Examining the Geography of Opportunity through a New Public Transit Opportunity Index

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16. Abstract
The project introduces a new index of geographic opportunity that improves upon existing measures to analyze the spatial mismatch between job growth and populations in urban settings. Past measures of job accessibility have relied on measures of linear distance between populations and job, actual commute times for those working, or much simpler regional approaches. These past measures suffer from combinations of measurement error and endogeneity due to the fact that linear distance is most relevant if someone has a car and commute times derived from a working population subsumes a set of job market and residential choices for this population. Past measures are most problematic for the most disadvantaged populations that are unlikely to have a car. The new gravity model focus on travel time in public transportation using Generalized Transit Feed Specification (GTFS) data. We compare this measure of job accessibility to measures of auto and walking accessibility in 9 large metropolitan areas to determine the association between job accessibility and employment outcomes at the Census tract level. We find that labor force participation is consistently higher in places with greater transit accessibility between 15-45 minutes away. In contrast, accessibility by automobiles is most consistently associated with jobs that can be reached within 15 minutes.

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About the Pacific Southwest Region University Transportation Center

The Pacific Southwest Region University Transportation Center (UTC) is the Region 9 University Transportation Center funded under the US Department of Transportation's University Transportation Centers Program. Established in 2016, the Pacific Southwest Region UTC (PSR) is led by the University of Southern California and includes seven partners: Long Beach State University; University of California, Davis; University of California, Irvine; University of California, Los Angeles; University of Hawaii; Northern Arizona University; Pima Community College.

The Pacific Southwest Region UTC conducts an integrated, multidisciplinary program of research, education and technology transfer aimed at *improving the mobility of people and goods throughout the region.* Our program is organized around four themes: 1) technology to address transportation problems and improve mobility; 2) improving mobility for vulnerable populations; 3) Improving resilience and protecting the environment; and 4) managing mobility in high growth areas.

U.S. Department of Transportation (USDOT) Disclaimer

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Disclosure

Principal Investigator, Professor Gary Painter, along with co-PI Marlon Boarnet and student researcher Madison Swayne conducted this research titled, "Examining Spatial Mismatch through a New Geography of Opportunity Index" at the Sol Price School of Public Policy at the University of Southern California. The research took place from January 31, 2018 to December 31, 2019 and was funded by a grant from the U.S. Department of Transportation in the amount of $99,983. The research was conducted as part of the Pacific Southwest Region University Transportation Center research program.

Abstract

The project introduces a new index of geographic opportunity that improves upon existing measures to analyze the spatial mismatch between job growth and populations in urban settings. Past measures of job accessibility have relied on measures of linear distance between populations and job, actual commute times for those working, or much simpler regional approaches. These past measures suffer from combinations of measurement error and endogeneity due to the fact that linear distance is most relevant if someone has a car and commute times derived from a working population subsumes a set of job market and residential choices for this population. Past measures are most problematic for the most disadvantaged populations that are unlikely to have a car. The new gravity model focus on travel time in public transportation using Generalized Transit Feed Specification (GTFS) data. We compare this measure of job accessibility to measures of auto and walking accessibility in 9 large metropolitan areas to determine the association between job accessibility and employment outcomes at the Census tract level. We find that labor force participation is consistently higher in places with greater transit accessibility between 15-45 minutes away. In contrast, accessibility by automobiles is most consistently associated with jobs that can be reached within 15 minutes.

Examining the Geography of Opportunity through a New Public Transit Opportunity Index

Executive Summary

The objective of this project is to develop a new index of geographic opportunity that improves upon existing measures to analyze the spatial relationship between the location of jobs and populations in urban settings. We develop a job accessibility measure based on Generalized Transit Feed Specification data which can be used to replace measures of actual commute times of workers and linear distance measures of job access to produce better estimates for job accessibility for the most vulnerable populations. We then test this new measure of the Geography of Opportunity in regression models to determine how job accessibility is associated with employment outcomes. This study has important implications for understanding patterns of unemployment, underemployment, and access to labor markets, especially for populations with employment barriers.

Past measures of job accessibility have relied on measures of linear distance between populations and jobs, actual commute times for those working, or much simpler regional approaches. These past measures suffer from combinations of measurement error and endogeneity due to the fact that linear distance is most relevant if someone has a car and if commute times derived from a working population subsume well represent a set of job market and residential choices. Past measures are most problematic for the most disadvantaged populations that are unlikely to have a car. This research highlights the need to develop an exogenous measure of job access that does not require car ownership.

This job accessibility measure in this study is created using Generalized Transit Feed Specification (GTFS) data. Using Remix (a commercially available tool), we constructed travel time isochrones at 15, 30, 45, and 60 minute thresholds. By way of comparison (Figure 1), we also construct walking and auto access isochrones based on linear distance and average speeds that someone of each commute type would travel. Jobs are then counted within each isochrone to obtain the total number of jobs that can be accessed via each mode. We compare these three alternative measures of job accessibility in nine large metropolitan areas to determine the association between job accessibility and employment outcomes at the Census tract level using a regression based framework.

The results suggest that greater job accessibility by transit within 15-45 minute travel time isochrones increases the likelihood of being in the labor force (Table 1). In contrast, additional jobs accessible via automobile are only predictive of higher labor force participation rates if

those jobs can be reached within a 15-minute commute. These contrasting results suggest at least two important distinctions. First, except for 15-minute commute-time isochrones, additional job access by transit has a larger magnitude of association with labor force participation than does additional access by cars. Second, because access by transit is highly connected to having a rail station or rapid bus station nearby, these accessibility gains are currently localized. Both of these facts suggest that a more robust transit system would improve accessibility for transit dependent populations.

While this study did not establish causality in the relationship between job accessibility and labor market outcomes, it does provide insights into future work. The public transit job accessibility measure derived here could be used to determine how the most vulnerable and transit dependent populations benefit from better accessibility. While it is true that endogeneity is an important obstacle to overcome in studies of the geography of opportunity, it is also true that the vulnerable populations have the fewest choices on where to live based on housing quality and affordability. Transit agencies can increase frequencies to places where transit population reside and improve network accessibility at intervals up to 45 minutes to improve accessibility from these communities.

Introduction

Over the past 60 years, social scientists and policymakers have been concerned with how to create the basic, necessary neighborhood conditions that give urban minorities an equal opportunity to succeed in life. There is a well-established literature that finds that job growth often happens in places away from where the populations that need the new jobs the most often are able to reside. One of the earliest thinkers and proponents of this idea, economist John F. Kain of Harvard, coined this phenomenon the **Spatial Mismatch** (SMH) Hypothesis. Kain (1968b) found that, all else equal, the central city concentration of the African American population led to inferior labor market outcomes because of the suburbanization of jobs. He writes:

> "Hypotheses evaluated in this paper are that racial segregation in the housing markets (1) affects the distribution of Negro employment and (2) reduces Negro job opportunities, and that (3) postwar suburbanization of employment has seriously aggravated the problem."

Since Kain's seminal work, there have been many studies, especially as the U.S. has increasingly ethnically diverse. Later studies have clarified that the SMH mostly applies to low-skilled center-city based Blacks and entry-level jobs in the suburbs; this is why an alternative phrasing the spatial/skill mismatch arose (Gobillon et al., 2007; Ong and Blumenberg, 1998; Immergluck, 1998). Kain (1992) reviews many of these pieces three decades later, particularly exploring the role of housing market discrimination. Even with the repeal of most overt discrimination laws and increased rates of Black suburbanization, African Americans continue to face higher costs with finding housing in predominantly white neighborhoods (Galster, 1991; Urban Institute, 1993). However, increasing numbers of African Americans are living in suburban neighborhoods (Liu and Painter, 2012). This has led authors to face methodological challenges in estimating the cost of the spatial mismatch to minority populations (Weinberg, 2000; Ellwood, 1986, Raphael, 1998a, O'Regan & Quigley, 1998). Other authors have extended this work to Latino immigrant populations (Painter et al., 2007; and Zhu et al., 2014) and identified the specific mechanisms of the SMH.

In the 1990s, urban sociologists and regional scientists began to propose new ways to frame the policy debate toward solutions; we call this the *geography of opportunity* literature. In 1995, George C. Galster and Sean P. Killen of The Urban Institute proposed a "geography of metropolitan opportunity" conceptual framework to understand how regions create unequal "opportunity structures," particularly for inner-city youth, across the domains of housing, labor, crime, politics, education, and social networks. Their metropolitan opportunity structure idea involved both a "process" dimension (i.e. markets, institutions, and service delivery systems) and a product (or outcome) dimension (i.e. future streams of income, consumption, and productivity). Thus, they define more "opportunity" for youth as being able to make more "choices about education, fertility, work and crime" within this model (Galster and Killen, 1995: 11). The main argument and contribution that they added to this equal opportunity debate was that geography matters both conceptually and in their associated mathematical model for an opportunity structure.

