SOCIAL EQUITY IN TRANSIT SERVICE: TOWARD SOCIAL AND ENVIRONMENTAL JUSTICE IN TRANSPORTATION

By

Torrey James Lyons

A dissertation submitted to the faculty of the University of Utah in partial fulfillment of the degree of

Doctor of Philosophy

Department of City and Metropolitan Planning

The University of Utah

August 2019

Statement of Approval

ABSTRACT

This dissertation explores social equity as it applies to public transportation. Transit has long been considered a tool to alleviate inequity by limiting the effects of spatial mismatch and providing access to opportunity to disadvantaged populations. This theory, however, has not been adequately proven empirically. The first chapter of this dissertation tests the theory that spatial mismatch is moderated by quality transit service. We do this by taking a cross section of the largest urban areas in the United States and applying structural equation modeling to identify relationships between exogenous and endogenous factors. We find that higher quality transit service and compactness are associated with lower levels of unemployment, poverty, and income inequality. The second chapter of this dissertation outlines the development of a novel index for objectively measuring social equity in transit service. This methodology improves upon previous efforts to quantify equity in transit by using emerging techniques in geographic information systems (GIS) software and by incorporating a comprehensive set of index components. The third chapter explores how transit agencies plan for providing equitable transit service. We interview transit agency planners to understand the way that agencies consider equity, to determine how equity considerations are shaped by agency and federal policy, and we compare these considerations to themes in the academic literature. We find that while academic efforts have focused primarily on accessibility as the most important facet of equity in transit service, transit agency planners think of equity in a more wholistic manner. The accessibility framework, as we describe it here, is a less nuanced way to think of and plan for equity than how transit agencies are currently operating. Additionally, we attribute part of agencies' more

comprehensive construction of equity to Title VI of the Equal Rights Act of 1964. This legal framework for planning for equity is ubiquitously criticized in the academic literature for being inadequate at measuring the accessibility effects of changes to transit service. Although these claims have merit, the framework considers equity in a way that goes beyond just measuring accessibility and therefore contributes to a broader lens through which transit agencies think about and plan for equity.

CONTENTS

LIST OF TABLES

Tables

LIST OF FIGURES

Figures

CHAPTER 1: INTRODUCTION

Social and environmental justice have been a concern in transportation planning for almost as long as these terms were in the national policy lexicon. Social equity can be defined as an equitable distribution of goods, services, rights, and opportunities (Deka, 2004). Equity is often categorized as either vertical or horizontal; the former describing a scenario in which all people are treated the same, and the latter in which intentionally disparate impacts of policy are designed to advance traditionally marginalized groups. Title VI of the Civil Rights Act of 1964 introduced the concept of environmental justice to transportation by directing agencies to "demolish the barriers to full participation faced by minorities." In this act, Congress further stipulates that "[n]o person in the United States shall, on the ground of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance." (Colopy, 1994) Given the heavy subsidization of US transportation systems, it is not surprising that equity considerations have been mandated for some time. Equity analyses are required of transit agencies and metropolitan planning organizations (MPOs), although the methods that they use are rudimentary at best (Karner & Niemeier, 2013; Sanchez & Wolf, 2005)

The topic of income inequality has recently come to the forefront of political discourse (Deininger & Squire, 1996; Atkinson, 1983; Glomm & Ravikumar, 1992; Ngamba, Panagioti & Armitage, 2017; Jacobs & Dirlam, 2016; Hero, 2016). Although it was posited by Kuznets (1955) that income inequality would decline with the progression of the development of a nation, the United States has not followed his proposed theoretical trajectory. In fact, the recent decades have been characterized by a decline in the share of wealth controlled by the bottom 90% of American workers. (Corak, 2013) This is a troubling trend, and its causes must be examined.

Interestingly, it has been posited that the way that our cities are configured has had an influence on economic opportunity for marginalized populations in the US (Durlauf, 1996; Rey, 2004; Lessman, 2014.) Spatial mismatch is a theory that was first developed in 1968 by John Kain which highlights the geographic disparity of low skill jobs and the location of low skilled workers' housing. The exodus of affluent white households to the suburbs after WWII precipitated a change in the location of low-skilled service jobs from the city to the suburbs. The workers best suited for these jobs, however, were forced to remain in the city for the lack of affordable housing options in the newly minted suburbs. Kain attributed high unemployment rates and persistent poverty to spatial mismatch.

While those who have access to private vehicles appreciate an expansive roadway system, this luxury is not available to the most disadvantaged populations. Those without access to an automobile rely on transit for much of their transportation needs. These populations are considered "transit dependent" (Litman, 1996). Transit dependency describes an economic condition of being mostly reliant on transit to access one's daily transport needs. This population depends on bus and rail networks to partake in even the most basic activities such as work, education, and even health care. Consequently, many argue that we must provide adequate public transit networks to increase access to daily needs for the most vulnerable and economically disadvantaged populations.

While automobile travel is greatly subsidized through low fuel prices, free access to high quality roads, purchasing incentives, free parking, uncompensated accident costs, and externalized environmental costs, so, too, is public transit (Hanson, 1992; Wachs, 1989;

Mallinckrodt, 2003; Ewing, 1997; Shoup, 2017; Beck, 2003; Delucchi, 1996; Edlin & Karaca-Mandic, 2006; Delucchi, 2000). Investment per rider is a term used by transit agencies to quantify the dollar amount that it actually costs to take a passenger on an average length trip, and this number can far-exceed the normal cost of the fare (Litman, 2008). With such public investment into the affordability of transit service, it should be established whether or not agencies are achieving their goals of improving accessibility to jobs and other daily needs of disadvantaged riders.

Some researchers have attempted to develop methodologies for measuring social equity in transit service. The focus thus far has been on the spatial component of transit service, measuring accessibility for disadvantaged populations. A few studies have taken it a step further by including temporal elements as well. It is important to measure both time and space when considering the equity of transportation systems, as people interact with the built environment along a spectrum of these dimensions. There are two key shortcomings of the efforts of researchers thus far. The first of these is the exaggerated focus on the spatial aspect of transit equity. While transportation is ultimately about linking origins and destinations, there are many more facets of transit systems which either improve equity in transportation or limit it. This calls for a measure that is more comprehensive, including more aspects of transit service than just spatial and temporal elements. Second, the methodologies of previous studies are rigorous to a point of being inaccessible to the typical transit planner. What good is a methodology which can only be replicated by select researchers with a very specialized skill set? This highlights the need for a comprehensive, accessible methodology which can be widely applied to transit agencies around the country for the purpose of evaluating their efficacy in promoting social equity.

After constructing the improved methodology for measuring equity in transit service, we can then better understand how agencies are achieving equitable transit systems. We relate agency practices and policies to performance with respect to the index in order to determine what practical aspects of transit agencies lend themselves to equitable systems. We then investigate transit agencies with varying degrees of success in providing equitable systems to identify best practices. Finally, the index allows for an investigation of whether regions with equitable transit systems experience improved economic outcomes like lower levels of persistent poverty and unemployment. Determining whether there is an economic case for socially equitable transit service helps in determining whether additional public funding for the mode is warranted. These efforts are a novel contribution to the field and will provide insight into the important issue of social equity in transit.

