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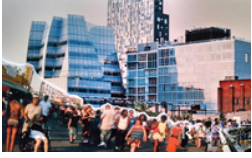
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Low-wage jobs-housing fit: identifying locations of affordable housing shortages

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ABSTRACT

Finding the right jobs-housing *balance* has long been an important concern for urban planners. More recently, attention has turned to jobs-housing *fit* – the extent to which housing price is well matched to local job quality. Prior analyses have been constrained by a lack of local data on job quality, making it difficult to identify the geography and scale of the problem. We introduce a new methodology for calculating the low-wage jobs-housing fit at both a jurisdiction and neighborhood scale that was designed in collaboration with affordable housing advocates and has been directly applied in urban planning and affordable housing policy efforts. Low-wage fit is particularly important because of ongoing difficulties with affordable housing provision and the disproportionate benefits of reducing transportation costs for low-income earners. We use the calculated metric at both a city and neighborhood scale to identify what can be learned from a low-wage jobs-housing fit metric that is not evident in traditional measures of jobs-housing balance. In contrast to jobs-housing balance, the low-wage fit analysis clearly highlights those jurisdictions and neighborhoods where there is a substantial shortage of affordable housing in relation to the number of low-wage jobs. Because of the geographic coverage of the data sources used, the results can be widely applied across the United States by affordable housing advocates, land-use planners, and policy makers.

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Introduction

Planners have long promoted the benefits of jobs-housing balance within local areas (Cervero, 1989, 1991; Frank, 1994). Colocating housing and jobs can allow people to live close to their workplace, thus reducing overall congestion, vehicle miles traveled (VMT), and associated greenhouse gas (GHG) emissions (Cervero & Duncan, 2006; Ewing, Bartholomew, Winkelman, Walters, & Anderson, 2008). Ensuring an approximate balance of housing and jobs is also important for maintaining overall housing affordability, since an inadequate supply of housing in relation to jobs inevitably results in rising housing prices (Dowall, 1982; Gober, McHugh, & Leclerc, 1993).

In addition to the overall *balance* between jobs and housing, planners and affordable housing advocates have also long recognized the importance of jobs-housing *fit*, though the concept has been much harder to operationalize and measure (Cervero, 1996; Smith, 2012). Jobs-housing fit refers to the extent to which the character and affordability of housing units in a particular area are well matched to the quality of locally available jobs. Although a poor fit at any income level could signal the potential for poor transportation performance, prior work has consistently demonstrated the unique barriers faced by low-income households, especially low-income households of color, as they engage in housing searches (Pendall, 2000b; Sharkey, 2012). In addition to outright discrimination in the housing market (Massey & Denton, 1993; Ross & Turner, 2005), land-use policies that restrict the supply of affordable housing, sometimes referred to as exclusionary zoning, are prevalent in suburban areas across the United States and have been shown to have measurable effects on neighborhood composition (Pendall, 2000a). Although some progress has been made in increasing affordable housing production in certain locations that have enacted inclusionary zoning policies, the pace of change has been slow (Bratt & Vladeck, 2014).

Because of this history and ongoing difficulties with affordable housing provision, ensuring *low-wage* jobs-housing fit is especially important from an equity perspective. Areas that perform well on this metric would generally evidence affordable housing provision adequate for the size of their low-wage workforce. Additionally, people employed in low-wage jobs spend a greater portion of their income on housing and transportation, are likely to value marginal monetary savings more than high-wage workers, and are more constrained in their ability to commute long distances (Haas, Makarewicz, Benedict, Sanchez, & Dawkins, 2006; Holzer, 1991; Murakami & Young, 1997). As a result, it is likely that low-wage workers in particular would be more likely to choose a residential location close to their workplace, if one is available.

Achieving low-wage jobs-housing fit could also yield environmental benefits, since low-income households on average drive older and less fuel-efficient cars (Binder, Macfarlane, Garrow, & Bierlaire, 2014; Kahn, 1998). Ensuring a low-wage jobs-housing fit might have a particularly substantial impact on GHG and air pollution emissions. Further, an imbalance in low-wage jobs and housing between particular jurisdictions can contribute to fiscal challenges and regional inequity (Miller, 2000; Orfield, 1997; Parlow, 2012; Rusk, 2003). This is because many low-wage jobs are in retail and restaurant industries that contribute substantial sales tax revenue to local jurisdictions, but affordable apartments and homes – which still create demand for local services but generate less tax revenue – can be a net fiscal drain on city coffers. Thus, jurisdictions with high numbers of low-wage jobs in relation to affordable apartments and homes realize a fiscal benefit, while simultaneously burdening those jurisdictions that possess the affordable housing needed to house those same low-wage workers. For these reasons, in this article, we design and apply a metric that characterizes low-wage jobs-housing fit at two geographic scales: the jurisdiction and the census tract. The metric is a ratio of the total number of low-wage jobs within a particular geography to the total number of affordable rental units; appropriately defining both the numerator and denominator requires a number of judgment calls. To the best of our knowledge, no such metric has previously been developed. The low-wage jobs-housing fit measure calculated here allows us to address a number of related research questions, specifically:

What value does a low-wage jobs-housing fit metric add above traditional measures of jobs-housing balance in terms of identifying locations with affordable housing shortages? What analytical choices need to be considered when constructing such a jobs-housing fit measure? How sensitive are the results to different calculation methods when looking at the census tract, or neighborhood, scale?

We subsequently employ the metric to analyze the geography of affordable housing in the San Francisco Bay Area in relationship to the geography of low-wage jobs. This mapping approach helps us identify key areas – primarily in the core of Silicon Valley and in the suburban East Bay – where the lack of affordable housing is particularly acute, given the concentration of low-wage jobs in those areas. For census tracts, we assess the implications of different units of analysis for our understanding of the adequacy of low-wage jobs-housing fit by comparing the use of a distance decay function and a hard distance threshold around census tract centroids for calculating the ratio. We argue that the hard distance threshold has significant advantages over the distance decay function. In our case study region, the statistical differences between these measures are minimal, and a particularly attractive property of a threshold-based metric is its interpretability and immediate identification of the affordable housing need in terms of number of units. In this way, it is intuitive for affordable housing advocates, planners, and elected officials, thus making it more amenable to incorporation into participatory planning and policy advocacy efforts. California is a particularly appropriate test location for this work because of the 2008 passage of Senate Bill (SB) 375, also known as the Sustainable Communities and Climate Protection Act (Barbour & Deakin, 2012). The law requires California's regions to reduce vehicle travel by pursuing integrated transportation, land use, and housing planning. Its implementation has sparked substantial interest regarding the implications of innovative planning measures on low-income and people of color populations and the integration of environmental and social equity goals (Marcantonio & Karner, 2014). The metrics developed in this paper are a first step toward quantifying the implications of related inequities in housing markets including exclusionary zoning and outright discrimination.

