Transit as Solution for Spatial Mismatch

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Abstract

From the late 1980s, as the trend of suburbanization and welfare reform draw researchers and policymaker's attention, the Spatial Mismatch Hypothesis had again brought into the field and raised discussion. Transportation, especially transit, have been noted as an important commuting mode for them. As the researchers and policymakers facilitated to transfer welfare participants into the labor market and improve the employment of low-income households, many policies and programs were promoted to improve the transit system. However, how did those policies and advocated transit system perform so far? This literature review aims at taking a look at previous researches and tries to answer this question.

Key words: Spatial mismatch hypothesis; welfare recipients; low-income households;

transit.

Overview

Equity has long been discussed with heat in various of fields, including transportation. Since Kain introduced the hypothesis of spatial mismatch in 1968, which described the situation for low-income and minority groups that job opportunities around their residence were limited and thus commute longer time was needed, transit, as a substitution for private automobiles, has been noticed and talked over, not only in academic field, and also in political arenas. (Guiliano 2001). Started in the 1960s, scholars and even National Advisory has recommended improvement of public transit as a linkage between minority and low-income groups and job opportunities (Kain & Meyer, 1970; National Advisory Commission on Civil Disorders, 1968). Later, in the 1990s, with the heated discussion of spatial mismatch hypothesis, the Intermodal Surface Transportation Efficiency Act was published in 1991 to improve this linkage (Bullard, 1996, p. xi;Sanchez,1999). Since then, funding and grants have been continually invested into transit infrastructure construction, yet the debate about the influence of transit on economically disadvantaged groups ongoing.

While investments in transit have been made to improve the inequity on minority and low-income groups, it is irrefutable that, despite substantial and increasing public subsidies the market of transit ridership has been shrinking (Fielding, 1995). It is also pointed out by some scholars that, although low-income groups are more likely to have lower percentage of car ownership, only small portion of personal trips are made by transit among them. In 1995, within the lowest income class (less than $15,000 in 1995), transit only made up 6.8 percent of their personal trips. (Pucher, Evans, and Wenger, 1998).

Thus, four decades after the spatial mismatch hypothesis initially founded, with the economic growing, two questions, which are to be found the answers in this paper, merge: First, after four decades of debates, is the spatial mismatch hypothesis still valid nowadays? Moreover, following is another question, if the spatial mismatch still truly exist, is transit able to improve the situation for minority and low-income groups?

literature review

Welfare Reform and Spatial Mismatch Hypothesis

Enacted in 1996, the Personal Responsibility and Work Opportunity Reconciliation Act (PRWORA) devolved the responsibility and authority of public assistance responsibilities from federal to state level. As the act facilitated to transfer welfare participants into the labor market, many policies and programs are promoted by state governments to help welfare recipients got employed, including transportation policies and programs(Blank, 2002; E. Blumenberg, 2002). Plenty of researches have been supporting the claim that transportation is a significant element that affects the employment rate of low-income welfare recipients. For example, a case study in Cleveland confirmed the spatial-mismatch between welfare recipients home locations and the low-skill work opportunities (Coulton, Leete, & Bania, 1999), and E. Blumenberg(2002)stated that as the impedance between welfare recipients and work opportunities are consist of multiple factors including transportation.
Accordingly, the Spatial Mismatch Hypothesis had brought the field with a discussion. Firstly proposed by Kain, the hypothesis, where Kain(1968) discussed the spatial mismatch for black workers in Chicago, has gain broadly academic support and discussion as the suburbanization in the US continued. From the late 1980s, with the trend of suburbanization growing, the hypothesis of Spatial Mismatch revived and has been raising discussion since then. The hypothesis described the situation that minorities and low-income groups concentrated in inner-city were limited to work opportunities in suburban areas and might have to tolerate longer commute distances (Ihlanfeldt & Sjoquist, 1998). At the meanwhile, not only black males, spatial mismatch for other minority groups and females have also been studied gradually. Holzer H. J mentioned that residential segregation had been slowly declining for blacks in metropolitan areas and suburbanization has been increasing, yet, blacks still fall behind Asian and Latino groups(Holzer, Quigley, & Raphael, 2003). McLafferty and Preston (1992) relied on the PUMS data and made the conclusion with their research on Blacks and Latina Women in New York region that Black women relied heavily on mass transit while Latina women originally lacked access to well-paid jobs (McLafferty & Preston, 1992).Later in 1996 and 1999, they continued to address the existence and significance of spatial mismatch for minority groups with regression tools and literature review. (McLafferty & Preston, 1996; Preston & McLafferty, 1999). Though, the hypothesis of spatial mismatch is still universal enough for all regions.
Blumenberg & Shiki examined spatial mismatch in medium-sized cities and rural areas. They suggested findings for spatial mismatch and related recommendations for policy and planning in those mid-size cities and rural areas did not follow that typical modal of spatial-mismatch model. They also found that welfare recipients in Fresno County, California, lived near to their jobs and did not face the exact problem of spatial mismatch but more unique and complex pattern instead (E. A. Blumenberg & Shiki,2003).

Discussion on Transit for Spatial Mismatch

As an alternative mode of transit, the influence of private ownership on employment rate for welfare recipients has also been addressed in previous researches. As low income-households are faced with more complex travel needs, such as longer travel time and longer or irregular working hours, they are more eager for mobility, especially private transportations. (Alwitt & Donley, 1996; Fan, 2012; Presser & Cox, 1997) However, According to Blumenberg, only 7% to 50% of the welfare participants have access to cars (E. Blumenberg, 2002). Thus, transit has been an important alternative for welfare recipients or other low-income groups to commute while they had limited access to own and operate private vehicles. Sanchez embarked the first empirical analysis as claimed on examining the connection between transit accessibility and employment based on the scale of Atlanta and Portland (Sanchez, 1999). Ihlanfeldt & Sjoquist(1991) asserted that across 43 analyzed SMSAs, commute time was able to affect employment rate of black youth comparing to white youth (Ihlanfeldt & Sjoquist, 1991). An empirical study by Immergluck showed that job proximity did influence neighborhood employment in Chicago metropolitan (1998) (Immergluck, 1998). Ong and Blumenberg (1998) also draw the conclusion that proximity and access to job matters to improve employment (Ong & Blumenberg, 1998).

Nonetheless, some researchers suggested that the existing transit system was not performing well so far. Blumenberg pointed out in 2002 that commuting by public transit reduced the possibility of employment by welfare recipients. Giuliano (2005) concluded in the paper that transit system was still providing limited services and hardly accomplished its goals of providing mobility to transportation disadvantaged groups and reduce car use (Giuliano, 2005). Moreover, as the discussion goes on, plenty of scholars raised doubt on transit as a remedy to spatial mismatch problem. Bania's (2008) research, which was based on a random sample of adults who left TANF in Cuyahoga County, Ohio, between October 1998 and July 2000, selected welfare leavers to examine the causations between multiple variables and employment with regression tools. Bania found that there was barely statistical evidence to support the connection between employment and job access variables including proximity and travel time. (Bania, Leete, & Coulton, 2008). Similarly, Sanchez (2003) also examined if multiple variables, including demographic features and employment access, are statistically significant to influence employment with regression. Although Sanchez examined across multiple metropolitan areas (Sanchez, Shen, & Peng, 2004). Grengs (2010) asserted that: "in a place like Detroit, accessibility by transit is currently so low that no amount of transit investment could be implemented fast enough to address the urgent problems of joblessness and poverty. The car's advantages in job accessibility are so extreme, and the prospects for serving the most disadvantaged people with public transit are so limited, that the problem facing poor people in Detroit is a ''modal mismatch" rather than a ''spatial mismatch"(Grengs, 2010), which was in consistent with the earlier research of Taylor

and Ong (Taylor & Ong, 1995) that there were no significant commuting time difference between groups- the mismatch was rather “mode mismatch” rather than “spatial mismatch”.

Conclusion

Various of distinctive evidence and research results, as addressed by Ihlanfeldt & Sjoquist, were possibly caused by different methods applied by scholars (Ihlanfeldt & Sjoquist, 1998). It is also possibly caused by different research geographic scale. Not only the debate on the validation of spatial mismatch, the argument about whether transit is capable of mending the situation of long-commuting-time low-income groups continues. As Sanchez concluded later in 2008, it was directly pointed out that even with $3.3billion devoted, we are still not able to clearly clarify how transit investment could improve employment for low-income groups.

Methodology & Data

To answer the question that if spatial mismatch exists and if transit play any role compensating those spatial-mismatched groups, the most recent Longitudinal Employer-Household Dynamics (LEHD) Origin Destination Employment Statistics data (LODES) and 5-year estimate data from American Community Survey (ACS) are applied in this paper. With Atlanta, Los Angeles, Seattle and Portland Metropolitan Statistical Areas as four research areas, the methodology of this paper can be divided into three parts:

First, a demographic overview of these four regions with 5-year ACS. The demographic, employment and commuting situations are available for each block group (factors including block group number population, population density (per. sq. mile), minority rate, low skill rate, rate of commute by public, employment rate, percent of commute more than half hour, and percent of commute more than 1 hour). After joining the data spatially to each block group in ArcMap, Block groups that fall within each MSA are selected and reported for the next step analysis. In this step, the statistics are also summarized to give a general review.

Then, OnTheMap, a web-based mapping and reporting application that shows where workers are employed and where they live with LODES dataset, is applied to visualize the distribution of employees and jobs at different income level, to give a graphic image of if any spatial mismatch exist. Last but not least, a linear regression is utilized to investigate if transit could cast effect on employment conditions, especially for low-income and minority groups.

Longitudinal Employer-Household Dynamics Origin Destination Employment Statistics (LODES)

The United States Census Bureau provide a web page application On The Map that can visualize LODES data for selected regions, which are able to give us a general glance about whether the spatial mismatch exists in those selected areas. In this part, the 2014 LODES data was chosen to produce maps showing the geographic distribution of home and workplaces for different income groups: monthly income less than 1250 dollars, between 1250 and 3333 dollars and monthly income more than 3333 dollars. Although On The Map is easy to use, it has its advantage that the interval for categorization is not changeable. For instance, the groups with monthly income less than 1250 dollars and monthly income more than 3333 dollars could not be changed to another amount. However, it is acceptable, considering that this step is only to overview the spatial mismatch trend of selected regions qualitatively.

