



## Transitway Impacts Research Program Report #19 in the series

# Value of Transitways to Regional Economies: National and Twin Cities Perspectives

Yingling Fan, Noah Wexler  
Andrew Guthrie, Leoma Van Dort, Yuxuan Guo  
April 2020

CTS Report 20-08

## Technical Report Documentation Page

1. Report No. CTS 20-08, TIRP #19	2.	3. Recipients Accession No.	
4. Title and Subtitle Value of Transitways to Regional Economies: National and Twin Cities Perspectives		5. Report Date April 2020	
		6.	
7. Author(s) Yingling Fan, Noah Wexler, Andrew Guthrie, Leoma Van Dort, Yuxuan Guo		8. Performing Organization Report No.	
9. Performing Organization Name and Address Humphrey School of Public Affairs University of Minnesota 301 19th Avenue South Minneapolis, MN 55444		10. Project/Task/Work Unit No. CTS#2019043	
		11. Contract (C) or Grant (G) No.	
12. Sponsoring Organization Name and Address Center for Transportation Studies University of Minnesota 200 Transportation and Safety Building 511 Washington Ave. SE Minneapolis, MN 55455		13. Type of Report and Period Covered Final Report	
		14. Sponsoring Agency Code	
15. Supplementary Notes <a href="http://www.cts.umn.edu/Publications/ResearchReports/">http://www.cts.umn.edu/Publications/ResearchReports/</a>			
16. Abstract (Limit: 250 words) This study is comprised of two main analyses: (1) a national analysis that assesses the relationship between the presence and quantity of transitway service with the overall economic strength of US Metropolitan Statistical Areas (MSAs) and (2) a comparative analysis of accessibility to regional employment centers, educational institutions, and workforce development service providers under current and hypothetical future transit conditions. For the first analysis, two-way fixed effects regressions controlling for demographics and total transit activity provide evidence that transitway investment is associated positively with GDP and job growth. However, no statistically significant relationship exists between transitway investment and median household income or inequality. The regional comparison analysis finds that fixed-guideway transit is widely accessible, yet slightly concentrated in higher-income or gentrifying neighborhoods.			
17. Document Analysis/Descriptors Public transit, economic development, gross domestic product, jobs, income, metropolitan areas, guideways, rail transit, bus rapid transit		18. Availability Statement No restrictions. Document available from: National Technical Information Services, Alexandria, Virginia 22312	
19. Security Class (this report) Unclassified	20. Security Class (this page) Unclassified	21. No. of Pages 39	22. Price

# VALUE OF TRANSITWAYS TO REGIONAL ECONOMIES: NATIONAL AND TWIN CITIES PERSPECTIVES

## FINAL REPORT

*Prepared by:*

**Yingling Fan**

**Noah Wexler**

Humphrey School of Public Affairs  
University of Minnesota

**Andrew Guthrie**

Department of City and Regional Planning  
University of Memphis

**Leoma Van Dort**

**Yuxuan Guo**

Humphrey School of Public Affairs  
University of Minnesota

## APRIL 2020

*Published by:*

Center for Transportation Studies  
University of Minnesota  
University Office Plaza, Suite 440  
2221 University Avenue SE  
Minneapolis, MN 55414

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TIRP funding partners and program supporters have included: Anoka County, Center for Transportation Studies, Center for Urban and Regional Affairs, City of Bloomington, City of Minneapolis, City of Saint Paul, Dakota County, Federal Transit Administration, Hennepin County, Hennepin–University Partnership, Humphrey School of Public Affairs State and Local Policy Program, Metropolitan Council, Metro Transit, Minnesota Department of Transportation, Ramsey County, University Metropolitan Consortium, Washington County.

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## EXECUTIVE SUMMARY

This study is comprised of two main analyses: (1) a national analysis that assesses the relationship between the presence and quantity of transitway service with the overall economic strength of US Metropolitan Statistical Areas (MSAs) and (2) a comparative analysis of accessibility to regional employment centers, educational institutions, and workforce development service providers under current and hypothetical future transit conditions. For the first analysis, two-way fixed effects regressions controlling for demographics and total transit activity provide evidence that transitway investment is associated positively with GDP and job growth. However, no statistically significant relationship exists between transitway investment and median household income or inequality. The regional comparison analysis finds that fixed-guideway transit is widely accessible, yet slightly concentrated in higher-income or gentrifying neighborhoods.

## CHAPTER 1: INTRODUCTION

Fixed-guideway transit is defined as any transit that runs on a dedicated right-of-way. Thus, it is a broad category that includes any rail transit as well as bus lines such as bus rapid transit (BRT) that run along dedicated lanes. Because the development of fixed-guideway transit usually relies on substantial capital investment among transitways, it has been associated with increased economic activity and occasionally displacement. However, research has typically captured the micro-level effects of transitway investments, observing the effect of new fixed-guideway infrastructure on nearby property values, business, and job opportunities. In contrast, this study explores the value of transitways to regional and state economies by answering two specific research questions. First, we use a rich 10-year panel of the 100 largest Metropolitan Statistical Areas to understand how investment in fixed-guideway transit affects regional GDP growth, job growth, household income, and inequality. Second, we conduct a multi-destination accessibility analysis considering the impacts of proposed transitways on access to long-term economic opportunity, comparing the Twin Cities region to two regions with higher and lower levels of transitway development.

The report is structured as follows. In Chapter 2, we review literature broadly relevant to the economic impact of fixed-guideway transit. Chapter 3 discusses the data, methods, results, and policy implications of our national analysis of the relationship between transitway investment and regional economic health. Chapter 4 comprises our regional comparative analysis and includes its data, methods results, and policy implications. Chapter 5 concludes.

## CHAPTER 2: LITERATURE REVIEW

The literature on the economic impacts of transitways can be categorized into three main bodies of research: the first focuses on the effects of transitways on property values, the second focuses on the impacts of transitways on jobs, and the third focuses on the impacts of transitways on businesses. Summarized below are key findings from these three bodies of research.

### 2.1 EFFECTS OF TRANSITWAYS ON PROPERTY VALUES

Most research exploring the economic impacts of transitways investigate the effects of transit systems, on residential, industrial, and commercial properties in station areas, using property value data. Overall, this line of research finds an association between increased property values and close proximity to transit stops.

Bowes & Ihlanfeldt (2001) use the hedonic price model and auxiliary models to explore the direct and indirect impacts of Metropolitan Atlanta Rapid Transit Authority (MARTA) rail stations on residential property values in the Atlanta region. In assessing the relationship between residential property values and station proximity, Bowes & Ihlanfeldt (2001) take into account neighborhood income, distance from central business district (CBD), and the availability of a parking lot. They find that property values are higher in areas close to a MARTA station, particularly in high-income neighborhoods; within one mile of a rail station away from the CBD; and one to three miles of a station if the nearest station has a parking lot (Bowes & Ihlanfeldt, 2001). They also find that densities of crime and retail activity can indirectly affect the value of single-family homes depending on station proximity (Bowes & Ihlanfeldt, 2001).

A study by Hess & Almeida (2007) in Buffalo, New York, found a \$2.31 and \$0.99 average increase in residential property values with every foot closer to a light rail station, using geographical straight-line distance and network distance, respectively. Similar to Bowes & Ihlanfeldt (2001), this study too found that residential property values were higher in high-income station areas compared to low-income station areas. However, this study also found that the number of bathrooms, size of the parcel, and its location on either the East or West side of the city had a greater effect on property values than rail proximity (Hess & Almeida, 2007).

Other researchers examining the effects of transitways on residential property values have reached conclusions generally similar to Bowes, Ihlanfeldt, Hess, and Almeida through studies on transit systems across the United States (Mathur & Ferrell, 2013; Zhong & Li, 2016; Cervero & Duncan, 2002a; Gatzlaff & Smith, 1993).

In addition to these studies, some studies explore the impacts of transitways on industrial and commercial property values. Ko and Cao (2013) found that the Blue Line light rail system in Minneapolis, Minnesota, increased the values of industrial and commercial properties within one-mile of light rail stations. Cervero & Duncan (2002b) also found that in Santa Clara County, California, commercial properties near light rail transit stops yielded a 23 percent increase in property values compared to more than a 120 percent increase in property values for commercial properties located within a quarter

mile of a commuter light rail station and in a business district. Additionally, Nelson (1999) found that increased access to MARTA stations and policies that encouraged station-area development positively influence commercial property values in the Atlanta region. Similarly, a study by Cervero (1994) that examined five LRT stations in Washington, D.C. and Atlanta, Georgia found that over an eleven-year period an increase in rail ridership also increased average office rents in station-areas by three dollars per square foot annually, as a result of joint public-private transit-oriented development.