The remainder of this article is structured as follows. We first summarize previous literature on jobs-housing balance and the relatively new efforts to measure jobs-housing fit. We then describe our methodology for calculating the low-wage jobs-affordable housing fit ratio, including a discussion of the strengths and weaknesses of the datasets employed. We subsequently use the metric to visualize jobs-housing fit at a jurisdiction and census tract level in the San Francisco Bay Area while discussing the strengths and weaknesses of alternative operationalizations of the metric. We conclude with a discussion of future research opportunities to develop the relationship between the low-wage jobs-housing fit indicator and travel patterns.

Literature review

There is a substantial literature examining the issue of jobs-housing balance. In the late 1980s, policies to ensure that aggregate numbers of jobs and housing units were approximately balanced in an area were thought to be important for achieving regional congestion mitigation and air quality improvements. Academic studies soon followed,

with some authors arguing against the effectiveness of using jobs-housing balancing as transportation policy. In more recent years, the focus of jobs-housing research has expanded to include housing availability and affordability as well as the geographic influences of economic development strategies.

Early work by Cervero indicated that, in some cases, more closely balanced jobs and housing numbers tended to result in improved performance on congestion metrics (Cervero, 1989). That work showed that suburban job centers with balanced numbers of jobs and housing units tended to see increased rates of walking and bicycling and reduced congestion on nearby freeways. Other authors disputed whether specific policies should be pursued to achieve balance. Giuliano argued that areas naturally tended toward balance over time (Giuliano, 1991). For her and others (Downs, 2004; Gordon, Richardson, & Jun, 1991), attempting to achieve balance through policy was unnecessary. During typical urban development processes, these authors argued, jobs initially cluster in the city center to take advantage of proximity to other firms and workers (via transportation networks). Later, as congestion occurs, jobs migrate to suburban locations where workers soon follow. Market dynamics efficiently allocate land and commuters make rational choices – trading-off commuting distance with other quality-of-life factors including school quality, housing character, neighborhood amenities, and the needs of dual-earner households. For these authors, jobs-housing balance would explain only a small portion of location decisions and commuting behavior.

What these authors neglected, however, was the reality of actually functioning housing markets. Work in urban economics has documented the existence of exclusionary zoning practices and incentives that drive jobs-housing imbalances and create places where affordable housing is in extremely short supply and others where it is abundant (Hernandez, 2009; Quigley & Rosenthal, 2005). Cervero elaborated on some of these practices, noting that jurisdictions prefer to zone land for high revenue generation and low service demand (typically commercial properties) and that growth moratoria and restrictions limit the application of building permits and allowable densities, particularly in suburban locales (Cervero, 1989). He showed that the amount of residentially zoned land and housing prices affected the amount of in-commuting to employment sites in the San Francisco Bay Area. An analysis conducted by Levine corroborated these findings (Levine, 1998). That work showed that low- and middle-income workers had stronger preferences for affordability and density than did high-income workers. To the extent that suburban land use controls artificially restricted density and the total number of affordable housing units, then low- and middle-income workers would be disadvantaged by a “normally” functioning market.

Later work by Cervero complicated the debate while providing support for the focus on market failures in suburban job locations (Cervero, 1996). He found that, from 1980 to 1990, the Bay Area’s largest cities tended toward increasing balance, but that this trend was uneven. Cities that were historically housing rich (early suburbs) saw increase in jobs over that period and tended to become more balanced. But, even in areas that had achieved balance, the proportion of local jobs that were filled by employed residents (referred to as “self-containment”) was low. This led Cervero to conclude that there was a mismatch between the quality and character of available housing and the tastes, preferences, and resources of locally employed workers. Reframing the issue of jobs-housing balance, he stated that

If reducing VMT and encouraging more walking, biking, and transit riding are explicit policy objectives, then building housing suited to the earnings and preferences of local workers and attracting industries suited to the skill levels of local residents could very well pay more dividends than ensuring parity in numbers of jobs and housing units would. (Cervero, 1996, p. 499)

In other words, it is not the *balance* between jobs and housing that matters for transportation outcomes, but rather the *fit* between locally available housing and the ability of locally employed workers to afford it. Because high-income workers inherently have more flexibility and choice in terms of their housing location decisions, and because of the dynamics of suburban housing markets, this is a problem that manifests primarily in suburban locations that tend to underprovide affordable housing options for low-wage workers. The marginal value of a dollar saved is also likely to be higher for a low-wage worker. When provided with an opportunity to live closer to where they work, the reduction in transportation costs would be comparably much more attractive for a low-wage worker than a high-wage worker, all else equal.

Although much of the prior work examined trends in jobs-housing balance indicators and location choices, explicit differences in observed commuting behavior and travel outcomes have also been observed in the literature, further underscoring the importance of looking at fit, not just balance. Using travel survey data for the Portland metropolitan region, Peng showed that areas with larger imbalances between jobs and housing attracted more in-commuting VMT while controlling for population density and number of high-income households (Peng, 1997). Similarly, Sultana examined mean commute travel times between zones in the Atlanta metropolitan region, showing that workers commuting to areas with balanced jobs and housing had shorter commute travel times than workers commuting to imbalanced areas (Sultana, 2002). These links to travel behavior appear to hold in the aggregate, for particular regions, but stronger predictions can be made when accounting for differences in subpopulations. For example, Cervero and Duncan calculated daily VMT for respondents to a Bay Area travel survey and included an indicator of the fit between jobs and housing (Cervero & Duncan, 2006). They demonstrated that a measure of “occupationally matched” jobs within 4 miles of a census tract was a better predictor of work tour VMT than total jobs.