The boundary for area analysis is city boundary. Four regions, Atlanta, Georgia, Los Angeles, California, Portland, Oregon and Seattle, Washington are chosen to be the four study areas. The specific study scale for LODES data is city boundary, of which the reason is to be described in the following section.

American Community Survey 5-year estimate data

Obviously, simply take a glance of the general trend of the region is not enough. Thus, the 5-year ACS estimate data from 2011 to 2015 are collected for the four regions to complete the regression analysis. Access to transit, commuting time, commuting mode, population and density, skill level, employment rate, and income are included in the linear regression model to observe if those factors are dependent to others statistically. The ACS 5-year dataset include the variables of:

Total population; population density (Per Sq. Mile); population by race; population by highest educational attainment for population 25 years and over; population of employment and unemployment rate for civilian population in labor force 16 years and over; per capita income (in 2015 inflation adjusted dollars); population by means of transportation to work for workers 16 years and over; and population by travel time to work for workers 16 years and Over. All of these data are on block group level.

In order to analyze with the linear regression model, raw data from ACS is not sufficient. The skill level variable, low skill rate, is made from block group's population whose highest education attainment under college, divided by Population 25 Years and Over. The employment rate is also

calculated in order to show the employment condition of each block groups, with the employed divided by Civilian Population in Labor Force 16 Years and Over. Similarly, a rate of population commute by transit is calculated; and percent of populations commuting more than half hour and commuting more than one hour are also produced.

Another key factor related to the topic of this paper, spatial mismatch and transit, is represented as the distance from each census block group, to its nearest transit station. Geographic Information System is used to calculate the distance from each census block group to its nearest transit station. The GIS shapefile of different regions are collected as open sources from municipalities and local transit operators.

Geographic Scale

The study areas for this research were the cities of Atlanta, Georgia, Los Angeles, California, Portland, Oregon and Seattle, Washington. Initially, metropolitan statistical areas (MSAs) are decided to be the boundaries of analysis, since it is possible that commuters might need to commute across and outside of the city boundaries.

However, the GIS profile for transit stops provided by municipals and local transit operators are rarely available outside city regions. After calculating the distance from each census block group to nearest transit station with Near tool in ArcGIS, a filter of 2 kilometers is applied to exclude the possible deviation caused by the missing information of transit and bus stops. That is, only block groups having transit stations within 2 km distance are counted in the next steps of analysis. This filter is aimed at excluding the block groups where information of transit stops is missed to eliminate the possible deviation- areas do not have any transit stops including buses and rails within this maximum acceptable walking distance are very likely facing the missing of transit stop information.

2 km is decided as the last-mile transit distance, or also usually recognized as walking distance to or from transit stations. Sanchez used 0.4 miles as walking distances (Sanchez, 1999). And in 1993, city of Calgary, the average walking distance to suburban stations was 649 m, with a 75th-percentile distance of 840 (O'Sullivan and Morrall, 1993). As mentioned by Guiliano, 2001, at that time, 8.5 percent of all households do not have cars, one-third of the lowest-income households have no car, and almost half have one car, and the vast majority of all person-trips take place in private vehicles, even among the lowest-income households. Thus, after another decade of development, with the trend of private ownership expanding with economic growth, it is reasonable to take into considerations of the possibility of the park-and-ride mode- commuters are possible to transfer longer distance than formerly acceptable walking distance. Hence, 2 kilometers is chosen as the filter distances. After

filtering with the maximum acceptable travel distance, the areas covered by remaining census blocks are relatively similar to city boundaries.

The four chosen areas have similarities in their demographic, political and economic scales, and they all have developed transit systems. Yet, there are further disparities not only in their demographic but also transit services aspects, which are going to be discussed in the following sections. To be mentioned, the MSA of Portland city crossed over two states: Oregon and Washington, yet the city or Portland only locates in the southern bank in Oregon. Therefore, only GIS transit stations files and block groups ACS data in the city boundary located in Oregon State, are included in the analysis.

Analysis

Overview

To initiate the analysis section, general sketch of the four metropolitan statistical areas is outlined with data to show their regional demographic and employment conditions. Statistical results of the five years ACS data for the block groups in the four MSAs are summarized in the table below.

Table 1. Statistical Overview of Four Regions

	Atlanta	Los Angeles	Seattle	Portland
Block Group Number	3025	10829	3088	1545
Population	6306481	18464453	4504073	2506275
Population Density (per. sq. mile)	430	395	181	166
minority rate	41%	41%	26%	18%
Low skill rate	38%	42%	30%	32%
commute by public	3%	5%	8%	6%
Employment Rate	91%	90%	93%	91%
percent of commute more than half hour	44%	43%	41%	33%
percent of commute more than 1 hour	11%	12%	10%	6%

From the table, we can easily observe that, employment rate and percentage of residents commuting more than half hour do not differ much from one another. Atlanta, Seattle and Portland have relatively more similar population count, while Los Angeles has a much larger population. However, its population density does not differ much from Atlanta, probably because of the Los Angeles MSA has larger geographical area. Though, Atlanta and Los Angeles have more characteristics in common comparing to other two MSAs. Compared to Seattle and Portland, Atlanta and Los Angeles both have higher population density: 430 and 395 per square mile comparing to 181 and 166, higher non-white

composition rate (41 percent to 26 and 18 percent), higher low skill population composition, which means more population (38 and 42 percent to 30 and 32 percent) do not have college degree. Also, a larger proportion of residents in Atlanta and Los Angeles regions have to commute more than 1 hour with 11 and 12 percent compared to 10 and 6 percent for Seattle and Portland. However, interestingly, although Atlanta and Los Angeles have larger proportion of low-skill or minority residents, less of them commute by transit (3 and 5 percent compared to 8 and 6 percent).

OnTheMap

After getting the first impression for each region, this part is going to show the visualization of LODES data. As mentioned above, Atlanta and Los Angeles are more likely to share similar demographic features, so do Seattle and Portland. Thus, maps of Atlanta and Seattle, as representatives of each similar groups, showing the employment and residences distribution followed as below; both display a sign of spatial mismatch. None the less, the maps of Los Angeles and Portland are also attached in the appendix.

