronger negative results for foreign-born population in southern California only is that the San Francisco region has far fewer low-education immigrants. The share of foreign-born population is lower (27.9% foreign-born versus 29.4% in southern California). Consistently, high levels of immigration—particularly from Asian and Latin American countries—are a distinctive feature of the southern California population and likely explain some of the different relationships between neighborhood characteristics and HBBs.

Finally, broadband coverage is actually negatively related to HBB growth in northern California in the model despite positive bivariate correlations between broadband coverage and HBB levels ($r = 0.36$ in 1997 and $r = 0.33$ in 2014). It is likely that by 2014, the FCC's 200 kbps standard for connection speed is no longer considered fast and that connectivity at this level has become ubiquitous even in areas unrelated to HBB growth. This may be particularly meaningful in the region known for high-tech connectivity.

Discussion and conclusions

The research reported in this paper makes four important contributions to the growing literature on HBBs. Previous work on telecommuting and home working has emphasized how the use of the home for work can change where people choose to live and the neighborhood-level resources they rely upon. Previous work on HBBs specifically emphasized how their economic impact may be overlooked, their proclivity toward wealthier neighborhoods and single-family detached homes, and in some instances an association with knowledge or technology-intensive industries. HBBs can also be the most flexible businesses since they do not require a new location other than an existing home—a key linkage for regional planners given the prevalence of this form of economic activity.

First, this paper develops a new method of identifying HBBs that relies on GIS and micro-level data sources, using the residential status which underlies "home-based" to identify such businesses. Using GIS to identify at-home status circumvents the problem of limited samples or underreporting, while capturing the home-based workers' multitasking tendency. In doing so, we demonstrate that establishment-level business data may be more appropriate for studying this type of economic activity than aggregated, official statistics, which tend to undercount the types of small businesses that are more likely to be home-based.

Second, the study enlarges the focus from the knowledge-intensive industries and the telecommuting link to HBB literatures in the US, to show that HBBs are a mix of knowledge-oriented and basic and routine services including construction, professional, scientific, and technical services, healthcare and social assistance and retail functions. Nearly one in six businesses in our study area is home-based, home-based employment growth outpaced overall employment growth 37 to 24%, and 8.9% of new jobs between 1997 and 2014 were in HBBs, suggesting a sizeable role for HBBs in economic growth.

Third, it shows that HBBs are broadly distributed across the urban landscape. They are found in a wide variety of urban settings but breaking somewhat with previous work, employment growth in HBBs is found at both middle and top income quintiles. HBB growth is clearly associated with lower density suburbanizing areas with high levels of homeownership in southern California, but not in northern California. While low unemployment and a high nonwhite population is universally associated with HBB growth, in southern California, a low share of foreign-born population and high education levels predict it as well. Lower levels of college education are actually positively associated with HBB growth in northern California, which may be reflective of different types of neighborhood-level mixing experienced in the Los Angeles versus San Francisco urban areas. While this

study only covers two major urban regions in the same state, the difference in results suggests that the local social, economic, and built environment contexts can strongly shape the dynamic of HBBs in other American and world regions.

Fourth, this study situates the research on HBBs in the context of the social changes surrounding work relationships, beyond consideration of technological changes. While in this study HBB growth clearly does not follow broadband availability, we draw an important distinction between activities that are internet dependent, that is they can only occur in the home because the internet exists, and businesses that are internet enabled. While the ability to shift white-collar, office-based work into the home depends on at-home connectivity, in the latter case, the rise of a supply and service home-based activity is stimulated or enabled by additional connectivity. Where once these activities might have relied on personal and professional networks, the telephone, or mailer advertising, they now can reach a wider clientele.

Finally, much of the work to date has had a European perspective—similar social and organizational trends affecting work are in play in the US, using the large, variegated metropolitan regions of California as a test case. While in the US, federal and state tax burdens are largely thought to have a disproportionate impact on small businesses, regulatory impacts specifically on home businesses are largely the purview of local authorities and include zoning practices which may, for example, restrict exterior signage, prohibit the parking of a commercial vehicle, or restrict the number of visitors to a home (Beale, 2004). Smart growth advocates have aimed to promote compact and flexible urban development, one component of which is to ensure that zoning does not unduly burden the potential for economic activity in the home (Talen and Knaap, 2003). The findings from this paper suggest that such restrictions could become problematic if economic changes continue to increase the importance of the home as a business resource, though homeowners' association covenants or restrictive apartment lease terms may contain similar barriers to home business creation. We noted already the state mandate in California which preemptively circumscribes local efforts to out-zone home-based care facilities, preserving their ability to provide this neighborhood service. This type of protection could be extended to other business activities which provide economic opportunity, so long as any adverse impacts on the local community are mitigated. While much emphasis is placed on regional development policy in the UK and Europe where HBB research is more developed, the US is the world's largest economy yet lacks comprehensive welfare and regional development policy which characterize many European economies. This study shows HBBs in a context where regulation, if any, is likely to be highly localized and where HBBs are very unlikely to be a component of national or even state-level economic planning. Since this implies great potential variation across US urban regions, future studies could expand to other areas to analyze specific local policy contexts.