The literature on “excess commuting” has also found fruitful points of contact with the jobs-housing balance literature and can provide results disaggregated by income group (Horner, 2002, 2007; White, 1988). Excess commuting is concerned with the optimal location of workers and households within a region, given existing spatial structure. In other words, given the extant transportation network and household locations, how short could the mean commute be if workers could be reassigned to new jobs closer to their residences? The result is referred to as the “theoretical minimum commute” and can be thought of as an indicator of aggregate jobs-housing balance, since it represents the locations of jobs and housing units independent of individual choices (Horner, 2002). Much of the excess commuting literature is based on aggregate indicators calculated for entire regions, with studies generally showing that the spatial arrangement of jobs and housing explains statistically significant but modest portions of commuting behavior (Giuliano & Small, 1993; Scott, Kanaroglou, & Anderson, 1997; Sultana, 2002). Few studies have looked in detail at whether the relationship might differ for low-income workers, but Giuliano and Small did present

results disaggregated by occupational category, noting that, “although the mismatch most commonly cited involves income level, it is very difficult to define accurately the relationship between observed incomes and feasible housing prices” (Giuliano & Small, 1993, p. 1496). In other words, determining which housing units would be affordable to which classes of workers would be quite a difficult exercise. Their results showed little difference between employment categories and the overall regional average minimum commute, but this result could have been due to the relatively wide variation in incomes possible within a single coarse job category. Larger differences in commuting behavior between occupational categories were described by O’Kelly and Lee using data for Boise, Idaho and Wichita, Kansas (O’Kelly & Lee, 2005).

Until recently, detailed data on job wage levels and commuting behavior simply were not available. Many of the prior studies on excess commuting relied on Census Transportation Planning Package (CTPP) data to examine the demographics of workers and employed residents. Horner and Mefford, for example, analyzed 1990 CTPP data disaggregated by race in Atlanta, showing that Black and Latino workers were relatively more constrained in their home and work location choices than were White workers (Horner & Mefford, 2007). Similarly, Stoker and Ewing used CTPP data to investigate the extent to which the proportion of people living and working in the same local area is related to both jobs – worker balance and income match (Stoker & Ewing, 2014). They found that both income match between residents and workers and overall jobs–worker balance influenced the internal capture of trips, but the effect size for balance was larger than that for income match. This analysis is constrained by limitations in the CTPP data for this purpose. The CTPP contains place-of-work data, but the income characteristics are based on individuals, not jobs, and are annual income, not wage levels. Given that more than 10% of US workers separate from their employers each quarter, and perhaps as much as 40% in a single year (Andersson, Holzer, & Lane, 2005; Burgess, Lane, & Stevens, 2000; Davis, Faberman, & Haltiwanger, 2006), it can be misleading to assign annual income figures to a single place of work.

The Longitudinal Employer-Household Dynamics (LEHD) dataset provides an opportunity for more detailed analysis of jobs-housing fit than was previously possible. The excess commuting literature is beginning to use these data and has compared results for workers in the three categories of wages available in the LEHD. For example, Horner and Schleith showed that low-wage workers in Leon County, Florida, had a shorter theoretical minimum commute than high-wage workers, indicating that the spatial arrangement of low-wage jobs and employed low-wage residents was relatively more balanced than other wage groups (Horner & Schleith, 2012). For the particular county examined in that study, high-wage workers tended to locate their residences at greater distances from available jobs than did low-wage workers. These theoretical minimum commute measures provide concise indicators of regional balance or fit, but provide little insight into subregional variation. Although the metric can be used to compare different groups (Horner & Mefford, 2007; Horner & Schleith, 2012), it has no ability to identify problematic areas in need of mitigation (i.e., the provision of affordable housing).

The conclusion that one can draw from this work is that jobs-housing fit appears to be more important than aggregate jobs-housing balance. In other words, aggregate numbers of jobs and housing can be approximately similar, but if the type of housing

available is not well matched in terms of quality and character to the wage and salary levels of jobs in the area, then there will still be an effective imbalance, resulting in the need for workers to commute long distances. While past work was limited in its ability to examine this issue due to data constraints, the emergence of new data sources allows researchers to take a new look at the issue of jobs-housing fit and apply some of the insights gleaned from the excess commuting literature regarding the travel behavior of different market segments. The remainder of this article describes the development and application of an explicit indicator of low-wage jobs-housing fit. We argue that the indicator can highlight problematic areas in a region that are in need of affordable housing development that are not evident from a traditional measure of jobs-housing balance, and illustrate the impact of using different distance thresholds for the neighborhood-level analysis.

Data and methods

In order to address some of the prior shortcomings identified in the broader jobs-housing balance literature, we develop an indicator of *low-wage jobs affordable housing fit*. An important consideration that guided the design process was the need to ensure both the metric's validity and its ease of use (Reed, Fraser, & Dougill, 2006). Specifically, we collaborated with affordable housing, civil rights, and climate change advocates throughout Northern California in a broadly collaborative process to determine the indicator's properties and data sources. Their fundamental concern involved identifying jurisdictions that were underperforming on their affordable housing production. They sought an indicator that was easy to use, could inform their advocacy, and could be updated over time as new data became available. We employed publicly available data on job numbers from the LEHD and housing numbers from the American Community Survey (ACS). Developing a metric from these two sources required a number of design decisions. These were made in collaboration with community partners and are discussed in detail below.

Jobs data

To avoid some of the limitations of CTPP data mentioned above, we extracted low-wage job numbers for census blocks from the 2011 LEHD Origin-Destination Employment Statistics (LODES) dataset. The dataset is developed by the US Census Bureau in collaboration with state partners and combines a variety of federal and state administrative data on employers and employees with core census products to provide employment characteristics based on place of residence and place of work, as well as commute flow data. The data are available at the census block level and can be aggregated to other geographies. We used the 2011 LEHD California Work Area Characteristics (i.e., job location) file. The low-wage job variable in the LEHD counts number of jobs with monthly earnings of \$1250 or less. This is the equivalent of \$15,000/year for someone working for 12 full months.¹

Unlike the CTPP, the LEHD can contain multiple records per worker. Additionally, the LEHD does not indicate whether a job is full-time or part-time, short-term or long-term – it simply measures monthly earnings. There is a danger, then, that jobs

identified as low-wage in the LEHD could actually be held by individuals earning a higher annual income than the monthly earnings in that job would suggest. Individuals piecing together employment can afford more housing than they could if they were working a single job. However, our concern is not with the overall job searching behavior of a household, but whether a single job provides an income adequate to house a worker nearby. It is important to note that the jobs that are counted are those that are unemployment insurance-covered wage and salary jobs, as reported by state labor market information offices and by the Federal Office of Personnel Management. This covers most public- and private-sector employment, but excludes the self-employed, postal workers, the military and other security-related federal agencies, and some employees at nonprofit and religious institutions (Graham, Kutzbach, & McKenzie, 2014).