## **2.2 IMPACTS OF TRANSITWAYS ON JOBS**

Several studies have found a positive correlation between job growth and transitways. Guthrie & Fan (2016) found that light rail transit (LRT) produced positive effects on station-area job growth compared to bus rapid transit in fifteen regions in the nation. Among the jobs that grew over time, lower-skills service industry jobs and low wage jobs showed the most growth. In a study that examined how the implementation of the Blue Line LRT in Minneapolis, Minnesota, has impacted job accessibility in the region, Fan et al (2012) found that the Blue Line increased job accessibility for low-, medium-, and high-wage workers. Increased accessibility to jobs as a result of increased accessibility to transitways becomes particularly important in a region where a spatial and skills mismatch exists, that is, a mismatch in where job seekers live and where jobs suitable to them are located (Fan et al, 2016; Fan & Guthrie, 2013b). Tilahun & Fan (2014) also argue that centralizing jobs and housing along transit corridors can increase regional accessibility and ultimately, increased regional economic strength.

By contrast, a study on the economic impacts of Atlanta's MARTA rail system found that it neither positively nor negatively affected the total population and total jobs in MARTA station areas (Bollinger & Ihlanfeldt, 1997) The researchers attributed this finding to Atlanta being a highly decentralized, auto-oriented city. The study also found that the transit line changed the composition of jobs, favoring public sector jobs over private sector jobs (Bollinger & Ihlanfeldt, 1997).

## **2.3 IMPACTS OF TRANSITWAYS ON BUSINESSES**

A study on the impact of light rail transit on new business establishments in the Phoenix Metropolitan Area in Arizona found that the opening of the light rail system in 2008 led to an increase in new businesses in the knowledge (88%), service (40%), and retail (28%) sectors in areas adjacent to transit, compared to automobile-oriented areas (Credit, 2018). The study also found that the number of new businesses decreased in all three sectors over time, with more decreases seen in areas within one mile of transit stations compared to areas within a quarter mile (Credit, 2017). Another research shows that streetcar lines support commercial development, particularly in neighborhoods closest to streetcar stops. A study by Guthrie & Fan (2013) find a significant increase in the number of commercial building permits around streetcar stops in New Orleans, Louisiana, after hurricane Katrina, while controlling for pre-Katrina conditions. Other research explores the perceptions of small businesses in relation to transit investments. A survey of businesses along two existing and two planned fixed-guideway transit corridors in the Twin Cities area found that businesses generally had positive perceptions in relation to the effects future transit corridors may have on their businesses, with perceptions varying across business size,

location, sector and demographic factors (Fan & Guthrie, 2013a). Ross & Stein (1985) similarly find generally positive perceptions towards the MARTA North Line from station-area businesses.

Overall, the literature supports a positive link between investments in transit and economic growth. However, most studies that include economic analyses of the impacts of transit investments are localized, focusing on residential, commercial, and industrial property values, job growth, increased access to jobs, and increased commercial development in station areas. The literature tells us little about the economic impacts of transitways at a national and inter-regional level. One study that examines transportation systems, including highway, airport, transit, and waterways in the northeast megaregion of the United States finds that while public transit systems significantly impact regional economic growth, the impact varies across geographic scales and locations, showing higher impacts at the metropolitan and state levels (Chen & Haynes, 2018).

However, studies do not systematically establish if the association between transitways and regional economic outcomes differ by type of transit mode. Some transit modes may be more critical to a region's economic growth than others may, and increasing investment in these transit modes can be an important policy consideration. A national and inter-regional analysis of the economic outcomes of different types of transit modes can help transit planners and policymakers identify which transit modes to invest in to foster regional economic growth.

## CHAPTER 3: NATIONAL ANALYSIS

This section aims to understand how increasing investment in transitways between 2008 and 2017 affected regional economies across the United States. To estimate the effect of transitway investment on economies, we use four economic indicators as dependent variables: GDP, job growth, median household income, and GINI index. Each index captures a different aspect of regional economic prosperity and is measured at the Metropolitan Statistical Area (MSA) level.

Many micro-level analyses find that transitway investment produces economic growth in surrounding areas. However, transitway investment is also associated with gentrification and displacement of small businesses and low-income housing, as real estate developers exploit increased travel along transitways. Thus, we hypothesize that in our nationwide analysis of MSAs, transitway investment will be associated positively with MSA GDP and job growth, but not with MSA inequality or median household, since median household income would remain unaffected by gains in income concentrated in higher quantiles in the income distribution.

### 3.1 DATA AND METHODS

We employ a 10-year panel dataset of the 100 largest US MSAs to determine how investment in fixed-guideway transit is associated with several regional economic indicators. This section describes the composition of this panel as well as our econometric approach.

#### 3.1.1 Data

---

Our data come from several public sources. First, we employed data on transit modes and transitway extent in UZAs for a period of ten years (2008-2017) from the Federal Transit Administration's National Transit Database (NTD). We aggregated UZA level transit data to the MSA level under the assumption that transitways are mostly concentrated in urban areas. To do this, we computed the centroids of UZAs using ArcGIS, spatially joined UZAs to the MSA they were located, and aggregated UZA-level transit data to the corresponding MSA. We also employed socioeconomic data for MSAs from the US Census Bureau's American Community Survey (ACS) for the same years. GDP and jobs related data for MSAs were obtained from the US Bureau of Economic Analysis (BEA). MSA data were compiled by merging data obtained from multiple sources using the MSA name and ID number, and MSAs that entirely lacked transit and/or socioeconomic data were removed from the dataset. Our final analysis only included the hundred largest MSAs, ranked by the 2017 population size.

We chose this 10-year period to keep data relevant to current conditions and avoid anomalies associated with inconsistencies in NTD and ACS data. We used ACS single-year estimates instead of multi-year estimates because our analysis involved large geographic areas and because single-year data are more likely to show year-to-year fluctuations than multi-year data due to the absence of overlap from one year to the next (Census Bureau, 2018). The use of data over a period of ten years also allows consideration of to what degree transitways are a causal, contributing, and/or enabling factor for

regional economic growth by analyzing the extent of transitways and the underlying factors contributing to regional economic growth.

Our analysis includes four dependent variables and four explanatory variables, excluding year and MSA fixed effects. Table 3.1 presents descriptions, summary statistics, and data sources for these variables. Each of the dependent variables measures a different facet of regional economic health. While GDP and Jobs capture aggregate economic activity, GINI specifically captures inequality. If Median Household Income is significantly associated with an explanatory variable, said variable affects the economy across most or all income quantiles. The first three dependent variables are log transformed to better fit the underlying data distribution and to specify marginal effects in terms of percentage changes. As an standardized index, GINI is not log transformed.

Our main explanatory variable is FGR, the ratio of Fixed-Guideway Vehicle Revenue Miles (VRM) to total VRM. Controlling for total VRM, the variation in FGR should capture each MSA’s operation of fixed-guideway transit. Thus, it reasonably serves as a proxy for total transitway infrastructure development, a metric that is harder to measure in a standardized manner.

**Table 3.1: Descriptions and Summary Statistics for Main Dependent and Explanatory Variables in National Analysis – 10-year Panel of 100 Largest MSAs**

	Variable	Description	Mean	Std. Dev.	Min	Max	Source
Dependent	ln(GDP)	Natural log of MSA GDP	11.15	0.98	9.50	14.36	BEA
	ln(Jobs)	Natural Log of MSA Employment	13.61	0.85	12.39	16.38	BEA
	ln(MHIN)	Natural Log of MSA Median Household Income	10.93	0.19	10.32	11.67	BEA
	GINI	MSA GINI Index Coefficient	0.46	0.02	0.39	0.55	BEA
Explanatory	FGR	Ratio of MSA Fixed-Guideway VRM to MSA Total VRM	0.09	0.15	0.00	0.77	NTD
	ln(VRM)	Natural Log of MSA Total VRM	16.36	1.29	12.78	20.62	NTD
	ln(Pop)	Natural Log of MSA Population	14.13	0.82	13.04	16.83	ACS
	%White	Percentage White Residents of MSA Population	74.00	11.90	20.81	94.52	ACS

### 3.1.2 Econometric Methodology

To explore the associations between transitways and MSA economies we specify a two-way fixed effects model. Such an approach controls for time-invariant differences between MSAs as well as MSA-invariant effects associated with any given year. To account for heteroskedastic and serially correlated errors, we cluster standard errors at the MSA-level. Our final regression equation is provided below:

$$Y_{it} = \beta_0 + \beta_1 FGR_{it} + \beta_2 \ln(VRM)_{it} + \beta_3 \ln(Pop)_{it} + \beta_4 \%White_{it} + \alpha MSA_i + \tau Year_t + \varepsilon_{it}$$

$Y_{it}$  represents each of the four dependent variables described in Table 3.1 measured in MSA  $i$  and at time  $t$ . Each model regresses  $y_{it}$  on the four explanatory variables in Table 3.1 as well as a full set of MSA and year fixed effects.  $\alpha$  and  $\tau$  represent a full set of binary variables for MSA and year fixed effects respectively. Each equation includes 99 MSA fixed effects and 9 year fixed effects, leaving out a reference group for each set to avoid perfect multicollinearity. This allows for us to capture the effects of the main explanatory variables, controlling for unobserved factors that affect all MSAs in any given year and time-invariant variation associated with each MSA.