CHAPTER 2:
THE EFFECTS OF TRANSIT AND COMPACTNESS ON REGIONAL ECONOMIC OUTCOMES

ABSTRACT

Kain's theory of spatial mismatch states that the physical separation of people from their employment contributes to persistent unemployment and poverty. Transit has long been considered a way to alleviate this issue by providing access to opportunity for disadvantaged populations. In this paper we test the theory that transit can act as a moderator on the relationship between spatial mismatch and unemployment and poverty. We find that transit does affect unemployment and poverty indirectly through its effect on compactness. This study is the first to find a relationship between transit and poverty using a national sample of large US regions. The findings give credence to transit supportive policies that seek to use transit as a lever to improve regional economic conditions and alleviate unemployment and poverty.

INTRODUCTION

In the late 1960s, Kain observed that the exodus of affluent white Americans to the suburbs was creating what he called the problem of spatial mismatch. Spatial mismatch describes the phenomenon wherein people and jobs are separated by space, making it harder for specific populations to access economic opportunities. Access to transportation, in theory, can act to moderate the effect of spatial mismatch on poverty and unemployment. Personal vehicles effectively nullify the problem, as access to this mode allows commuters to travel great distances from their homes to workplaces in a relatively short amount of time. What about those who do not have access to personal vehicles? Transit, again theoretically, can help to extend the amount of opportunities for those without automobiles. The assumption that transit provides economic opportunity is a basic assumption in transportation planning practice and academia, but there has been limited empirical study of this premise to date. As Sanchez (2008) puts it, "The connection between transportation mobility and poverty is laden with untested assumptions,"

Updates to this work have found associations between poor public transit access and higher rates of unemployment and poverty (Kain & Meyer, 1970; Kasarda, 1983; Elwood, 1986; Ihlanfeldt, 1993; Sanchez, 1999; Sanchez, 2008). Many studies have examined the relationships between transportation investments in given areas and their corresponding impacts on regional economies. These studies associate lagged changes in economic variables to transportation investments or policies (Berechman, Ozmen, & Ozbay, 2006; Sanchez, 2008). A large-scale examination of how transportation variables interact with socioeconomic and built-environmental determinants of unemployment and poverty is an effort that has not yet been undertaken in the urban planning literature. With this paper, we study how transit affects regional economic outcomes, unemployment and poverty. We do this using a cross-sectional study design of 113 US urbanized areas. We use structural equation modeling to determine if transit can act as a moderating factor on the relationship between spatial mismatch and unemployment and poverty.

LITERATURE REVIEW

SPATIAL MISMATCH

The above problems have been studied by economics scholars and are known to be caused by a variety of factors including wage stagnation, banking practices, public policy, and sprawling development patterns. (Reed, 1999; Dabla-Norris et al., 2015; Kaplan et al., 1996; Bakija et al., 2012; Ewing et al., 2016) However, there are only so many ways in which urban planners can attempt to tackle this problem. One way, as is posited in this dissertation, is through addressing yet another issue that has been suggested to influence intergenerational poverty: spatial mismatch.

Spatial mismatch is a theory that was first developed in 1968 by John Kain, which highlights the geographic disparity of low skill jobs and the location of low skilled workers' housing. The exodus of affluent white households to the suburbs after WWII precipitated a change in the location of low-skilled service jobs from the city to the suburbs. The workers best suited for these jobs, however, were forced to remain in the city for the lack of affordable housing options in the newly minted suburbs. Kain attributed high unemployment rates and persistent poverty to spatial mismatch. The theory originally focused on inner city African American populations, but it has now expanded to incorporate all vulnerable populations around the world. They posit that it is the reformation of urban structure that has created the serious economic problems facing the most vulnerable populations (Wolf, 2007; Harper, Marcus & Moore, 2003; Moore, 2005; Horrell, Humphries & Voth, 2001).

Later on, transportation researchers began to refine the theory to incorporate the evolving expertise of the field. Cervero (1989) discovered that regional mobility is related to spatial mismatch. He went on to develop the concept of jobs-housing balance, which attempts to pinpoint a comfortable equilibrium of land uses that allows residents to easily access sufficient employment opportunity. In 2002, Cervero et al. further advanced the understanding of this relationship by linking transportation policy to the ability of individuals to find employment. This study used a rich longitudinal dataset which followed individuals that had been on welfare. Cervero et al. use the switch from welfare to work as an indicator of a sign of improvement of an individual's economic situation. They find that car ownership and educational attainment were the strongest predictors of individuals' ability to transition from welfare to work. This indicates a transportation system which is not properly providing opportunity for the most disadvantaged populations like those who do not have access to a private vehicle.

INCONME INEQUALITY AND INTERGENERATIONAL MOBIITY

Income inequality is an issue that has garnered a great deal of attention in the past few years. From the work of Chetty and other researchers to the political talking points of Sanders and Warren of the political left, we are increasingly more aware of the potential of this problem to continue to fragment our society.

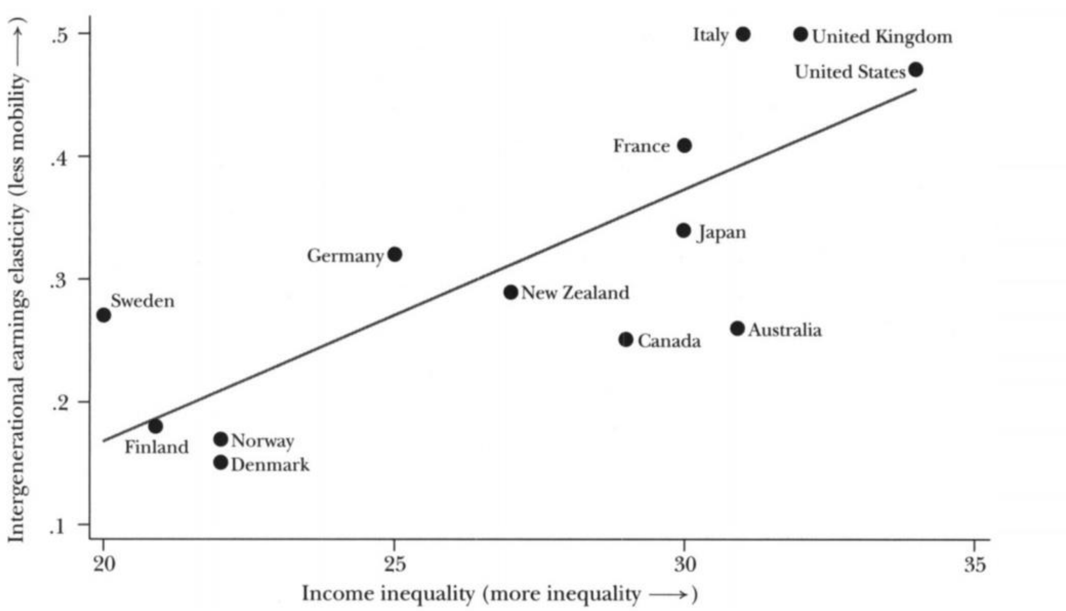
One of the first researchers on the topic, Simon Kuznets (1955) claims that after the First World War, income distribution in the US and England was actually becoming more equitable. In the US, for example, the proportion of total income attributable to the lowest two quintiles rose from 13.5% in 1929 to 18% in 1950. Comparing this trend to today, we see much more inauspicious figures. Although it was posited by Kuznets (1955) that income inequality would decline with the progression of the development of a nation, the United States has not followed his proposed theoretical trajectory. In fact, the recent decades have shown a decline in the share of wealth controlled by the bottom 90% of earners. (Corak, 2013) Just as disheartening are the findings of a recent OECD report which established the gap between the rich and poor to be at its highest level in the past 30 years. (Cingano, 2014) This report also determined that the expanding gap has a significant impact on aggregate economic growth. Interestingly, Cingano demonstrates that it is not the elevation of the highest earners, which has the largest negative effect, but rather the depression of low-income households that harms the economy. Forster and Pellizzari (2000) suggest that this is a global trend, with no OECD nations experiencing decreases in inequality.