In this study, we introduce a new job accessibility measure focused on travel times on public transit. Measuring travel time using public transit, not car, as the mode of mobility is important because many poor people take transit out of necessity. This is especially true for urban youth who seek entry-level jobs; they are not afforded cars. In 2001, Raphael and Stoll find that raising minority car-ownership rates to the White car-ownership rate would considerably narrow interracial employment rate differentials, but that is not a policy prescription; that is a market outcome. Car ownership also entails many negative environmental externalities (i.e. pollution, reduced space for housing, etc). As the world urbanizes, transit will become an even greater regional asset to connect urban cores to suburban commuter neighborhoods. Transit investments could improve overall mobility for car owners and non-car owners seeking jobs in distant labor markets as well because of mode-shifting.

This job accessibility measure in this study is created using Generalized Transit Feed Specification (GTFS) data. Using Remix (a commercially available tool), we constructed travel time isochrones at 15, 30, 45, and 60 minute thresholds. By way of comparison, we also construct walking and auto access isochrones based on linear distance and average speeds that someone of each commute type would travel. Jobs are then counted within each isochrones to obtain the total number of jobs that can be accessed via each mode. We compare these three alternative measures of job accessibility in nine large metropolitan areas to determine the association between job accessibility and employment outcomes at the Census tract level using a regression based framework.

As past research has found, the estimates demonstrate a positive relationship between job accessibility and labor force participation across all modes. We find that labor force participation is consistently higher in places with greater transit accessibility between 15-45 minutes away. In contrast, accessibility by automobiles is most consistently associated with jobs that can be reached within 15 minutes. These results are consistent across models that include census tract controls and in the most dense census tracts. Interesting differences emerge across metropolitan areas. Namely, transit access in Atlanta and Miami is not associated with greater labor force participation rates, but short distance auto accessibility to jobs is important in almost all areas.

Geographies of Access: Beyond Gravity Models

In the context of the Spatial Mismatch Hypothesis, gravity models are used to estimate the number of jobs available per worker within a certain area. Such models incorporate a distance-decay function that discounts job opportunities as they increase with linear distance (Ihlanfeldt, 2006). The use of linear distance, however, is unrealistic and may provide unreliable estimates, since it does not take into account variations between modes of transportation, topography, urban form, or other factors that may affect the mobility of job seekers as they travel towards jobs located far from them.

For this reason, in addition to gravity models, other types of approaches have been explored to understand the relationship between distance and access to transportation. In geography, the use of mixed methods such as Geographic Information Systems (O'Sullivan, Morrison, & Shearer, 2000), Remote Sensing, (Delamater, Messina, Shortridge, & Grady, 2012), Network Analysis (Biba, Curtin, & Manca, 2010; Delamater et al., 2012), and Spatial Statistics has allowed the development of more nuanced estimations that approximate the mobility of a population in relation to access to various services such as health care providers (Guagliardo, 2004; Schuurman, Bérubé, & Crooks, 2010; Wan, Zou, & Sternberg, 2012).

In particular, understanding of access to transportation has been recently improved by new methods that take advantage of advances of computing power, increased capabilities of Geographic Information Systems, and the availability of high-quality transportation and cadastral data. These methods have tackled different parts of the problem of access, such as travel times, populations, and areas, which are critical to derive complementary insights that allow a more comprehensive picture of the mechanisms articulating distance, location, mobility, and access.

O'Sullivan et al (2000) developed a significant improvement to the use of GIS in calculating access to public transportation by developing the isochrone application. Given that most use of GIS had focused on travel networks using private vehicles, the isochrones application provided an automated way to address this issue by calculating the coverage areas of multiple modes of transpiration. This consists of programming desktop GIS to draw isochrones, or lines of equal travel time, which can encompass any combination of modes of transportation, such as walk, train, and bus, and can be modified to target exact or approximate travel times.

Shifting the focus on the population with access to a particular means transportation, rather than on the travel time, Biba et al (2010) proposed the parcel-network method. This integrates the spatial (area and location) and aspatial (cadastral data) attributes of parcels with the networked distances between those parcels and bus stop locations. The parcel-network method addresses the common problem of overestimation of population with access to transportation by providing conservative population estimates based on high-quality cadastral data.

More recently, Langford et al (2012) proposed to estimate access to transportation using a modified two-step floating catchment area technique (2FSCA). Drawing on advances in health geographies, they analyzed access to bus transit systems. This method accounts for a number of factors shaping access to transportation, such as proximity, balance between supply and demand, temporal fluctuations in service provision, cumulative opportunity, and specific features of the transport system. By calculating 'buses per person' instead of the more common 'percent of population served', the modified 2FSCA technique provides a measure of access that more closely approximates the experiences of users as they navigate transportation systems. This approach can have important implications in addressing equity of transport provision, since the 2FSCA technique can also be expanded to include possible changes to timetables and transportation networks.

Travel times, skills, and opportunity

In light of the inadequacies presented by the use of linear distance in gravity models, we must complicate this spatial-skill mismatch hypothesis, which still dictates the geography of opportunity for minorities, by raising inquiries about how we measure distance. In a traditional SMH-driven study, physical distance plays a large role in defining access. However, we recognize that not all distances are created equally; the same 1.5 miles from a job site could take twice as long to travel depending on mode(s) of travel available on that route and even the time of day. Few studies have incorporated these realities, but with the availability of open data on transit schedules (i.e. GTFS) as well as demographics on skills at the neighborhood level (i.e. Census LEHD Origin-Destination Employment Statistics, LODES), we can challenge this theory with a focus on travel time and distance as well as skills. Sociologists have pointed to seven mechanisms - both racial and spatial - that that enable the spatial-skill mismatch (Gobillon et al., 2007: 2408). Five of these could be empirically refined by the use of travel time, not just physical distance:

1) Workers may refuse a job that involves commutes that are too long because commuting to that job would be too costly in view of the proposed wage.
2) Workers' job search efficiency may decrease with distance to jobs. In other words, for a given search effort, workers who live far away from jobs have fewer chances to find a job because, for instance, they get less information on distant job opportunities.
3) Workers residing far away from jobs may not search intensively. For instance, when house prices decrease with distance to jobs, distant workers may feel less pressured to search for a job in order to pay their rent.

4) Workers may incur high search costs that cause them to restrict their spatial search horizon at the vicinity of their neighbourhood.

5) Employers may refuse to hire or prefer to pay lower wages to distant workers because commuting long distances makes them less productive (they are more tired or more likely to be absent) (Gobillon et al., 2007: 2048).

While the primary focus of this study is to focus on travel times, it is worth noting that additional approaches have been and should be considered when developing a full picture of job accessibility. Measuring job access based on skills could also better specify our vision of the geography of opportunity. Physical or temporal distance are moot if the job seekers do not possess the human capital to succeed in those roles.

All of these factors create a ripe policy environment to explore new job accessibility measures that expand the effort to create a more equitable geography of opportunity in a way that sociologists focused on the roles of housing, crime, and education often are not (Galster & Killen (1995), De Souza Briggs et al. (2004), Chetty (2014), Lens (2015)). Currently, the most vulnerable populations (i.e. under-employed youth between ages of 18-24 not in college) still require special attention for public services to help recover what some call "The Lost Decade" of employment due to the Great Recession. By focusing on transit-based measure of job accessibility, we aim to contribute to help build the case for addressing environmental, economic, and social inequality by highlighting areas within metropolitan regions with dense, unmet needs - all of which transit could simultaneously address.

Methodology

As noted previously, gravity models are often used to estimate the number of jobs available per worker within a certain area. Further, we have argued that travel time is more relevant to job accessibility than are physical distances. For this reason, we instead rely on travel-time estimates of access to jobs using public transportation to increase accuracy of job access estimates. With the availability of open-source General Transit Feed Specification (GTFS) data and Remix, an online public transportation planning application, we estimate the accessibility to jobs within a selected time interval.

Building Isochrones for Multimodal Analysis

Accessibility isochrones for each of the three transportation modes were generated and intersected with jobs data. We relied on a commercial software tool, Remix, and a program our team created which calculates large numbers of isochrones and jobs within those isochrones (aRat, Swayne, 2019) to generate the transit access isochrones for each census tract. Remix uses GTFS data of the transit system and schedule to determine how far a public transportation user can travel from a user-defined origin point in 15, 30, 45, or 60 minutes using any combination of bus, rail, or walking. aRat interfaces with Remix to automate rapid downloads of Remix transit isochrones for thousands of origin points across the map. The size of these transit isochrones are determined by actual transit availability and provide us with a best possible estimate of actual accessibility for public transit users (Figure 1).