## 3.2 RESULTS

The section below includes results from three regressions. First, we provide results from the equation provided in the last section. Then we specify a robustness check using generalized estimating equations. Finally, we specify a sensitivity analysis by removing the New York City-Newark-Jersey City MSA from our sample and rerunning the main TWFE regression model.

### 3.2.1 Main TWFE Model

Table 3.2 displays results of our four main models, with the relevant dependent variable displayed for each column of coefficients and robust standard errors. Results from the four main fixed-effects regressions show FGR is positively associated with logged GDP at 95% confidence and with logged employment at 90% confidence.

**Table 3.2: Results of Main Two-Way Fixed Effects Models**

Var.	(1) <i>ln(GDP)</i>	(2) <i>ln(MHIN)</i>	(3) <i>ln(Jobs)</i>	(4) <i>GINI</i>
<i>FGR</i>	0.0678** (0.0314)	-0.00240 (0.0116)	0.0344* (0.0203)	-0.000624 (0.00275)
<i>ln(VRM)</i>	-0.00124 (0.00781)	0.00106 (0.00276)	0.000938 (0.00499)	-0.000640 (0.000796)
<i>ln(Pop)</i>	0.291*** (0.0744)	0.0320 (0.0340)	0.283*** (0.0660)	-0.0197*** (0.00579)
<i>%White</i>	-0.000620 (0.00218)	0.000597 (0.00119)	-0.000589 (0.00121)	-0.000398** (0.000170)
Observations	1,000	1,000	1,000	1,000
R-squared	0.867	0.873	0.839	0.315

Notes: Models also full set of year fixed effects and a full set of MSA fixed effects. Standard errors in parenthesis and are clustered at MSA level.

\*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

Because the *FGR* variable is not log-transformed, its coefficients do not exactly indicate the marginal effect of *FGR*. The marginal effect of an increase in *FGR* by 1% point is computed according to the below equation.

$$ME_{FGR} = e^{\beta_1} - 1$$

Thus, a 1% point increase in FGR is associated with a 0.07% increase in GDP and with a 0.035% increase in employment. Notably, the coefficient on FGR was not significant for Median Household Income or GINI. Logged Population significantly affected logged GDP, logged employment, and GINI. Figure 3.1 plots  $\ln(\text{GDP})$  and  $\ln(\text{Jobs})$  on FGR, showing generally positive relationships and reinforcing our regression analysis.

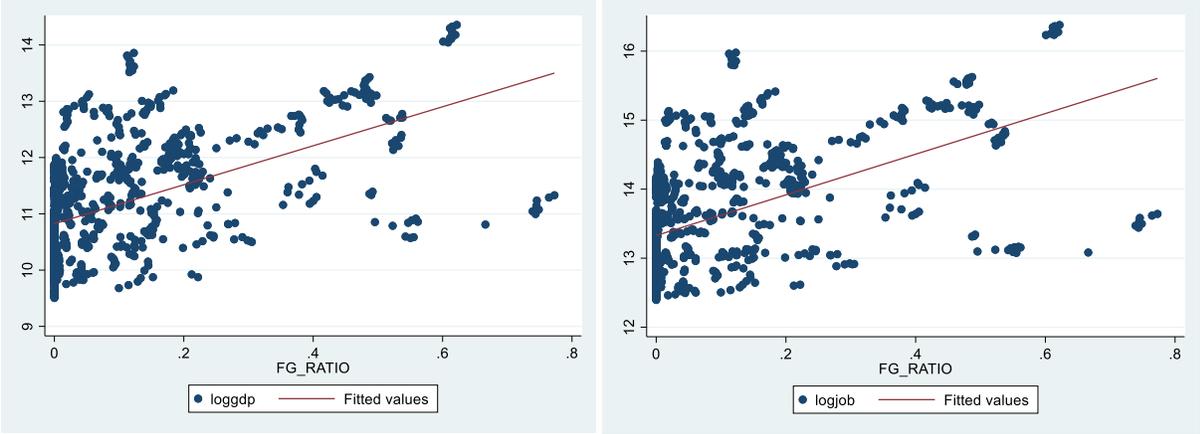


Figure 3.1:  $\ln(\text{GDP})$  and  $\ln(\text{Jobs})$  plotted on FGR, with line of best fit

### 3.2.2 Robustness Check

To ensure validity of results, we specify one robustness check and one sensitivity analysis. To ensure the robustness of our model to potential misspecification, we employ the Generalized Estimating Equations (GEE) approach first developed by Liang and Zeger (1986). Unlike our main two-way fixed effects approach, GEE does not rely on any specifications of the underlying data distribution (Wang, 2014). Thus, we re-estimate our model using GEE, with robust “sandwich” standard errors to ensure cluster-robust inference. Notably, GEE coefficients are population-averaged, so if our initial model is specified correctly the coefficients between the two models should be similar, given our use of MSA and year fixed effects. As Table 3.3 illustrates, GEE coefficients remarkably mirror our main model results, suggesting that the data distribution assumed in two-way fixed effects estimation is indeed valid.

**Table 3.3: Robustness Check – GEE estimations of full sample**

	(1)	(2)	(3)	(4)
VAR.	<i>ln(GDP)</i>	<i>ln(MHIN)</i>	<i>ln(Jobs)</i>	<i>GINI</i>
<i>FGR</i>	0.0668** (0.0313)	-0.000746 (0.0116)	0.0340* (0.0202)	-0.00111 (0.00278)
<i>ln(VRM)</i>	0.000725 (0.00816)	0.00179 (0.00292)	0.00155 (0.00510)	-0.000452 (0.000796)
<i>ln(Pop)</i>	0.452*** (0.0792)	0.0655*** (0.0178)	0.334*** (0.0685)	0.00341 (0.00246)
<i>%White</i>	-0.00200 (0.00227)	1.07e-05 (0.00110)	-0.00101 (0.00121)	-0.000450*** (0.000150)
Observations	1,000	1,000	1,000	1,000

Notes: Models also full set of year fixed effects and a full set of MSA fixed effects. Standard errors in parenthesis and are clustered at MSA level.

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

### 3.2.3 Sensitivity Analysis

We also specify a sensitivity analysis by excluding the New York City-Newark-Jersey City MSA from our sample and re-estimating our main model. The aim of this analysis is to ensure that the large population, economy, and FGR of the country's largest MSA does not disproportionately contribute to our findings, despite the inclusion of MSA fixed effects. Table 3.4 presents these results. No major difference exists when the NYC MSA is excluded. Coefficients and standard errors are similar to those in Tables 3.2 and 3.3.

**Table 3.4: Sensitivity Analysis TWFE Regressions w/out NYC MSA**

	(1)	(2)	(3)	(4)
VAR.	<i>ln(GDP)</i>	<i>ln(MHIN)</i>	<i>ln(Jobs)</i>	<i>GINI</i>
<i>FGR</i>	0.0677** (0.0314)	-0.00242 (0.0116)	0.0343* (0.0204)	-0.000603 (0.00275)
<i>ln(VRM)</i>	-0.00119 (0.00781)	0.00108 (0.00277)	0.000978 (0.00498)	-0.000646 (0.000798)
<i>ln(Pop)</i>	0.292*** (0.0745)	0.0321 (0.0340)	0.284*** (0.0661)	-0.0198*** (0.00579)
<i>%White</i>	-0.000598 (0.00218)	0.000595 (0.00119)	-0.000570 (0.00121)	-0.000399** (0.000170)
Observations	990	990	990	990
R-squared	0.866	0.872	0.837	0.314

Notes: Models also full set of year fixed effects and a full set of MSA fixed effects. Standard errors in parenthesis and are clustered at MSA level.

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

### 3.3 DISCUSSION

While FGR does not perfectly capture MSA investment into transitways, the above models suggest that controlling for total transit operation, the proportion of VRM associated with fixed-guideway transit is positively and significantly associated with job and GDP growth. This reflects the results of local-level analyses discussed in the literature review. Our results find that the microeconomic effects of transitways on local real estate and job markets are noticeable at an aggregate level. However, there is no statistically significant aggregate effect on regional median household income or GINI coefficient. This non-result is important, especially considering the positive findings of effects on GDP and job growth. As economic indicators, both GINI and household income depend on the distribution of economic gains or losses. Positive findings for jobs and GDP, but not for GINI or median household income suggest that many of the gains from transitway-associated economic activity are concentrated to higher-income earners. Additionally, job growth may not be substantial enough to lift median household income. Further research should examine the distribution of the gains from transitway investment. Additionally, it would be valuable to place this work in conversation with aggregate effects of transitway-induced gentrification. It is possible that the nonsignificant coefficients on FGR for GINI and median household income are partially due to displacement associated with economic activity captured in the GDP and job growth models.