A related topic of interest to urban researchers that is simply an extension of the issue of income inequality is intergenerational poverty. As compassionate observers of social issues, we are indeed troubled by the impoverished conditions of so many citizens. What is even more troubling, however, is when those impoverished households are unable to help lift their children out of similar circumstances, leaving them to lead a similar taxing existence. Corak (2013) finds that increasing polarization of income inequality leads to decreased intergenerational mobility. Intergenerational mobility is a concept that can be defined by a child’s likelihood of finding himself in a different income category than he was born into specifically from a lower category to a higher category. While Corak’s assertion is not uniformly supported by other economic scholars, it is an unsettling notion that warrants further examination. (Chetty, 2014; Bratberg et al., 2017; Landerso & Heckman, 2017; Blanden et al., 2013; Stoker & Ewing, 2014)

Corak (2013) introduces and interesting economic theory which he calls the Great Gatsby Curve. The Great Gatsby is a considered a cautionary tale which warns of the downfalls of excess and resistance to change. This important and effective visualization depicts OECD countries on a graph of income inequality and intergenerational mobility. Below, the Great Gatsby Curve shows the United States at the extreme of income inequality with a reciprocal inferiority in intergenerational mobility among the countries included in the graph.

FIGURE 2.1 Great Gatsby Curve

The Great Gatsby Curve: More Inequality is Associated with Less Mobility across the Generations



Source: Corak (2013) and OECD.

DETERMINANTS OF UNEMPLOYMENT AND POVERTY

The theory of spatial mismatch suggests that the separation in space between people and jobs leads to unemployment and poverty in disadvantaged populations. However, this certainly is not the only driver of economic outcomes for individuals, regions, or countries. Economists have long studied the determinants of unemployment and poverty, but have traditionally looked at differences between nations, as this allows for the analysis of how national policies can affect economic outcomes. The determinants of regional economic outcomes are studied less, but those that have examined these relationships have reported similar findings. Demographic factors such as race and ethnicity, educational attainment, age, religion, and diversity have been aggregated to varying geographies and related to regional economic outcomes (Achia, Wagombe, & Khadioli, 2010; Moller et al., 2003; Rapusingha & Goetz, 2007; Filitztekin, 2008; Bardinger et al., 2002; Sanchez, 1999, Zenou, 2000). Economists and planners have also found that built-environmental factors such as employment density, population density, and distance to jobs affect unemployment and poverty (Rapusingha & Goetz, 2007; Filitztekin, 2008; Bardinger et al., 2002; Sanchez, 1999, Zenou, 2000). Others have examined how labor force characteristics, household structure, public policy, and even transportation factors influence regional economic outcomes (Achia, Wagombe, & Khadioli, 2010; Pichaud, 2002; Moller et al., 2003; Rapusingha & Goetz, 2007; Filitztekin, 2008; Bardinger et al., 2002; Sanchez, 1999).

The best effort to date to relate transportation infrastructure with unemployment is Sanchez, 2007. In this study, Sanchez investigates the relationship between access to public transportation and labor force participation rates. Sanchez analyzes two case studies, comparing block groups and measuring a variety of demographic information for this geography. The author found that access to public transit was a good indicator of workforce participation in Portland, OR and Atlanta, GA. While this study provides some evidence that transit service provision can affect economic outcomes at the block group level, the findings of this study are limited in their generalizability due to the small sample of regions (Pichaud, 2002) and the smaller geographic level of analysis. This paper will build upon the findings of Sanchez (2007) by expanding the sample to almost all large regions in the US, and analyzing economic outcomes at the regional level. Such an improvement also has the potential to strengthen the case for using transportation spending as an economic lever if it were to find that transit is, in fact, a determinant of regional economic outcomes.

METHODS

STUDY DESIGN

This study tests the hypothesis that a robust transit system can influence regional economies. Kain (1955) posits that spatial mismatch leads to issues of persistent poverty and low intergenerational mobility. By relating transit service provision to income inequality and poverty, we can potentially verify the theory that transit service can function as a moderator on the relationship between spatial mismatch and persistent poverty. This paper employs a cross-sectional study design using structural equation modeling on an enhanced database, combining built-environmental, socioeconomic, and transportation system variables. The addition of new variables brings the total number of regions in the database to 113.

DATA AND VARIABLES

While we rely on the expertise of the authors and contributors to determine which transportation and built-environmental variables will best serve the purposes of the models, sociodemographic and economic factors needed to be more explicitly-informed by the literature. We performed an additional literature review of the determinants of regional unemployment and poverty to help decide which constructs would be operationalized, and how. Table 2.1 depicts the determinants of unemployment and poverty as defined by the literature. We also highlight which variables we included in early model iterations as well as those persisting to final models.

TABLE 2.1 Literature-Informed Variable Selection

Category	Literature Variables	Tested in Models	In Final Models
Demographics	Education Level (1,3,4,5,6,7)	Education	***Education***
	Youth Population	Age	
	Age (1,3,4,5)	Race	
	Race (3,4,7)	Population	***Population***
	Ethnicity (1)		
	Religion (1)		
	Vocational Education (6)		
	Diversity (4)		
Built Environment	Physical (built) environment (4)	Compactness	***Compactness***
	Schools (2)		
	Health and social services (2)		
	Urban and employment density (5)	Land Area	***Land Area***
	Population density (6)		
	Distance from jobs (8)	Jobs-Population Balance	***Jobs-Population Balance***
Transportation	Distance to nearest transit stop (7)		
	Job access via transit (7)	Transit Factor	***Transit Factor***
	Commute time (7)		
	Transit service frequency (7)		
	Vehicle ownership (7)		
	Non-peak hour departure for work (7)		
Employment	De-industrialization (3,4)	Unemployment	***Unemployment***
	Unemployment (3)	Low-Wage Sectors	
	Female Labor Force Participation (3,4)	Poverty	***Poverty***
	Private Employment (4)	Income Inequality	***Income Inequality***
	Labor Sectors (4,5,6)	De-Industrialization	
	Working age (5)	Female Workforce Proportion	***Female Workforce Proportion***
	Euntrapenouirs (6)		
	New Businesses (6)		
	Start-ups (6)		
	Guest workers (6)		
Households	Number of Household Members (1)	Single Mothers	
	Age of Household head (1)	Auto Ownership	***Auto Ownership***
	Single Mother families (3)		
	Housing tenure (6)		
	Public Housing (6)		
	Housing affordability (6)		
Policy and Services	Public Housing (6)		

	Schools (2)		
	Health and social services (2)		
	Government Expenditure (4)		