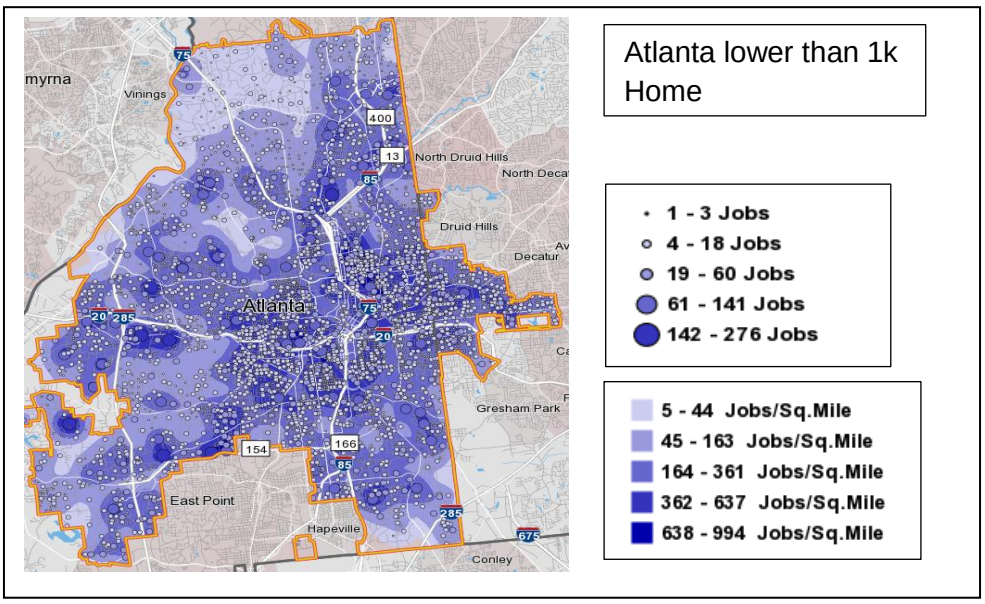

Figure 1. Geographic Distribution of Low-Income Employee Residence, Atlanta

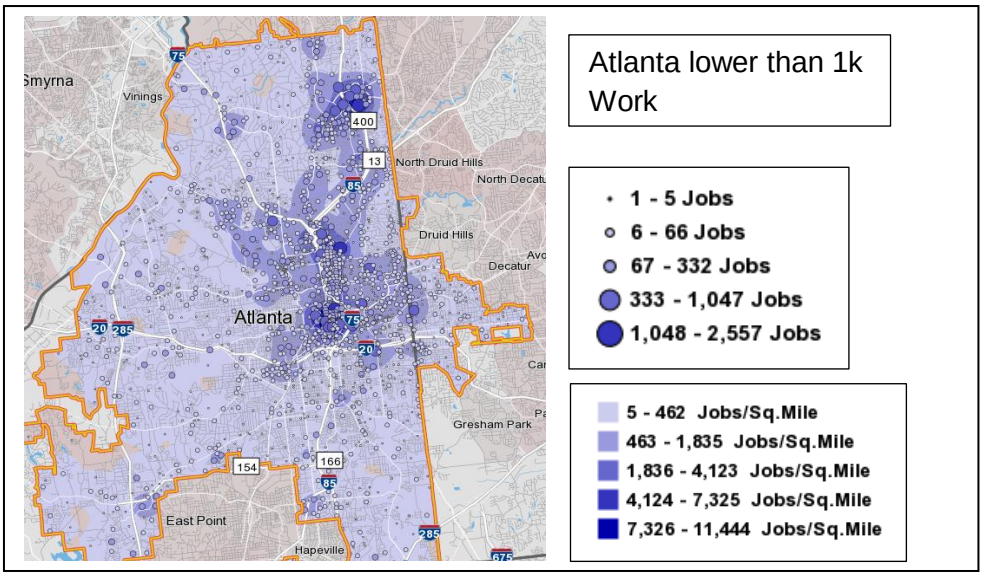

Figure 2. Geographic Distribution of Low-Income Employee Workplace, Atlanta

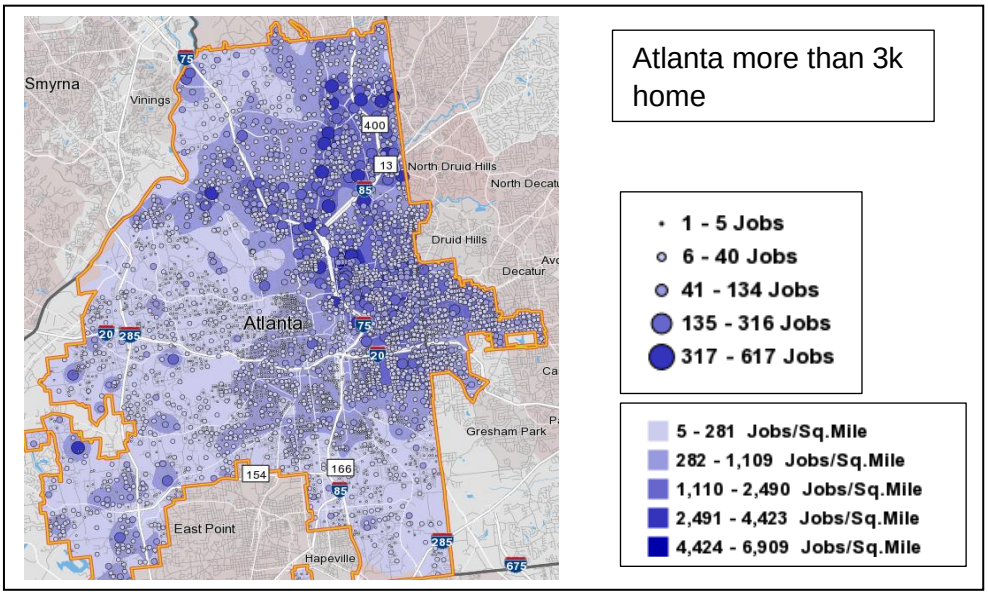

Figure 3. Geographic Distribution of High-Income Employee Residence, Atlanta

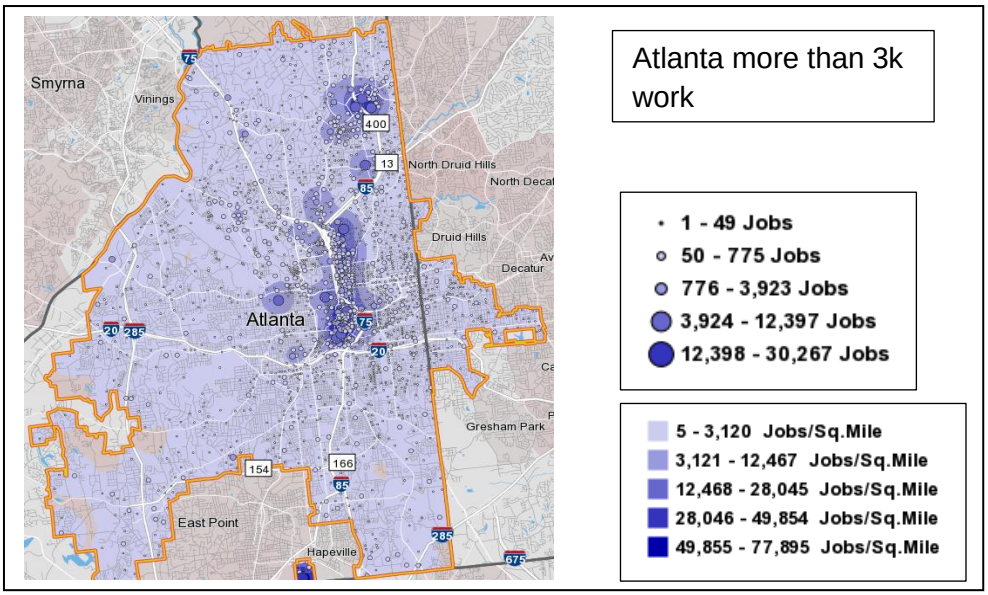

Figure 4. Geographic Distribution of High-Income Employee Workplace, Atlanta

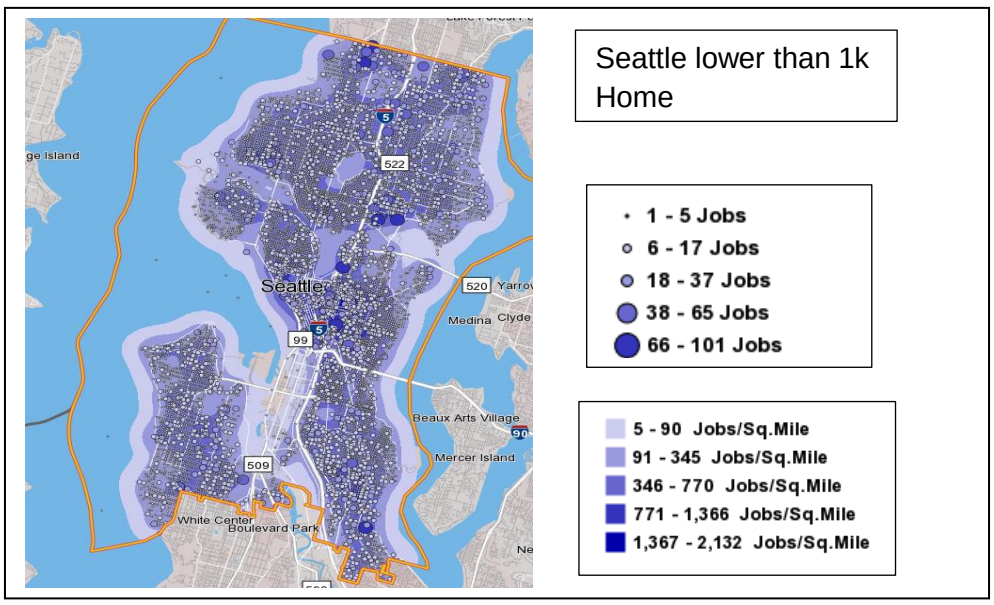

Figure 5. Geographic Distribution of Low-Income Employee Residence, Seattle

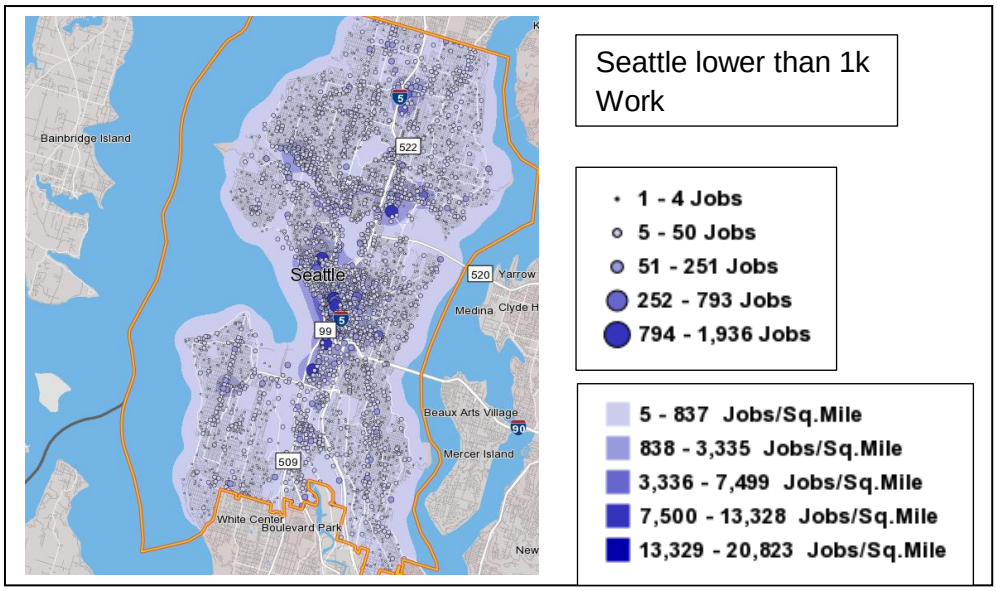

Figure 6. Geographic Distribution of Low-Income Employee Workplace, Seattle

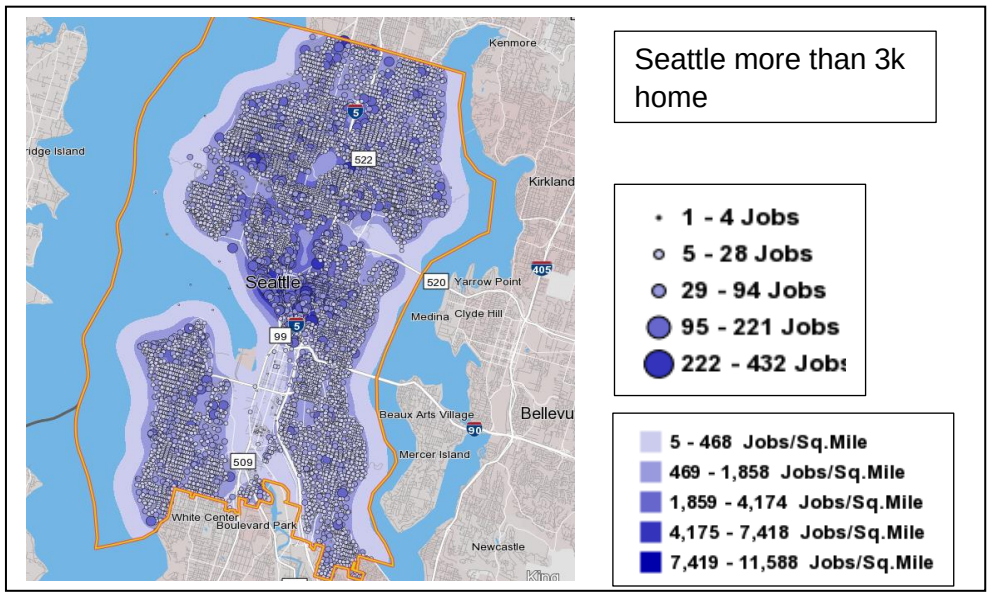

Figure 7. Geographic Distribution of High-Income Employee Residence, Seattle

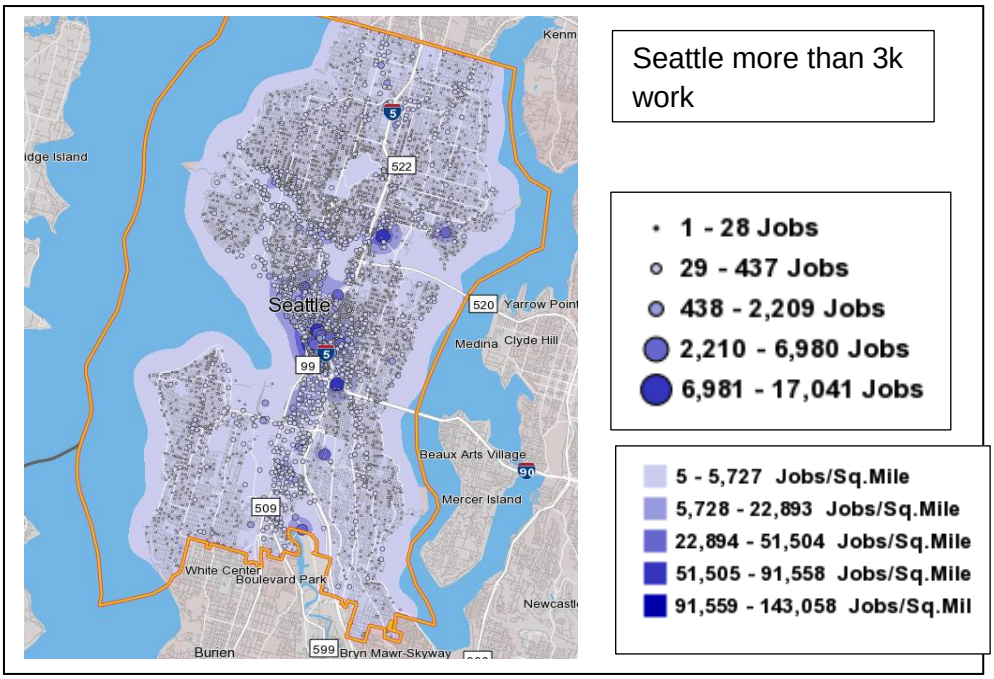

Figure 8. Geographic Distribution of High-Income Employee Workplace, Seattle

The maps from the census bureau express clearly a tendency of spatial mismatch. For example, in Atlanta, both jobs paying less than 1250 and more than 3333 monthly are concentrated around the northeast side of the region, along the interstate highways. However, what have revealed the situation of spatial mismatch is the difference of residence location of commuters at different income level. While workers with monthly income lower than 1,250 dollars dispersed over the whole Atlanta City region, or even more likely to cluster in the southern part, workers with monthly income higher than 3,333 dollars apparently cluster in the northeast part of the Atlanta City region- that is, closer to work.

Spatial Mismatch in Seattle is not as obvious as in Atlanta, yet still observable. In Seattle, both jobs paying less than 1250 and more than 3333 monthly concentrate around the central part of the region. Although residence location of those workers all seems to be distributed all over the Seattle city region, low-income workers are more evenly distributed while higher income workers live closer to the central part- where the jobs are.

Regression

All the variable discussed above are applied in the regression analysis stage. The analysis is conducted among three sample groups: All transit-accessible block groups that locate within 2 km of any transit stops, all transit-accessible block groups that are minority-dominated, and all transit-accessible that are low-skill dominated.

The way to filter out these two new subgroups is only to include block groups where specific variables are higher than regional average value. For Example, in Atlanta, the average minority composition rate and low-skill rates are 41 and 38 percent. Thus, minority dominated block groups should have a minority rate no less than 41 percent, as low-skill dominated block groups should have a low skill rate more than 38 percent.

All Transit- Accessible Block Groups

Table 2. regression results for All Transit- Accessible Block Groups with Employment rate as dependent variable

Employment rate	Atlanta		Los Angeles		Seattle		Portland	
	B	sig	B	sig	B	sig	B	sig
(Constant)	0.982	0	0.942	0	0.969	0	0.942	0
Total Population	1.69E-06	0.239	2.98E-06	0.02	-2.36E-06	0.293	2.98E-06	0.02
commute by public	6.22E-07	0.21	-0.205	0.432	-1.05E-07	0.523	-3.11E-07	0
Low skill rate	-0.124	0	-0.065	0	0	0.986	-0.205	0.432
minority rate	-0.081	0	-0.03	0	-0.07	0	-0.065	0
DISTANCE TO NEAREST STOP	-0.105	0	7.91E-06	0	-0.028	0	-0.03	0
percent of commute more than 1 hour	-6.33E-06	0.087	-0.033	0.009	-2.17E-06	0.458	7.91E-06	0
percent of commute more than half hour	-0.017	0.534	0.007	0.344	0.009	0.681	-0.033	0.009
Population Density	0.008	0.569	-3.11E-07	0	-0.01	0.37	0.007	0.344
Adj R square	0.344		0.122		0.085		0.122	