## CHAPTER 4: COMPARATIVE MULTI-DESTINATION ACCESSIBILITY ANALYSIS

Cumulative opportunity accessibility analysis—simply, the count of destinations reachable from a given origin point by a given mode in a given amount of time—offers a powerful measure of transportation system performance by directly measuring what it is possible for users to achieve by traveling (Levinson & Krizek, 2005; Owen & Levinson, 2015). As such, it provides more practical information than simple mobility measures and fits with established theoretical understandings of transportation as a derived demand. (We travel to reach places, not for the sake of moving through space in and of itself.)

In practice, cumulative opportunity accessibility analysis requires researchers to consider access to a specified *type* of destinations. For one thing, a comprehensive count of *all* places one might care to visit is difficult, if not impossible, to obtain at a systematic, regional scale; for another, destinations are not equally valuable to all users. As a result, most existing accessibility analyses measure access to jobs, due both to the importance of access to employment in determining users' life outcomes and to the fact that most regularly visited, non-home destinations have some level of employment associated with them, allowing jobs to function as an approximation of activity in general (Fan, et al, 2012; Guthrie, A. & Fan, 2016).

In reality, of course, people need access to other destinations besides jobs (Fan, Y., 2010; Grengs, 2015). This is especially the case with regard to generationally poor and/or long-term unemployed workers, who often require access to education, training and job search services to expand the number of jobs they are qualified for. As a result, for a significant number of disadvantaged individuals, we can conceptualize access to opportunity for bettering one's lot in life as accessibility to employment *and* education *and* workforce development services. Measuring access to opportunity from this perspective requires a different approach than the simple count of jobs reachable common in the cumulative opportunity approach.

To address this requirement, in this chapter we perform a multi-destination transit accessibility analysis to regionally significant employment centers, public colleges, universities and community colleges and workforce development service centers in six U.S. regions, as well as current, full proposed transitway buildout and three partial buildout scenarios for the Twin Cities. Specifically, we identify census block groups with access to at least one of each type of destination within 45 minutes of walk-ride transit travel. We present maps of results, as well as percentages of MSA population as a whole and broken down by race and income living in block groups with access to all destination types. We also estimate binary logistic regression models to explain the probability of a block group having access to all three destination types as a function of its distance from rail transit and downtown, residents' demographics and travel behavior and regional economic growth.

This chapter proceeds with an explanation of our study regions, data and research approach, then presents mapping, tabular and regression results. It concludes with discussion of policy implications for transit policy and transitway planning arising from the research findings.

## 4.1 DATA AND METHODS

This analysis examines transitways' value in terms of access to opportunity through both a cross-sectional comparison of six U.S. regions with each other. We also undertake a panel data-based comparison of current conditions in the Twin Cities region with four potential future Twin Cities transit systems based on a full buildout of the regional transitway system as proposed by the 2040 Transportation Policy Plan as well as on three partial buildout scenarios.

### 4.1.1 Regions for Cross-sectional Comparison

A cross-sectional comparison across regions allows us to test the accessibility outcomes of different transit system designs and modal mixes under the same national, macroeconomic conditions. By selecting regions with significant variation in levels of transitway investment and deployment yet broadly similar regional economic strength at the time of data collection, we can partially isolate the relationship between a transit system's modal mix and the access to opportunity it provides. Specifically, we begin by selecting two regions with broadly similar economic conditions to the Twin Cities, one with a significantly greater level of transitway investment to date, one with a conventional bus-only transit system.

Table 4.1 shows the regions selected for the analysis along with basic regional economic characteristics. Denver and Indianapolis both have generally similar populations and GDPs—as well as *more* similar GDPs per capita—and have experienced robust GDP growth in recent years. Denver has a well-developed regional transitway system, currently of significantly greater extent than that of the Twin Cities, while Indianapolis had yet to implement any transitways at all at the time of data collection.

**Table 4.1: Economic Comparison of Study Region**

Region		2017 GDP	Δ GDP 2012-17	MSA Population	GDP/ capita
Fast Growth	Minneapolis-St. Paul-Bloomington, MN-WI	\$226,152,000,000	11%	3,397,781	\$66,559
	Denver-Aurora-Lakewood, CO	\$185,942,000,000	18%	2,798,684	\$66,439
	Indianapolis-Carmel-Anderson, IN	\$122,608,000,000	12%	1,989,032	\$61,642
Slow Growth	Memphis, TN-MS-AR	\$62,059,000,000	1%	1,038,617	\$59,752
	Birmingham-Hoover, AL	\$55,927,000,000	3%	1,144,097	\$48,883
	New Orleans-Metairie, LA	\$67,023,000,000	2%	1,260,660	\$53,165

In addition to the three regions mentioned above, we include a parallel group of three slow-growing regions to examine the accessibility implications of fixed-guideway transit in differing regional economic circumstances. Memphis, New Orleans and Birmingham are all similar in terms of the same regional economic comparisons as the fast-growth regions. In addition, though none of these three has a light rail/commuter rail/BRT transitway system, two—New Orleans and Memphis—have heritage streetcar systems, which are more common in smaller, slower growing regions. Paralleling the relationships of the

fast-growth regions' transit systems, the New Orleans streetcar system is quite extensive, the Memphis system much less so; like Indianapolis, Birmingham has a bus-only system. Figure 4.1 shows the studied metropolitan regions and the broader U.S. regions in which they are located.

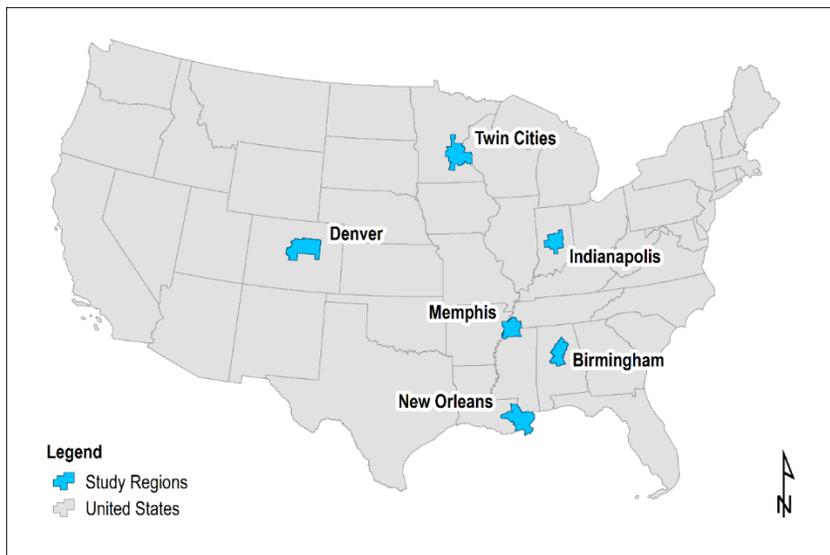


Figure 4.1: Study Regions

#### 4.1.2 Scenarios for Twin Cities Panel Comparison

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The future scenarios for the Twin Cities region are based on the 2040 Transportation Policy Plan included in the Thrive MSP Regional Development Framework. Proposed transitways far enough to have a Locally Preferred Alternative (LPA) designated are based on the LPA. Transitways which do not yet have an identified LPA have alignments, modes, station locations and running times estimated based on existing feasibility study and/or Alternatives Analysis documents (Metropolitan Council, 2014).

The machine-readable route and schedule data used to calculate future accessibility scenarios are based on data produced for the prior TIRP-affiliated project *Spatial and Skills Mismatch of Unemployment and Job Vacancies* (Guthrie, Andrew, Fan, & Das, 2017). The data were updated to reflect subsequent development of the transitway system—for example, all partial buildout scenarios now include the Green Line extension, which was already under construction at the time of data collection, and unlikely to be left unfinished.

The full buildout scenario includes all transitways included in the Transportation Policy Plan as well as all rapid bus routes recommended for development in the Arterial Transit Corridor study. In addition to the full buildout scenario, we consider the following partial buildout scenarios:

- **No Blue Line Extension**—The full buildout scenario minus the planned Blue Line Extension. (Note: The Green Line Extension is included in all future scenarios.)
- **No East-Metro Rail/BRT**—The full buildout scenario minus the proposed Gold Line, Red Rock, Riverview and Rush Line corridors.

- **No Further Rapid Bus**—The full buildout scenario minus all unbuilt rapid bus routes. (Note: The A and C Lines are included in all scenarios.)

### 4.1.3 Data Sources

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The accessibility analysis centers on several basic types of data: transit route and schedule data produced by transit authorities, geographic, employment and demographic data provided by the Census Bureau and addresses of educational institutions and workforce development service providers collected by the researchers from individual institutions, university systems and state/county agencies. Table 4.2 shows specific data types and sources.

