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Assessing the Balance of Modest-Wage Jobs and Low-Cost Housing: a Case Study of the Richmond Region[1]

Territorio Italia 2017, 2, 2; doi:10.14609/Ti_2_17_2e

Keywords: **Jobs-Housing Balance, Affordable Housing, Thiessen Polygon, Gravity Model, Geographic Information Systems.**

Abstract The spatial mismatch of jobs and housing that characterizes many American metropolitan areas undermines both economic efficiency and the quality of life for workers and residents. Persons of limited means without access to an automobile suffer the most, because they cannot access jobs at far remove from their residences, and affordable housing is often located far from clusters of moderate-skill / moderate-wage jobs.

Jobs-housing balance analyses have been employed for some time to describe these issues. However, previous studies often use data that are not sufficiently granular to identify areas where imbalances are most acute. Using a very granular and complete database for the Richmond metropolitan area that we have constructed, and Thiessen polygons as well as a gravity model analysis, we describe areas, and policy interventions, where the problems of jobs-housing imbalance for persons of limited means are most acute.

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1 This paper is based on a study funded through the generous support of The Community Foundation Serving Richmond and Central Virginia, and the Richmond Association of Realtors: Understanding the Jobs-Affordable Housing Balance in the Richmond Region, by Thomas Jacobson, I-Shian Suen, Mike MacKenzie and Fabrizio Fasulo, Center for Urban & Regional Analysis, L. Douglas Wilder School of Government & Public Affairs, Virginia Commonwealth University (2017).

1 | INTRODUCTION

The spatial mismatch of jobs and housing that characterizes many American metropolitan areas undermines both economic efficiency and the quality of life. Even in those metropolitan areas that have adequate transportation networks and mass transit systems, the jobs-housing mismatch leads to long commuting times that exact significant monetary and psychic costs on commuters. But in areas that lack adequate regional mass transit systems – often second-tier metro areas – the problem is made worse because persons of limited means without access to an automobile cannot access jobs at far remove from their residences.

The mismatch between jobs and housing in the United States is, in large part, a result of the dominance of the automobile for personal transportation since 1950 and the sprawling settlement patterns that have both resulted from and, in turn, led to further sprawl and automobile dependence. In brief, the second half of the Twentieth Century witnessed the outmigration of manufacturing, residents, and then retail stores and services from the central city to outlying areas of the metropolis, followed by the gradual melting together of the suburbs of adjacent metro areas into metro regions. Although the auto-linked metropolis brings some advantages to its residents (Bogart, 2006), it exacts costs, especially on its low-wealth residents who can only find affordable housing in areas that are far removed from jobs for which they qualify.

Increasing polarization of wages in the United States since the early 1970s, driven partly by changes in production technology but also, in significant measure, by public policy, has severely exacerbated this problem. Politics and public policy have exacerbated this problem in other ways as well. In the United States, at least part of the reason for the spatial mismatch of affordable housing and moderate-wage jobs is traceable to racial and ethnic conflict, which leads to segregation. And it is also due to the fiscal structure of American municipalities, which drives them to attract wealthier residents and to exclude those of modest means. Yet, those same municipalities develop retail centers with low-wage jobs to serve their residents. Proposals to introduce affordable housing closer to lower wage retail centers are resisted by residents, who argue that lower-income persons will bring crime and reduce property values. A number of studies have demonstrated that these fears are unfounded.

Alternative development concepts, such as new urbanist settlements, while inspiring in some ways, do not adequately address racial and fiscal issues, and they may also unwittingly exacerbate sprawl and inaccessibility problems in areas surrounding the settlements (Marshall, 2000). Yet, it is entirely unrealistic to expect that American regions will create comprehensive mass transit systems and overcome their structural and political challenges anytime soon. Most American regions have neither the resources nor the political will to undertake such tasks. We must look, instead, for more pragmatic and perhaps, partial, measures.

The European concept of the “city region of short distances” provides a pragmatic ideal toward which policy and planning can strive in order to promote regional economic efficiency and social welfare in a world that may be dominated for some time to come by the personal automobile (Wankiewicz, 2012). Applied to the American context, a “community of short distances” would be one in which travel via transit or personal transportation may take place from home to work, to school, to shopping, and to recreation, but such trips would be for relatively short distances and they would not pose hardships, especially on those of limited means.

Although the policymaking process must determine what distances are “short” or which ones cause unacceptable hardships, policymakers must understand the reality on the ground. That is, they must

understand the extent to which the region fails to be a community of short distances with a relative balance of jobs, housing, services and amenities in reasonably close proximity to each other. The present study attempts to do that for the Richmond, Virginia metropolitan area, via jobs-housing balance analyses and pragmatic policy recommendations.

For some time, regional scientists and planners have conducted jobs-housing balance and similar types of studies (See for example, Cervero, 1989; Giuliamo, 1991). This body of work has informed our thinking and approach considerably. Here we build on those concepts but we use data that are more granular and which allow for aggregation at levels that follow the actual geography of the spatial jobs-housing relationship. This is important, because in America's politically fragmented metropolitan regions, policymakers are unlikely to look across jurisdictional boundaries to even understand jobs-housing imbalances, let alone address them effectively. A first step toward helping policy makers take a metropolitan-wide view of spatial relationships and craft realistic policies to improve these connections, is an information and analytical system that is at once sufficiently granular to show the relationships at micro scale, as well as at various scales of aggregation up to the entire metropolis itself.

We begin by reviewing the literature on the jobs-housing balance in the United States. We then introduce Metro View, a data system we have built using the Richmond Virginia Metropolitan Statistical Area's 17 local governments' administrative data (which are publicly available, but laborious to clean and aggregate for analysis) (See Figure 1). Next we present the results of our analyses of the spatial relationships between jobs and housing in the Richmond metro area, using the Metro View system. These analyses show significant imbalances and lack of access to jobs for low-wealth persons throughout the metro area. We conclude with policy recommendations that are pragmatic and which seek to address the region's most serious imbalances.