Among all the four regions, minority rate and distance to nearest stops are statistical significantly influence the dependent variable employment rate. However, while in Atlanta, Seattle and Portland, living closer to a transit stop means higher employment rate for the block group, living further to a stop in Los Angeles means lower employment rate. It could be possibly described with the population density: the population density only significantly influence the employment rate in Los Angeles with the trend that the increase of population density decrease the employment rate, which could probably indicate those low-income and minority population are more likely to locate in central urban areas where density is higher. Portland workers also show higher employment rate if more residents in the block group commute by public transit.

Table 3. Regression Results for All Transit- Accessible Block Groups With Per Capita Income as Dependent Variable

Per Capita Income	Atlanta		Los Angeles		Seattle		Portland	
	B	sig	B	sig	B	sig	B	sig

(Constant)	73266.382	0	72187.052	0	74637.536	0	72187.052	0
Total Population	-1.359	0	-1.51	0	-0.772	0.185	-1.51	0
commute by public	9398.948	0.025	1990.664	0.976	-13505.516	0.001	1990.664	0.976
Low skill rate	-53799.525	0	-62057.228	0	-66718.24	0	-62057.228	0
minority rate	-25990.059	0	-21315.15	0	-14959.288	0	-21315.15	0
DISTANCE TO NEAREST STOP	-3.113	0	-1.748	0.001	-2.46	0.001	-1.748	0.001
percent of commute more than 1 hour	1675.791	0.739	-19361.038	0	-13255.326	0.017	-19361.038	0
percent of commute more than half hour	-12126.217	0	5056.24	0.008	-16580.174	0	5056.24	0.008
Population Density	-0.226	0.015	-0.124	0	-0.131	0.002	-0.124	0
Adj R square	0.643		0.589		0.545		0.589	

Significant variables differ when dependent variableschange to per capita income for each census block groups. In this case, low skill rate, minority rate, distance to nearest stops, commuting time and population density are all significantly influencing income. Moreover, living closer to a transit stop increases the average income for all four regions.

Table 4. Regression Results for All Transit- Accessible Block Groups with Percent of Commute More Than Half Hour as Dependent Variable

DV percent of commute more than half hour	Atlanta		Los Angeles		Seattle		Portland	
	B	sig	B	sig	B	sig	B	sig
(Constant)	0.333	0.051	0.12	0	0.475	0	0.364	0
Total Population	1.67E-05	0	6.55E-06	0	7.40E-06	0.193	1.40E-06	0.587
DISTANCE TO NEAREST STOP	-6.51E-06	0	-9.17E-08	0.299	-2.73E-06	0	7.41E-07	0
commute by public	0.213	0.041	-0.673	0.027	0.15	0	-0.189	0.718
Employment rate	0.033	0.049	-0.03	0.057	0.037	0.565	-0.006	0.815
Low skill rate	0.074	0.024	0.027	0	0.036	0.188	0.084	0
minority rate	0.081	0.016	0.014	0.002	-0.103	0	0.093	0
Per Capita Income (In 2015 Inflation Adjusted Dollars)	5.45E-05	0	-2.50E-06	0.285	1.47E-05	0.047	-5.97E-06	0.137
Population Density	-1.28E-06	0	-3.10E-07	0	-1.87E-06	0	8.73E-09	0.934
Adj R square	0.243		0.044		0.101		0.094	

Table 5. Regression Results for All Transit- Accessible Block Groups with Percent of Commute More Than One Hour as Dependent Variable

DV percent of commute more than 1 hour	Atlanta		Los Angeles		Seattle		Portland	
	B	sig	B	sig	B	sig	B	sig
(Constant)	0.04	0.146	0.364	0	0.048	0.127	0.12	0
Total Population	9.22E-06	0	1.40E-06	0.587	6.43E-06	0.026	6.55E-06	0
DISTANCE TO NEAREST STOP	-2.56E-06	0	7.41E-07	0	-1.14E-06	0	-9.17E-08	0.299
commute by public	0.311	0	-0.189	0.718	0.12	0	-0.673	0.027
Employment rate	-0.008	0.764	-0.006	0.815	0.033	0.31	-0.03	0.057
Low skill rate	0.036	0.006	0.084	0	0.103	0	0.027	0
minority rate	0.041	0	0.093	0	-0.042	0	0.014	0.002
Per Capita Income (In 2015 Inflation Adjusted Dollars)	2.93E-05	0	-5.97E-06	0.137	1.82E-05	0	-2.50E-06	0.285
Population Density	-2.44E-07	0.08	8.73E-09	0.934	-6.76E-07	0	-3.10E-07	0
Adj R square	0.643		0.094		0.17		0.044	

When it comes to the commuting time as a dependent variable, minority rate and low skill rate are the universal variables that increase the percentage of residents in the block groups that commuting time exceeds 1 hour. However, in Atlanta and Seattle, it seems that higher per capita income raise the ratio of percentage of commuting time over 1 hour, which contradicts to the previous assumption that population of economic disadvantaged have longer commuting time. To figure out which of the assumptions is closer to the fact, regression on two subgroups are embarked and showed as followed.