To compare transit access to walking and automobile access, we relied on estimated travel speeds to determine isochrone coverage. To generate walking isochrones, we estimated an average walking speed of three miles per hour. The 15-minute walking isochrones has a measured radius from the origin point of 0.75 miles, the 30-minute isochrone a radius of 1.5 miles, the 45-minute isochrones a radius of 2.25 miles, and the 60-minute isochrones a radius of 3 miles (Figure 2).

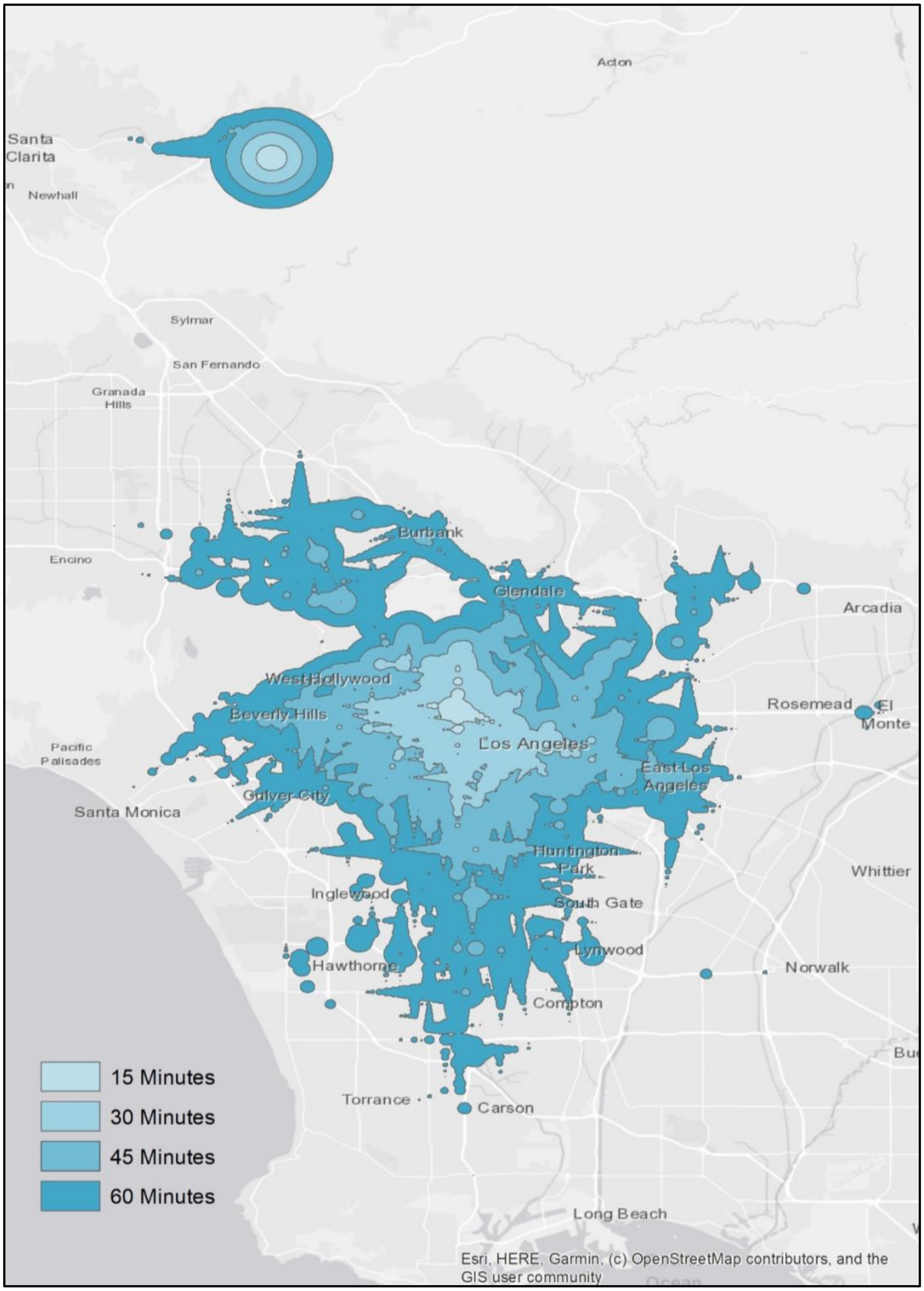

Figure 1. Representative Transit Access Isochrones at Two Locations

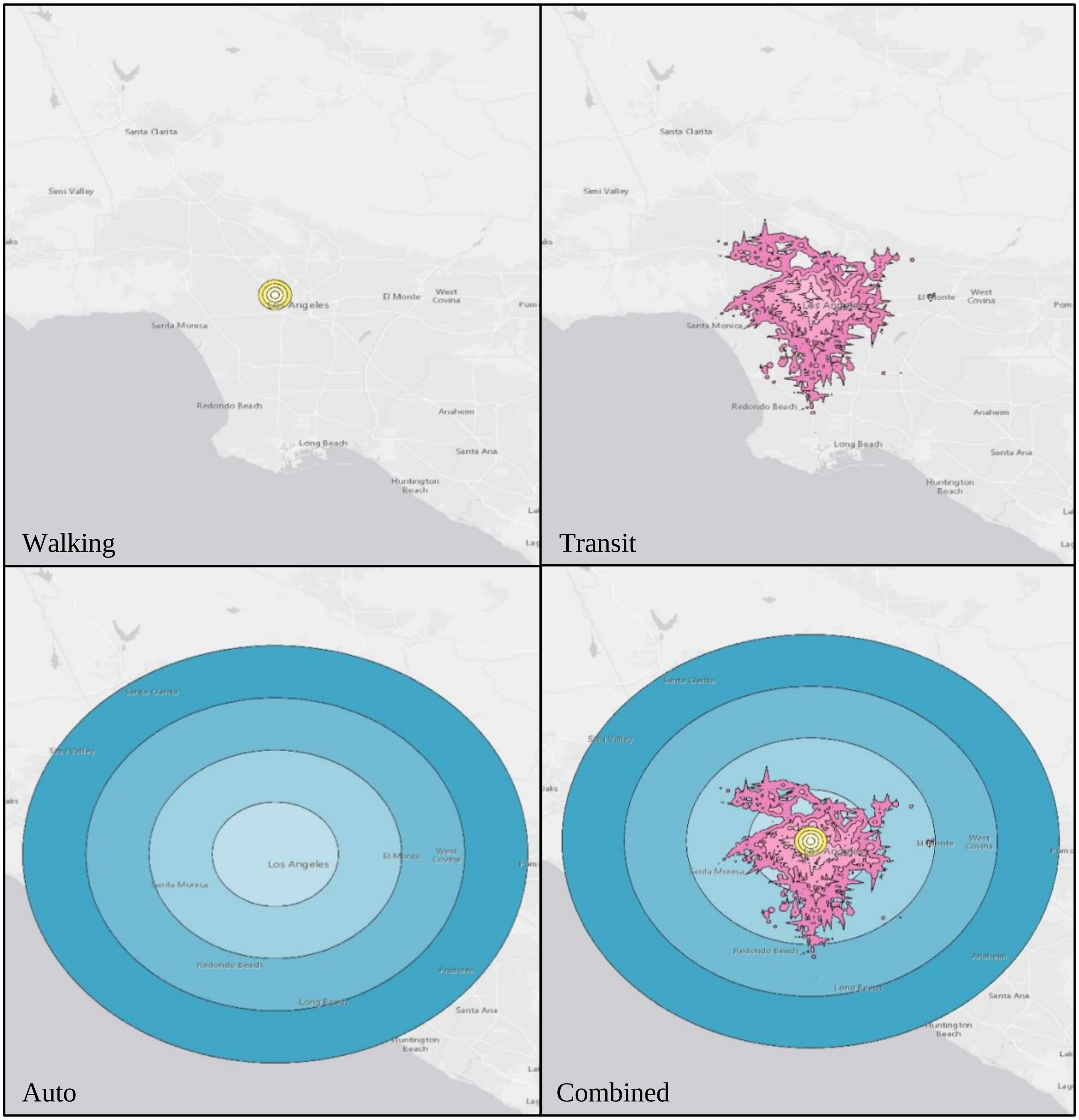

Figure 2. Example Isochrones for Each Access Mode

Metro Area Selection

Nine metropolitan statistical areas (MSAs) were selected for analysis based on 2016 US Census American Community Survey (ACS) 5-year estimated data on mode share for commute to work; geographic distribution; and public transportation system data availability. Commute share is a measure of the percentage of workers over the age of 16 who commute to work by: bicycle;

private vehicle (carpool or alone); public transportation; taxi, moto, bike; or by foot. Mode share data on each of the nine study MSAs is reported in Table 1.