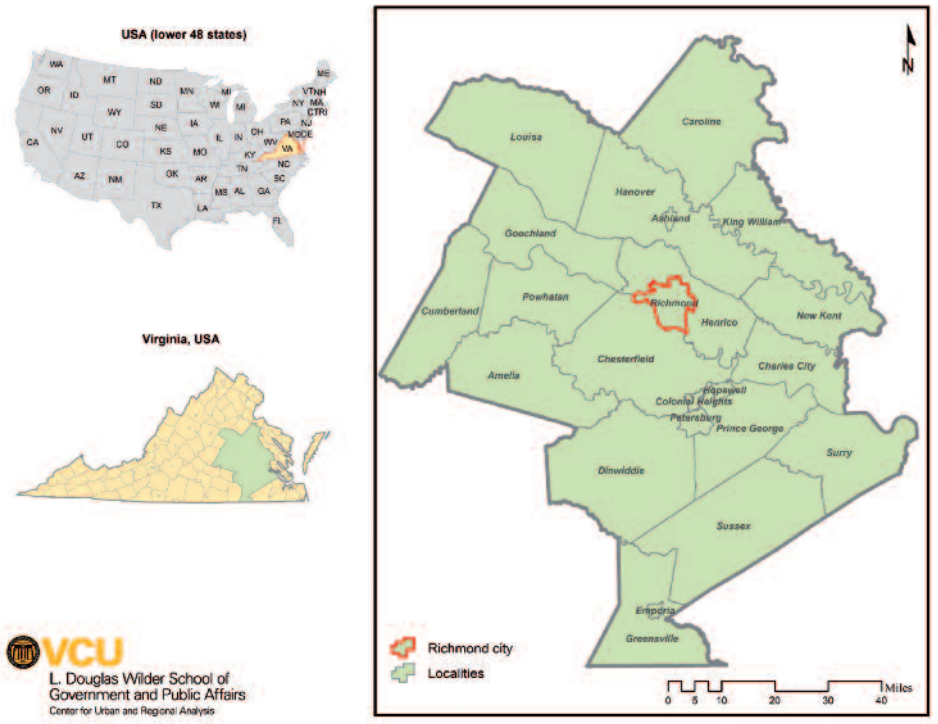

Figure 1 Study area map – the Richmond region

2 | BACKGROUND: MEASURING JOBS-HOUSING BALANCE

The concept of jobs-housing balance refers to the spatial relationship between places of work and places of residence. As discussed previously, suburban development throughout the second half of the Twentieth Century is typified by the shift of housing further from urban centers, resulting in longer commutes for residents of those suburban areas. The design of suburban residential neighborhoods, office parks, and commercial centers in combination with low density development has resulted in an urban form that promotes the use of automobiles to travel from residential uses to work and commercial uses (Cervero, 1988). Cervero noted that as workplaces move into suburban areas, workers are often forced to reside further away from those workplaces due to an insufficient supply of housing and unaffordable housing costs. Hence, the jobs-housing balance describes this relationship – the distance between workplaces and workers, often measured in the following ways:

- **Jobs-households ratio** compares the number of jobs in an area to the number of occupied households (a measure of persons). This measure may be difficult to use, as it requires adjustment to account for the average number of workers per household (Cervero, 1996).
- **Jobs-housing units ratio** compares the number of jobs in an area to the number of physical housing units in an area, without regard to whether those units are occupied (a measure of structures).
- **Jobs-employed residents ratio** compares the number of jobs in the area to the number of employed residents in the area. The ratio should result in a one-to-one relationship in a self-contained economic region.

However, jobs-housing balance may also be measured by indices typically utilized in studies of spatial segregation. The dissimilarity index measures how evenly two values are distributed across a larger area (Miller, 2010; Horner and Marion, 2009). In each, the measure ranges from 0.0 to 1.0, with the lowest measurement indicating complete separation and the highest measure indicating perfect integration.

2.1 Study area and subareas

All measures of jobs-housing ratio have certain elements in common: a larger region of study, subareas of that region, a measure of jobs within each subarea, and a measure of housing units within each subregion. In a larger economic region, the jobs-housing relationship should be relatively balanced. Assuming that the vast majority of jobs in an economic region are held by workers who live in that economic region, the number of jobs and the number of housing units, households, or employed individuals are balanced. A self-contained region in which people live and work, such as a metropolitan statistical area, presents an ideal scale for measuring the jobs-housing balance differences among subareas (Cervero, 1989; Giuliano, 1991).

Determining the spatial units of analysis for jobs-housing balance remains difficult. Many transportation-focused studies have utilized Traffic Analysis Zones (TAZ), census tracts, or census places due to the availability of Census counts/estimates and commuting data at those levels (Cervero, 1989; Taylor and Ong, 1995; Levine, 1998; Cervero, Rood, and Appleyard, 1999; Margulis, 2007; Horner and Marion, 2009; Sang, O'Kelly, and Kwan, 2011). Others utilize municipal boundaries, noting that the boundaries represent the entities with authority to regulate land use (Cervero, 1996). Giuliano notes several issues that arise when attempting to define a subarea. For example, inherent in the jobs-housing units ratio is the concept of a commuting range. Defining a reasonable commuting distance carries a certain degree of arbitrariness (Giuliano, 1991). Even when that range is defined,

home and work locations have commute sheds that, in reality, overlap rather than adhere to boundaries (Giuliano, 1991). Levine notes, "That there is no non-arbitrary geographic scale within which to assess the match or mismatch implies that nearly any desired outcome could be generated by simply adjusting catchment area boundaries" (Levine, 1998).

Some studies have sought to resolve this by creating overlapping subareas. One approach created 7-mile buffers around the centroid of each TAZ, agglomerating jobs and housing numbers from all other TAZ centroids that fell within that buffer (Sultana, 2002). A similar approach used a 5-mile buffer around each TAZ boundary and aggregated jobs and housing numbers from any TAZs crossing that buffer (Peng, 1997). In a study of Mexico City, tract-level data was used to generate 1-mile radius neighborhoods through GIS (Suárez and Delgado, 2009). The 1-mile distance represented a 20-minute walk, which was considered an appropriate commute shed for Mexico City. The data was then reapportioned under an assumption that jobs and population were distributed evenly across tracts.

Planning practice documents utilize similar methodologies. The Southern California Association of Governments chose Regional Statistical Areas, which were based on countywide planning areas and coterminous with census tracts (Southern California Association of Governments 2001). Planners in Austin, TX used ZIP codes (HousingWorks Austin, City of Austin, and Austin Housing Finance Corporation, 2014). Fairfax County, VA focused on 13 regional activity centers previously identified by the Metropolitan Washington Council of Governments (Fairfax County Department of Planning & Zoning, 2012). The Atlanta Regional Commission has used both census tract and TAZ (Atlanta Regional Council, 2002). And the Chicago Metropolitan Agency for Planning has used census tracts (Chicago Metropolitan Agency for Planning, 2009). Some plans establish subareas through a combination of factors. The Southeastern Wisconsin Regional Planning Commission created subareas by aggregating census tracts to fit a combination of municipal boundaries, existing and potential water/sewage service areas, existing and potential transit service areas, land uses, travel patterns, school districts, commercial corridors, and natural and manmade barriers (Southeastern Wisconsin Planning Commission, 2013, 10).

2.2 Jobs and housing data

Estimating jobs for an area presents a number of challenges. Employment for large institutions or companies may be reported from a central administrative office when actual work locations are spatially distributed across a larger area. This issue is noted by the California Planning Roundtable, as are difficulties estimating self-employment, counting workers with multiple jobs, inability to count full and part time jobs differently, and multiple-earner households (California Planning Roundtable, 2008). No academic studies were found that explicitly address these issues. The California Planning Roundtable report simply notes, "Jobs-housing ratios therefore involve a higher level of estimation on the jobs side than on the housing side."

To better understand the relationship between jobs and housing, the data must be disaggregated. As noted, many studies choose TAZs as spatial units in order to utilize commuting data. The dataset often used is the United States Census of Transportation Planning Package (CTPP), which includes data on occupation, income, median housing value, mean travel time, and race for both residents and workers in a given TAZ (Cervero, 1989; Sultana, 2002; Horner and Mefford, 2007). Other studies and plans have utilized Longitudinal Employer-Household Dynamics (LEHD) data, which can be obtained at the census-based geography levels of detail (HousingWorks Austin, City of Austin, and

Austin Housing Finance Corporation, 2014). Austin's report on jobs-housing balance notes the limitations associated with LEHD data, such as its currency (how up to date it is) and granularity. Jobs by earnings are aggregated into three broad groups that may not offer the detail desired.