Overall, this study demonstrates that HBBs are multi-faceted and a focus on technological or knowledge-oriented service employment is insufficient for understanding the nature of the increase in business activity in the home. While methodological improvements to the identification of HBBs using land use data can be made, the insights provided by a fine-grained spatial approach allow for a much sharpened understanding of this sizeable and often overlooked phenomenon.

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Notes

1. These data are very similar in construction and scope to Dun and Bradstreet's National Establishment Time Series (NETS) database compiled by Walls and Associates, which have been used in a number of research applications regarding employment dynamics (see, e.g. Funderburg and Zhou, 2013; Meltzer and Capperis, 2016; Neumark et al., 2005). Reference USA, similarly constructed, only recently (2015) made time-series data available which is the reason for its relative absence in extant research.
2. The NAICS 62 category also includes physicians' offices; however, an online search revealed at least some instances where a practice was registered to a residential address but an office for a physician of the same name could be found in an office park or medical complex elsewhere. While these idiosyncrasies call into question the veracity of our HBB identification method, this problem appeared to be somewhat unique to the medical industry, in which practitioners such as massage therapists often see patients in their own home offices. Given the breadth of business types in this study and 1.3m overall records, we leave a verification of these industry-specific practices for a future, more targeted study.

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Appendix 1

Comparison of reference USA and Bureau of Labor Statistics (BLS) data

		Reference USA		BLS QCEW	
	Land use data—MPO source[a]	2014 establishments	2014 employment	2014 establishments	2014 employment
Alameda	ABAG	68,582	746,680	56,780	698,536
Contra Costa	ABAG	42,706	449,897	29,524	339,281
Los Angeles	SCAG	455,425	4,512,321	439,097	4,154,640
Marin	ABAG	18,454	130,235	11,903	110,424
Napa	ABAG	8,239	75,751	5,465	72,568
Orange	SCAG	183,558	1,741,329	106,546	1,472,171
Riverside	SCAG	76,643	732,013	52,858	625,942
San Bernardino	SCAG	71,854	718,839	50,922	659,116
San Diego	SANDAG	146,420	1,544,068	99,422	1,332,960
San Francisco	ABAG	57,598	636,277	57,020	640,378
San Mateo	ABAG	34,594	371,865	25,670	372,192
Santa Clara	ABAG	79,983	1,069,939	65,277	973,668
Solano	ABAG	15,091	153,376	10,191	127,175
Sonoma	ABAG	26,472	217,408	18,796	191,686
Ventura	SCAG	39,876	405,988	24,631	313,766
		1,325,495	13,505,986	1,054,102	12,084,503
	Pct. Overcount	25.75%	11.76%		

ABAG: Association of Bay Area Governments; MPO: municipal planning organizations; QCEW: Quarterly Census of Employment and Wages; SANDAG: San Diego Association of Governments; SCAG: Southern California Association of Governments.

[a]Municipal planning authority (MPO) records used are from authorities covering the San Francisco Bay Area (ABAG), San Diego (SANDAG), and the remainder of Southern California not including San Diego (SCAG).