**Table 4.2: Data Sources**

Purpose	Dataset	Provider
Transit routes and schedules	GTFS	Transit authorities
Census geographies and streets	TIGER/Line	Census Bureau
Employment	LEHD	Census Bureau
Demographics and travel behavior	ACS	Census Bureau
Colleges and workforce centers	n/a	Original data collection

### 4.1.4 Data Preparation

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The GTFS feeds (including the hypothetical future Twin Cities feeds), along with street data from the Census Bureau form the basis of a machine-readable network dataset, which describes the locations of transportation links, how they connect with one another and what they cost—in terms of time in this case—to traverse. This network dataset is then used to compute polygons describing the geographic area reachable in 45 minutes or less of walk-ride transit travel from every census block group within three miles airline distance of a transit stop in one of the studied regions under current conditions. This inclusion standard ties the overall area of analysis organically to the general portions of each metropolitan area without skewing the results by only considering units of analysis [block groups] within prime walking distance of transit. It also allows for the use of a constant area of analysis even with the proposed expansions of the Twin Cities transit system reflected in the future buildout scenarios.

Every block group, educational institution and workforce center which intersects one of these polygons is considered a potential destination for the origin block. Destination block groups with a job density more than one standard deviation greater than the regional mean are identified as regionally significant employment centers which offer job seekers a wide range of options. Block groups with 45-minute transit access to at least one employment center *and* at least one public university or community college *and* at least once workforce center are identified by the binary variable All 3 Access, which is the response variable for all analyses.

#### 4.1.5 Analysis Approach

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We begin analysis by mapping locations of block groups with access to all three destination types in relation to majority-minority Areas of Concentrated Poverty (ACP50s; block groups in which over 40% of residents live on less than 185% of poverty and in which over 50% are people of color). We also cross-tabulate population, race, and poverty by residence in a block group with access to all three destination types and graph the results. Finally, to more systematically examine determinants of access to opportunity, we estimate a pair of binary logistic regression models to explain the probability of a block group having access to all three destination types as a function of transit system characteristics, location in the city and demographic characteristics.

Specifically, we estimate a cross-sectional multi-region model under current conditions, both to understand patterns of access and to calibrate the model specification using as broad a dataset as possible. Finally, we estimate a pooled model based on the same variables (less a slow-growth/fast-growth region indicator variable) using the current Twin Cities transit system and the full buildout scenario for the proposed future Twin Cities system as panel data to directly compare current and future access. The models are based on the following variables:

- **Access to All 3**—Binary response variable identifying block groups with access to at least one employment center *and* at least one public university or community college *and* at least once workforce center.
- **Rail**—Ordinal explanatory variable describing proximity to the nearest rail transit station (0 = more than a mile network distance, 1 = 0.5-1 mile, 2 = 0.25-0.5 miles, 3 = less than 0.25 miles); used instead of a continuous distance variable to allow the same variable for all regions, including those without rail.
- **Distance from Downtown**—Continuous explanatory variable measuring airline distance to the central business district of the region, measured in miles.
- **Residents Below 185% Poverty**—Continuous explanatory variable measuring residents whose households fall below the threshold used for determining ACP status, measured in percent.
- **People of Color Residents**—Continuous explanatory variable measuring residents who self-identify as non-white and/or Hispanic, measured in percent.
- **Transit Commuters**—Continuous explanatory variable measuring workers who primarily commute using public transit, measured in percent.
- **Workers in Carless Households**—Continuous explanatory variable measuring workers who live in households without a motor vehicle, measured in percent.
- **Fast-Growth Region**—Binary explanatory variable identifying block groups in the Twin Cities, Denver or Indianapolis regions. (This variable is only used in the multi-regional, cross-sectional

model. Individual regional variables cannot be included due to collinearity caused by Indianapolis and Birmingham both having all 0-values for Rail.)

## 4.2 RESULTS

Figures 4.2 through 4.11 show locations of ACP50s with and without access to all destination types in the six regions and hypothetical future Twin Cities scenarios. For the sake of comparison, all regions are shown at the same scale. Notably, the bus-only regions perform worst for access to opportunity by this measure, with only a small area with access to all three destination types in Birmingham, and no such areas at all in Indianapolis. (Upon inspection of educational institution and workforce center address lists, Indianapolis has few of either, all of which are distant from each other.) Memphis and New Orleans have significant areas with access in their urban cores, though more of New Orleans' population would appear to have access due to higher central city density than Memphis. Accessible areas in Memphis are also somewhat concentrated in gentrifying neighborhoods.

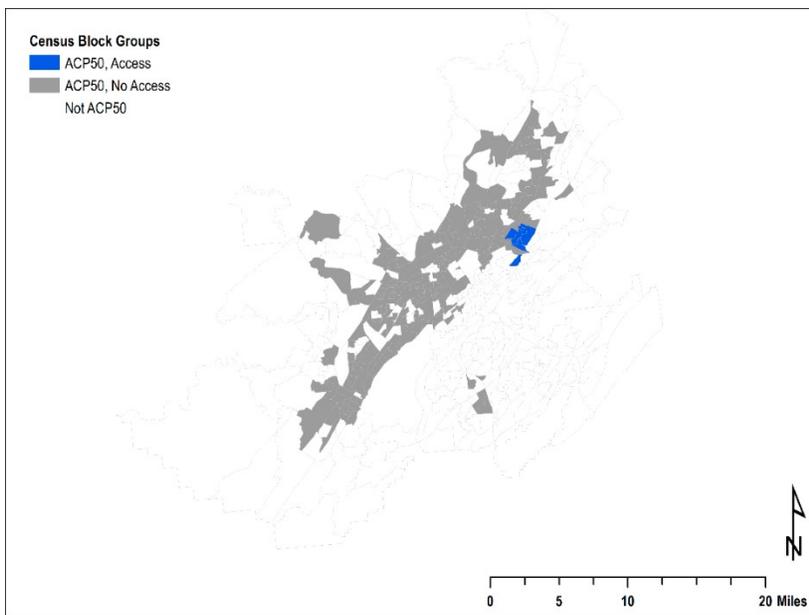
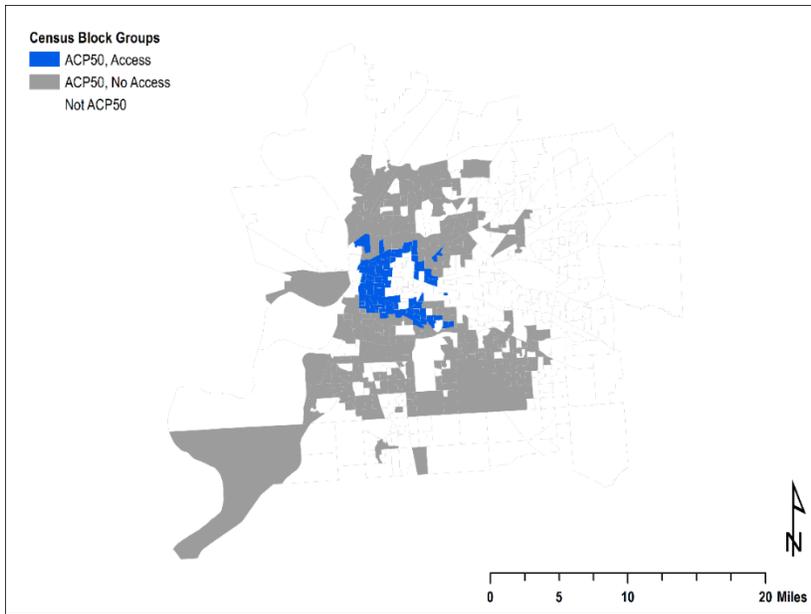
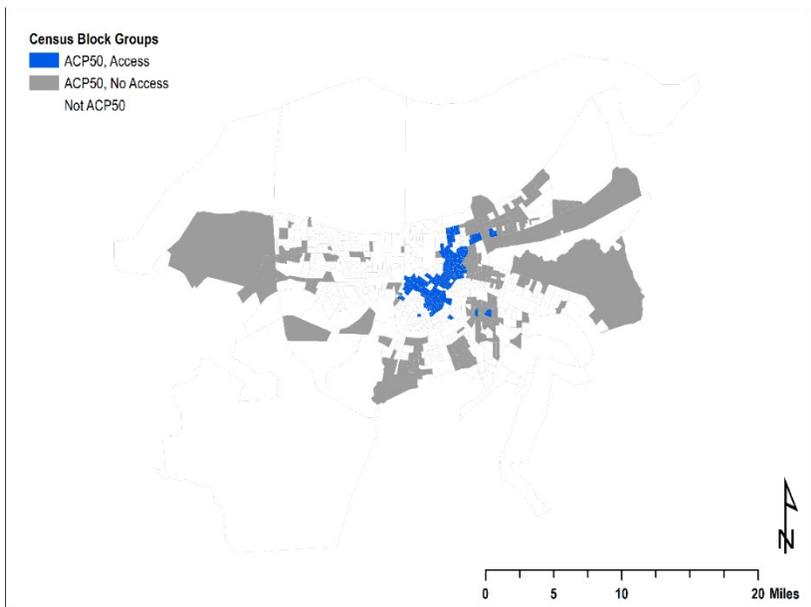