Housing data

Data on housing units were taken from the ACS 2007 – 2011 5-year estimates.² For this assessment of low-wage workers and low-wage jobs, we focused on rental units because low-income earners are far more likely than high-income earners to rent their homes (Schwartz, 2010). To calculate an affordable monthly rent for low-income households, we assumed that spending 30% of total household income on housing costs is reasonable. This figure is widely accepted among affordable housing developers and advocates, and is the threshold above which the US Department of Housing and Urban Development considers a household to be cost-burdened and may have difficulty in affording other necessities (Hulchanski 1995; Schwartz, 2010). But what is the appropriate total household income that would be appropriate for this low-income jobs/affordable housing ratio? Many affordable housing developers are accustomed to thinking about household income levels that are based on the area median income (AMI) and number of people per household, since these are used as criteria for various state and federal housing subsidy programs. For example, in 2011, 50% of AMI income limit (considered very low income) for a single person and four-person household in the City and County of San Francisco was \$37,400 and \$53,400, respectively.³

For the purposes of this analysis, however, it is essential to use some multiple of the \$1250/month wage threshold, rather than AMI. This is because one of the primary strengths of the LEHD is that it is updated annually, making it possible to assess changes over time. But the \$1250/month threshold used by the LEHD data has not been adjusted for inflation since the dataset was first developed. Thus, the percentage of jobs falling into that low-wage category shrinks year to year simply as a result of inflation. If some portion of the AMI was used as the housing affordability threshold, this figure would adjust year to year with inflation, thus artificially and inappropriately reducing the low-wage jobs to affordable housing ratio.

We thus considered several possible multiples of \$1250/month for our low-income household income level. The overall jobs to housing ratio in all census places in the nine-county San Francisco Bay Area is 1.2,⁴ suggesting that an annual income of \$18,000 ($\$1250/\text{month} \times 12 \text{ months} \times 1.2$) might be reasonable. An alternative figure could be based on the average number of jobs per households headed by the *working age population*, since there are many households in the region headed by retirees, and

calculations of housing needs for this population are not directly related to jobs. This would suggest multiplying \$1250 by 1.5 (the average number of jobs per household with the householder aged under 65 years in the region).⁵ This calculation would result in an annual household income of \$22,500 as the threshold. Since low-income households on average have fewer income earners than high-income households, this might provide a reasonably accurate picture of the challenges people employed in low-wage jobs actually face in trying to find affordable apartments and homes. On the other hand, some portion of people in these jobs are likely to be younger people still living with their parents, or students (and other young people) living in group houses or apartments. Furthermore, a threshold of \$22,500 would be substantially below those used by affordable housing developers to define low-income status.⁶

Given these considerations, we decided to set the low-income threshold at \$30,000 a year of household income, or two times the \$1250/month threshold of the low-wage job category. It is important to stress that in selecting \$30,000/year as our threshold, we are not assuming that there would necessarily be two low-income earners per household. We are simply selecting what we believe is a reasonable value to designate a low-income household that is a multiple of the low-wage job threshold, so that we can make consistent comparisons over time, including when the Census Bureau inevitably changes their low-wage definition in the LEHD data. Using this threshold, an affordable monthly rent for a low-income household with an annual income of \$30,000 would be \$750/month ($30\% \times \$30,000/12$). We summed counts of rental units with both contract rent (renter-occupied units) and rent asked (vacant for-rent units) less than \$750/month as well as the category “no cash rent” to count the number of affordable rentals. These variables measure the rent of housing units independent of the incomes of their current residents and are likely to understate the barriers to renting faced by newcomers to the market since they include rents for units that have been occupied for extended periods of time and rent-controlled units.

The smallest census geography for which there are ACS data available is the block group, but the associated margins of error (MOEs) are quite large and geographic coverage is not complete. We instead used affordable unit totals at both the census place and tract scale. From the tract, we created estimates of affordable rental units for census blocks assuming that affordable rentals were distributed throughout the blocks in the same proportions as total housing units according to the 2010 decennial census totals.

Geographic scale and metric calculation

With both housing units and jobs tabulated for census blocks, it is possible to calculate the low-wage jobs-housing fit metric for arbitrary geographies. Our primary interest here is at two scales: census places (including incorporated cities and towns as well as census-designated places) and a neighborhood (census tract) measure. Using places as the unit of analysis can highlight jurisdictions that are underproviding affordable housing relative to their demand for low-wage labor. The jurisdiction is important because it is ultimately jurisdictions that control land-use decisions. In California, jurisdictions are also responsible for meeting housing targets by affordability category under the state’s Regional Housing Needs Allocation (RHNA) (Barbour & Deakin, 2012; Lewis, 2003). The metric for census places is calculated using Equation 1,

$$\text{Low-wage jobs-housing fit}_i^1 = \sum_j \frac{\text{Low-wage jobs}_j}{\text{Aff. Rentals}_j}, \quad (1)$$

where superscript 1 indicates that this is the place metric and j indexes all census blocks located within place i .

While important from the perspective of affordable housing provision, the jurisdiction level is quite coarse. Analyzing only jurisdictions can miss variations in jobs-housing fit that occur at a neighborhood scale within cities or locally, across jurisdictional boundaries. On the other hand, expecting individual census tracts to evidence perfect fit is not likely to be reasonable; these are often relatively small-area geographic units whose scale represents an unreasonably low commute distance. It is likely appropriate to develop a buffer distance based on a judgment regarding reasonable commute sheds or buffers around the tract (Cervero & Duncan, 2006; Peng, 1997; Stoker & Ewing, 2014).

We tested two different buffer definitions for the tract measure: one designed to be interpretable (an unweighted measure) and another designed to privilege the concentration of low-wage jobs and affordable housing near population centers by weighting using a distance-decay function. The first step for both measures was to calculate a population-weighted centroid for each tract based on the population within census blocks. Determining an appropriate method for calculating the number of low-wage jobs and affordable rental units within a reasonable or desirable commute distance of this population-weighted tract centroid is challenging. Depending on the decision, substantially different conclusions can be drawn. However, in an investigation of the scale dependence of three measures of commuting efficiency, Niedzielski, Horner, and Xiao (2013) found that measures of capacity used and commuting economy were relatively unaffected by the areal unit, though a measure of excess commuting was highly sensitive to modifiable areal unit problems, confirming earlier findings (Horner & Murray, 2002). The authors concluded, though, that “more aggregated data, such as LEHD data aggregated to census tracts for example, can be used safely in the knowledge that the metric results will hardly be different from those based on less aggregated data” (Niedzielski et al., 2013, p. 141).