Minority dominated block groups

Table 7. Regression Results for Minority Dominated Block Groups with Employment Rate As Dependent Variable

Employment Rate	Atlanta		Los Angeles		Seattle		Portland	

	B	sig	B	sig	B	sig	B	sig
(Constant)	0.982	0	0.942	0	0.969	0	0.942	0
Total Population	1.69E-06	0.239	2.98E-06	0.02	-2.36E-06	0.293	2.98E-06	0.02
commute by public	6.22E-07	0.21	-0.205	0.432	-1.05E-07	0.523	-3.11E-07	0
Low skill rate	-0.124	0	-0.065	0	0	0.986	-0.205	0.432
minority rate	-0.081	0	-0.03	0	-0.07	0	-0.065	0
NEAR_DIST	-0.105	0	7.91E-06	0	-0.028	0	-0.03	0
percent of commute more than 1 hour	-6.33E-06	0.087	-0.033	0.009	-2.17E-06	0.458	7.91E-06	0
percent of commute more than half hour	-0.017	0.534	0.007	0.344	0.009	0.681	-0.033	0.009
Population Density	0.008	0.569	-3.11E-07	0	-0.01	0.37	0.007	0.344
Adj R square	0.344		0.122		0.085		0.122	

It is hard to find a common variable every region share that are significantly influencing the employment rate for minority dominated block groups other than minority rate, yet for all the four regions, higher minority rate means lower employment rate. In Atlanta and Portland, shorter distance to nearest transit stops means higher employment rate.

Table 8. Regression Results for Minority Dominated Block Groups with Per Capita Income as Dependent Variable

Per Capita Income	Atlanta		Los Angeles		Seattle		Portland	
	B	sig	B	sig	B	sig	B	sig
(Constant)	47609.942	0	51257.977	0	67183.837	0	51257.977	0
Total Population	-0.344	0.038	-0.637	0.003	0.095	0.88	-0.637	0.003
commute by public	2172.289	0.345	-119411.305	0.003	-9344.915	0.038	-119411.305	0.003
Low skill rate	-33566.461	0	-43641.826	0	-59403.718	0	-43641.826	0
minority rate	-13867.965	0	-7513.792	0	-11004.57	0	-7513.792	0
DISTANCE TO NEAREST STOP	-1.09	0.029	-1.065	0.007	-2.692	0.006	-1.065	0.007
percent of commute more than 1 hour	-4890.912	0.092	-9493.276	0	-20406.918	0.005	-9493.276	0
percent of commute more than half hour	3347.118	0.036	4905.345	0	-11671.364	0.001	4905.345	0
Population Density	-0.425	0	-0.08	0	-0.151	0.005	-0.08	0
Adj R square	0.54		0.64		0.537		0.641	

When it comes to per capital income, more factors display significance. In this case, it is clearly shown that per capital income would be lower in areas with higher population density. In Los Angeles and Portland, higher commuting by transit rate decrease per capital income, which could probably indicate transit is more likely chosen to be commuting mode for lower income minority population.

Nevertheless, according to the regression results, there is no evidence showing accessibility to transit could improve the employment rate, or per capita income for minority dominated groups.

Table 9. Regression Results for Minority Dominated Block Groups with Percent of Commute More Than Half Hour as Dependent Variable

percent of commute more than half hour	Atlanta		Los Angeles		Seattle		Portland	
	B	sig	B	sig	B	sig	B	sig
(Constant)	0.308	0	0.273	0	0.365	0	0.273	0
Total Population	1.99E-05	0	-2.40E-06	0.485	6.66E-06	0.329	-2.40E-06	0.485
DISTANCE TO NEAREST STOP	5.38E-05	0	1.43E-06	0	-2.28E-06	0	1.43E-06	0
commute by public	0.233	0	-0.348	0.586	0.108	0.028	-0.348	0.586
Employment rate	-0.023	0.698	0.042	0.238	0.133	0.094	0.042	0.238
Low skill rate	0.119	0.001	0.11	0	0.008	0.818	0.11	0
minority rate	0.076	0.007	0.121	0	-0.03	0.358	0.121	0
Per Capita Income (In 2015 Inflation Adjusted Dollars)	1.06E-06	0.138	-1.45E-05	0.019	1.16E-05	0.279	-1.45E-05	0.019
Population Density	-6.49E-06	0	5.52E-07	0.063	-1.93E-06	0	5.52E-07	0.063
Adj R square	0.113		0.08		0.064		0.08	

Table 10. Regression Results for Minority Dominated Block Groups with Percent of Commute More Than One Hour as Dependent Variable

percent of commute more than 1 hour	Atlanta		Los Angeles		Seattle		Portland	
	B	sig	B	sig	B	sig	B	sig
(Constant)	0.038	0.309	0.14	0	0.029	0.43	0.14	0
Total Population	8.15E-06	0	5.92E-06	0.003	5.75E-06	0.082	5.92E-06	0.003
DISTANCE TO NEAREST STOP	3.69E-05	0	1.72E-07	0.111	-5.70E-07	0.042	1.72E-07	0.111
commute by public	0.342	0	-0.775	0.039	0.093	0	-0.775	0.039
Employment rate	-0.006	0.846	-0.045	0.031	0.066	0.087	-0.045	0.031
Low skill rate	0.02	0.316	0.025	0.016	0.084	0	0.025	0.016
minority rate	0.05	0.001	0.007	0.446	-0.034	0.03	0.007	0.446

Per Capita Income (In 2015 Inflation Adjusted Dollars)	-3.20E-07	0.414	-9.57E-06	0.009	1.35E-05	0.01	-9.57E-06	0.009
Population Density	-2.62E-06	0	-4.25E-07	0.015	-9.06E-07	0	-4.25E-07	0.015
Adj R square	0.228			0.031	0.163		0.031	

Otherwise, among the minority dominated block groups, in Atlanta and Seattle, living in high-density area and commuting by public transit causes a higher percent of long commuting time. At the same time, living near to a transit stop also increase commuting time in Atlanta. Still, although evidence of spatial mismatch is evident for minority groups, the regression results is not showing proof for transit improving longer commuting time situation for the minorities.

Low-skill dominated block groups

Table 11. Regression Results for Low-skill Dominated Block Groups with Employment Rate as Dependent Variable

Employment rate	Atlanta		Los Angeles		Seattle		Portland	
	B	sig	B	sig	B	sig	B	sig
(Constant)	1.02	0	0.945	0	0.971	0	0.945	0
Total Population	2.32E-06	0.424	4.40E-06	0.032	-6.86E-06	0.138	4.40E-06	0.032
commute by public	1.44E-06	0.137	-1.39E-07	0.183	7.06E-09	0.99	-1.39E-07	0.183
Low skill rate	-0.121	0	-0.353	0.26	-0.035	0.268	-0.353	0.26
minority rate	-0.114	0	-0.061	0	-0.07	0.002	-0.061	0
DISTANCE TO NEAREST STOP	-0.134	0	-0.042	0	-0.004	0.783	-0.042	0
percent of commute more than 1 hour	-7.53E-06	0.324	3.71E-06	0.28	-5.20E-07	0.921	3.71E-06	0.28
percent of commute more than half hour	0.002	0.955	-0.072	0	0.104	0.006	-0.072	0
Population Density	-0.006	0.816	0.008	0.439	-0.038	0.085	0.008	0.439
Adj R square	0.213		0.045		0.024		0.045	

In this subgroup, minority rate decreases the employment rate over four regions. Interestingly, in low-skill dominated block groups, low skill rate is not the universal variable that affects the employment rate, not does population density; yet, for low-skill dominated block groups, living closer to transit stops does increase the employment rates, which is different from the regression results for all the block groups.

Table 12. Regression Results for Low-skill Dominated Block Groups with Per Capita Income as Dependent Variable

Per Capita Income	Atlanta		Los Angeles		Seattle		Portland	
	B	sig	B	sig	B	sig	B	sig
(Constant)	40552.932	0	38799.57	0	47432.86	0	38799.57	0
Total Population	-0.667	0	0.101	0.444	-0.77	0.125	0.101	0.444
commute by public	-230.008	0.903	-155788.833	0	3722.682	0.28	-155788.833	0
Low skill rate	-27995.558	0	-28287.8	0	-34529.75	0	-28287.8	0
minority rate	-8928.636	0	-3983.729	0	-9488.592	0	-3983.729	0
DISTANCE TO NEAREST STOP	0.354	0.427	0.415	0.062	-0.021	0.97	0.415	0.062
percent of commute more than 1 hour	-3129.362	0.197	-4251.247	0	-5144.685	0.206	-4251.247	0
percent of commute more than half hour	2632.029	0.07	811.558	0.244	3057.295	0.202	811.558	0.244
Population Density	-0.17	0.003	-0.064	0	-0.28	0	-0.064	0
Adj R square	0.394		0.542		0.433		0.543	

Nonetheless, living closer to a station does not necessarily increase the per capita income. For low-skill dominated groups, low skill rate, minority rate and population are three universal factors that decrease income.