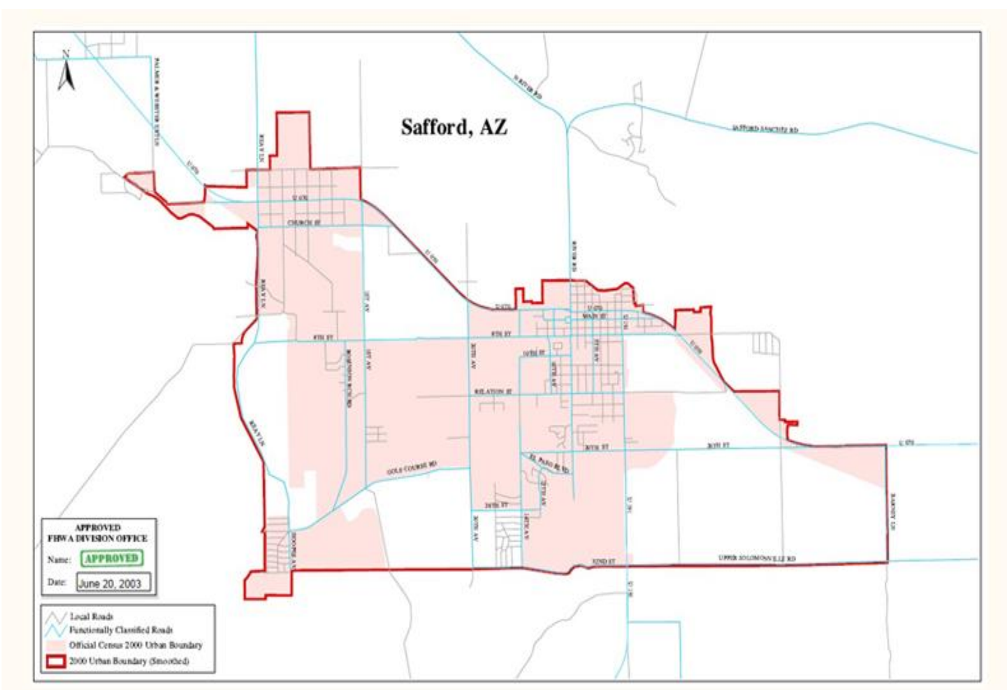
1: Achia, Wagombe, and Khadioli (2010)
2: Pichaud (2002)
3: Moller et al. (2003)
4: Rapusingha & Goetz (2007)
5: Filitstekin (2008)
6: Bardinger & Url (2002)
7: Sanchez (1999)
8: Zenou (2000)

TABLE 2.2 Variables and Data Sources

Variable	Description	Computation	Unit of Measurement	Data Source	Method or Data Contributors
lnlandarea	Natural log of land area	ln(land area in square miles)	Block Group	NHGIS/US Census	Ewing, Hamidi, & Grace, 2016
lnfmlwrkfc	Natural log of female workforce	ln((number of female workers/total workers)*100)	Block Group	NHGIS/US Census	Lyons
lnedattnmnt	Natural log of educational attainment	ln((number of residents with associates degree or higher/total residents)*100)	Block Group	NHGIS/US Census	Lyons
lnjobpop	Natural log of job-population balance	ln(1−(ABS(employment−0.2 p population)/(employment + 0.2 p population))	Census Tract	LEHD	Tian et al., 2015
lnnoveh	Natural log of carless households	ln((carless households/total households)*100)	Block Group	NHGIS/US Census	Lyons
pop000	Natural log of population	ln(population)	Block Group	NHGIS/US Census	Lyons
lncompact	Natural log of compactness index	ln(100+((compactpca-mean of compactpca*25)))	FHWY UZA	VMT Growth Database	Ewing, Hamidi, & Grace, 2016
lntransit1	Natural log of transit factor	ln(100+((transit factor-mean of transit factor*25)))	FHWY UZA	VMT Growth Database	Ewing et al., 2014
lnUnemployment	Natural log of unemployment	ln(unemployed population/total population*100)	Block Group	NHGIS/US Census	Lyons
lnpoverty	Natural log of proportion of residents below 1.5 * poverty level	ln((number of residents below 1.5 poverty/total residents)*100)	Block Group	NHGIS/US Census	Lyons

Many of the above variables, their computation, and sourcing do not demand further explanation. However, here we will discuss the computation of some of the variables, the decision to choose varying units of measurement, and the process of spatially apportioning data. The final unit of analysis was the Federal Highway Administration Urbanized Area. This research is built partially on the efforts of previous work that has emerged from the colleagues at the University of Utah. Ewing, Hamidi, and others have worked to develop sprawl metrics that have been linked to urban phenomena like obesity, vehicle miles traveled, traffic safety, and congestion. They have created a rich database that was generated using GIS to measure many attributes of sprawl. Socioeconomic data gathered from IPUMS' National Historical GIS (NHGIS) are measured at US Census geographies. The boundaries for Census geographies and those of FHWA UZAs differ, and therefore, spatial apportioning of NHGIS data was necessary. Below, Figure 2.1 depicts the dissimilarities between Census and FHWA geographies.

Figure 2.1 Census Tracts and FHWA Urbanized Area



The area highlighted in pink represents the Census urban area, and the area outlined in red represents the FHWA adjusted urbanized area. A reason for FHWA's adjustments is to reduce the irregularity in Census designations for the purpose of improved transportation planning. In order to use data measured at the Census geography within the UZA, first we must determine the smallest possible geography for the variables in question. Census block groups were used for most variables, except when a larger unit of analysis was the most prudent way to measure a construct. An example of a case where a larger unit of analysis was more appropriate is job-population balance. This is a construct that considers the availability of jobs within relatively close proximity to residents (Cervero & Duncan, 2006; Weitz, 2003; Stoker & Ewing, 2014). We assert that a block group, which is often considered the best analog to a neighborhood of census geographies is too small. A typical conceptualization of a neighborhood is small, and will often not contain any areas of meaningful employment. Thus, we measure job-population balance at a Census tract level, which is larger than a block group, but still small enough to reasonably apportion within the UZA boundary. Census tracts were also used as the unit of measurement for income inequality for the same reason.

We used spatial apportioning to assign data measured at smaller geographies (tracts and block groups) to the UZA. We intersected tracts and block groups with UZA's and measured the proportion of the tract or block group that falls within the UZA boundary. That proportion was then used to assign the appropriate amount of data to the urbanized area. This process is known as simple area weighting, and is detailed in the below equation:

$$V_t = \sum_{s=1}^{s} \frac{V_s \,.A_{st}}{A_s}$$

Where: Vt is the value in the target zone t; Vs is the population in source zone s; As is the area of source zone s; and Ats is the area of target zone t overlapping source zones.

Two of the variables in the dataset are factors derived from principal component analysis. Principal component analysis (PCA) is a process wherein a researcher creates a new variable that represents the shared variation between multiple like variables. This allows the researcher to create a more parsimonious model using only a single variable that explains the variation of multiple variables. This method was used by Ewing et al. in 2018 when they tested Newman and Kenworthy's theory of density and automobile dependence. In order to more succinctly express the inverse of sprawl, they created an index which they called "compactness". Their compactness variable was the product of a principle component analysis four factors including density, mixed-use, centering, and street network design. This measurement was taken directly from the dataset that Ewing et al. constructed, with the authors' permission. Additionally, we used PCA to create a new "transit" factor. The transit factor represents the common variation in five variables that express different elements of transit service provision: route density; service frequency; total operating expenditure; fare price; and unlinked passenger trips per capita. Below, Tables 2.3 and 2.4 depict the extractions from each original transit service provision variable as well as the total variance explained by the new PCA variable.