Table 1.

Metropolitan Statistical Area	% Commuters - Car Truck Van - Alone	% Commuters - Car Truck Van - Carpool	% Commuters - Public Transport	% Commuters - Walked	% Commuters - Taxi Moto Bike	% Commuters - Work at Home
San Francisco	59.34%	9.81%	16.53%	4.47%	3.71%	6.14%
Washington DC	65.91%	9.70%	14.03%	3.29%	1.90%	5.18%
Boston	67.67%	7.17%	12.91%	5.33%	2.09%	4.83%
Chicago	70.68%	8.04%	11.78%	3.12%	1.80%	4.57%
Seattle	69.08%	9.96%	9.21%	3.76%	2.31%	5.69%
Portland	70.42%	9.77%	6.42%	3.40%	3.44%	6.55%
Los Angeles	74.61%	9.77%	5.52%	2.58%	2.26%	5.26%
Miami	78.04%	9.28%	3.88%	1.75%	1.97%	5.07%
Atlanta	77.89%	9.93%	3.02%	1.38%	1.50%	6.28%

Each of the MSAs and their associated GTFS transit data were mapped in Remix. In each MSA, the transit network is the bus and rail system. A map showing each of the nine MSAs and their associated transit networks is provided below in Figure 3. Additionally, MSA geographies were joined to underlying census tract geography for integration with sociodemographic and jobs data.

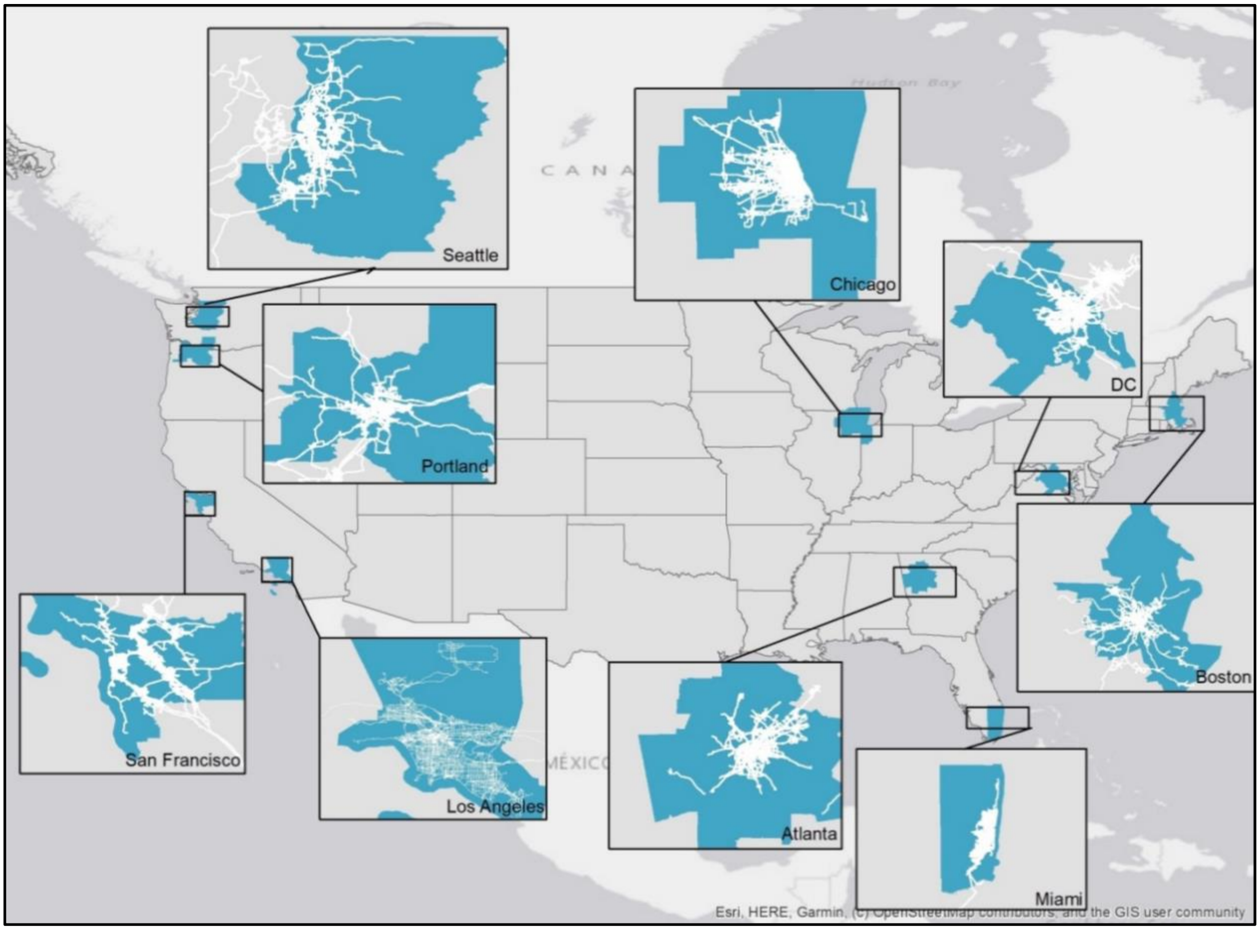

Figure 3. Metropolitan Statistical Area (MSA) Study Areas with Transit Overlays

Variable Construction

The sociodemographic data in this analysis come from the United State Census American Community Survey (ACS). Census-tract level ACS estimates from 2017 were used. The dataset is comprised of all census tracts within each of the nine MSAs (N = 11,631) under investigation and includes information on population, race, education, poverty status, employment status, average commute time, rent burden and homeownership.

To examine the association between job accessibility and labor market outcomes, we estimate a linear probability model of the form,

$$LFP_i = \beta_0 + \beta_1 Jobs_i + \beta_2 X_i + \mu_i + \varepsilon_i$$

where the employment outcome is the Labor force participation rate of the census tract. The job accessibility measure varies depending on the mode choice and catchment area. Some models include census tract controls, mentioned above, that are associated in the literature with labor market outcomes. In some models, a city fixed effect (μ_i) is included.

Results

Summary Statistics

Table 2. Descriptive Statistics

Variable	Description	Data Source	Mean	Std. Dev.	Min	Max
total_jobs	Total jobs in census tract	LODES	2200.10	5554.03	1	310535
avg_vehicles	Average number of vehicles per household	ACS	1.74	0.4781665	0	3.139535
highschool_dropout%	Percentage of the populatiton ages 25 and older without a high school diploma	ACS	13.86	12.94838	0	100
highschool_grad%	Percentage of the population ages 25 and older with a high school diploma	ACS	47.94	15.5817	0	100
college_grad%	Percentage of the population ages 25 and older with a bachelor's degree or higher		37.78	21.96056	0	100
homeowner_%	Percentage of housing units occupied by	ACS	58.13	25.38527	0	100

	the owner of the unit					
pop_under_18_%	Percentage of the population under age 18	ACS	21.74	6.903466	0	59.95413
pop_18_to_24_%	Percentage of the population aged 18 to 24	ACS	9.17	6.864692	0	100
pop_25_to_34_%	Percentage of the population aged 25 to 34	ACS	14.98	7.271937	0	100
pop_35_to_44_%	Percentage of the population aged 35 to 44	ACS	13.59	3.677526	0	55.55556
pop_45_to_54_%	Percentage of the population aged 45 to 54	ACS	13.95	3.712865	0	100
pop_55_to_64_%	Percentage of the population aged 55 to 64	ACS	12.27	3.924946	0	61.29032
pop_over_65_%	Percentage of the population aged 65 or older	ACS	13.91	8.017898	0	100
total_pop	Total population	ACS	4762.35	2089.748	0	28192
black_%	The percentage of the population identifying as Non-Hispanic Black	ACS	14.76	23.34333	0	100

hispanic_&	The percentage of the population (of any race) identifying as Hispanic	ACS	25.56	26.15321	0	100
white_%	The percentage of the population identifying as Non-Hispanic White	ACS	61.62	25.979	0	100
pov_below100_%	The percentage of the population living in a family earning below 100% of the federal poverty threshold	ACS	13.49	11.06429	0	100
pov_below200_%	The percentage of the population living in a family earning below 200% of the federal poverty threshold	ACS	29.99	19.05519	0	100
rent_more_30_%	The percentage of renters who are paying more than 30 percent of their monthly income on	ACS	48.52	15.49555	0	100