Table 13. Regression Results for Low-skill Dominated Block Groups with Percent of Commute More Than Half Hour as Dependent Variable

percent of commute more than half hour	Atlanta		Los Angeles		Seattle		Portland	
	B	sig	B	sig	B	sig	B	sig
(Constant)	0.346	0	0.387	0	0.493	0	0.387	0
Total Population	2.04E-05	0	-1.49E-06	0.703	1.26E-05	0.184	-1.49E-06	0.703
DISTANCE TO NEAREST STOP	1.99E-05	0.109	1.70E-06	0	-2.22E-06	0.054	1.70E-06	0
commute by public	0.229	0	-0.576	0.341	0.185	0.004	-0.576	0.341
Employment rate	-0.034	0.585	-0.036	0.328	-0.086	0.334	-0.036	0.328
Low skill rate	0.077	0.156	0.077	0.002	0.005	0.925	0.077	0.002
minority rate	0.032	0.217	0.095	0	-0.047	0.118	0.095	0
Per Capita Income (In 2015 Inflation Adjusted Dollars)	1.58E-06	0.138	-2.39E-05	0	-7.73E-06	0.472	-2.39E-05	0
Population Density	-1.92E-06	0.231	-1.19E-07	0.835	8.83E-07	0.281	-1.19E-07	0.835

Adj R square	0.045		0.081		0.014		0.083	

Table 14. Regression Results for Low-skill Dominated Block Groups with Percent of Commute More Than One Hour as Dependent Variable

percent of commute more than 1 hour	Atlanta		Los Angeles		Seattle		Portland	
	B	sig	B	sig	B	sig	B	sig
(Constant)	0.056	0.225	0.184	0	-0.032	0.535	0.184	0
Total Population	8.67E-06	0.002	4.14E-06	0.076	1.47E-05	0.008	4.14E-06	0.076
DISTANCE TO NEAREST STOP	3.35E-05	0	4.23E-07	0	-1.17E-06	0.084	4.23E-07	0
commute by public	0.351	0	-0.832	0.021	0.18	0	-0.832	0.021
Employment rate	0.003	0.933	-0.072	0.001	0.134	0.01	-0.072	0.001
Low skill rate	0.003	0.924	-0.01	0.496	0.061	0.057	-0.01	0.496
minority rate	0.025	0.11	0.017	0.012	-0.064	0	0.017	0.012
Per Capita Income (In 2015 Inflation Adjusted Dollars)	-3.77E-07	0.555	-8.68E-06	0.027	2.56E-06	0.684	-8.68E-06	0.027
Population Density	-2.17E-06	0.024	-8.65E-07	0.011	-7.11E-07	0.139	-8.65E-07	0.011
Adj R square	0.394		0.024		0.056		0.024	

For low-skill dominated block groups, there is no shared variable that affects the percentage of commuting time for all four regions. In these block groups in Atlanta, Los Angeles and Portland, living near to a stop, although would probably bring working opportunities, increase commuting time. In Seattle, only commuting mode contribute to the commuting time significantly: taking transit means longer commuting time. Thus, it could be concluded that, for low skill dominated block groups, transit bring jobs but does not shorten the commuting time.

Conclusion

Both data from LODES and ACS 5-year statistics show that spatial mismatch still exists among four chosen analysis regions: Atlanta, Los Angeles, Seattle and Portland. Generally, workers with low income or low-skill dominated block group residents are more likely to commute longer distances. Although there is argument about whether transit ridership fall among low-income transit riders with economic growth and increased private vehicle ownership, according to the regression results, transit

is still being an alternative of economical disadvantaged groups. Among low-skill groups, living closer to transit station increases employment rate, yet commuting by transit extend the commuting time. However, although minority rate and accessibility to transit are statistical significantly influencing the employment rate, there is no strong evidence found in the minority dominated block groups showing the relationship between transit, commuting time and employment.

A possible solution is to develop a complete model other than linear regression to see if any results change. Yet, tracing back to the contradictory results between different sample subgroups (for example, in Los Angeles, an upsurge income increase commuting time for all block groups, while among low-skill dominated block groups, commuting time decrease as income rise, the only possible assumption could be made as explanation is that among population with higher skill, higher income means longer commuting time, even if they have proper jobs in shorter distances), it seems to be too complicated for the equity issue of employment among diverse groups to be described only by spatial mismatch model. Hence, transit as a method to shorten the commuting distance for low-income and minority population to enhance their employment condition makes sense, yet not necessarily fully effective, that is another possible explanation for the reason why transit accessibility and mode choice do not display much significance among minority groups. Transit as the solution for spatial mismatch was intended to provide accessibility and mobility to employment or better working opportunity for those disadvantaged group, but maybe more thoughts beside accessibility and mobility need to be considered to make the solution more effective.

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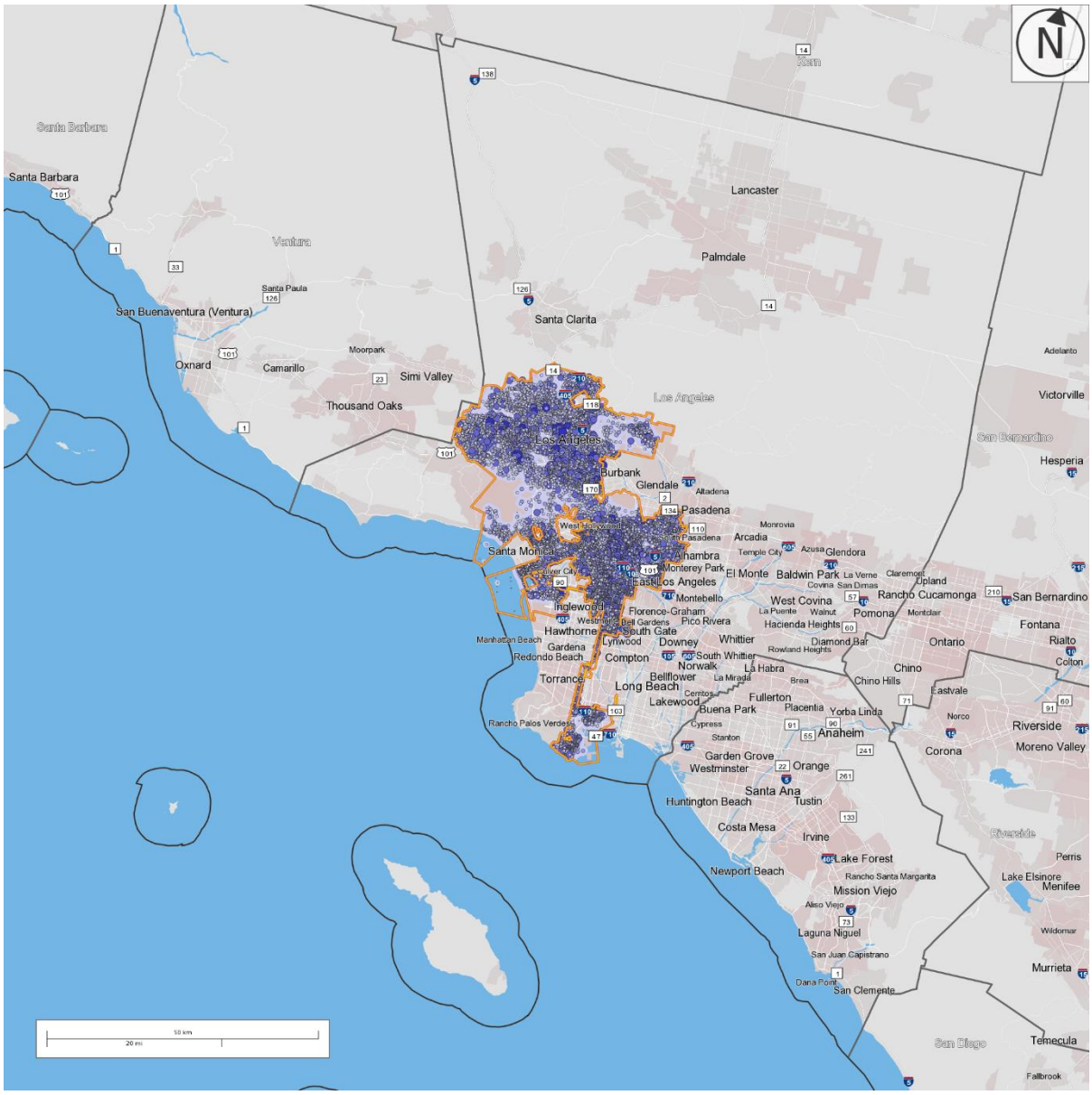
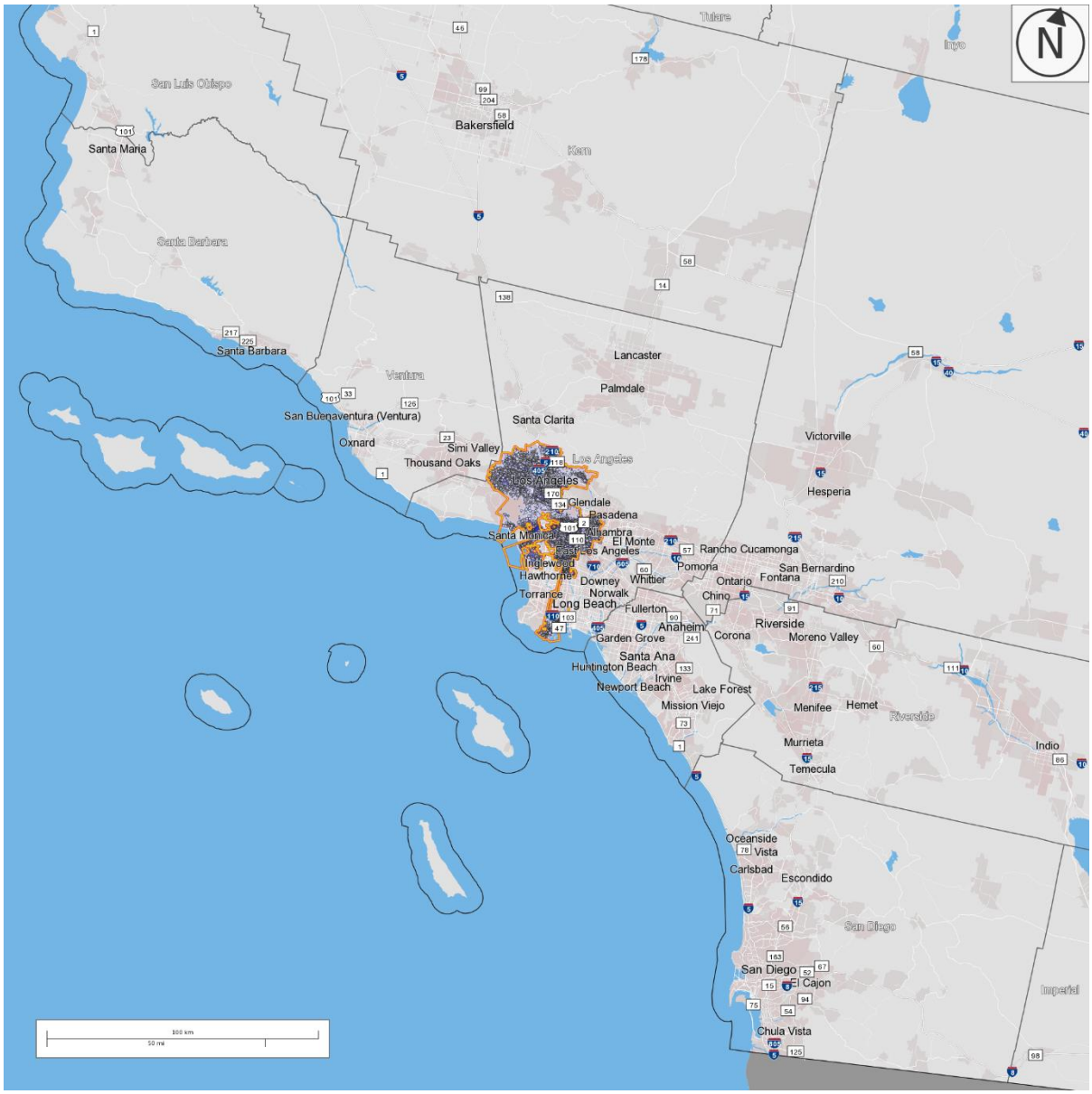
Appendix