TABLE 2.3 PCA Extraction

Communalities

	Initial	Extraction
lnfare	1.000	.709
rtden	1.000	.725
tfreq	1.000	.654
lntotalopexp	1.000	.854
UnlkdPasTripCap	1.000	.913

TABLE 2.4 PCA Variance Explained

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.728	54.557	54.557	2.728	54.557	54.557
2	1.127	22.540	77.097	1.127	22.540	77.097
3	.791	15.818	92.915			
4	.227	4.538	97.453			
5	.127	2.547	100.000			

Extraction Method: Principal Component Analysis.

SPSS software produces a new variable that is an expression of the shared variance of the variables that are included in the PCA. We use just the first PCA variable as it alone explains the majority of the common variance of all component variables. Adding a second PCA variable would complicate the model theoretically with limited gains in explanatory value. This new variable is scaled to be normally distributed, have a mean of zero, and a standard deviation of one. In order to have the variable expressed in a way that is more intuitively interpretable, we transformed the resulting PCA variable to have a mean of 100 and a standard deviation of 25. Below, Table 2.5 includes descriptive statistics for all variables included in the final models. The variables described below are not log-transformed as they are in the models.

TABLE 2.5 Descriptive Statistics of Final Model Variables

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
GiniCT	113	.351	.469	.405	.019
jobpop	113	47.39	92.80	58.30	5.04
noveh	113	2.61	31.27	8.08	3.14
fmlwrkfrc	113	44.04	53.09	47.98	1.69
edattain	113	20.28	57.43	36.97	7.75
landarea	113	75.72	4438.64	522.87	640.75
Below1.5pov	113	8.80	53.67	24.16	5.79
transit1	113	38.50	182.72	100.00	25.00
compact	113	45.80	155.08	98.14	23.38
Unemployment	113	8.70	21.67	14.62	2.24
pop000exp	113	200.96	18536.84	1106.74	2120.89

One might notice that the "compact" variable does not, in fact, have a mean of 100 and a standard deviation of 25. This is due to the fact that some cases were lost between the first creation of the database and the inclusion of additional variables for this study.

STRUCTURAL EQUATION MODELING

This study employs structural equation modeling as the principal tool for evaluating relationships between the variables of interest. Structural equation modeling (SEM) is a statistical methodology for evaluating complex hypotheses involving multiple, interacting variables. SEM is a 'modelcentered' methodology that seeks to evaluate theoretically justified models against data. The SEM approach is based on the modern statistical view that theoretically based models, when they can be justified on scientific grounds, provide more useful interpretations than conventional methods that simply seek to reject the 'null hypothesis' of no effect. SEM is a series of statistical methods that allow complex relationships between one or more independent variables and one or more dependent variables. Expert dissertation committee members will be invited to discuss models as they are being formulated and refined.

RESULTS

We developed two models to analyze the effects of exogenous and endogenous variables on income inequality and poverty.

INCOME INEQUALITY MODEL

The income inequality model in Figure 1 has a chi-square of 10.47, with 17 model degrees of freedom, and a p-value of .883. The low chi-square relative to model degrees of freedom, as well as the high p-value indicate good model fit. Additionally, other goodness of fit measures produce promising results. The root mean square error of approximation (RMSEA) of 0.00 falls below the conventional threshold of .05, indicating good model fit. (24) Finally, the comparative fit index (CFI) of 1.00 achieves that measure's optimum value. All pertinent goodness of fit measures indicate this model fits the data well. Below, Figure 2.2 depicts the path diagram produced by the AMOS software.

FIGURE 2.2 Inequality Model SEM Path Diagram

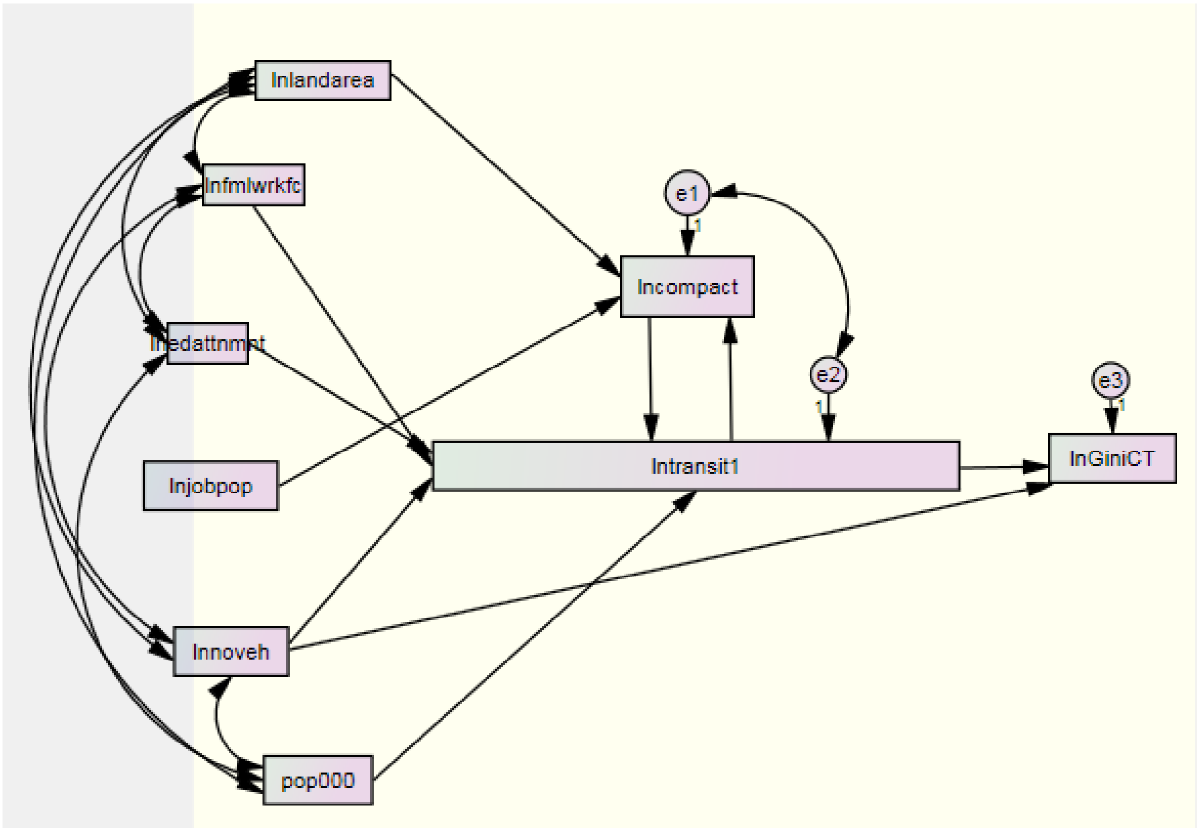


Figure 1 illustrates a path diagram with variables affecting poverty directly and indirectly through endogenous variables. Straight arrows indicate causal pathways, and curved bidirectional arrows indicate covariances, or correlations. For example, the diagram shows that job-population balance affects compactness, which, in turn, influences transit factor, which directly affects the outcome variable, income inequality. Land area also affects compactness, transit factor, and inequality in the same succession. Female workforce participation, educational attainment, and population directly affect transit factor, which in turn affects inequality. This means that these variables directly affect transit factor, and indirectly affect through through their influence on transit factor.