Our interest here is primarily in determining whether affordable housing and low-wage jobs are relatively balanced, rather than on regional-scale commuting patterns, so we used a distance buffer that would be relevant for an analysis based on walking or biking as the primary means of travel to work. It is important to emphasize that focusing on a relatively short walk/bike-scale buffer can also provide insights into broader commute patterns, since home – workplace proximity continues to be a major factor in household location choice, and this is particularly important when people change their home or workplace. In the case of Paris, for example, commute length “exerts a much stronger influence [than economic, social, or demographic characteristics] on the likelihood that home or workplace changes will shorten trips to work” (Korsu, 2012, p. 1963).

A half-mile has become widely accepted as the appropriate distance for gauging people’s willingness to walk to transit (Guerra, Cervero, & Tischler, 2012). The 2009 National Household Travel Survey (NHTS) found that the average commute trip length for those who walked on the day of the survey and reported a “usual commute” mode

of walking in the previous week was 0.98 miles (Santos, McGuckin, Nakamoto, Gray, & Liss, 2011, p. 48). According to the 2010–2012 California Household Travel Survey (CHTS), the equivalent figure for the state was close to 0.44 miles, and for the nine Bay Area counties, it was about 0.41 miles (California Department of Transportation, 2013).

For biking to work, the 2009 NHTS found that the average distance was 3.8 miles (Kuzmyak and Dill 2012; Stinson, Porter, Proussaloglou, Calix, & Chu, 2014). In the CHTS, the average bike commute statewide was 3 miles and in the nine Bay Area counties, it was about 2.8 miles. There are obviously a wide range of factors that shape the frequency and distribution of bike commutes, including topography, street connectivity, gender, and whether employers provide bike parking, lockers, and showers (Buehler, 2012; Iseki & Tingstrom, 2014; Winters, Brauer, Setton, & Teschke, 2013), but our analysis here only allows us to look at overall average patterns, not based on characteristics of individual workplaces.

Using these average walk- and bike-commute distances, we developed our two low-wage jobs-housing fit measures. For the intuitive metric, we followed the jurisdiction-based approach and calculated an unweighted ratio using a hard cutoff, counting all low-wage jobs and affordable rentals within a 2.5-mile buffer, as shown in Equation 2,

$$\text{Low-wage jobs-housing fit}_i^2 = \sum_j \frac{\text{Low-wage jobs}_j}{\text{Aff. Rentals}_j}, \quad (2)$$

where the superscript 2 indicates that this is the intuitive metric and j indexes census blocks within a 2.5-mile straight line distance of the population-weighted centroid of tract i .

For the weighted distance-decay metric, each low-wage job and affordable rental unit within 0.5 miles of the population-weighted tract centroid was weighted at 1.0. Jobs and housing units located between 0.5 and 3.0 miles were assigned a declining weight using a linear function, and those located further than 3.0 miles from the centroid were weighted at 0. This calculation is summarized in Equation 3,

$$\begin{aligned} \text{Low-wage jobs-housing fit}_i^3 \\ = \frac{\sum_j \text{Low-wage jobs}_j + \sum_k \text{Low-wage jobs}_k \times (-0.4d + 1.2)}{\sum_j \text{Aff. Rentals}_j + \sum_k \text{Aff. Rentals}_k \times (-0.4d + 1.2)}, \end{aligned} \quad (3)$$

where the superscript 3 indicates that this is the distance-weighted metric, i indexes census tracts, j indexes census blocks within 0.5 miles of tract i 's population-weighted centroid, k indexes census blocks between 0.5 and 3.0 miles of tract i 's population-weighted centroid, and d is the straight line distance between the population-weighted tract centroid of tract i and block k .

Results and discussion: Bay Area low-wage jobs-housing fit

Jurisdiction-level analysis

A key goal of this study was to compare traditional measures of jobs-housing balance with low-wage jobs-housing fit. Figure 1 shows a comparison of these metrics for census places in the San Francisco Bay Area by overlaying the kernel density plots



Figure 1. Kernel density plots for traditional jobs-housing balance and low-wage jobs-housing fit in census places in the Bay Area.

illustrating the distribution of each measure. The figure clearly shows that there is a dramatic difference between balance and fit. According to the traditional balance measure, most jurisdictions seem to have an adequate supply of housing units in comparison to the number of jobs available. The ratios cluster around 1. The low-wage jobs-affordable housing fit measure, however, shows that a substantially larger number of jurisdictions have a poor fit between the number of low-wage jobs and availability of affordable rental units, with much larger values of the ratio indicating that there are many more low-wage jobs than affordable rental units in many jurisdictions across the Bay Area. These results are obscured using traditional measures.

Figure 2 maps the actual low-wage jobs-affordable housing fit for census places in the Bay Area. Jobs-housing fit ratios are grouped into four categories, indicated by increasingly dark shades of grey: <1 (lightest grey), 1–2, 2–4, >4 (darkest grey). Hash-marks indicate places where the calculated MOEs cross these categorical boundaries, with the shading indicating whether the calculated MOEs include simply an adjacent category, or whether they are so large as to cross to multiple other categories.