	rent and utilities					
avg_commute	Average commute time measured in minutes	ACS	31.00	5.34414	7.1	65.4
unemployed_pct	The percentage of people in the civilian labor force who are unemployed	ACS	7.05	4.828133	0	92.82297
lfp_rate	Labor force participation rate. The percentage of the population over the age of 16 who is in the civilian labor force - includes employed and unemployed looking for work	ACS	66.02	10.13233	0	100
auto_jobs15_min	Number of jobs accessible within 15 minutes by car	LODES + Calculated	392147.80	338624.7	0	1430976
auto_addtnl_30min	Additional jobs accessible between 15 and 30 minutes	LODES + Calculated	738478.60	528546.7	9	2255578

	commute by car					
auto_addtnl_45min	Additional jobs accessible between 30 and 45 minutes commute by car	LODES + Calculated	719732.70	536469.2	0	2529237
auto_addtnl_60min	Additional jobs accessible between 45 and 60 minutes commute by car	LODES + Calculated	658645.70	541647.6	0	3827389
transit_15min	Number of jobs accessible within 15 minutes by transit	LODES + Calculated	5225.10	19897.15	0	448872
transit_addtnl_30min	Additional jobs accessible between 15 and 30 minutes commute by transit	LODES + Calculated	38924.75	91665.79	0	726276
transit_addtnl_45min	Additional jobs accessible between 30 and 45 minutes commute by transit	LODES + Calculated	107230.60	163763.8	0	855903

transit_addtnl_60min	Additional jobs accessible between 45 and 60 minutes commute by transit	LODES + Calculated	177737.50	211202.9	0	1085994
walking_15min	Number of jobs accessible within 15 minutes by walking	LODES + Calculated	2836.73	8504.998	0	340807
walking_addtnl_30min	Additional jobs accessible between 15 and 30 minutes commute by walking	LODES + Calculated	8114.84	18994.93	0	381164
walking_addtnl_45min	Additional jobs accessible between 30 and 45 minutes commute by walking	LODES + Calculated	12595.77	23500.17	0	357990
walking_addtnl_60min	Additional jobs accessible between 45 and 60 minutes commute by walking	LODES + Calculated	16665.84	26950.13	0	355036

Table 2 displays key summary data by census tract. It is most important to highlight that, on average, there are very few jobs available within 15 minutes by transit. There are very large improvements in accessibility as distances increase by 15 minutes by transit. The number of jobs accessibility by car are much larger. However, as distances move out, there is not the same rate of increase.

Regression Results

Table 3. Regression Results for Transit Access to Jobs

Dependent variable = census tract Labor Force Participation rate

VARIABLES	Model 1	Model 2	Model 3	Model 4
transit_jobs_15_min	1.93e-05***			
	4.72E-06			
transit_jobs_30_min		1.11e-05***		
		9.01E-07		
transit_jobs_45_min			4.77e-06***	
			3.95E-07	
transit_jobs_60_min				2.15e-06***
				2.33E-07
Constant	65.92***	65.53***	65.30***	65.31***
	0.0971	0.101	0.111	0.121
Observations	11,631	11,631	11,631	11,631
R-squared	0.001	0.013	0.012	0.007

*** p<0.01, ** p<0.05, * p<0.1

We first show the regression models that display the bivariate relationship between the job accessibility measures and labor force participation (LFP). In each column, a different commute time is associated with labor force participation and each mode choice is presented in turn. In Models 1-4 (Table 3), the estimates the impact of an additional 1000 jobs with 15 minutes increases the LFP rate by about .02 percentage points. When the catchment area is extended to 30 minutes, 45 minutes, and 60 minutes, the impact of each additional 1000 jobs falls by about 50% as each catchment increases. At 60 minutes, the impact of each additional 1000 jobs is .002 on LFP rates.

Table 4. Regression Results for Walking Access to Jobs

Dependent variable = census tract Labor Force Participation rate

VARIABLES	Model 5	Model 6	Model 7	Model 8
walking_jobs_15_min	4.32e-05***			
	1.10E-05			
walking_jobs_30_min		2.28e-05***		
		3.56E-06		
walking_jobs_45_min			1.78e-05***	
			1.99E-06	
walking_jobs_60_min				1.55e-05***
				1.36E-06
Constant	65.90***	65.77***	65.60***	65.40***
	0.099	0.102	0.105	0.108
Observations	11,631	11,631	11,631	11,631
R-squared	0.001	0.004	0.007	0.011

*** p<0.01, ** p<0.05, * p<0.1

A similar pattern of results emerges in the bivariate regression models for walking (Table 4: Models 5-8). At 15 minutes, an additional 1000s jobs is associated with an increase in LFP rates of .04. The measured association declines, although not as sharply as it does for transit accessibility. At 60 minutes, the measure association is .01. The pattern for auto access is different (Table 5: Models 9-12). The association between auto access and LFP rates is smaller at 15 minutes (.02). As this catchment area increases to 30 minutes, the association falls to .002. As the catchment area increases to 45 minutes and 60 minutes, the association is actually negative.

Table 5. Regression Results for Auto Access to Jobs

Dependent variable = census tract Labor Force Participation rate

VARIABLES	Model 9	Model 10	Model 11	Model 12
auto_jobs_15_min	2.35e-06***			
	2.77E-07			
auto_jobs_30_min		2.21e-07*		

		1.21E-07		
auto_jobs_45_min			-1.18E-07	
			8.09E-08	
auto_jobs_60_min				-1.75e-07***
				6.74E-08
Constant	65.10***	65.77***	66.24***	66.46***
	0.143	0.166	0.177	0.194
Observations	11,631	11,631	11,631	11,631
R-squared	0.006	0	0	0.001

*** p<0.01, ** p<0.05, * p<0.1

In Table 6, we provide models of the association between jobs accessible at 15 minutes by transit, and then additional jobs within 30, 45, and 60 minutes. In Model 1 (Table 6), the estimates suggest that additional jobs between 15-30 minutes have the largest positive association on LFP rates (.01). The association is about half as large for the additional 1000 jobs between 30-45 minutes. However, the measured associations are actually negative for both the closest and farthest rings.

Table 6. Regression Results, Additional Jobs Accessed in 15-minute Isochrones

Dependent variable = census tract Labor Force Participation rate

VARIABLES	Model 1	Model 2	Model 3
transit_jobs_15_min	-1.62e-05***		
	5.58E-06		
transit_addtnl_30_min	1.33e-05***		
	1.41E-06		
transit_addtnl_45_min	3.12e-06***		
	8.43E-07		
transit_addtnl_60_min	-1.51e-06***		
	5.81E-07		
walking_jobs_15_min		-3.58e-05*	
		1.93E-05	

walking_addtnl_30_min		1.19E-05	
		1.26E-05	
walking_addtnl_45_min		-1.52E-06	
		1.06E-05	
walking_addtnl_60_min		4.73e-05***	
		6.32E-06	
auto_jobs_15_min			4.11e-06***
			3.42E-07
auto_addtnl_30_min			-1.41e-06***
			2.65E-07
auto_addtnl_45_min			-8.87e-07***
			2.21E-07
auto_addtnl_60_min			-2.86E-07
			1.79E-07
Constant	65.52***	65.26***	66.28***
	0.123	0.11	0.194
Observations	11,631	11,631	11,631
R-squared	0.017	0.016	0.016

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The measured associations for walking are largely insignificant (Table 6: Model 2). Only the additional jobs between 45-60 minutes have a positive association. The pattern for auto access (Table 6: Model 3) displays that only jobs accessible within 15 minutes are associated with increases in LFP rates. In Table 6, the associations suggest that public transit access measures may be more salient. It is worth noting that the differences between walking and taking public transit at 15 minutes are quite small because of the wait times associated with riding transit.

Table 7. Regression Results: Labor Force Outcomes with Census Controls

Dependent variable = census tract Labor Force Participation rate

VARIABLES	Model 1	Model 2	Model 3
transit_jobs_15_min	-1.16e-05***		

	4.29E-06		
transit_addtnl_30_min	1.11e-05***		
	1.10E-06		
transit_addtnl_45_min	3.24e-06***		
	6.68E-07		
transit_addtnl_60_min	-1.11e-06**		
	4.74E-07		
walking_jobs_15_min		-5.65e-05***	
		1.47E-05	
walking_addtnl_30_min		2.34e-05**	
		9.54E-06	
walking_addtnl_45_min		-5.28E-06	
		8.05E-06	
walking_addtnl_60_min		3.21e-05***	
		4.98E-06	
auto_jobs_15_min			3.14e-06***
			3.16E-07
auto_addtnl_30_min			-1.62e-06***
			-2.03E-07
auto_addtnl_45_min			-1.76e-06***
			1.74E-07
auto_addtnl_60_min			-3.10e-07**
			1.36E-07
avg_vehicles	5.878***	5.326***	5.839***
	0.298	0.286	0.286
hs_grad_pct	0.0141	0.00654	0.00352
	0.0127	0.0125	0.0126
college_grad_pct	0.0839***	0.0809***	0.0917***
	0.0111	0.0111	0.011
homeowners_pct	-0.233***	-0.234***	-0.238***
	0.00539	0.0054	0.00535
black_pct	0.0812***	0.0769***	0.0644***
	0.00574	0.00573	0.00569
hispanic_pct	0.0408***	0.0382***	0.0547***
	0.00486	0.00487	0.00497
white_pct	0.0393***	0.0379***	0.0129**