Figure 4.2: Access in Birmingham



**Figure 4.3: Access in Memphis**



**Figure 4.4: Access in New Orleans**

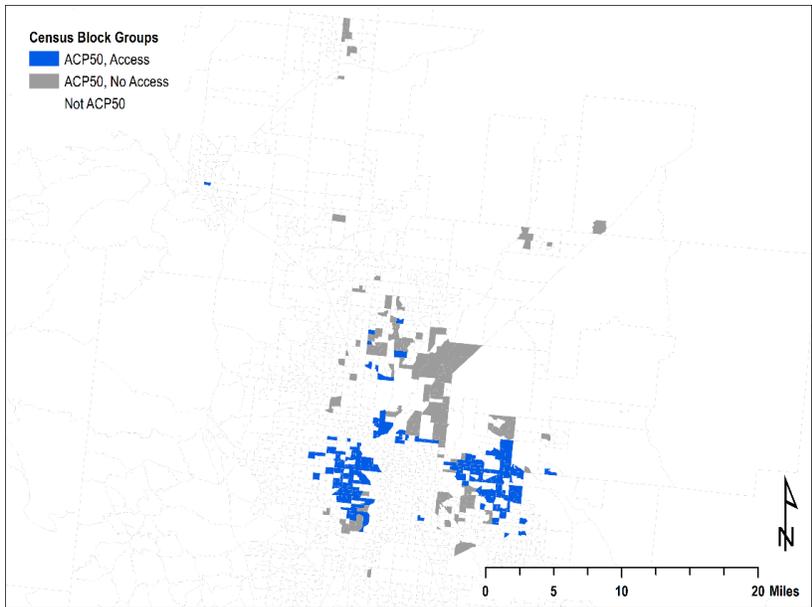


Figure 4.5: Access in Denver



Figure 4.6: Access in Indianapolis

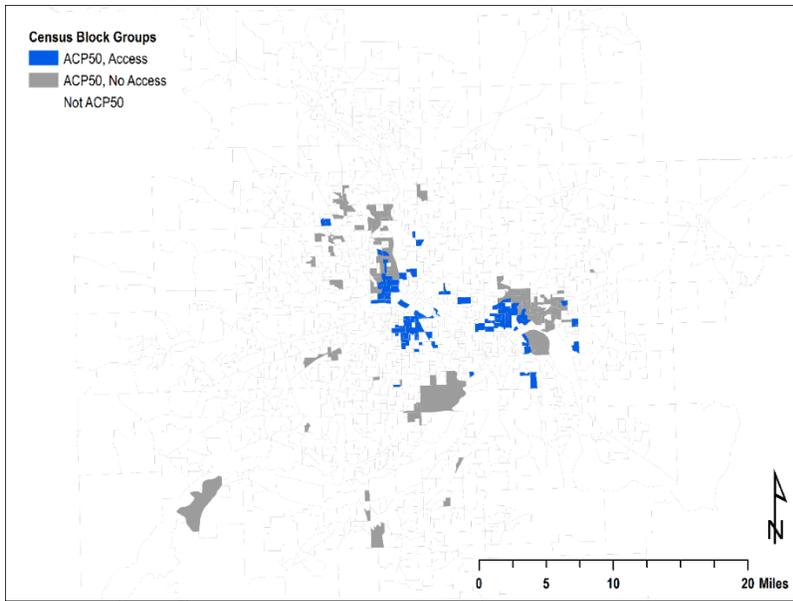


Figure 4.7: Current Access in the Twin Cities

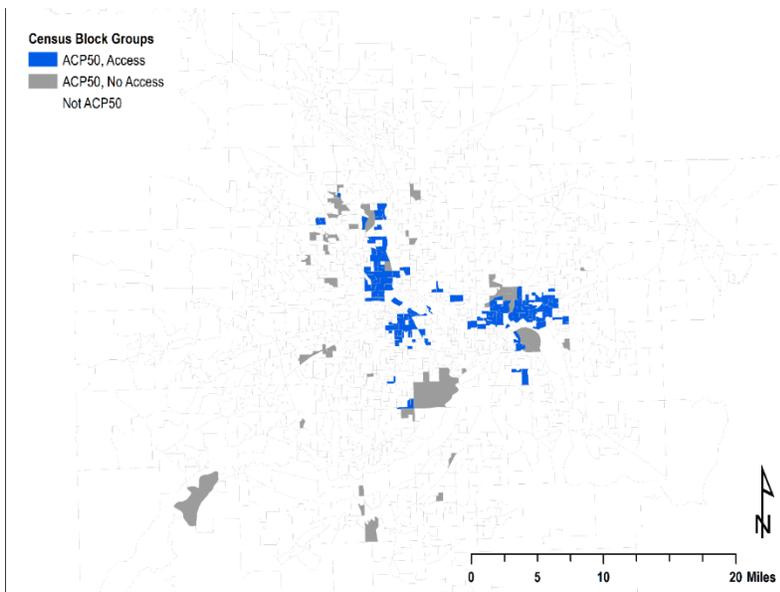


Figure 4.8: Future Access in the Twin Cities, No Blue Line Extension

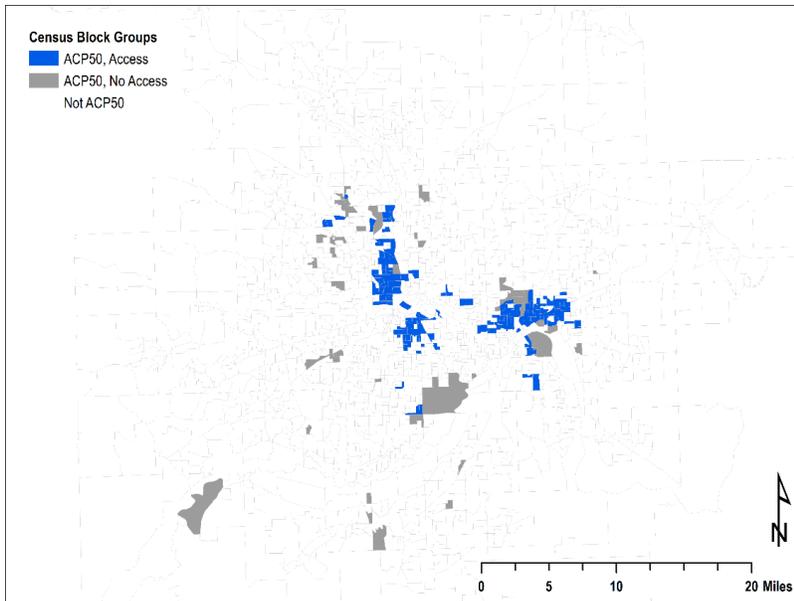


Figure 4.9: Future Access in the Twin Cities, No East Metro Rail/BRT

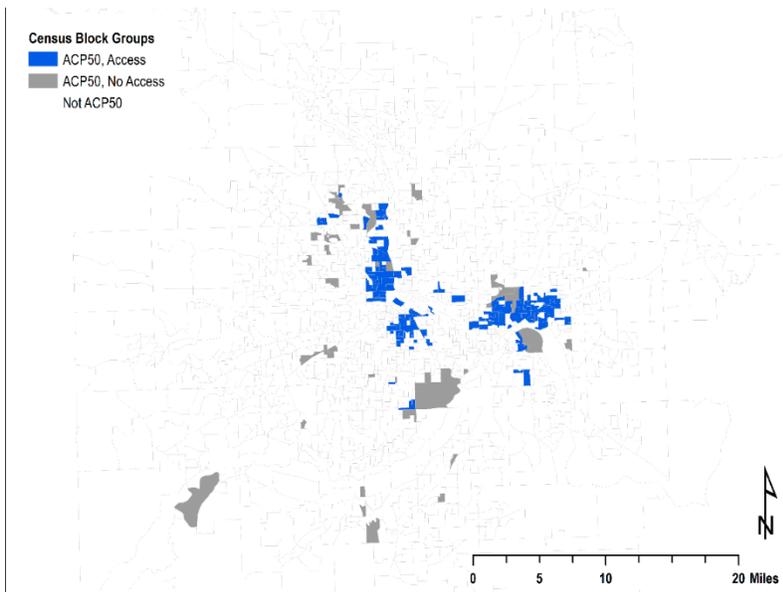
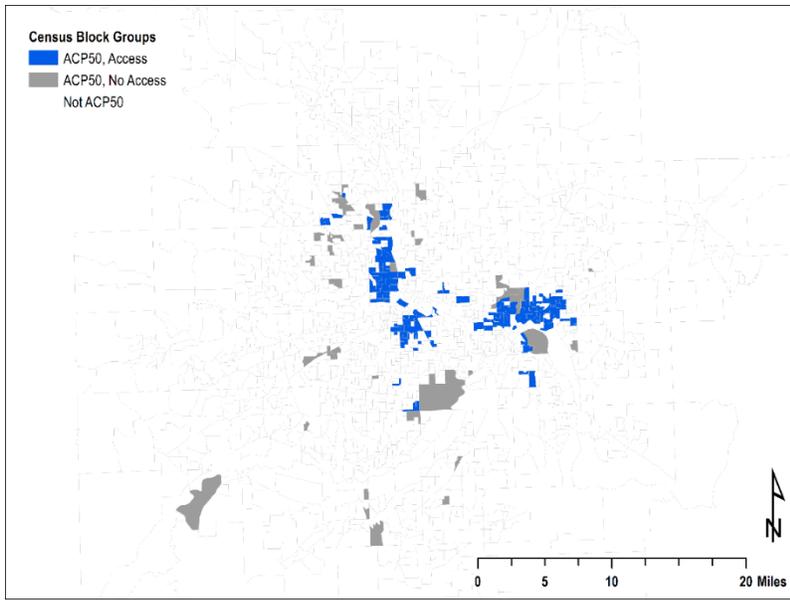


Figure 4.10: Future Access in the Twin Cities, No More Rapid Bus



**Figure 4.11: Future Access in the Twin Cities, Full Buildout**

Denver and the Twin Cities both show much larger accessible areas under current conditions, with access to all three destination types currently somewhat more prevalent in Denver, in part reflecting the more advanced state of Denver’s regional transitway system. The future buildout scenarios in the Twin Cities all appear to erase this gap, however. In fact, by the measure used in this research, all future buildout scenarios produce very similar results, likely due to the fact that all of the partial buildout scenarios considered involve building *most* of the proposed future system.