Housing data presents similar hurdles. Studies that utilize CTPP data for workplace information also utilize the CTPP database for housing information, which is aggregated at census boundaries. Several studies utilized parcel-level housing or assessment data to analyze housing cost. In one case, the total number of residential units (excluding multifamily) and total square footage of those units is aggregated by census tract (Margulis, 2007). The number of non-commercial residential units is divided by total employment (derived from CTPP data) in a tract to calculate the employment to residence ratio. However, other studies utilizing parcel level data often utilize those datasets in models, and no aggregating takes place (Song and Knaap, 2004; Giuliano *et al.*, 2010).

Thus, while prior studies have approached jobs-housing balance based on various types of geography and jobs-housing data, they are often limited by the level of detail in terms of the spatial unit of analysis or jobs-housing data. In this study, we drill down the jobs-housing relationship by using highly granular jobs-housing data and geography down to the Census block group level. Not only does this provide a view of the jobs-housing relationship across jurisdiction boundaries; it also indicates the nature of the imbalance with a means to pin-point imbalanced areas where interventions can be targeted. To accomplish our goal, we utilize two approaches, the Thiessen polygon method and a Gravity Model, to examine and interpret the spatial relationship between modest-wage jobs and low-cost housing units. We then suggest steps that may be taken to incorporate this understanding of the region's jobs-housing balance into long-term strategies and solutions.

3 | METHODOLOGY

Before discussing our approach in the Richmond metro area, an introductory word about the area is in order. The Richmond metropolitan statistical area is a second-tier region with a population of 1.1 million persons who reside in 17 different independent political jurisdictions (cities and counties), including the City of Richmond and the cities of Petersburg, Hopewell and Colonial Heights. Figure 1 above shows these 17 local jurisdictions and the location of the Richmond metro area within Virginia and the United States. Like other American cities, these cities experienced the outmigration of population after 1945 and the formation of suburbs with vibrant job centers to which low-wealth residents of the aforementioned cities cannot get ready residential access.

In order to assess the balance of modest-wage jobs and low-cost housing, we need to identity their location and quantity in the Richmond region. We approached it by means of housing affordability based on the percent of household income spent for housing. In the United States, the convention is the 30% rule[2] and according to the 2013 American Housing Survey, 34% of the households in the Richmond region are considered housing cost-burdened, meaning they spend more than 30 % of their income for housing. Consequently, we used 34% as the cut-off point to identify low-cost housing and modest-wage jobs. Specifically, we define low-cost housing based on the assessed property value that is at or below the 34th-percentile among all housing units in the Richmond region. Similarly, we define modest-wage jobs based on wages at or below the 34th percentile among all jobs in the Richmond region.

Given the above definitions, we utilized the Metro View[3] system to identity the location and quantity of low-cost housing and modest-wage jobs in the Richmond region. The Metro View system is a regional information and analysis system developed by the Center for Urban and Regional Analysis (CURA) in the Wilder School of Government and Public Affairs at Virginia Commonwealth University to provide citizens, political decision makers, businesses and investors with a holistic, yet highly detailed picture of the Richmond region. Metro View is unique in the way it involves the collection and use of the total population rather than a sample of highly detailed data sets at the parcel or address level including land use, employment, population, infrastructure, public facilities, environment, and government plans. In our study, Metro View allows for the aggregation of the entire 2014 housing data at the parcel level and the 2015 jobs data from the U.S. Department of Labor's Quarterly Census of Employment and Wages (QCEW) at the address level. Applying the 34% cut-off resulted in low-cost housing units assessed at $109,000 or less in 2014, and modest-wage jobs that paid an annual salary of $27,664 or less in 2015.

We have taken two methodological approaches to understanding the jobs-housing balance throughout the region. The first approach utilizes the Thiessen polygon method to delineate subareas based on job center locations and assess the distribution of low-cost housing and modest-wage jobs in each subarea. The second approach uses a gravity model in which each Census block group is scored based on its access – as a measure of quantity and distance – to modest-wage jobs and low-cost housing units. We describe the two approaches in detail below.

2 U.S. Department of Housing and Urban Development (HUD) describes cost-burdened families as follows: "Families who pay more than 30 percent of their income for housing are considered cost burdened and may have difficulty affording necessities such as food, clothing, transportation and medical care." https://www.hud.gov/program_offices/comm_planning/affordablehousing/

3 See https://cura.vcu.edu/ongoing-projects/metro-view/ and http://metroview.vcu.edu/

4 | APPROACH 1: THIESSEN POLYGON METHOD

Thiessen polygons (also known as Voronoi diagrams or Dirichlet tessellations) are often used in geospatial analysis to delineate catchment areas by relating point data to the surrounding space (Burrough, McDonnell, and Lloyd, 2015). The ESRI GIS Dictionary defines Thiessen polygons as "Polygons generated from a set of sample points. Each Thiessen polygon defines an area of influence around its sample point, so that any location inside the polygon is closer to that point than any of the other sample points."[4]

Based on our knowledge of the major employment centers in the Richmond region (derived also from analysis of geographic employment data), we identified 34 spatial clusters that have a high concentration of jobs, and digitized the centroid of each cluster to represent the job center location as a point. We then applied the Thiessen polygon method to generate Thiessen polygons around the job centers. The resulting map (see the red boundaries in Figure 2) divides the Richmond region into 34 subareas (*i.e.*, Thiessen polygons) based on job center locations. The Thiessen polygon method ensures any location within each subarea is closer to the job center of that subarea than any other job centers. To determine the number of modest-wage jobs within each subarea, we geocoded the job locations and spatially joined them to the Thiessen polygons. Similarly, we overlaid the Thiessen polygons with residential parcels to determine the number of low-cost housing types and units in each subarea.