	0.0049	0.00482	0.00505
pov_below_100_pct	-0.429***	-0.422***	-0.433***
	0.0114	0.0114	0.0113
rent_more_than_30_pct	-0.0482***	-0.0527***	-0.0486***
	0.00546	0.00545	0.00541
avg_commute_to_work	0.132***	0.158***	0.154***
	0.0143	0.0142	0.014
Constant	64.70***	65.79***	68.12***
	1.394	1.359	1.37
Observations	11,554	11,554	11,554
R-squared	0.285	0.282	0.295

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

In Table 7, the models add tract level Census controls that are associated with labor market outcomes in the literature. The Census controls largely have the expected signs. One possible exception is the association between average commute times and LFP. The locations where the households have higher commute times are more likely to be in the labor force Another is the association between tracts with larger numbers of black households and LFP. Because these models with Census controls include many variables that are correlated with each other and are the result of choices that some households have made, the individual coefficients should not be strictly interpreted as the impact of a particular tract characteristics, but rather as a set of controls to adjust correlations for the variables of interest. The pattern of the results for job accessibility are very similar to those without Census controls. In Model 1 (Table 7), the estimates on accessibility are a little smaller, but the pattern is the same. Namely, additional jobs between 15-30 minutes and 30-45 minutes are positively associated with LFP rates. The results for walking accessibility do changes as the coefficients on 3 of the 4 rings are statistically significant. However, there is a negative association at 15 minutes, and positive association for longer distances. Finally, the impacts for auto access are a little smaller, but the pattern of results is not changed.

Table 8. Job Access for Tracts with Densest Populations

VARIABLES	Model 1	Model 2	Model 3

transit_jobs_15_min	-1.74e-05***		
	5.37E-06		
transit_addtnl_30_min	1.54e-05***		
	1.44E-06		
transit_addtnl_45_min	4.78e-06***		
	9.60E-07		
transit_addtnl_60_min	-3.32e-06***		
	8.27E-07		
auto_jobs_15_min		5.07e-06***	
		5.11E-07	
auto_addtnl_30_min		-3.72e-06***	
		4.12E-07	
auto_addtnl_45_min		1.63E-07	
		4.65E-07	
auto_addtnl_60_min		-1.14e-06***	
		3.86E-07	
walking_jobs_15_min			-1.10E-06
			1.98E-05
walking_addtnl_30_min			1.67E-06
			1.27E-05
walking_addtnl_45_min			-5.83E-06
			1.14E-05
walking_addtnl_60_min			4.88e-05***
			6.86E-06
Constant	65.93***	68.44***	65.81***
	0.341	0.516	0.222
Observations	2,907	2,907	2,907
R-squared	0.069	0.071	0.04

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Next, we estimated models only for the Census tracts with the highest densities. It is quite possible that tracts that are suburban or exurban are not likely to have much transit access and the importance of a car may vary by population density. The results in Table 8 present estimates for only the census tracts with the top quartile in population density.[1] In accordance with expectations, the coefficients on public transit access do increase for the densest tracts (Model 1). However, there is little change for walking access. The changes to the coefficients for auto access (Model 3) suggest that the 15 minute ring for densest tracks contains the most important association between jobs and LFP. After 15 minutes, the associations are negative or insignificant.

Table 9

VARIABLES	Model 1 - Atlanta	Model 2 - Boston	Model 3 - Chicago	Model 4 - D.C.	Model 5 - Los Angeles	Model 6 - Miami	Model 7 - Portland	Model 8 - San Francisco	Model 9 - Seattle
transit_jobs_15_min	-8.03e-05**	9.67E-06	1.16e-05*	6.08E-05	-2.08e-05***	0.000148***	-0.000218***	-2.44e-05**	-5.69e-05**
	4.05E-05	1.57E-05	6.38E-06	6.07E-05	5.90E-06	4.45E-05	7.52E-05	1.05E-05	2.33E-05
transit_addtnl_30_min	9.54E-06	1.13e-05***	1.30e-05***	5.68E-06	6.02e-06***	-5.49E-06	4.73e-05**	1.84e-05***	3.38e-05***
	1.20E-05	4.21E-06	1.39E-06	6.75E-06	1.91E-06	1.70E-05	2.36E-05	3.25E-06	8.39E-06
transit_addtnl_45_min	1.37e-05*	1.43e-05***	2.11e-06**	5.08e-06**	1.80E-06	1.08E-05	3.22e-05***	1.07e-05***	1.45e-05***
	7.04E-06	2.36E-06	9.00E-07	2.58E-06	1.17E-06	8.92E-06	1.16E-05	2.00E-06	4.72E-06
transit_addtnl_60_min	1.96E-06	2.35E-06	-2.17e-06***	-1.82E-06	3.51e-06***	-4.50E-06	5.57E-06	3.68e-06**	6.03e-06*
	4.16E-06	1.78E-06	7.57E-07	1.48E-06	8.84E-07	5.00E-06	7.11E-06	1.49E-06	3.57E-06
avg_vehicles	4.699***	7.835***	9.872***	3.308***	5.924***	20.36***	4.304**	7.027***	1.875
	1.449	1.24	0.772	0.949	0.61	0.96	1.83	1.134	1.55
hs_grad_pct	0.282***	0.0999*	0.306***	0.231***	0.101***	0.112**	0.263**	0.127***	0.189**
	0.0491	0.0555	0.0299	0.0548	0.0193	0.0437	0.105	0.0418	0.0794
college_grad_pct	0.373***	0.0442	0.356***	0.290***	0.258***	0.0797**	0.335***	0.216***	0.230***
	0.0391	0.047	0.0275	0.0471	0.0198	0.037	0.0925	0.0385	0.0689
homeowners_pct	-0.219***	-0.159***	-0.256***	-0.158***	-0.241***	-0.374***	-0.123***	-0.226***	-0.110***
	0.0216	0.0213	0.0131	0.0157	0.00969	0.018	0.0304	0.0176	0.0282
black_pct	0.0843***	0.012	0.00602	0.0224	0.0429***	-0.502***	0.0438	0.0926***	0.0439
	0.0299	0.0287	0.0155	0.0245	0.0138	0.0471	0.108	0.0262	0.0621
hispanic_pct	0.351***	0.0655***	0.163***	0.292***	0.144***	0.0345**	0.246***	0.173***	0.259***
	0.0278	0.0213	0.0133	0.0299	0.0106	0.0146	0.0527	0.0243	0.0489
white_pct	0.0537*	0.0257	0.0124	-0.0532**	0.0310***	-0.611***	-0.119***	0.0103	-0.0485*
	0.0285	0.0251	0.0144	0.0221	0.00718	0.0455	0.0439	0.013	0.026
pov_below_100_pct	-0.244***	-0.397***	-0.303***	-0.292***	-0.377***	-0.338***	-0.208***	-0.440***	-0.502***
	0.0365	0.0363	0.0221	0.0471	0.0184	0.0371	0.0684	0.039	0.0487
rent_more_than_30_pct	-0.0330*	-0.0272*	-0.0404***	-0.0563***	0.0223**	0.0183	7.46E-05	-0.00659	-0.0412*
	0.0174	0.0158	0.00993	0.0137	0.0105	0.0174	0.0269	0.0177	0.0214
avg_commute_to_work	0.275***	0.105**	0.200***	0.172***	0.0877***	-0.102**	0.0633	0.120***	0.294***
	0.0529	0.0481	0.0317	0.0466	0.0267	0.0507	0.0892	0.0454	0.0598
Constant	30.48***	57.09***	33.01***	48.61***	44.87***	102.6***	45.20***	44.99***	48.75***
	5.487	5.046	3.331	5.809	2.529	6.19	10.64	4.576	7.791
Observations	939	989	2,198	1,161	2,890	1,198	489	972	718
R-squared	0.42	0.261	0.514	0.318	0.374	0.543	0.319	0.406	0.337

Finally, we compare differences in the impacts of accessibility via different modes in each of the 9 cities included in the study to determine what associations are robust and the extent to which any differences can be attributed to particular characteristics of each metropolitan area's

[1] Results are the same, in terms of sign and significance, when the top quintile is used instead of the top quartile.

transit infrastructure. In Table 9, each row displays the coefficients for job accessibility by transit. It is worth noting first that the accessibility by transit is unimportant in Atlanta, Boston, and Miami. While those results may not be surprising, it is surprising that accessibility is not more important in Washington, D.C. Increased job accessibility has the association in Portland in the 15-30 minute ring. Results in Chicago, San Francisco, and Seattle are very similar. In Los Angeles, increases in accessibility are smaller in magnitude than for those other cities where transit accessibility is associated with higher LFP rates.