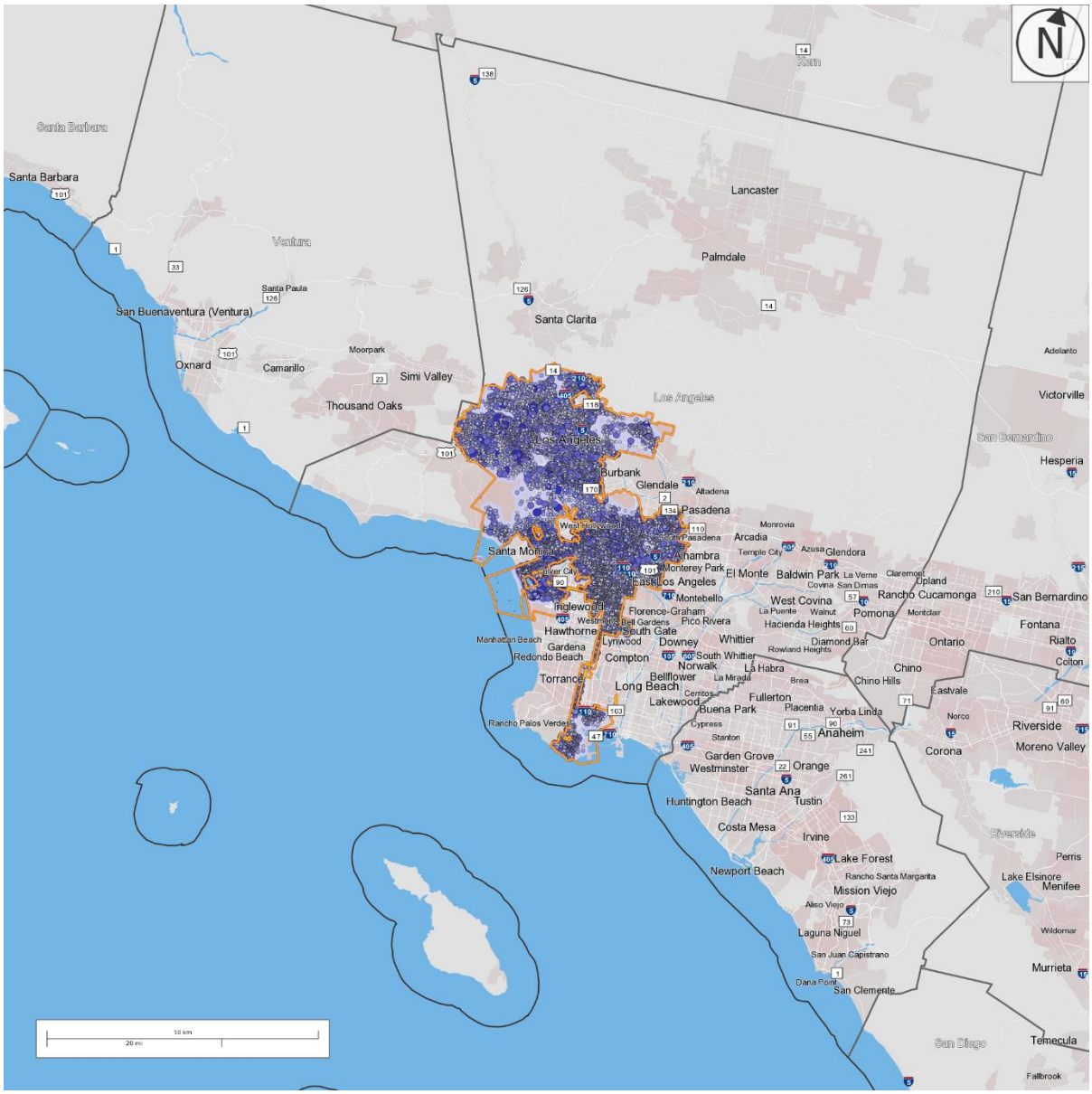
Los Angeles Low-income Home



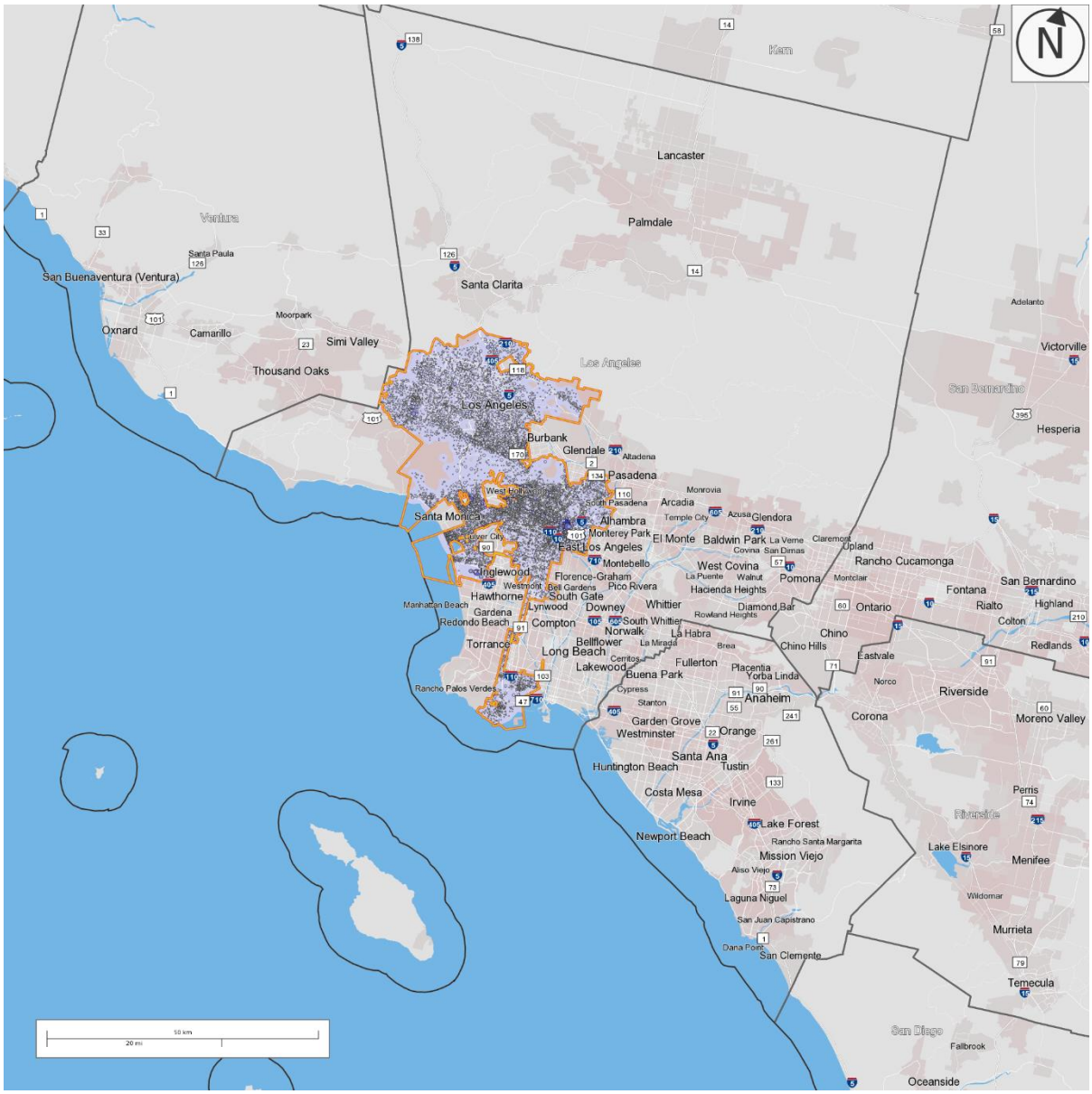
Los Angeles Low-income Work



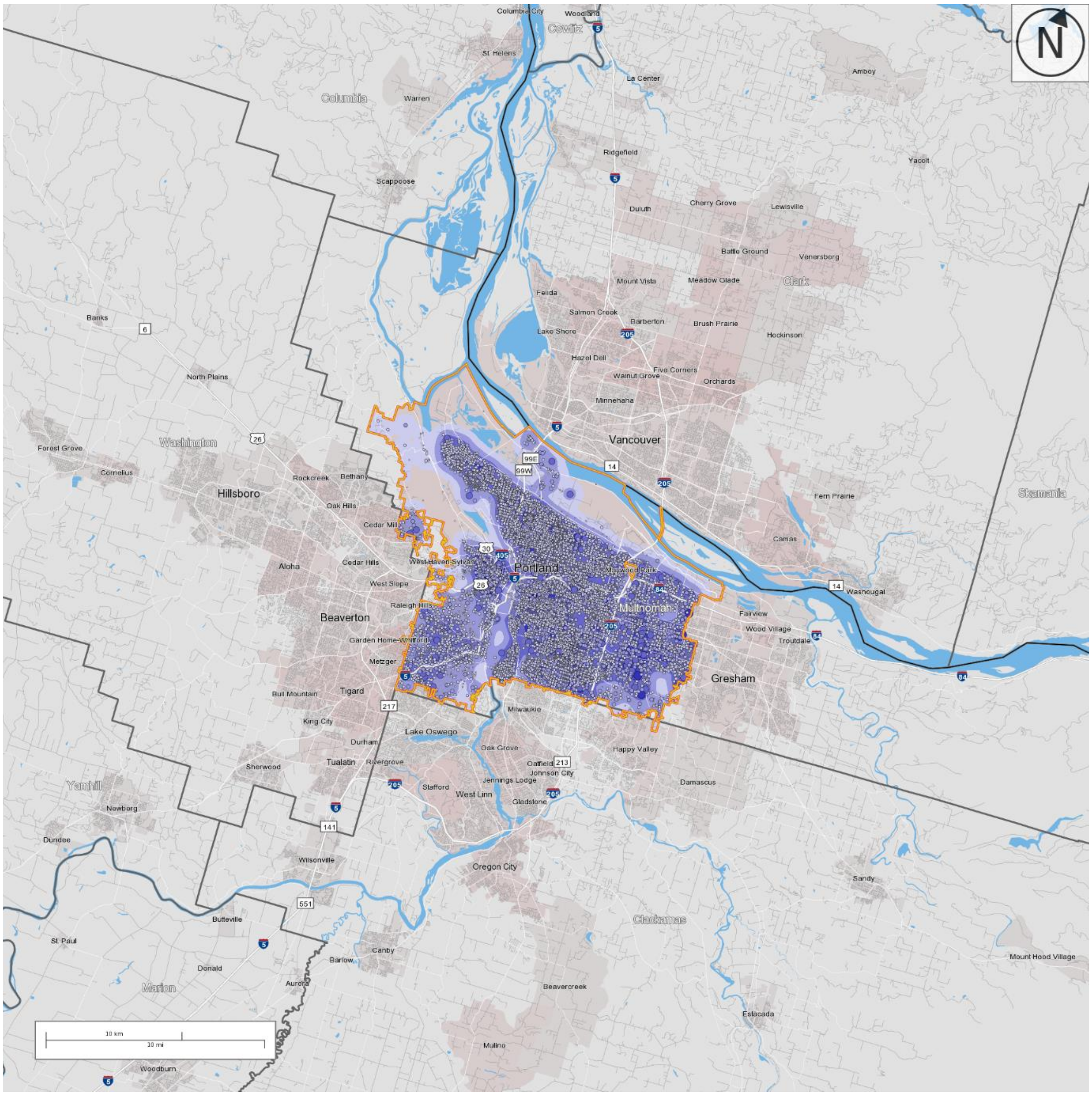
Los Angeles High-income Home



Los Angeles High-income Work