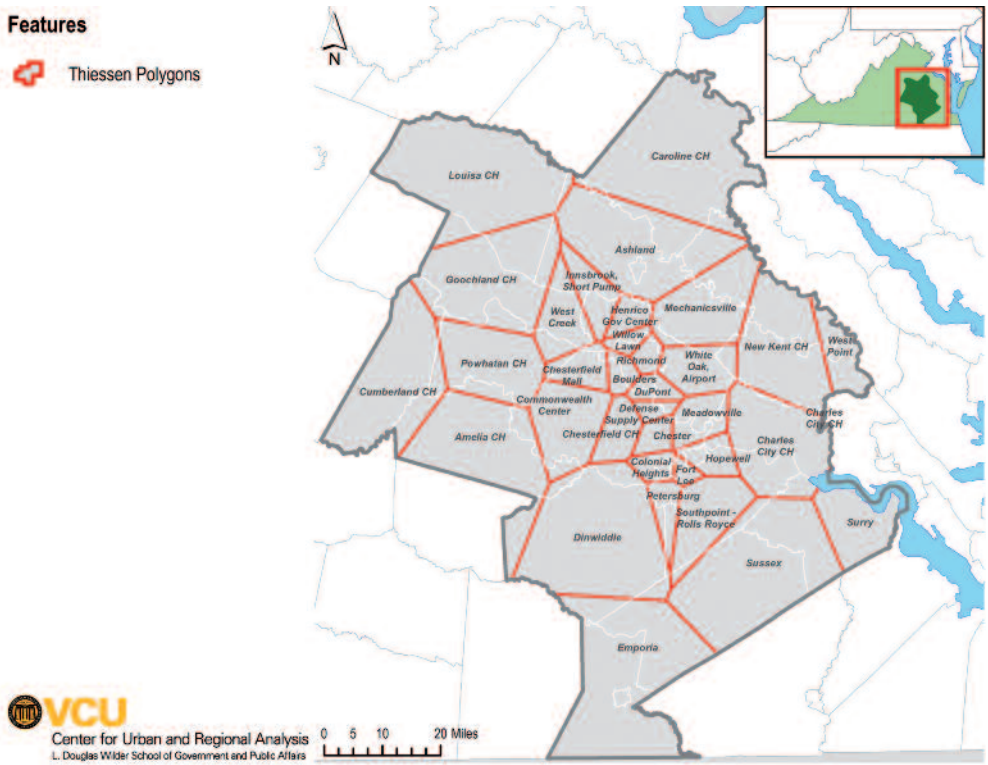

Figure 2 Thiessen polygons derived from job centers

Job and housing unit counts were aggregated in two ways. First, total jobs and total housing units allowed for a broad understanding of the jobs-housing balance of each subarea. Second, we identified modest-wage jobs and affordable-housing units by examining those at, or below, the 34th-percentile of all jobs and housing units by wage or assessed value. As noted earlier, the 34th-percentile cut-off

4 http://support.esri.com/en/other-resources/gis-dictionary/term/thiessen%20polygons

was determined as a function of the percent of households experiencing housing-cost burden in 2014. Table 1 breaks down the jobs-housing ratio and gap for job centers as identified through the Thiessen polygon method.

Job center Thiessen polygons	Modest wage jobs	Low cost housing units	Jobs-Housing Ratio	Jobs-Housing Gap	Low cost single family units	Low cost multi family units
Ashland	10,649	3,483	3.06	7,166	958	2,525
Richmond	34,228	31,312	1.09	2,917	11,187	20,125
Willow Lawn	17,713	7,780	2.28	9,933	739	7,041
Meadowville	3,228	837	3.86	2,391	349	488
Henrico Gov Center	21,734	14,573	1.49	7,160	806	13,767
Innsbrook, Short Pump	18,642	10,422	1.79	8,220	61	10,361
West Creek	3,181	1,890	1.68	1,292	69	1,821
Chesterfield CH	6,081	1,985	3.06	4,096	333	1,652
White Oak, Airport	11,458	16,037	0.71	-4,579	7,694	8,343
Chesterfield Mall	13,346	3,266	4.09	10,080	386	2,880
Mechanicsville	8,724	5,271	1.66	3,453	1,517	3,754
Boulders	11,290	18,506	0.61	-7,216	4,883	13,623
Defense Supply Center	2,208	2,553	0.86	-345	615	1,938
Chester	4,981	2,996	1.66	1,985	543	2,453
DuPont	4,141	11,285	0.37	-7,144	4,871	6,414
Commonwealth Center	9,717	2,761	3.52	6,956	282	2,479
Fort Lee	3,358	419	8.01	2,939	419	0
Colonial Heights	7,591	3,470	2.19	4,121	2,628	842
Southpoint - Rolls Royce	1,758	458	3.84	1,300	458	0
Petersburg	4,284	6,045	0.71	-1,761	6,045	0
Sussex	923	2,172	0.42	-1,249	2,157	15
Emporia	2,544	5,091	0.50	-2,547	4,996	95
West Point	800	574	1.39	226	538	36
Hopewell	2,416	4,332	0.56	-1,916	4,237	95
Charles City CH	417	1,413	0.30	-996	1,413	0
New Kent CH	1,139	603	1.89	536	599	4
Louisa CH	2,615	2,813	0.93	-199	2,813	0
Goochland CH	1,258	1,163	1.08	95	1,163	0
Dinwiddie	2,618	4,475	0.59	-1,857	4,459	16
Powhatan CH	1,679	514	3.27	1,165	514	0
Caroline CH	1,758	2,480	0.71	-722	2,480	0
Cumberland CH	429	1,444	0.30	-1,015	1,444	0
Surry	497	5	99.38	492	5	0
Amelia CH	845	102	8.28	743	102	0
Total	**216,907**	**172,422**	**1.26**	**44,485**	**71,655**	**100,767**

Table 1 Modest-wage jobs and low-cost housing in Thiessen polygons

4.1 Jobs-housing ratio

Focusing solely on modest-wage jobs and low-cost housing units reveals imbalances at the subarea level while total jobs and total units at the regional level appear to be balanced. Modest-wage jobs to low-cost housing ratios of 1.01 to 1.50 are presented as reasonably balanced around the region's overall ratio of 1.26. Where the ratio falls outside that range, jobs and housing units may be considered mismatched or imbalanced. Although low-cost housing and modest-wage jobs may be balanced overall, imbalances within subareas represent a lack of access to modest-wage jobs from affordable housing.

Richmond-region job centers with a balanced ratio of modest-wage jobs and low-cost housing (see the green shaded areas in Figure 3) include two central locations along the Broad Street corridor (an artery traversing Richmond's central business district and proceeding westward into Henrico County), and sparsely populated rural areas at the edges of the study area to the east (parts of New Kent and King William counties) and to the west (Goochland County).

Much of the region surrounding Richmond city could be considered rich in modest-wage jobs (see the blue shaded areas in Figure 3), meaning these areas have significantly more modest-wage jobs than affordable housing units. For example, Chesterfield County's Commonwealth Center (a retail center in the northwest part of Chesterfield County) has a greater than 3.5 ratio of modest-wage jobs to low-cost housing. This suggests that although the total number of housing units in that subarea is high, the number of affordable-housing units is relatively low compared to the number of modest-wage jobs in the area.

On the other side of the ratio, South Richmond (the lower portion of the city, outlined in red) and some of the more rural areas further outside the center of the region exhibit an excess of low-cost housing units relative to the number of modest-wage jobs (see the brown shaded areas in Figure 3).