Model fit, described above, is just part of the process of evaluating models. Next, we compare the relationships described in the model to our theoretical understanding. Table 2.6 includes path coefficient estimates that give the predicted effects of individual variables, ceteris paribus. Estimates can be interpreted as elasticities.

TABLE 2.6 Inequality Model SEM Path Coefficient Estimates

			Estimate	S.E.	C.R.	P	Label
lntransit1	<---	pop000	.149	.017	8.699	***	
lncompact	<---	lnjobpop	.190	.065	2.940	.003	
lncompact	<---	lnlandarea	-.189	.030	-6.307	***	
lntransit1	<---	lnedattnmnt	.118	.026	4.572	***	
lntransit1	<---	lnfmlwrkfc	-.261	.148	-1.762	.078	
lntransit1	<---	lnnoveh	.126	.023	5.547	***	
lnGiniCT	<---	lntransit1	-.068	.018	-3.832	***	
lnGiniCT	<---	lnnoveh	.056	.015	3.758	***	
lntransit1	<---	lncompact	.668	.107	6.246	***	
lncompact	<---	lntransit1	.877	.111	7.884	***	

All of the path coefficient estimates in Table 2.6 are significant at the standard threshold $P < 0.05$, except for female workforce proportion, which is significant at the $P < 0.10$ level.

Table 1 specifies that population is positively related to transit and is statistically significant. Job-population balance positively affects compactness and is statistically significant. Land area negatively affects compactness and is also significant. Educational attainment, no vehicle, and compactness all are positively related to transit factor and their effects are statistically significant. Female workforce proportion is negatively related to tranit factor and is significant at the $P < 0.1$ level. Finally, and most importantly, we see that transit factor negatively affects income inequality. The coefficient of -0.068 means that with an increase in transit factor we can expect to see a small decrease in regional income inequality. This comports with the hypothesis of this paper that transit can act as a moderating factor on spatial mismatch.

Additionally, the small elasticity is expected, given that the majority of cases in the study sample are mid-sized cities in which transit is only a small component of the transportation system, therefore contributing marginally to the regional economy.

TABLE 2.7 Inequality Model Covariance Estimates

			Estimate	S.E.	C.R.	P	Label
pop000	<-->	lnnoveh	.132	.028	4.704	***	
pop000	<-->	lnedattnmnt	.059	.018	3.330	***	
lnedattnmnt	<-->	lnfmlwrkfc	.002	.001	2.598	.009	
lnnoveh	<-->	lnfmlwrkfc	.005	.001	4.487	***	
lnedattnmnt	<-->	lnlandarea	.049	.015	3.249	.001	
lnnoveh	<-->	lnlandarea	.117	.024	4.821	***	
pop000	<-->	lnlandarea	.702	.097	7.229	***	
lnfmlwrkfc	<-->	lnlandarea	.004	.001	3.284	.001	
e2	<-->	e1	-.044	.006	-7.117	***	

All the covariances above indicate statistically significant relationships that all agree with our theoretical expectations of the interactions of these variables.

TABLE 2.8 Inequality Model Direct, Indirect, and Total Effects

Direct Effects

	lnlan darea	lnfmlwr kfc	lnjobp op	lnedattn mnt	lnnov eh	pop0 00	lncomp act	lntransi t1
lncompact	-.189	.000	.190	.000	.000	.343	.000	.877
lntransit1	.000	-.261	.000	.118	.126	.149	.668	.000
lnGiniCT	.000	.000	.000	.000	.056	.000	.000	-.068

Indirect Effects

	lnlandarea	lnfmlwrkfc	lnjobpop	lnedattnmnt	lnnoveh	pop000	lncompact	lntransit1
lncompact	-.268	-.553	.270	.250	.266	.315	1.417	1.242
lntransit1	-.305	-.370	.308	.167	.178	.211	.947	1.417
lnGiniCT	.021	.043	-.021	-.019	-.021	-.024	-.110	-.096

Total Effects

	lnlandarea	lnfmlwrkfc	lnjobpop	lnedattnmnt	lnnoveh	pop000	lncompact	lntransit1
lncompact	-.457	-.553	.460	.250	.266	.315	1.417	2.119
lntransit1	-.305	-.631	.308	.285	.304	.359	1.615	1.417
lnGiniCT	.021	.043	-.021	-.019	.035	-.024	-.110	-.164

The direct effects depicted above are the same as what we reported in Table 2.7 path coefficient estimates, however, here we also see indirect and total effects of exogenous and endogenous variables on the outcome variable. We see that land area has a positive indirect effect on income inequality through its effect on transit factor. This means that an urbanized area with a larger land area, and thus a higher potential for spatial mismatch, will lead to greater levels of income inequality. This is what we would expect to see, given the theory of spatial mismatch. We see that female workforce participation, job-population balance, educational attainment, no vehicle households, population, and compactness all have negative indirect effects on income inequality through their effects on transit factor. Again, these relationships agree with our theoretical understanding.

Figure 2.3 graphically depicts total effects of all variables on income inequality.