Portland Low-income Home



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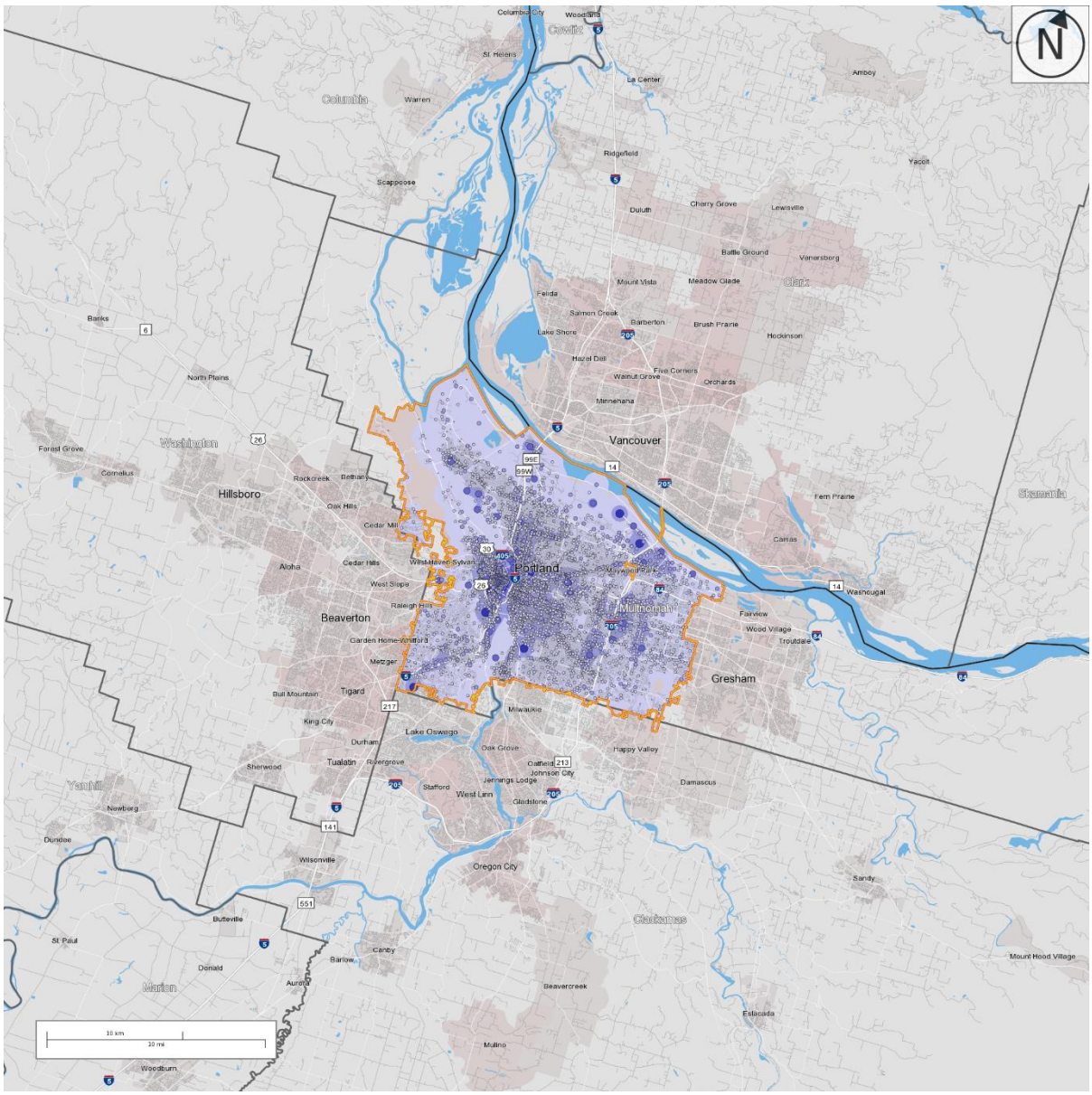
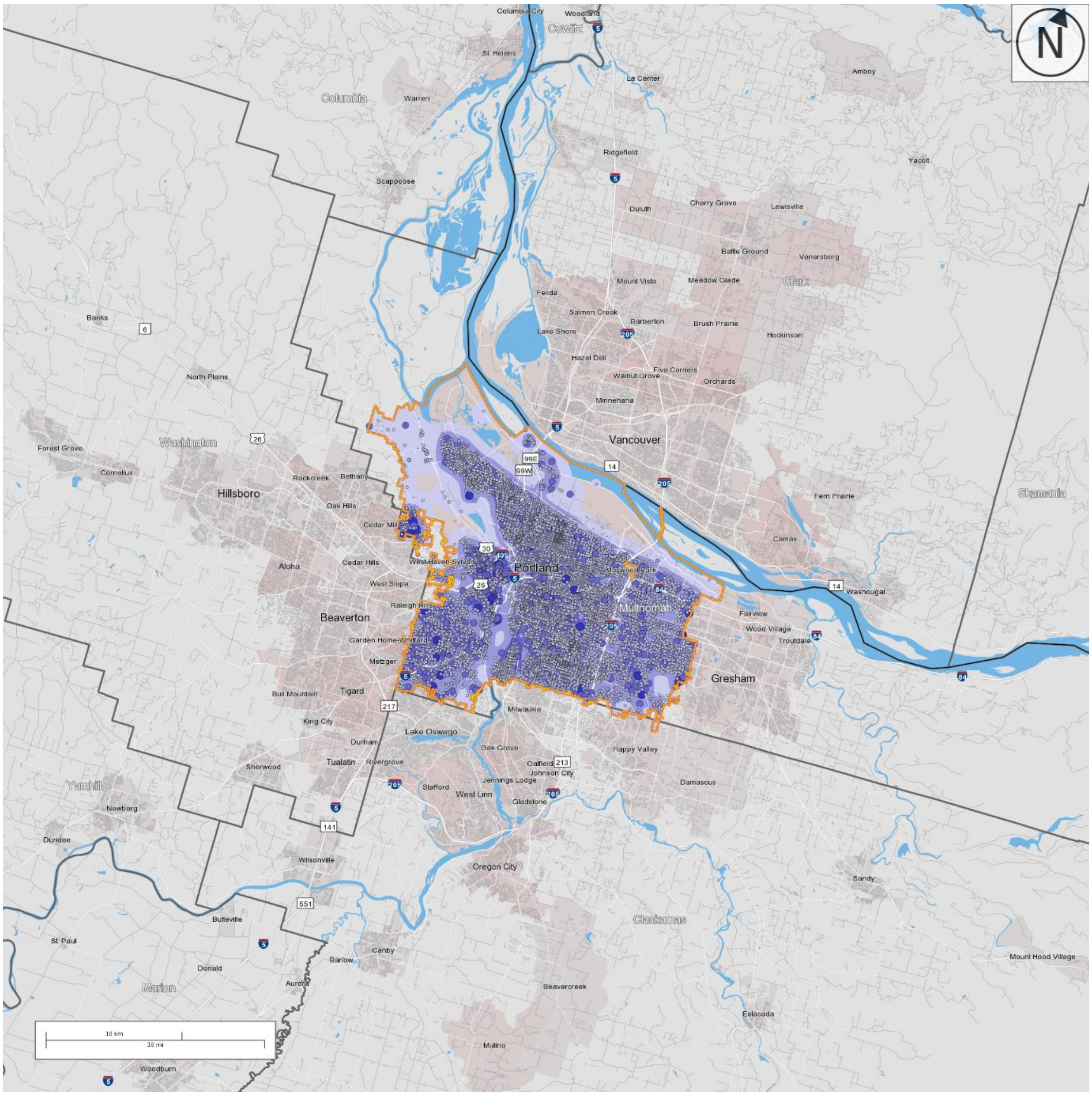


Portland High-income Home



Portland High-income Work