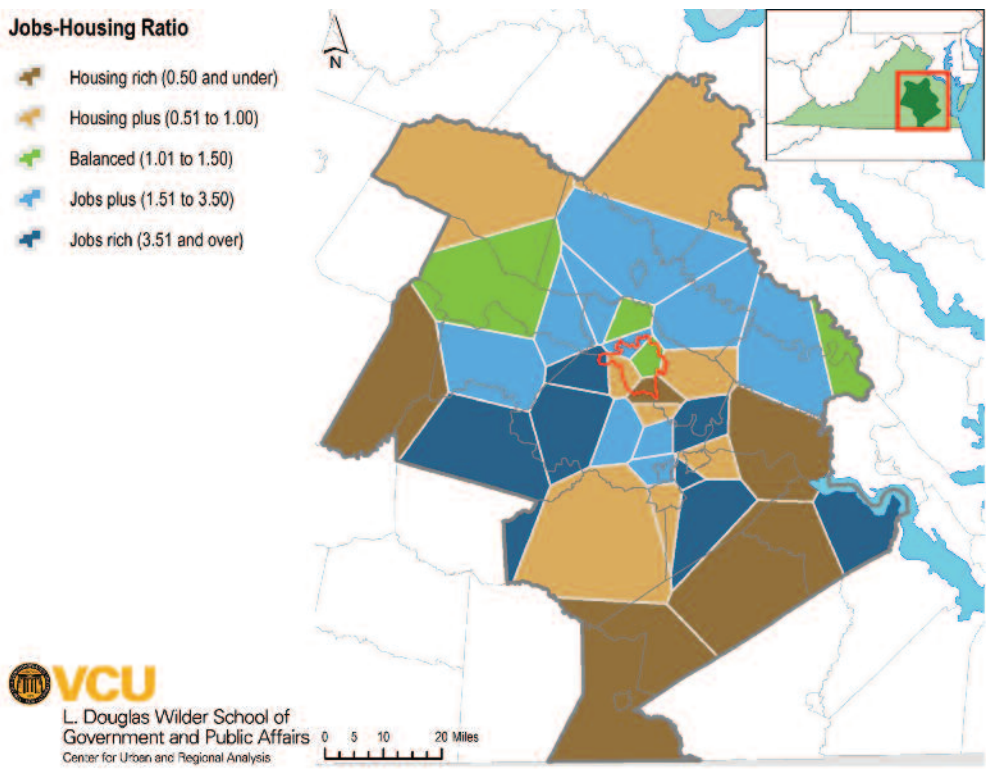

Figure 3 Thiessen polygon – jobs-housing ratio

4.2 Jobs-housing gap

The numeric gap between modest-wage jobs and low-cost housing units offers a picture of the magnitude of imbalance. Our analysis indicates South Richmond has at least 5,000 more low-cost housing units than it does modest-wage jobs (see the dark brown shaded areas in Figure 4). Suburban areas to the north and west of Richmond city, stretching from Ashland to Chesterfield County, have a significant numeric surplus of jobs. The areas shaded dark blue in Figure 4 have at least 5,000 more modest-wage jobs than low-cost housing units.

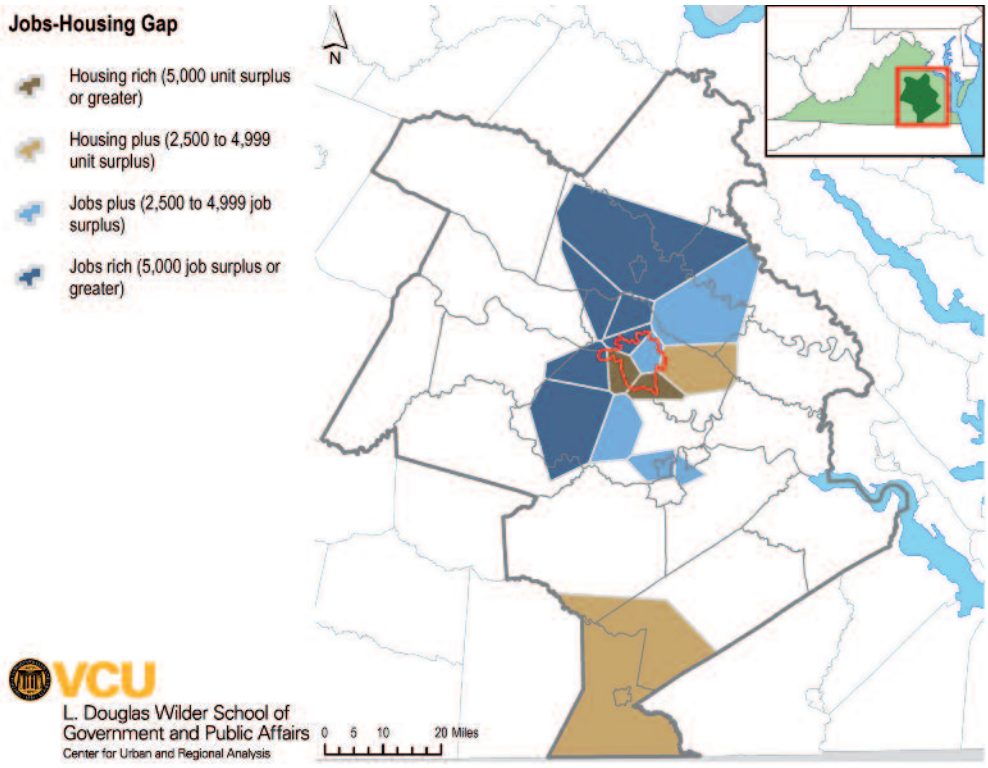

Figure 4 Thiessen polygon – jobs-housing gap

4.3 Focus areas for intervention

Combining ratio and numeric imbalances of modest-wage jobs and low-cost housing units offers areas where intervention should focus for housing, economic development, and transportation and transit efforts. These areas represent the greatest imbalances of jobs and housing in the region. Addressing these imbalances by seeking to attract jobs or additional housing could help to reduce travel times between work and home, allowing greater access to both jobs and housing for lower-income households throughout the area. Figure 5 shows primary and secondary focus areas for modest-wage jobs and low-cost housing units. These categories are designated as follows:

- Primary low-cost housing focus: areas with the greatest jobs-housing ratio (over 3.5) and the greatest numeric imbalance of jobs to housing units (5,000 or more jobs than housing units).
- Secondary low-cost housing focus: areas with the high jobs-housing ratios (over 1.5 but not more than 3.5) and high numeric imbalances of jobs to housing units (2,500 to 4,999).
- Primary modest-wage jobs focus: areas with the lowest jobs-housing ratio (0.5 or below) and the greatest imbalance of housing units to jobs (5,000 or more housing units than jobs).

- Secondary modest-wage jobs focus: areas with lower jobs-housing ratio (0.51 to 1.00) and a large imbalance of housing units to jobs (2,500 to 4,999).