Figure 2.3 Total Effects on Income Inequality

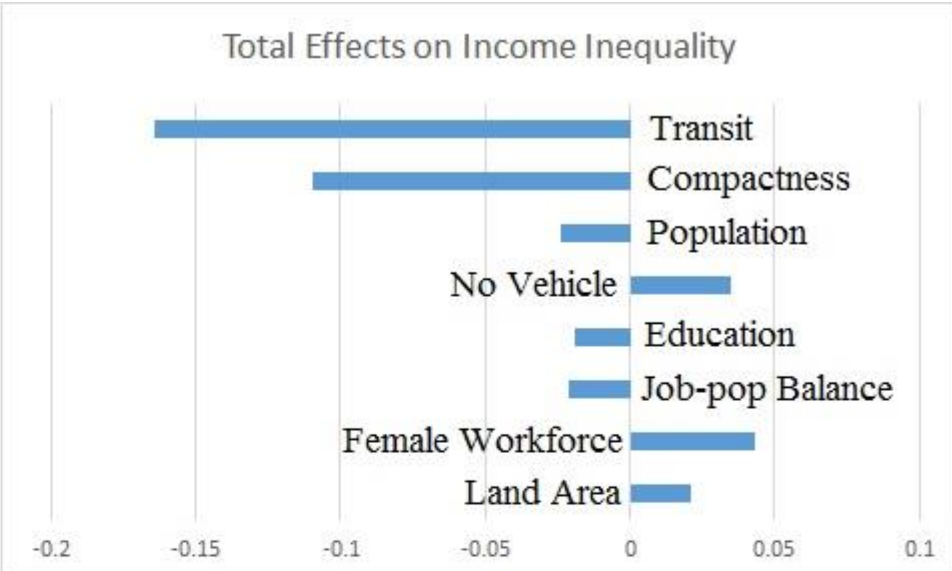
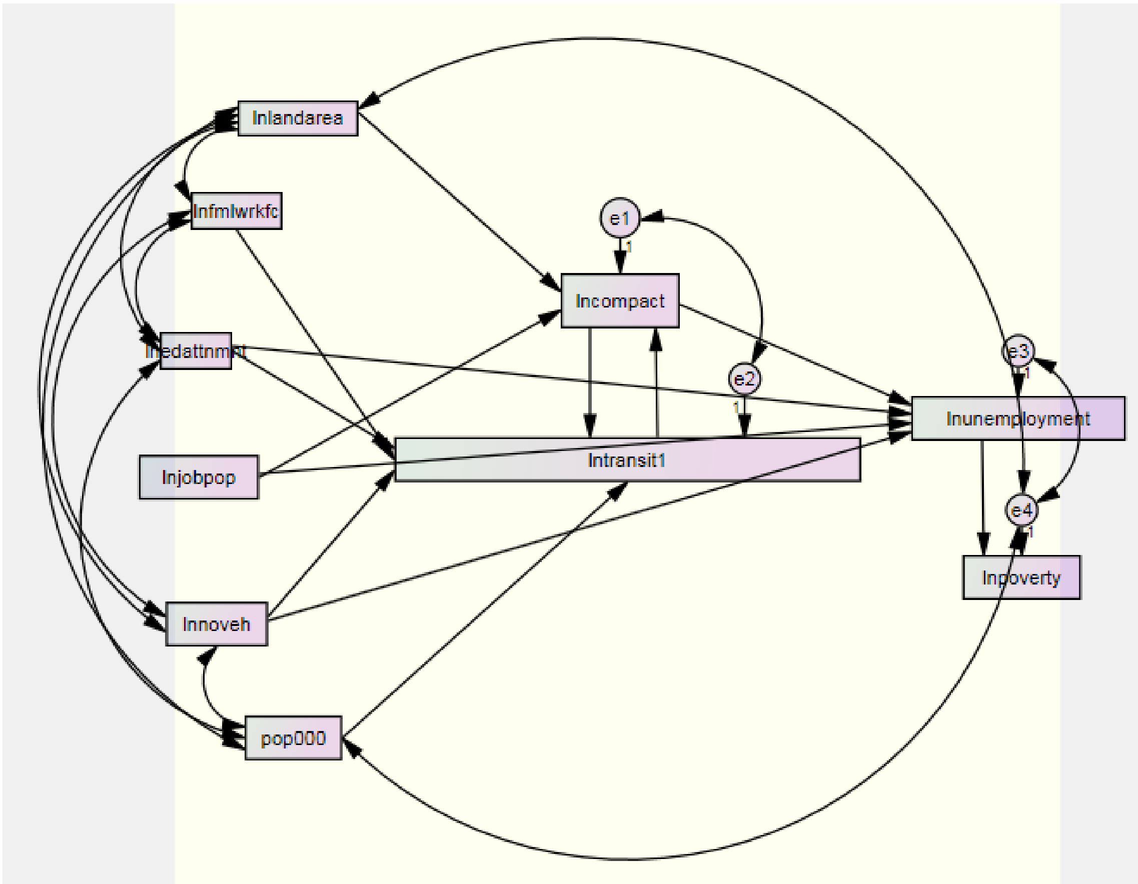


Figure 2.3 demonstrates that transit has the greatest total effect on income inequality, followed by compactness. The other variables in the model have significantly smaller effects on the outcome variable.

UEMPLOYMENT AND POVERTY MODEL

The poverty model in Figure 3 has a chi-square of 12.97, with 20 model degrees of freedom, and a p-value of .879. The RMSEA of .000 and CFI of 1 also suggest good model fit. Below, Figure 2.4 depicts the path diagram for the poverty model.

FIGURE 2.4 Unemployment and Poverty Model SEM Path Diagram



The path diagram shows some of the same relationships as the inequality model, but is more complex. Here, we have modeled two outcome variables: unemployment and poverty. Another obvious distinction between this and the inequality model is that compactness is directly affecting the outcome variable instead of transit. Here, transit affects unemployment and poverty indirectly through its effect on compactness. Both compactness and transit affect poverty indirectly through compactness' effect on unemployment. Another significant difference between this model and the inequality model is that some exogenous variables are directly affecting the outcome variable. This is to be expected, as socioeconomic variables should be directly related to unemployment

TABLE 2.9 Poverty Model SEM Path Coefficient Estimates

Regression Weights:

			Estimate	S.E.	C.R.	P	Label
lntransit1	<---	pop000	.149	.017	8.697	***	
lncompact	<---	lnjobpop	.190	.065	2.941	.003	
lncompact	<---	lnlandarea	-.189	.030	-6.315	***	
lntransit1	<---	lnedattnmnt	.118	.026	4.571	***	
lntransit1	<---	lnfmlwrkfc	-.261	.147	-1.772	.076	
lntransit1	<---	lnnoveh	.126	.023	5.552	***	
lnunemployment	<---	lncompact	-.103	.034	-2.997	.003	
lnunemployment	<---	lnjobpop	-.385	.092	-4.183	***	
lnunemployment	<---	lnedattnmnt	-.397	.048	-8.327	***	
lnunemployment	<---	lnnoveh	.077	.023	3.356	***	
lnpoverty	<---	lnunemployment	1.838	.249	7.378	***	
lntransit1	<---	lncompact	.668	.107	6.261	***	
lncompact	<---	lntransit1	.877	.111	7.904	***	

All the path coefficient estimates in Table 2.9 are significant at the standard threshold of P < 0.05, except for female workforce proportion, which is significant at the P < 0.10 level. This variable persisted to the final model as it performed the best of a group of similar socioeconomic variables that were tested including race, age, household head, and housing tenure. Table 4 specifies that transit compactness negatively affects unemployment. The coefficient of -0.103 means that with an increase in compactness we can expect to see a decrease in regional unemployment. In addition, unemployment is positively related to poverty, with a very large elasticity of 1.838. This means that with a positive change in unemployment, we can expect to see an even larger positive change in poverty. In line with the findings of the inequality model, the unemployment and poverty model comports with the hypothesis that transit can act as a moderating factor on spatial mismatch. Although not affecting these outcomes directly, transit contributes to unemployment and poverty indirectly through its effect on compactness.

TABLE 2.10 Unemployment and Poverty Model Covariance Estimates

			Estimate	S.E.	C.R.	P	Label
pop000	<-->	lnnoveh	.132	.028	4.775	***	
pop000	<-->	lnedattnmnt	.060	.018	3.387	***	
lnedattnmnt	<-->	lnfmlwrkfc	.002	.001	2.536	.011	
lnnoveh	<-->	lnfmlwrkfc	.005	.001	4.439	***	
lnedattnmnt	<-->	lnlandarea	.050	.015	3.302	***	
lnnoveh	<-->	lnlandarea	.116	.024	4.896	***	
pop000	<-->	lnlandarea	.701	.096	7.335	***	
lnfmlwrkfc	<-->	lnlandarea	.004	.001	3.350	***	
e2	<-->	e1	-.044	.006	-7.117	***	
e4	<-->	e3	-.023	.005	-4.793	***	
e4	<-->	pop000	-.044	.013	-3.513	***	
e4	<-->	lnlandarea	-.039	.012	-3.242	.001	

All of the covariances above indicate statistically significant relationships that all agree with our theoretical expectations of the interactions of these variables. It is also heartening that the relationships observed in the poverty model are all quite similar to those observed in the inequality model.