This figure shows locations in the Bay Area facing substantial challenges with their low-wage jobs-affordable housing fit. For nearly all of the southern San Francisco Bay (the heart of Silicon Valley), the ratio of low-wage jobs to affordable rental units exceeds 4.0. One exception is the small city of East Palo Alto, a well-known pocket of poverty in the region. Similar ratios are evident in the East Bay suburbs of Concord, Walnut Creek, Livermore, Pleasanton, and surrounding areas. These are all residential suburbs that have significant concentrations of low-wage work in the retail, restaurant, and accommodation sectors, but provide relatively few affordable rental units. Jurisdictions with relatively good fit (ratio of 1–2.5) include the inner East Bay cities of San Pablo (1.3), Oakland (1.4), Richmond (1.4), and Berkeley (2.0), as well as older inner-ring suburbs such as Pittsburg (2.1) and Vallejo (2.2). San Francisco also has a relatively good fit (2.1), which is perhaps surprising given its reputation as a high-housing-cost city. This is likely due to complementary factors that reduce the numerator and increase

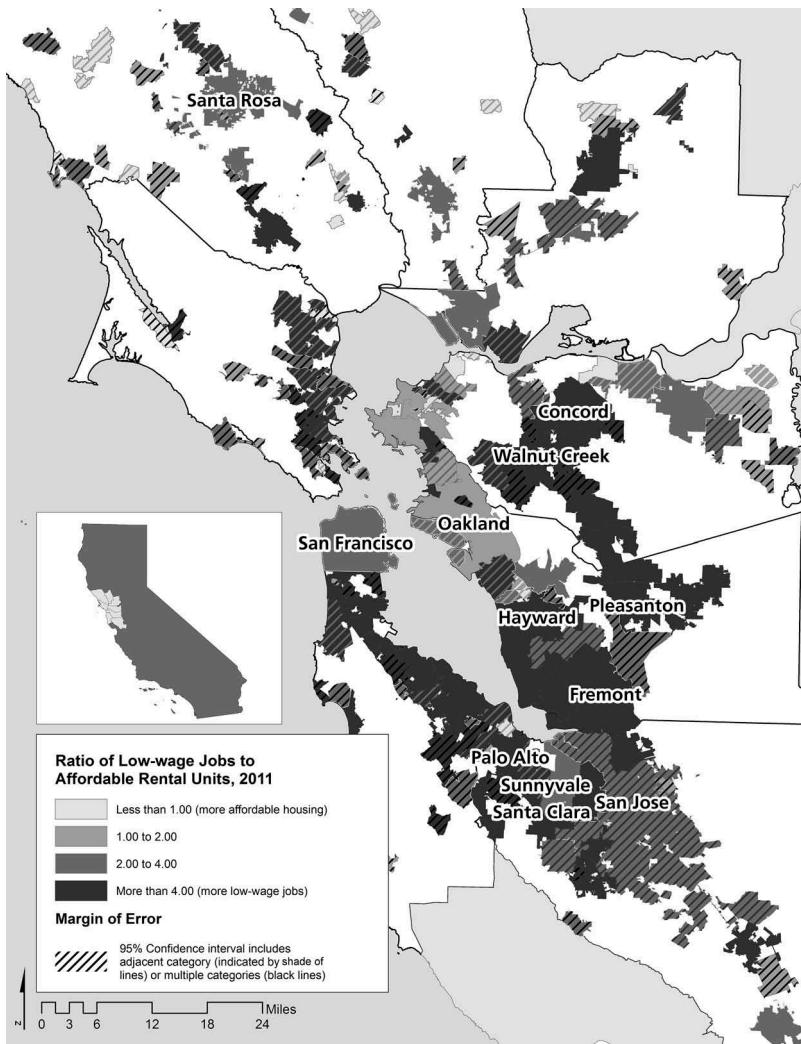


Figure 2. Low-wage jobs-housing fit for census places in the San Francisco Bay Area. Sources: 2011 LEHD Origin-Destination Employment Statistics dataset (job locations), 2007–2011 American Community Survey five-year estimates (rental unit locations and price).

the denominator of the jobs-housing fit ratio. The city's higher minimum wage (which was \$9.92 in 2011) reduces the number of jobs paying less than \$1250/month, and both rent control and an overall high proportion of rental units combine to increase the number of units below the \$750/month affordable rental threshold.

Neighborhood-level analysis

For the neighborhood (census tract)-level analysis, [Figure 3](#) compares the low-wage jobs-housing fit metric calculated using the unweighted 2.5-mile hard threshold to the 3.0-mile weighted distance decay metrics. The results are quite similar between both methods. A Kolmogorov–Smirnov test on the similarity of two variables fails to reject

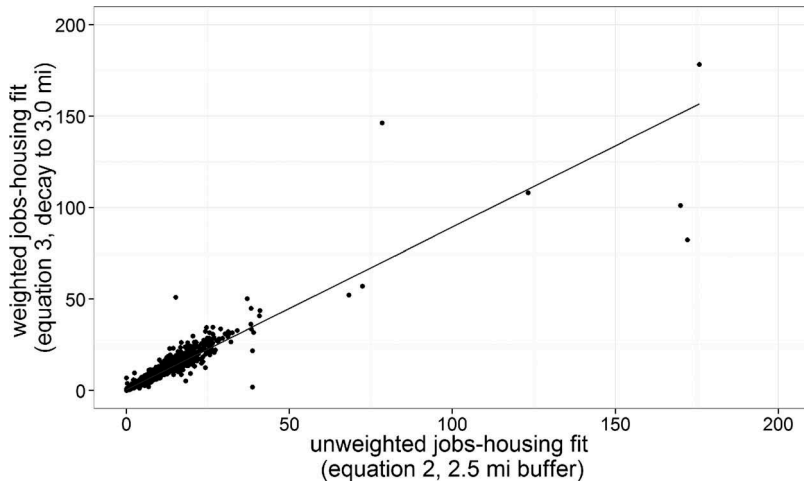


Figure 3. Comparison of low-wage job-housing fit metric calculated using unweighted 2.5-mile buffer (Equation 2) with weighted distance-decay metric to 3.0 miles (Equation 3).

the null hypothesis that the observations are drawn from the same distribution ($D = 0.0127$, p value = 0.5409). Accordingly, [Figure 3](#) shows a nearly 1:1 relationship. Further, 90% of the tracts do not shift categories between the two methods. Thus, given the greater ease of interpretability of the simple ratio measure to a broader public, we focus the remaining discussion on the unweighted ratio measure calculated using a 2.5-mile buffer.

[Figure 4](#) illustrates the result of calculating jobs-housing fit for 2.5-mile buffers around census tracts in the Bay Area. Two dimensions are plotted on the map: low-wage job density at the tract level and jobs-housing fit at the buffer level. Jobs-housing fit ratios are grouped into four categories: <1 (blue), 1–2 (green), 2–4 (yellow), and >4 (red). The three shades in each color indicate tertiles based on the number of low-wage jobs, with darker shades in each category indicating increasing numbers of low-wage jobs. [Figure 4](#) also clearly shows areas with substantial issues with low-wage fit in the Bay Area. The only areas that appear to have relatively good fit are the urban core areas of Oakland and Richmond. These are also jurisdictions that experience high poverty and have high populations of people of color. The areas with the worst fit are located in the East Bay suburbs, the Peninsula (south of San Francisco), and Silicon Valley. Low-wage workers employed in these areas are unlikely to find affordable housing close to their jobs and may have to commute long distances.