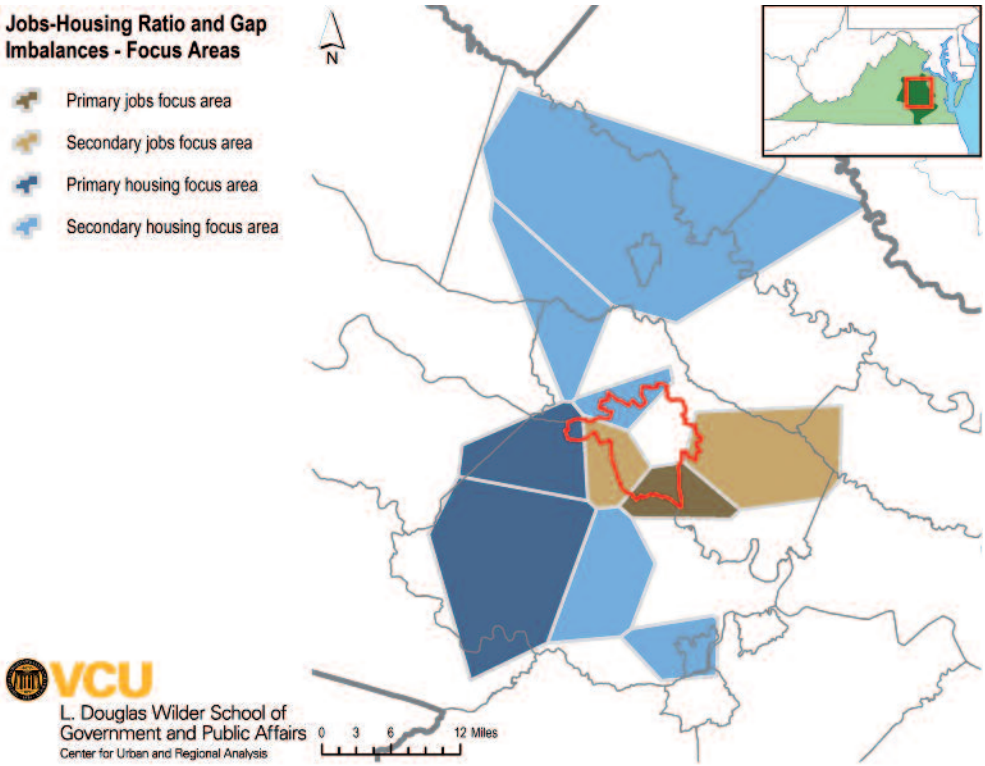

Figure 5 Thiessen polygon – primary and secondary focus areas

5 | APPROACH 2: GRAVITY MODEL

The Thiessen polygon method allows the delineation of catchment areas based on pre-determined job center locations; the resulting Thiessen polygons are not confined by jurisdiction boundaries. Aggregating jobs and housing units within the polygons and assessing their balance or imbalance is relatively straightforward. Also, the visual result presents a more or less clear picture to policy makers, and thus it is an excellent first approximation of jobs-housing balance issues. However, there are a few shortcomings of the Thiessen polygon method:

1. The determination of job center locations is subjective and qualitative in nature. It does not take into account the actual number of jobs and the extent of concentration within each job center.
2. The resulting Thiessen polygons are in isolation. In other words, jobs and housing only interact with one another within each Thiessen polygon, when in fact households in a given Thiessen polygon also have access to jobs in other polygons.
3. The distance between any point within a Thiessen polygon to the job center point in that polygon is based on Euclidean distance, when in fact journeys to work take place through highway and road networks.

To address these issues, we also employed a gravity model to measure access to jobs and housing in the Richmond region. Our gravity model approach utilizes Census block groups as the level of analysis. Total modest-wage jobs and total low-cost housing units are aggregated for each of the

789 block groups in the Richmond region. The model then scores each block group based on its accessibility to jobs and housing – both inside and outside of the block group. Where the Thiessen polygons look at jobs and housing units within each polygon, the gravity model scores a block group based on the number of jobs and housing units within that block group, as well as the block group's proximity[5] to jobs and housing units in other block groups. Each block group receives a jobs-accessibility score (see Equation 1) and a housing-accessibility score (see Equation 2).

$$Accessibilità\_lavori_i = \sum_{j=1}^{n} \frac{la}{}$$

(1)

$$Accessibilità\_UA_i = \sum_{j=1}^{n}$$

(2)
where,

$Accessibilità\_lav$ is the aggregated jobs-accessibility score of block group *i*

$Lavori_j$ is the number of modest-wage jobs in block group *j*

D_{ij} is the network distance (in miles) between block group *i* and block group *j*

$Accessibilità\_$ is the aggregated housing-accessibility score of block group *i*

UA_j is the number of low-cost housing units in block group *j*

D_{ij} is the network distance (in miles) between block group *i* and block group *j*

Note: higher scores indicate better accessibility.

The accessibility scores allow for a comparison of the magnitude of difference between access to jobs and housing in each block group. Closer proximity to block groups with many jobs or housing units will result in a higher score. Conversely, greater distance from those block groups will result in a lower score. The scores are standardized Z scores describing each block group's score in terms of its departure from the mean and may be added to create a total jobs and housing-accessibility score or subtracted to highlight accessibility imbalances.

In short, the gravity model measures accessibility to jobs and housing units by block group as a function of proximity to all jobs and housing units in all subareas rather than as a ratio within a single subarea. It is a relative measure of proximity to all jobs and housing units in a region. Access differentials equal the calculated difference between the two scores.

5 Measured by network distance in miles.

5.1 Access to low-cost housing

In scoring low-cost housing accessibility, the highest scoring block groups are also the most centrally located (see Figure 6). The region's areas with the greatest housing-accessibility scores, primarily central Richmond and the city's Northside and East End neighborhoods, also feature some of the densest development. Low-cost housing accessibility scores decline with distance from the central city. Accessibility in block groups in Richmond's Southside (the lower portion of the area outlined in red) remains high, while scores in West End block groups (the left portion of the area outlined in red) fall more rapidly. Low-cost housing accessibility falls rapidly outside the urbanized center of the region, especially as one moves west from the center of the city.

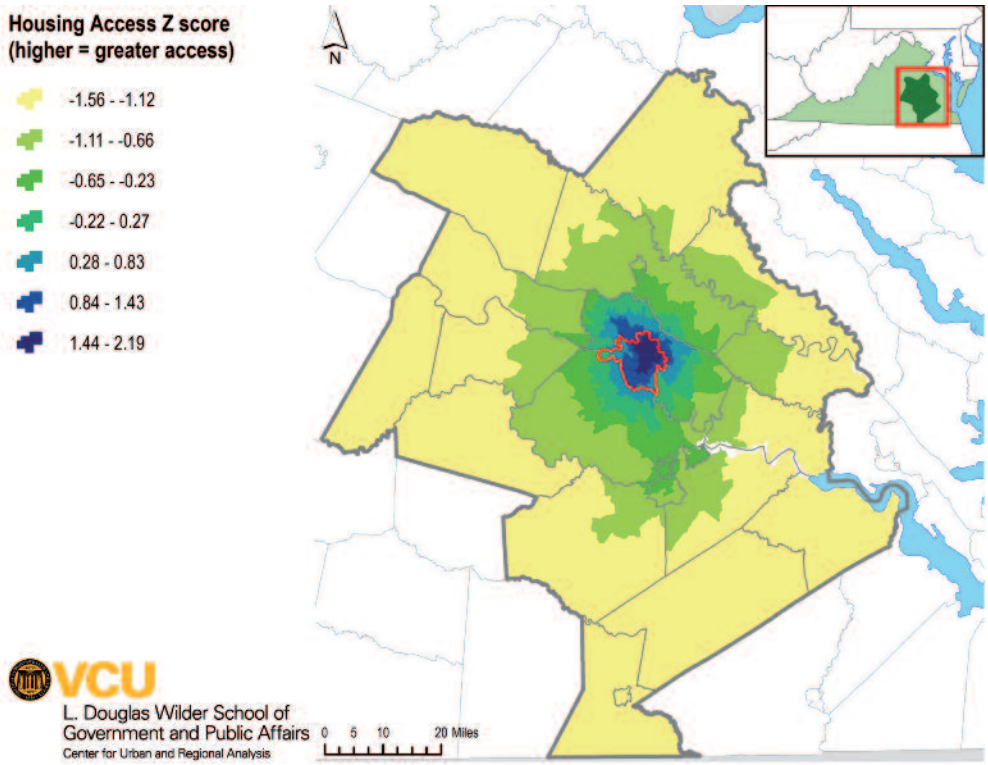

Figure 6 Gravity model – access to low-cost housing

5.2 Access to modest-wage jobs

Modest-wage jobs are most accessible at the center of the region, particularly in block groups in the City of Richmond's central business district and in the northern part of the city (see Figure 7). Moving westward from the city, job-access scores remain very high in western Henrico County (where housing-access scores decay more rapidly). Job-access scores in South Richmond block groups also suggest a difference in access between modest-wage jobs and low-cost housing.