Table 10

VARIABLES	Model 1 - Atlanta	Model 2 - Boston	Model 3 - Chicago	Model 4 - D.C.	Model 5 - Los Angeles	Model 6 - Miami	Model 7 - Portland	Model 8 - San Francisco	Model 9 - Seattle
walking_jobs_15_min	2.09E-06	-6.79e-05*	-1.88E-06	0.000178**	-0.000134***	0.000112*	-0.000423***	-3.03E-05	-0.000209***
	0.000113	3.56E-05	2.17E-05	8.31E-05	2.57E-05	6.77E-05	0.000136	3.16E-05	6.87E-05
walking_addtnl_30_min	-8.20E-05	8.39e-05***	2.15E-05	3.53E-05	1.62E-05	7.96E-05	-3.09E-06	1.94E-06	8.81E-05
	6.97E-05	2.14E-05	1.31E-05	6.55E-05	1.72E-05	5.09E-05	8.89E-05	2.26E-05	6.05E-05
walking_addtnl_45_min	1.36E-05	-3.81e-05**	-2.41E-06	-3.96E-05	2.26E-05	6.99E-05	5.82E-05	-1.84E-05	-1.89E-06
	5.70E-05	1.91E-05	1.05E-05	6.07E-05	1.40E-05	4.65E-05	9.43E-05	1.97E-05	5.82E-05
walking_addtnl_60_min	8.31e-05**	5.59e-05***	3.02e-05***	5.21E-05	2.98e-05***	-1.55E-05	0.000125**	5.42e-05***	9.83e-05***
	3.71E-05	1.24E-05	6.61E-06	3.27E-05	9.15E-06	3.12E-05	5.63E-05	1.20E-05	3.07E-05
avg_vehicles	3.593***	5.437***	9.289***	3.333***	5.524***	20.81***	1.482	2.380**	1.373
	1.373	1.186	0.698	0.92	0.592	0.94	1.78	1.032	1.556
hs_grad_pct	0.273***	0.125**	0.287***	0.234***	0.0856***	0.112***	0.208*	0.0799*	0.0961
	0.0488	0.0564	0.0302	0.0537	0.0187	0.0432	0.106	0.0432	0.0777
college_grad_pct	0.368***	0.0834*	0.352***	0.294***	0.253***	0.0707*	0.311***	0.179***	0.192***
	0.0396	0.0474	0.028	0.0467	0.0196	0.0368	0.094	0.04	0.0689
homeowners_pct	-0.212***	-0.173***	-0.270***	-0.160***	-0.252***	-0.367***	-0.106***	-0.195***	-0.111***
	0.0217	0.0216	0.0132	0.0157	0.00963	0.018	0.0307	0.0179	0.0283
black_pct	0.0896***	0.0249	0.011	0.0323	0.0660***	-0.517***	0.125	0.0940***	0.0735
	0.0299	0.0292	0.0158	0.0241	0.0127	0.047	0.109	0.027	0.0621
hispanic_pct	0.351***	0.0767***	0.157***	0.295***	0.143***	0.0238*	0.225***	0.172***	0.214***
	0.0278	0.0216	0.0132	0.0299	0.0105	0.014	0.0535	0.0251	0.0483
white_pct	0.0596**	0.0126	0.0248*	-0.0411*	0.0243***	-0.618***	-0.116***	-0.0194	-0.0461*
	0.0285	0.0253	0.0145	0.0217	0.00707	0.0456	0.0444	0.0129	0.026
pov_below_100_pct	-0.240***	-0.439***	-0.293***	-0.289***	-0.383***	-0.329***	-0.201***	-0.458***	-0.456***
	0.0364	0.036	0.0223	0.0472	0.0183	0.037	0.069	0.0404	0.0487
rent_more_than_30_pct	-0.0328*	-0.0413***	-0.0490***	-0.0581***	0.0270**	0.0177	0.00141	-0.0271	-0.0347
	0.0174	0.016	0.0101	0.0136	0.0105	0.0173	0.0273	0.0182	0.0215
avg_commute_to_work	0.295***	0.189***	0.180***	0.203***	0.0957***	-0.0641	0.115	0.106**	0.285***
	0.0543	0.0486	0.0296	0.0481	0.0266	0.0514	0.0907	0.0465	0.0601
Constant	31.66***	59.21***	35.96***	46.04***	47.54***	101.0***	52.53***	60.37***	56.58***
	5.42	5.09	3.337	5.741	2.459	6.121	10.62	4.355	7.557
Observations	939	989	2,198	1,161	2,890	1,198	489	972	718
R-squared	0.418	0.234	0.496	0.316	0.377	0.549	0.295	0.362	0.329

In terms of job accessibility by walking (Table 10), Chicago and Washington, DC, have the largest positive associations between job accessibility and labor force participation at near intervals. Job accessibility by walking is not associated with LFP rates in Boston and Miami.

Table 11

VARIABLES	Model 1 - Atlanta	Model 2 - Boston	Model 3 - Chicago	Model 4 - D.C.	Model 5 - Los Angeles	Model 6 - Miami	Model 7 - Portland	Model 8 - San Francisco	Model 9 - Seattle
auto_jobs_15_min	2.68E-07	6.43e-06***	2.93e-06***	1.30E-06	4.00e-06***	-3.73e-06**	1.81e-05***	9.28e-06***	1.92e-05***
	2.25E-06	9.17E-07	5.80E-07	1.00E-06	5.59E-07	1.90E-06	3.68E-06	1.30E-06	2.44E-06
auto_addtnl_30_min	2.27e-06*	-1.81e-06***	-1.84e-06***	-4.93e-06***	-1.70e-06***	2.56e-06*	1.34e-05***	-3.82E-07	2.19E-06
	1.37E-06	6.89E-07	3.46E-07	6.35E-07	3.79E-07	1.53E-06	3.01E-06	9.32E-07	1.42E-06
auto_addtnl_45_min	8.86E-07	-6.45E-08	-7.24e-07**	-1.71e-06**	-9.55e-07***	-3.88e-06**	5.44E-07	-1.32E-06	2.25e-06*
	1.43E-06	7.72E-07	3.48E-07	6.68E-07	3.24E-07	1.77E-06	3.23E-06	9.05E-07	1.31E-06
auto_addtnl_60_min	2.56e-06*	1.44e-06*	-1.17E-07	-9.27E-07	2.02E-08	9.09e-06***	1.31e-05***	-2.49e-06**	4.02e-06**
	1.42E-06	8.18E-07	2.87E-07	7.56E-07	2.33E-07	1.70E-06	4.17E-06	1.05E-06	1.63E-06
avg_vehicles	3.727**	4.743***	7.738***	2.191**	5.391***	19.81***	6.001***	5.981***	3.382**
	1.457	1.172	0.759	0.916	0.585	0.949	1.813	1.059	1.497
hs_grad_pct	0.240***	0.0822	0.305***	0.197***	0.0887***	0.105**	0.200*	0.131***	0.222***
	0.0508	0.0563	0.0307	0.0548	0.0194	0.0445	0.104	0.043	0.0798
college_grad_pct	0.326***	0.0442	0.375***	0.342***	0.256***	0.0918**	0.274***	0.238***	0.207***
	0.0426	0.0478	0.028	0.0478	0.0197	0.0381	0.0902	0.0388	0.0685
homeowners_pct	-0.223***	-0.151***	-0.241***	-0.146***	-0.242***	-0.380***	-0.151***	-0.236***	-0.153***
	0.022	0.0214	0.0135	0.0153	0.00961	0.0179	0.0302	0.0181	0.0282
black_pct	0.0940***	0.00862	0.00284	0.0324	0.0565***	-0.503***	0.107	0.118***	0.00314
	0.0298	0.0299	0.0159	0.0242	0.013	0.049	0.106	0.0277	0.0622
hispanic_pct	0.316***	0.0552**	0.164***	0.330***	0.159***	0.0521***	0.255***	0.200***	0.201***
	0.0306	0.0217	0.0135	0.0312	0.0107	0.0164	0.0525	0.0243	0.0483
white_pct	0.0832***	0.0263	0.00761	-0.0952***	0.0195***	-0.615***	-0.0306	0.013	-0.0219
	0.0292	0.0265	0.0149	0.0228	0.00754	0.0468	0.045	0.0138	0.0276
pov_below_100_pct	-0.242***	-0.405***	-0.314***	-0.306***	-0.386***	-0.327***	-0.224***	-0.462***	-0.489***
	0.0363	0.0373	0.0225	0.0463	0.0185	0.037	0.0654	0.0396	0.0487
rent_more_than_30_pct	-0.0374**	-0.0383**	-0.0447***	-0.0557***	0.0183*	0.0136	-0.0129	-0.0182	-0.0535**
	0.0174	0.0161	0.0101	0.0134	0.0105	0.0173	0.0262	0.0178	0.0214
avg_commute_to_work	0.235***	0.0901*	0.157***	0.0880*	0.0863***	-0.145***	0.194**	0.0946*	0.328***
	0.0551	0.0475	0.0302	0.0479	0.0265	0.0549	0.0905	0.0491	0.0608
Constant	34.15***	63.63***	38.30***	58.04***	49.20***	103.7***	30.27***	48.98***	40.82***
	5.607	5.083	3.46	5.824	2.561	6.191	10.69	4.811	7.871
Observations	939	989	2,198	1,161	2,890	1,198	489	972	718
R-squared	0.415	0.229	0.497	0.346	0.381	0.547	0.338	0.384	0.342