These results are broadly consistent with opinions expressed by Bay Area housing and transportation advocates, particularly in the context of new regional planning initiatives. With California's passage of the Sustainable Communities and Climate Protection Act (SB 375) in 2008, the integrated issues of land use, transportation, and housing have been combined into a single regional planning process. The Metropolitan Transportation Commission (MTC) and the Association of Bay Area Governments (ABAG) completed their 2013 Regional Transportation Plan (RTP) and Sustainable Communities Strategy (SCS) entitled *Plan Bay Area*. The SCS is a new document

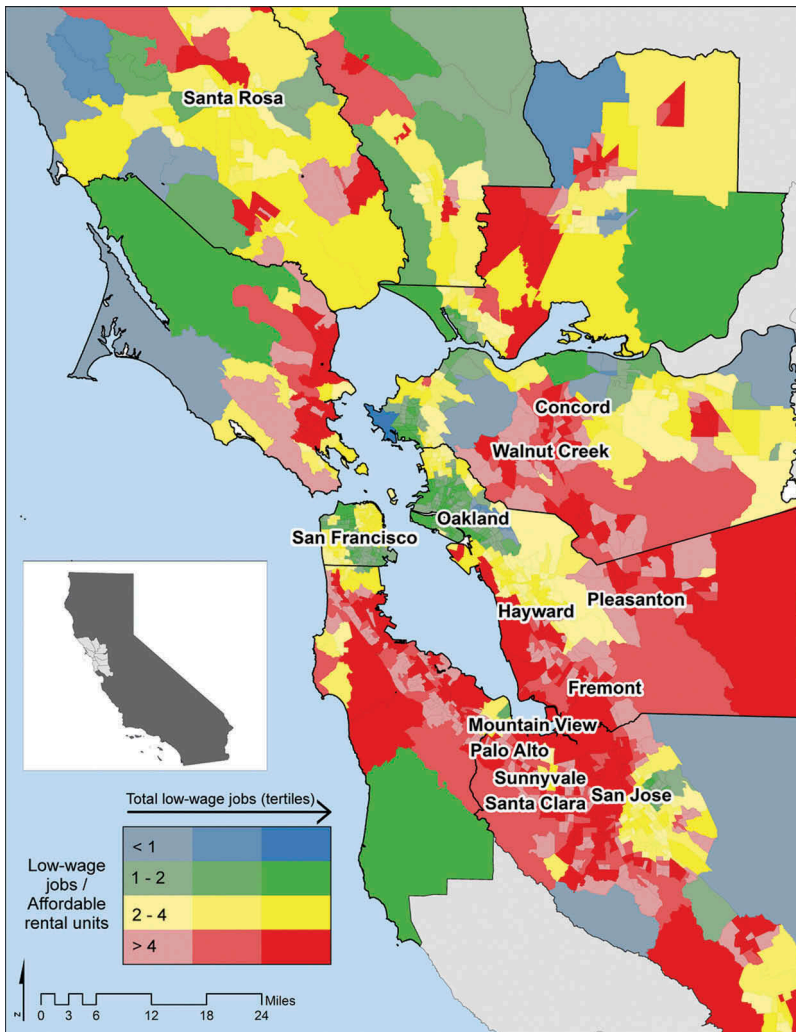


Figure 4. Jobs-housing fit for census tracts in the San Francisco Bay Area. Ratios calculated at 2.5-mile buffers around census tracts. Sources: 2011 LEHD Origin-Destination Employment Statistics dataset (job locations), 2007–2011 American Community Survey five-year estimates (rental unit locations and price).

required by SB 375 that illustrates how a region will meet a future GHG reduction target through coordinating transportation and land-use planning.

Advocates for affordable housing and transportation equity were deeply engaged in the *Plan Bay Area* public participation process and ultimately developed their own transportation–land-use scenario – entitled “Equity, Environment, and Jobs” (EEJ) – that was modeled by the regional agencies (Marcantonio & Karner, 2014). In contrast to the agencies’ proposed plan, EEJ increased local transit operating funding, shifted overall capital expenditures from highways to transit, and located more low-income earners closer to low-wage jobs in many of the suburban areas identified in Figures 2 and 4. The EEJ scenario was designated the environmentally superior alternative under California’s

environmental review laws. The agency plan placed most population growth adjacent to areas already well served by high-quality transit. While this strategy is important, it neglects areas with high numbers of low-wage jobs, poor transit service, and housing affordability issues. The EEJ scenario results show that strategies that simultaneously address housing affordability and transit-oriented development can perform better than those that focus only on the latter. The low-wage jobs-affordable housing fit metric developed here can identify areas in regions where such strategies could potentially result in overall environmental benefits, as there is some preliminary evidence that places in California with better low-wage jobs-affordable housing fit measures have lower VMT (Karner & Benner, 2016).

Limitations

There are a few important limitations to the use of this low-wage jobs-affordable housing fit metric that are rooted in the characteristics of the data sources and that are important to acknowledge. Probably the most important has to do with the earnings thresholds in the LEHD data. The LEHD only identifies jobs with monthly earnings of \$1250 per month or less, from \$1251 to \$3333 per month, or more than \$3333 per month. In the San Francisco Bay Area, the lowest wage category accounted for 19.7% of total jobs in 2011, and can be considered truly the lowest-wage jobs in the region. In other parts of the country, this threshold would include somewhat higher levels of the labor market. In the McAllen–Edinburg–Mission, TX MSA, for example, which is one of the lowest-earnings MSAs in the country, 36.1% of jobs in 2011 fell into the lowest wage category. Thus, in the San Francisco Bay Area, this metric does little to identify a lack-of-fit at higher earnings levels, and thus may understate housing affordability challenges for other low-wage workers who are not at the very bottom of the labor market.

Another limitation is that this analysis only looks at rental units. It is possible to develop a calculation of affordability based on the value of owner-occupied units, and we have done so in other venues (Benner & Tithi, 2012), but this approach requires various assumptions about mortgage interest rates, the value of mortgages in relation to home value, and other costs and benefits of ownership (e.g., property tax, insurance, mortgage interest, and property tax deductions) that make such analysis more speculative.