#### **4.2.1 Descriptive Analysis**

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Figure 4.12 shows a region/scenario breakdown of percentages of Metropolitan Statistical Area (MSA) populations with access to all three destination types by race. Denver and the Twin Cities once again outperform the other regions, with New Orleans showing the best access of the slow-growth regions.

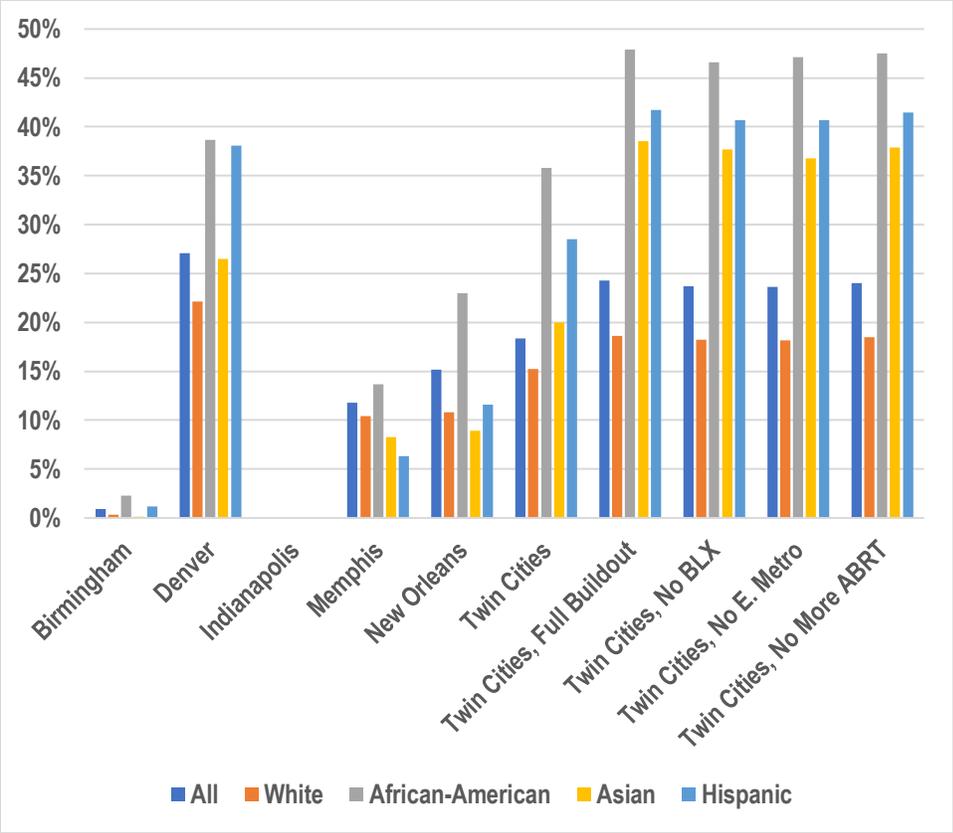
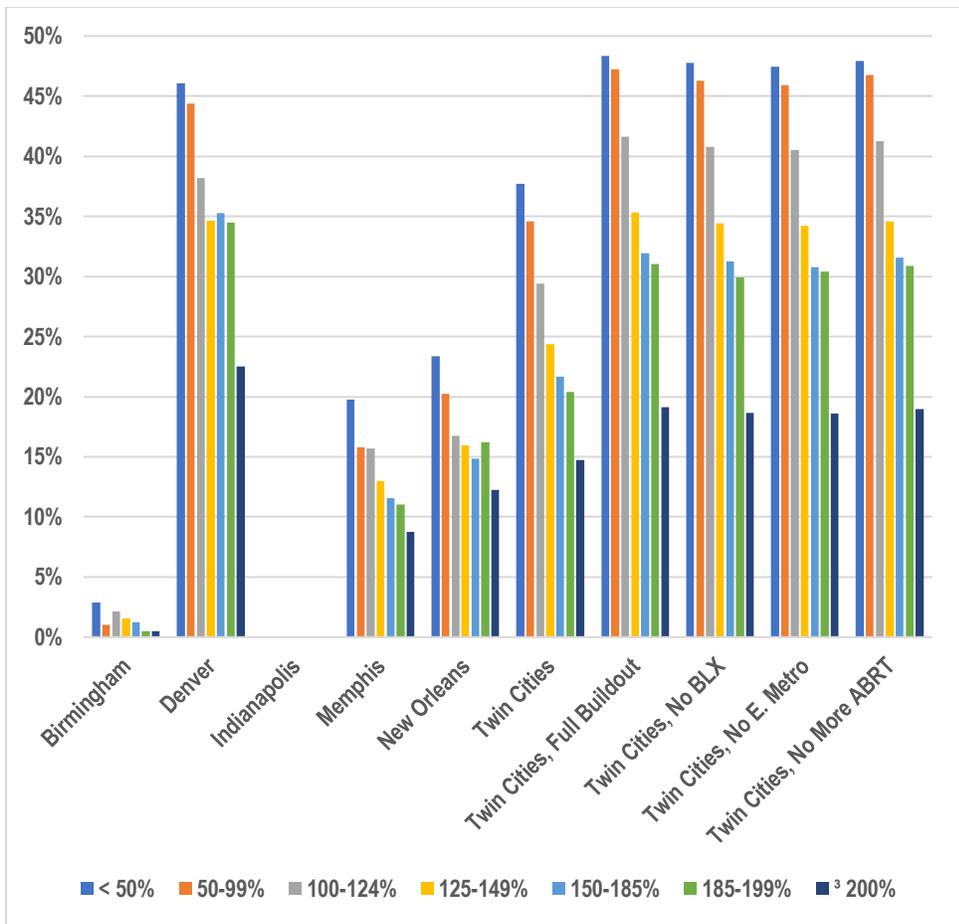


Figure 4.12: Access by Race

Notably, people of color are more likely than whites to live in block groups with access to all three destination types than whites, with African Americans having the highest levels of access in all regions and scenarios. This trend appears most weakly in Memphis, with whites having nearly the same access levels as Memphians as a whole, and African Americans only four percentage points more likely than whites to have access.

In the Twin Cities, once again, all future buildout scenarios tested significantly outperform the current transit system. In addition, the partial buildout scenarios are all quite similar to the full buildout scenario and to each other. Due to the relative lack of variation between scenarios, further future-oriented analysis focuses on comparing the current system to the full buildout scenario. It is worth noting that overall and white accessibility gains are modest, with the greatest gains going to people of color, with rates of transit access to all three destination types increasing nearly twenty percentage points for Asians, and between ten and fifteen percentage points for African Americans and Hispanics.



**Figure 4.13: Access by Income Relative to Poverty**

Figure 4.13 breaks down access by household income relative to the Federal poverty standard. Much the same inter-regional pattern appears as in Figure 4.12, with Denver and the Twin Cities performing best across income levels and a significant increase in future Twin Cities access. In all cases, poorer residents tend to have higher access levels than wealthier residents, though these differences are less in the three slow-growth regions. In the future Twin Cities scenarios, poorer residents see greater gains as well. As is the case with African Americans in Figure 4.12, access rates for Twin Cities residents living on less than 100% of poverty approach 50% in the full buildout scenario.

Table 4.3 presents descriptive statistics of the variables included in regression analysis for all current transit systems. Roughly 22% of block groups studied have 45-minute transit access to all three destination types. Thirty percent of residents, on average, are people of color, while 40% live on less than 185% of poverty. Nearly 5% of residents, on average, also normally commute by transit, and 12% live in households without a motor vehicle.