In the three of the metropolitan areas (Atlanta, Miami, and Washington, DC) where transit accessibility was not important, auto accessibility is positively associated with LFP rates. None of the accessibility measures are associated with the Boston metropolitan area. In most of the metropolitan areas, 15 minute job accessibility by automobile is the most important association with LFP rates.

Conclusion

This study created a new measure of job accessibility vis-à-vis public transit. In so doing, we demonstrate its efficacy in a number of the largest metropolitan areas. Further, we discover that the importance of transit accessibility to jobs is different in form than commonly used accessibility measure derived from automobiles and walking. These results suggest that transit accessibility should not be ignored when understanding the geography of opportunity.

While this study did not establish causality in the relationship between job accessibility and labor market outcomes, it does provide insights into future work. The public transit job accessibility measure derived here could be used to determine how the most vulnerable and transit dependent populations benefit from better accessibility. While it is true that endogeneity is an important obstacle to overcome in studies of the geography of opportunity, it is also true that the vulnerable populations have the fewest choices on where to live based on housing quality and affordability. Transit agencies can increase frequencies to places where transit population reside and improve network accessibility at intervals up to 30 minutes to improve accessibility from these communities.

Future research will want to focus on household data and link more specific industry and household skill data to provide more precise estimates of the importance of accessibility of all types in the geography of opportunity. These approaches will likely require linking data within a Census RDC. However, this effort will likely have a strong payoff as suggested by the estimates of this study. These studies can either focus on the metropolitan areas with the best network connectivity or focus in much great depth on a single metropolitan area.

References

Biba, S., Curtin, K. M., & Manca, G. (2010). A new method for determining the population with walking access to transit. *International Journal of Geographical Information Science*, *24*(3), 347–364. https://doi.org/10.1080/13658810802646679

de Grange, L., Fernández, E., & de Cea, J. (2010). A consolidated model of trip distribution.*Transportation Research Part E, 46*(1), 61-75.

Delamater, P. L., Messina, J. P., Shortridge, A. M., & Grady, S. C. (2012). Measuring geographic access to health care: raster and network-based methods. *International Journal of Health Geographics*, *11*, 15. https://doi.org/10.1186/1476-072X-11-15

Ellwood, David T. "The spatial mismatch hypothesis: Are there teenage jobs missing in the ghetto?." In *The black youth employment crisis*, pp. 147-190. University of Chicago Press, 1986.

Evans, S. P. (1973). A relationship between the gravity model for trip distribution and the transportation problem in linear programming. *Transportation Research*, *7*(1), 39-61.

Galster, George C. "Black suburbanization: Has it changed the relative location of races?." *Urban Affairs Quarterly* 26, no. 4 (1991): 621-628.

Galster, George C., and Sean P. Killen. "The geography of metropolitan opportunity: A reconnaissance and conceptual framework." *Housing Policy Debate* 6, no. 1 (1995): 7-43.

Gobillon, Laurent, Harris Selod, and Yves Zenou. "The mechanisms of spatial mismatch." *Urban studies* 44, no. 12 (2007): 2401-2427.

Guagliardo, M. F. (2004). Spatial accessibility of primary care: concepts, methods and challenges. *International Journal of Health Geographics*, *3*, 3. https://doi.org/10.1186/1476-072X-3-3

Ihlanfeldt, K. R. (2006). A Primer on Spatial Mismatch within Urban Labor Markets. In R. J. Arnott & D. P. McMillen (Eds.), *A Companion to Urban Economics* (pp. 404–417). Blackwell Publishing Ltd. https://doi.org/10.1002/9780470996225.ch24

Immergluck, Daniel. "Job proximity and the urban employment problem: do suitable nearby jobs improve neighbourhood employment rates?." *Urban Studies* 35, no. 1 (1998): 7-23.

Kain, John F. "The spatial mismatch hypothesis: three decades later." *Housing policy debate* 3, no. 2 (1992): 371-460.

Kain, John F. 1968b. Housing Segregation, Negro Employment, and Metropolitan Decentralization. Quarterly Journal of Economics, 82(2): 175–97.

Langford, M., Fry, R., & Higgs, G. (2012). Measuring transit system accessibility using a modified two-step floating catchment technique. *International Journal of Geographical Information Science*, *26*(2), 193–214. https://doi.org/10.1080/13658816.2011.574140

Ong, Paul, and Evelyn Blumenberg. "Job access, commute and travel burden among welfare recipients." *Urban Studies* 35, no. 1 (1998): 77-93.

O'Regan, Katherine M., and John M. Quigley. "Where youth live: economic effects of urban space on employment prospects." *Urban Studies* 35, no. 7 (1998): 1187-1205.

O'Sullivan, D., Morrison, A., & Shearer, J. (2000). Using desktop GIS for the investigation of accessibility by public transport: an isochrone approach. *International Journal of Geographical Information Science*, *14*(1), 85–104. https://doi.org/10.1080/136588100240976

Painter, Gary, Cathy Yang Liu, and Duan Zhuang. "Immigrants and the spatial mismatch hypothesis: Employment outcomes among immigrant youth in Los Angeles." *Urban Studies* 44, no. 13 (2007): 2627-2649.

Raphael, Steven, and Michael A. Stoll. *Modest progress: The narrowing spatial mismatch between blacks and jobs in the 1990s*. Brookings Institution Center on Urban and Metropolitan Policy, 2003.

Raphael, Steven, and Michael A. Stoll. Can boosting minority car-ownership rates narrow interracial employment gaps?, Brookings-Wharton Papers on Urban Economic Affairs, 2, pp. 99–145. 2001.

Raphael, Steven. "The spatial mismatch hypothesis and black youth joblessness: evidence from the San Francisco Bay Area." *Journal of Urban Economics* 43, no. 1 (1998): 79-111.

Rietveld, P. (1989). Employment effects of changes in transportation infrastructure: Methodological aspects of the gravity model. *Papers of the Regional Science Association, 66*(1), 19-30.

Roy, J. R., & Thill, J. (2003;2004;). Spatial interaction modelling. *Papers in Regional Science, 83*(1), 339-361.

Rucker, J.C. (2006). Landing a job in urban space: The extent and effects of spatial mismatch. *Regional Science and Urban Economics,* 36(2006), 331-372.

Schuurman, N., Bérubé, M., & Crooks, V. A. (2010). Measuring potential spatial access to primary health care physicians using a modified gravity model. *Canadian Geographer / Le Géographe Canadien*, *54*(1), 29–45. https://doi.org/10.1111/j.1541-0064.2009.00301.x

Wan, N., Zou, B., & Sternberg, T. (2012). A three-step floating catchment area method for analyzing spatial access to health services. *International Journal of Geographical Information Science*, *26*(6), 1073–1089. https://doi.org/10.1080/13658816.2011.624987

Weinberg, Bruce A. "Black residential centralization and the spatial mismatch hypothesis." *Journal of Urban Economics* 48, no. 1 (2000): 110-134.

Data Management Plan

Products of Research

The data for this project are derived from 3 primary sources. The LODES (Census LEHD Origin-Destination Employment Statistics) provide the jobs data by Census trace. The 2017 ACS (American Community Survey) provide the set of control variables in the regression analysis. Finally, the data on accessibility are derived from GTFS (General Transit Feed Specification) data using a commercial software package by REMIX. This software allowed us to create isochrones that can measure the distance covered by travel mode over a variety of time intervals. Additional details are provided in the report

Data Format and Content

All data are stored as CSV files.

Data Access and Sharing

The data are stored on Dataverse and can be accessed at the following URL:
https://doi.org/10.7910/DVN/HCAMST

Reuse and Redistribution

The data are available for reuse as long as the authors are properly cited.