As discussed in our methods section above, there are also limitations related to the spatial scale of analysis. The ACS has quite high MOEs at small geographies, and the LEHD LODES dataset is a partially synthetic dataset, so the small-area geographies are also especially sensitive to modeling assumptions. This limits a reasonable analysis to the tract scale or larger (e.g., tract plus buffer, or census place), and even here the findings should be interpreted as estimates subject to measurement error.

Conclusion

The literature on jobs-housing balance has long posited that aggregate balance between jobs and housing units, while important, is not by itself a sufficient indicator of transportation performance or housing market health. That work has argued for a

qualitative match between the quality and character of local housing and the wages, tastes, and preferences of the locally employed workforce. Moreover, prior work has shown that parochial housing policy will likely be promulgated in areas that are jobs rich but housing poor. This ensures that truly affordable units will be undersupplied. Although individuals choose home and work locations for a number of different reasons – not just to minimize commute distance – we expect that low-wage workers would be particularly sensitive to the impacts of housing prices and commute distances. With less disposable income, the opportunity to save money on transportation costs by living close to one's workplace is relatively more attractive for a low-wage worker than a high-wage worker.

Prior to the widespread availability of the LEHD data, there was no way to adequately identify and quantify the location of low-wage jobs with a reasonably high degree of spatial resolution. The work presented above shows how these data can be used to develop a metric of low-wage jobs-housing *fit* that can be calculated at multiple geographies and used to target affordable housing investments. The collaborative nature of the metric's development ensured that it would be intuitive and useful to those affordable housing advocates that desired to use it. It has been actively applied to ongoing conversations regarding housing affordability and economic development in the Bay Area and elsewhere in Northern California. While we have used data specifically for the San Francisco Bay Area to illustrate the utility of the method, the data are available in the vast majority of states for any geography of interest.

One promising area of future work involves relating jobs-housing fit to travel behavior, total VMT, and location affordability.⁷ After all, there are many factors that go into housing and workplace location decisions; a better jobs-housing fit on its own does not guarantee superior transportation and housing/labor market outcomes. Thankfully, the development of new data sources on job quality at a local level enables researchers and planners to more effectively investigate the impact of a better jobs-housing fit than was possible in the past. The development of the metric is timely, occurring in concert with the rise in concerns about housing affordability following the mortgage crisis and its aftermath. The development of improved measures of jobs-housing fit, like the one introduced here, will promote meaningful debates among a broad constituency about the relative importance and merits of promoting a jobs-housing fit in cities and neighborhoods throughout the country.

Notes

1. For comparison, the Federal poverty levels in 2011 for an individual, a family of two, and a family of four were \$10,890, \$14,710, and \$22,350, respectively.
2. See [Appendix 1](#) for a discussion of the associated margins of error (MOEs).
3. See: <http://www.hcd.ca.gov/fa/home/homelimits.html>.
4. Based on total number of jobs from the LEHD data, and total number of housing units from the ACS.
5. In the 9-County Area in 2011, the Employment Development Department estimates there were a total of 3,194,200 jobs, and the Decennial census identified 2,070,458 households with householders under the age of 65.
6. For San Francisco County in 2011, for example, the California Department of Housing and Community Development considered \$48,100 to be low-income for the purposes of the

Community Development Block Grant (CDBG) programs, and \$76,950 to be low-income for the purposes of the HOME Investment Partnerships Program. See <http://www.hcd.ca.gov/fa/home/homelimits.html>.

7. See <http://locationaffordability.info/>.

8. For details, see Appendix 3 of US Census Bureau (2008).

9. This value is calculated for each of the 50 states separately. Details of this methodology are described in chapter 12 of *American Community Survey Design and Methodology* (Washington, DC: UC Census) available here: http://www.census.gov/acs/www/methodology/methodology_main/.

Disclosure statement

No potential conflict of interest was reported by the author.

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Appendix 1. Margins of error in American Community Survey data

All of the data from the American Community Survey has a margin of error (MOE) associated with it, which represents the equivalent of a 90% confidence interval. In other words, we can be 90% confident that the actual value for any variable is the reported amount plus or minus the MOE. At the census place level, we calculated MOEs using the formula for calculating MOEs for derived ratios where the numerator is not a subset of the denominator.⁸ The formula for this is:

$$MOE_R = \frac{\sqrt{MOE_{num}^2 + (R^2 * MOE_{den}^2)}}{X_{den}},$$

where MOE_{num} is the MOE of the numerator, which in this case is 0 since the jobs numbers are reported without an MOE.

$R = \frac{X_{num}}{X_{den}}$ where the numerator is the job figure and the denominator is the housing figure.

MOE_{den} is the MOE of the denominator, which in our case is the housing figure. In all cases, we are combining figures for multiple different categories, so this figure is calculated from the formula for calculating MOEs when aggregating count data, which is:

$$MOE_{agg} = \sqrt{\sum_c MOE_c^2},$$

where MOE_c is the MOE of the c th component estimate.

We calculated this MOE_c by simply aggregating all the categories *below* our threshold (e.g., aggregating MOE values for contract rent that is less than \$100; \$100–\$149; \$150–\$199; \$200–\$249; and so on up to \$750/month), with some modifications as explained below.

In some of these narrow rent bands, the census has an estimate of zero. Since the normal way the census estimates MOEs is based in part on the survey weights assigned to the sample respondent, in these categories where there was no respondent selected, the formula used produces a zero standard error, which is clearly inaccurate since a different survey sample might have revealed some respondent in those categories. Thus, in those cases with a zero estimate, the census uses a method that is based on a comparison between the ACS and the decennial census that uses a calculation based in part on an *average* difference by state between the ACS estimate and the actual value from the census for variables in which this value is possible to compare. All geographies within a state are then assigned the same value as the state totals. In 2011, this resulted in a margin of error of ± 95 for all categories with a zero estimate in California.⁹ In most cases, therefore, the MOE for zero-estimate categories is actually higher than in cases where there is some estimate.

While this is reasonable for examining any single zero-estimate category, when aggregating across multiple zero-estimate categories in a single geography, we think this overstates the actual margin of error. To account for this, in calculating our combined MOE_{agg} , we combine all zero-estimate categories into a single category and use a single MOE_c of ± 95 . This was recommended to us by US Census Bureau technical data staff as an “unofficial” recommendation, and we believe it is a reasonable approach.