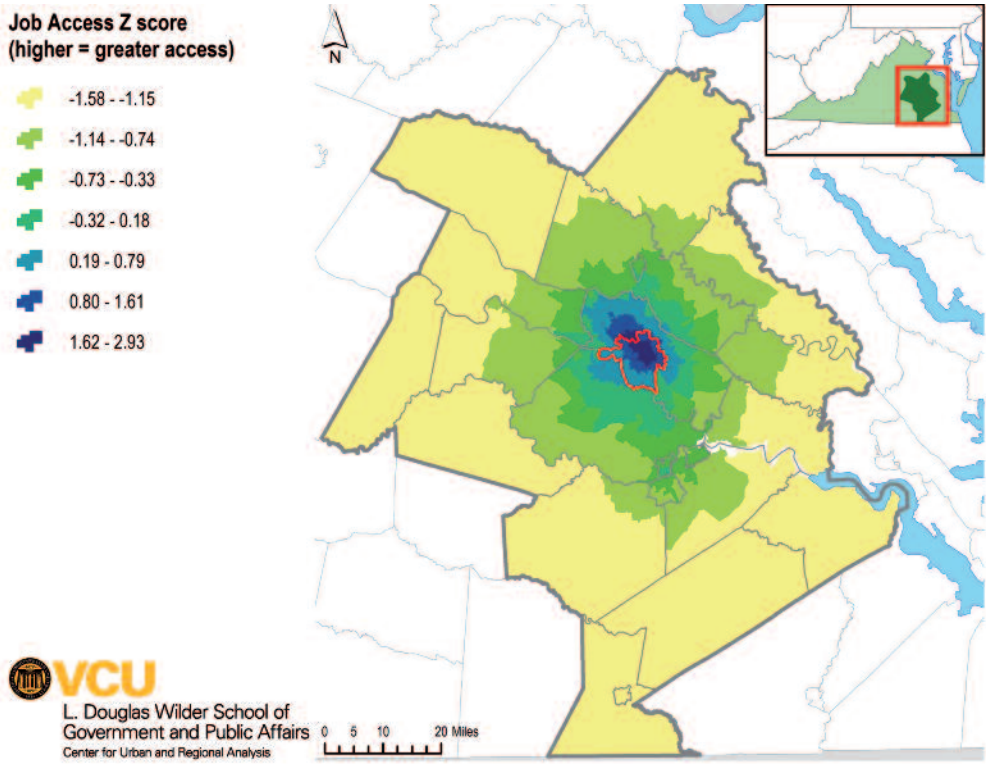

Figure 7 Gravity model – access to modest-wage jobs

5.3 Combined access to low-cost housing and modest-wage jobs

Adding the Z scores together creates a combined-access score (Figure 8), which amplifies the centralized pattern visible in the jobs and housing access models. This result suggests that the density of modest-wage jobs and low-cost housing (and jobs and housing in general) in the center of the region guides the patterns of accessibility shown in the gravity model maps. Accessibility alone does not describe the relationship between jobs and housing. Rather, it describes density of development.

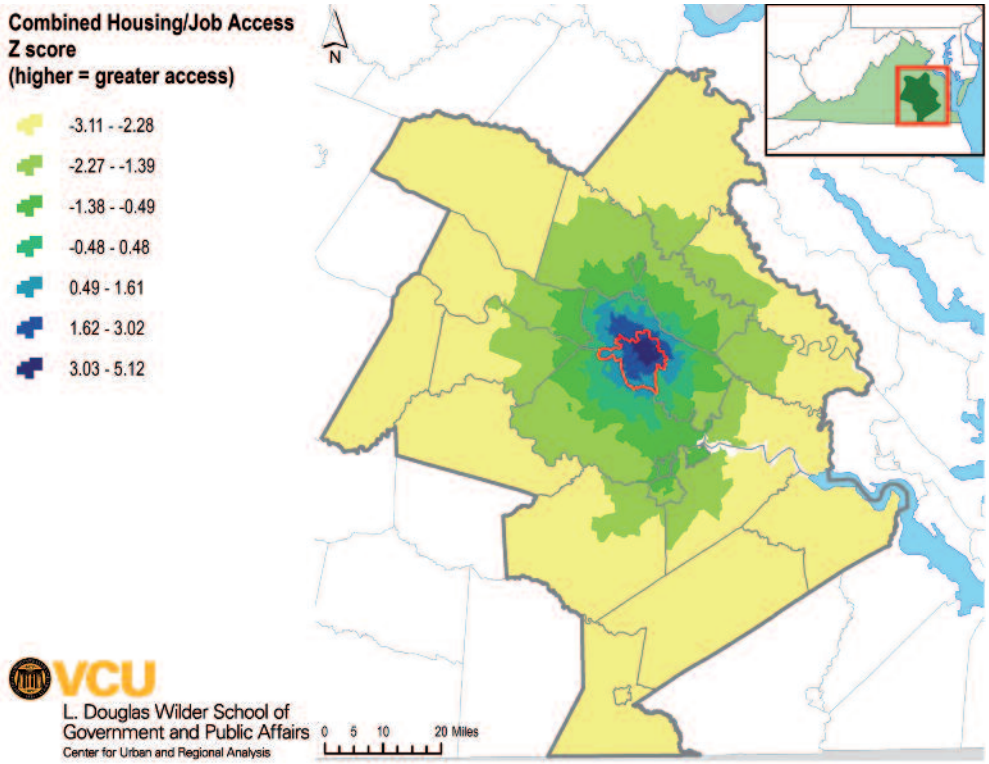

Figure 8 Gravity model – combined access to low-cost housing and modest-wage jobs

5.4 Jobs-housing access imbalance

To understand the balance of accessibility, and therefore, the relationship between job access and housing access, one may calculate the difference between the Z scores. Z scores represent a standardized measurement of departure from the regional mean. Where subareas score high on both jobs and housing access (or low, for that matter), subtracting one from the other will result in a score close to zero, indicating a balance of access to jobs and housing is similar, regardless of whether that access is high or low. In a subarea that scores above average on one measure of access but below average on another, subtraction will result in a score that moves away from zero, positively or negatively, depending on the direction of the imbalance of access. Calculating the difference between Z scores provides a measure of disparity in accessibility between modest-wage jobs and low-cost housing units.