Land use codes included as residential in this study

Code	Description	Agency[a]
1110	Single-Family Residential (unspecified density)	SCAG
1111	High-density Single Family Residential (>2 units/acre)	SCAG
1112	Low-density Single Family Residential (<2 units/acre)	SCAG
1121	Mixed Multi-Family Residential	SCAG
1122	Duplexes, Triplexes, and 2- or 3-unit Condominiums/Townhouses	SCAG
1123	Low-Rise Apartments, Condominiums, and Townhouses	SCAG
1124	Medium-Rise Apartments, Condominiums, and Townhouses	SCAG
1125	High-Rise Apartments, Condominiums, and Townhouses	SCAG
1130	Mobile Homes and Trailer Parks	SCAG
1140	Mixed Residential (i.e. single-family detached and multifamily together)	SCAG
1150	Rural Residential	SCAG
111	Residential, 1–5 acre lots	ABAG
112	Residential, 0.334–1 acre lots	ABAG
113	Residential, 0.126–0.333 acre lots	ABAG
114	Mobile homes and mobile home parks	ABAG
115	Less than 0.126 acre lots	ABAG
None	Single Family Detached	SANDAG (2013 only)
None	Single Family Multiple-Units	SANDAG (2013 only)
None	Single Family Residential	SANDAG
None	Single Family Residential Without Units	SANDAG (2013 only)
None	Multi-Family Residential	SANDAG
None	Multi-Family Residential Without Units	SANDAG (2013 only)
None	Mobile Home Park	SANDAG
None	Spaced Rural Residential	SANDAG (1995 only)

[a]Municipal planning organization (MPO) records used are from agencies covering the San Francisco Bay Area (ABAG, Association of Bay Area Governments), San Diego (SANDAG, San Diego Association of Governments), and the remainder of Southern California not including San Diego (SCAG, Southern California Association of Governments).

Appendix 2. Segmentation of industry (NAICS) and land use codes.

Industry codes—Authors' classifications

NAICS Code	Description	Category	Share of 2014 employment in home-based businesses
51	Information	Knowledge-Oriented Services	5.2%
52	Finance and Insurance	Knowledge-Oriented Services	4.2%
5312	Offices of Real Estate Agents and Brokers	Knowledge-Oriented Services	9.8%
5313	Activities Related to Real Estate	Knowledge-Oriented Services	24.4%
54	Professional, Scientific, and Technical Services	Knowledge-Oriented Services	9.4%
55	Management of Companies and Enterprises	Knowledge-Oriented Services	3.1%
5613	Employment Services	Knowledge-Oriented Services	5.6%
5614	Business Support Services	Knowledge-Oriented Services	5.6%
5615	Travel Arrangement and Reservation Services	Knowledge-Oriented Services	7.9%
		Subtotal	7.6%
23	Construction	Routine Services	18.8%
44-45	Retail Trade	Routine Services	4.2%
5617	Services to Buildings and Dwellings	Routine Services	19.8%
562	Waste Management and Remediation Services	Routine Services	7.5%
6233	Retirement Communities and Assisted Living for the Elderly	Routine Services	26.4%
6244	Child Day Care Services	Routine Services	17.1%
		Subtotal	9.2%
		All other codes	5.2%

NAICS: North American Industry Classification System.

Knowledge-oriented services using European labor force categorizations (see Reushke and Houston 2016)

NACE code	Description	
9	Mining support service activities	
19	Manufacture of coke and refined petroleum products	
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	
26	Manufacture of computer, electronic and optical products	
51	Air transport	
58	Publishing activities	
59	Motion picture, video and television programme production and pharmaceutical preparations	
60	Programming and broadcasting activities	
61	Telecommunications	
62	Computer programming, consultancy and related activities	
63	Information service activities	
64	Financial service activities, except insurance and pension funding	
65	Insurance, reinsurance and pension funding, except compulsory social security	
66	Activities auxiliary to financial services and insurance activities	
69	Legal and accounting activities	
70	Activities of head offices; management consultancy activities	
71	Architectural and engineering activities; technical testing and analysis	
72	Scientific research and development	
73	Advertising and market research	
74	Other professional, scientific and technical activities	
75	Veterinary activities	
78	Employment activities	
79	Travel agency, tour operator reservation service and related activities	
84	Public administration and defence; compulsory social security	
85	Education	
86	Human health activities	
90	Creative, arts and entertainment activities	
91	Libraries, archives, museums and other cultural activities	
94	Activities of membership organisations	
99	Activities of extraterritorial organisations and bodies	
	Share of 2014 employment in home -based businesses	5.2%

Appendix 3. Shares and location quotients (LQS) by type.

	Basic industries	Knowledge-intensive industries	*Knowledge-intensive, alternate classification*
1997: HBBs	35,078	28,903	51,047
1997: All	171,472	181,662	385,407
LQ-home-based status	*1.34*	*1.04*	*0.87*
2014: HBBs	68,882	59,384	72,660
2014: All	301,034	330,588	550,630
LQ-home-based status	*1.38*	*1.08*	*0.79*

HBBs: home-based businesses.