**Table 4.3: Descriptive Statistics for Multi-Region Model**

	N=	6679
<b>Variable</b>	<b>Mean</b>	<b>Std. Dev.</b>
Access to All 3 (binary)	0.2238	0.4168
Rail (ordinal)	0.1210	0.4699
Distance from Downtown (miles)	9.6400	7.6068
Residents Below 185% Poverty (%)	30.0027	22.4000
People of Color Residents (%)	40.2052	30.8142
Transit Commuters (%)	4.6065	4.9453
Workers in Carless Households (%)	11.7108	29.4620
Fast-Growth Region (binary)	0.7079	0.4548

Table 4.4 shows a comparison between current and future statistics for the Twin Cities. The percentage of block groups in the study area with access to all three destination types increases from 26% to 34% under the full buildout scenario, while significantly more block groups become proximate to rail transit as well. The Twin Cities region has fewer low-income residents and people of color than the six regions taken as a whole (23% and 27%, respectively), but higher rates of both transit commuting and carelessness (6% and 13%, respectively).

**Table 4.4: Current/Future Comparison of Descriptive Statistics**

	N= 2076			
<b>Variable</b>	<b>Current</b>		<b>Full Buildout</b>	
	<b>Mean</b>	<b>Std. Dev.</b>	<b>Mean</b>	<b>Std. Dev.</b>
Access to All 3 (binary)	0.263	0.440	0.340	0.474
Rail (ordinal)	0.106	0.414	0.236	0.613
Distance from Downtown (miles)	11.841	10.176	11.841	10.176
Residents Below 185% Poverty (%)	23.004	18.811	23.004	18.811
People of Color Residents (%)	27.062	22.396	27.062	22.396
Transit Commuters (%)	6.049	5.376	6.049	5.376
Workers in Carless Households (%)	12.645	29.529	12.645	29.529

#### 4.2.2 Regression Analysis

Table 4.5 presents the results of the multi-region, cross-sectional logistic regression model. Proximity to rail transit stations is associated with a large increase in a block group's odds of having transit access to all three destination types; specifically, each unit of increase in the ordinal variable Rail corresponds to roughly a seven-fold increase in those odds. Not surprisingly given the downtown focus of most U.S. transit systems, each additional mile of airline distance from the central business district corresponds to a 12% *decrease* in the probability of a block group having access to all three destination types.

**Table 4.5: Cross-sectional Logistic Regression**

Number of obs		6679
LR chi2(7)		2275.87
Prob > chi2		0
Pseudo R2		0.3204
<b>Variable (unit)</b>	<b>Coefficient</b>	<b>Odds Ratio</b>
Rail (ordinal)	1.9320 ***	6.903
Distance from Downtown (miles)	-0.1267 ***	0.881
Residents Below 185% Poverty (%)	-0.0045 *	0.996
People of Color Residents (%)	0.0326 *	1.033
Transit Commuters (%)	0.1731 ***	1.189
Workers in Carless Households (%)	-0.0084 **	0.992
Fast-Growth Region (binary)	0.7653 ***	2.150
Constant	-1.9178 ***	0.147
Legend: * p<.01; ** p<.05; *** p<.01		

A block group is slightly less likely to have access to all three destination types the more low-income residents it has, but slightly more likely the more people of color. (Though these variables are correlated, their bivariate correlation of < 0.8 does not raise undue concerns of collinearity.) Block groups with higher percentages of regular transit commuters are predictably more likely to have access to all three destination types, though it is unclear from the model what direction any causal relationship involved operates. (Transit systems are planned to serve areas with high demand, but high levels of accessibility also tend to encourage ridership.) Each percentage point increase in Workers in Carless Households, however, corresponds to roughly a 1% *decrease* in the probability of a block group having access. Finally, location in one of the three fast-growth regions (Denver, Indianapolis and the Twin Cities) is associated with just over a twofold increase in the probability of a block group having access to all three destination types.

Table 4.6 shows the results of the Twin Cities-focused panel logistic regression comparing current access with the future full buildout scenario. The odds ratio for Rail declines significantly in the full buildout scenario: Under this scenario, proximity to a rail station is no longer so remarkable a condition, and rail service extends farther into lower-accessibility suburban areas as well. Even in the full buildout scenario, however, the effects of proximity to rail transit are strong; each unit of increase in Rail corresponds to an increase in the probability of a block group having access to all three destination types by a factor of 2.6.

**Table 4.6: Twin Cities Panel Logistic Regression**

Number of obs		4152	
LR chi2(7)		1876.72	
Prob > chi2		0	
Pseudo R2		0.37	
Time	Variable (unit)	Coefficient	Odds Ratio
Current	Rail (ordinal)	1.755 ***	5.786
	Distance from Downtown (miles)	-0.065 ***	0.937
	Residents Below 185% Poverty (%)	0.027 ***	1.027
	People of Color Residents (%)	-0.289 ***	0.749
	Transit Commuters (%)	0.237 ***	1.267
	Workers in Carless Households (%)	-0.004	0.996
Full Buildout	Rail (ordinal)	0.958 ***	2.605
	Distance from Downtown (miles)	-0.078 ***	0.925
	Residents Below 185% Poverty (%)	0.022 ***	1.023
	People of Color Residents (%)	0.037	1.038
	Transit Commuters (%)	0.220 ***	1.246
	Workers in Carless Households (%)	-0.004	0.996
	Constant	-1.954 ***	

Legend: \* p<.01; \*\* p<.05; \*\*\* p<.01

Notably, while People of Color Residents is significant with a negative relationship to the probability of access under current conditions, it becomes insignificant under the full buildout scenario, meaning that if the full regional transitway system is implemented, the odds of having 45-minute transit access to a regional employment center, public institution of higher education and a workforce center will no longer differ based on race. Other variables show little change between current conditions and the full buildout scenario.

### 4.3 DISCUSSION

The results provide compelling evidence for a strong relationship between fixed-guideway transit investments and equitable access to opportunity. The difference in access between the two fast growth regions with regional transitway systems and Indianapolis is particularly stark. The effect size found for proximity to rail transit also demonstrates the value of transitways in providing access to the destinations needed to prepare for, get and keep a good job. It should be noted that a similar effect may exist for BRT as well. None of the regions studied had a true, dedicated guideway BRT in operation at the time of data collection. As a result, our rail variable measures *both* mode and fixed-guideway status, and with no non-rail fixed-guideway services to compare, it is impossible to determine how much of the effect is due to which. It is worth noting the strength of rail’s effects in the cross-sectional model, in which a significant portion of block groups proximate to rail stations are proximate to heritage streetcar

stops, which do not offer more rapid regional mobility than conventional buses. This finding may be possible due to rail supporting the development of a destination-rich environment, in which accessibility is high despite mobility being low (Levine, Grengs, Shen, & Shen, 2012). Nonetheless, the results should also be interpreted with caution because the limited number of cities examined in this study. In addition, Denver and the Twin Cities have a relatively smaller racial and ethnic minority population than the other regions examined. This difference may confound the results that Denver and the Twin Cities have more ACP50s with access to all types of economic and workforce development opportunities.

The social equity implications of transitways are also impossible to ignore in these results. By every measure considered, more extensive fixed-guideway transit systems do not only offer greater access overall, but greater racial and economic justice in terms of access as well. This finding is especially significant for the Twin Cities: Given the region's long and ongoing history of housing segregation and unusually wide racial income and wealth gaps, the fact that implementation of the proposed regional transitway system would make a person of color no less likely to have access to employment, education and job search resources than a white person is a consequential one.

These findings comparing current and future transitway scenarios do not directly assign a dollar amount to the economic value of transitways. However, they demonstrate that a well-developed regional transitway system offers significant connections to economic opportunities for large numbers of people, in particular those traditionally excluded from economic opportunity by transportation investments and development patterns. Based on this analysis, transitway investments extend the benefits of transit as a connection to economic opportunity to many more people than are able to reap them otherwise.

## CHAPTER 5: CONCLUSION

The results from both chapters in tandem suggested that there is a considerable economic value associated with transitways. Analysis from Chapter 3 concluded transitway investments are associated with gains in regional GDP and employment. However, aggregate two-way fixed effects regressions only provided aggregate estimates of the effects of transitway investment. The descriptive and regression analysis in Chapter 4 showed that given the status quo, transitways are generally accessible to people of different racial/ethnic backgrounds and socioeconomic status.

Equity concerns associated with transitway investment are notable. Although a public good is accessible given the current status quo, it may not necessarily affect all people equitably. These concerns are reinforced by FGR's statistically insignificant coefficients for Chapter 3's GINI and median household income models. Further, when examining the spatial distribution of transitways in Chapter 4, many transitways are concentrated in gentrifying areas, most notably in Memphis. Thus, it is important to consider adverse equity effects when examining the economic benefits of transitways. As municipalities continue to invest in rail transit and fixed-guideway bus systems, they must consider how development along transitways could displace low-income residents. In this case, a rising tide may not necessarily lift all boats, justifying the need for more granular investigation into how the economic benefits of transitways may be concentrated in certain conditions and circumstances.

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