Figure 9 shows the areas of the region in which modest-wage jobs access and low-cost housing access are imbalanced. Although much of suburban Richmond exhibits low jobs and housing access, that low access appears largely balanced. The greatest imbalances are visible across the region's more urbanized and densely suburbanized areas.

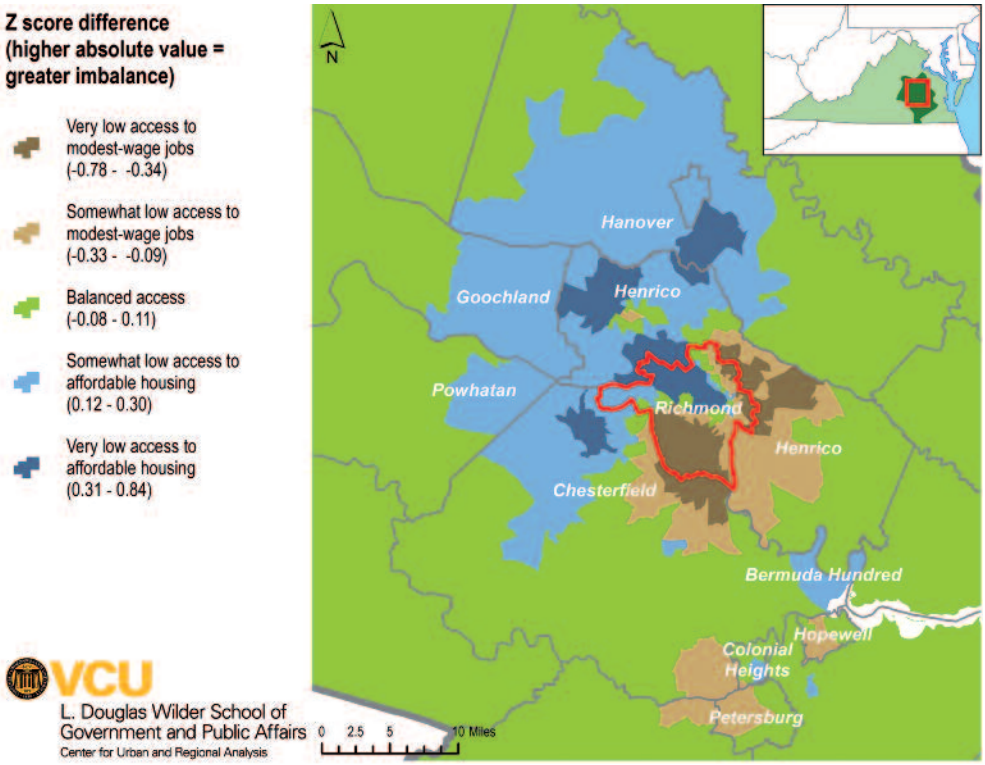

Figure 9 Gravity model – jobs-housing access imbalance

Imbalances of modest-wage jobs and low-cost housing access may favor housing or jobs. The greatest imbalances favoring housing (low access to jobs in brown on Figure 9) are visible through Richmond city's Southside, East End, and Northside, extending into the inner-ring suburbs of both Henrico and Chesterfield counties. These imbalances suggest that although modest-wage job access is high when viewed alone, access is actually low relative to low-cost housing access. Hopewell city and Petersburg city experience a similar imbalance to that of Richmond city. As discussed in the Introduction, this is a pattern that has prevailed throughout the United States for the past half century.

High housing imbalance calculations – areas in which access to low-cost housing is low relative to access to modest-wage jobs (blue-shaded areas in Figure 9) – suggest the greatest imbalance is stretching west from Richmond's downtown through much of Henrico County. The northern corner of Chesterfield County west of Richmond city – densely populated with big-box and chain-retail offerings – also exhibits high measures of imbalance. And the central portion of Hanover County to the north exhibits high housing imbalance as well.

Affordable housing imbalance (low access) stretches broadly across the region's western suburbs, covering North Chesterfield, western Henrico County, and large swaths of Powhatan, Goochland, and Hanover counties. Several smaller areas directly south of Richmond city also exhibit low relative access to affordable housing.

6 | CONCLUSIONS AND POLICY IMPLICATIONS

6.1 Comparison of the Thiessen polygon method and gravity model

Both approaches are capable of assessing jobs-housing balance but each has its unique strengths and weaknesses. The Thiessen polygon method is easier to compute and interpreting the jobs-housing ratio or gap is straightforward. On the other hand, the gravity model requires much computing power to calculate the accessibility scores and interpreting the Z-scores and their differentials is complicated. However, the Thiessen polygon method treats each subarea as a closed system and does not take into account the jobs and housing units located in nearby subareas. The gravity model uses the Census block group, a much smaller subarea, and scores a block group based on not only the number of jobs and housing units within that block group but also the block group's proximity to jobs and housing units in other block groups.

More importantly, both approaches offer a way to examine and view the jobs-housing relationship within a region across jurisdiction boundaries and identify imbalanced areas where intervention should be targeted. Although both approaches have their own merits in assessing jobs-housing balance, we find the gravity model approach to be more robust not only because it overcomes the issues associated with the Thiessen polygon method but it also provides a more detailed view of the jobs-housing relationship at the block group level. Employed together, the two methods provide both a first approximation of areas where attention should be focused (the Thiessen polygon method) as well as a more in-depth understanding (the gravity model method).

6.2 Policy implications

As noted previously, using granular data and small units of analysis to identify job-housing balance issues affords policy makers the ability to focus pragmatic interventions in parts of the region where the imbalances are most acute, and where opportunities for construction of affordable housing, of businesses or of transit, are greatest. The foregoing analysis leads to the following recommendations for policy and planning interventions:

- Focus construction of new affordable-housing units on sites with good access to modest-wage job locations, especially retail job centers west of Richmond city.
- Locate more economic development projects with a predominance of modest-wage jobs in areas with good access to lower-cost housing, especially areas in the southern portion of Richmond city and south of the city.
- Expand the Greater Richmond Transit Company's fixed-route transit service area to include concentrated locations of low-cost housing and modest-wage jobs. The Greater Richmond Transit Company provides bus service within Richmond city, but it runs only a couple of lines outside the city limits. This is due, in part, to reluctance on the part of residents of the counties surrounding Richmond (Henrico and Chesterfield) to have the bus come into their communities. Both racial and class issues underlie this reluctance. Hence,
- Frequently monitor changes in property values and crime incidents throughout the metropolitan area, and especially in areas where affordable housing development may arouse resident fears and concerns.

CONCLUSION

Ultimately, political leadership is required to help American metro areas improve the balance of affordable housing and modest-wage jobs. Data and analyses alone are not sufficient. They are, however, necessary to accomplish this task, as they provide the means of continual monitoring and messaging to the community in a focused, specific manner.

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14-16 May 2012, Schwechat. http://www.corp.at ISBN: 978-3-9503110-2-0 (CD-ROM); ISBN: 978-3-9503110-3-7 (Print). Editors: Manfred SCHRENK, Vasily V. POPOVICH, Peter ZEILE, Pietro ELISEI