TABLE 2.11 Poverty Model Direct, Indirect, and Total Effects

Direct Effects

	lnlandarea	lnfmlwrkfc	lnjobpop	lnedattnmnt	lnnoveh	pop000	lncompact	lntransit1	lnunemployment
lncompact	-.189	.000	.190	.000	.000	.000	.000	.877	.000
lntransit1	.000	-.261	.000	.118	.126	.149	.668	.000	.000
lnunemployment	.000	.000	-.385	-.397	.077	.000	-.103	.000	.000
lnpoverty	.000	.000	.000	.000	.000	.000	.000	.000	1.838

Indirect Effects

	lnlandarea	lnfmlwrkfc	lnjobpop	lnedattnmnt	lnnoveh	pop000	lncompact	lntransit1	lnunemployment
lncompact	-.268	-.553	.270	.250	.266	.315	1.417	1.242	.000
lntransit1	-.305	-.370	.308	.167	.178	.211	.947	1.417	.000
lnunemployment	.047	.057	-.047	-.026	-.027	-.032	-.146	-.219	.000
lnpoverty	.087	.105	-.795	-.777	.092	-.060	-.458	-.402	.000

Total Effects

	lnlandarea	lnfmlwrkfc	lnjobpop	lnedattnmnt	lnnoveh	pop000	lncompact	lntransit1	lnunemployment
lncompact	-.457	-.553	.460	.250	.266	.315	1.417	2.119	.000
lntransit1	-.305	-.631	.308	.285	.304	.359	1.615	1.417	.000
lnunemployment	.047	.057	-.432	-.422	.050	-.032	-.249	-.219	.000
lnpoverty	.087	.105	-.795	-.777	.092	-.060	-.458	-.402	1.838

We see that land area has a positive total effect on unemployment and poverty, mediated through its effects on transit and compactness. Similarly, female workforce proportion contributes to an increase in unemployment and poverty through its relationship with transit and compactness. The remaining relationships can be interpreted in the same manner. Below, Figures 2.5 and 2.6 depict the total effects of the explanatory variables on the outcome variables.

FIGURE 2.5 Total Effects on Unemployment

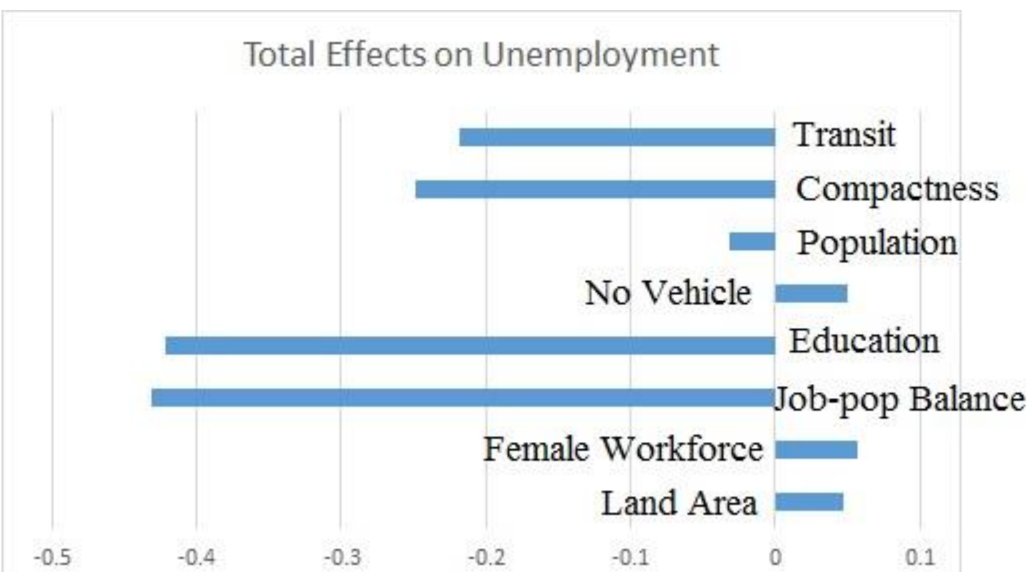
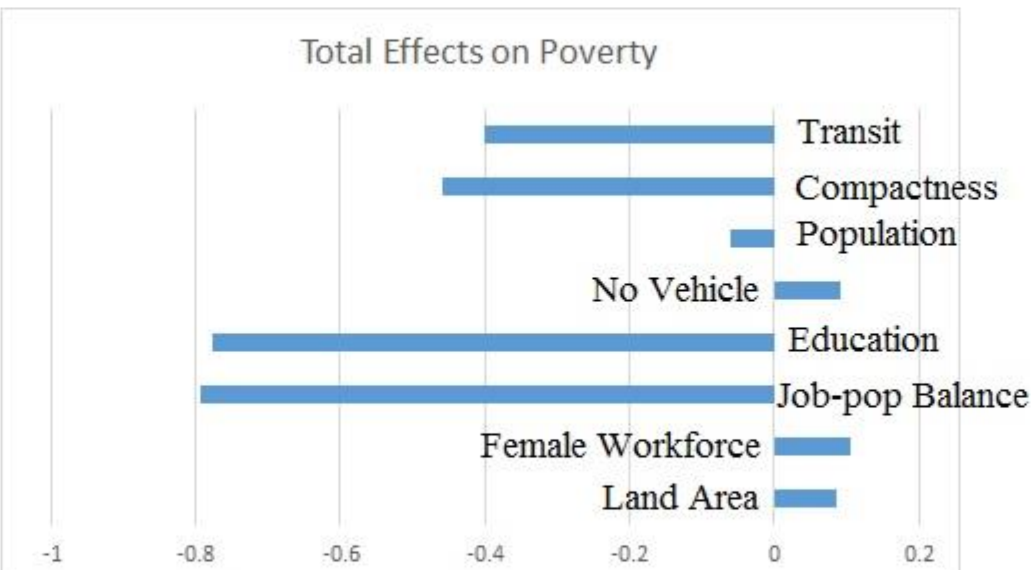


Figure 2.5 highlights that compactness has a slightly larger total effect on unemployment than poverty, both with elasticities just slightly larger than -0.2. However, we should note that education and job-population balance demonstrate much larger elasticities than those of transit and compactness. With an outcome variable of unemployment, it would follow that education is highly impactful on unemployment. However, the finding that job-population balance is very influential on unemployment is remarkable. While many have shown that an ideal job-population balance can lead to different transportation outcomes as well as income matching (Cervero, 1989; Zhao, Lu, & Roo, 2011; Stoker & Ewing, 2014), the connection between this variable and regional unemployment has yet to be made. We find that job-population balance is a strong determinant of regional unemployment, with an elasticity of -0.432.

FIGURE 2.6 Total Effects on Poverty



The total effects of the explanatory variables on poverty are similar in their effects relative to each other; however, the effects are magnified as compared to what we observe with unemployment. This magnification of total effects is due to the highly elastic relationship between unemployment and poverty.

CONCLUSION

The results of this study support the theory that transit can act as a moderator on the relationship between spatial mismatch and unemployment and poverty. Our models indicate that transit, measured as a factor of many indicators of transit service provision, has a negative indirect effect on unemployment and poverty through its effect on compactness. Relatively large elasticities of transit on unemployment and poverty suggest that supporting transit service can act as an effective lever on regional economies. Our models also demonstrate that transit can directly affect income inequality, although to a lesser degree than its total effects on unemployment and poverty. Again, these findings are similar to what we would expect, and support the theory that transit moderates the problem of spatial mismatch. Finally, we find that jobs-housing balance is highly influential on regional unemployment and poverty, even more so than transit and compactness.

The finding that transit limits regional unemployment and poverty is the most significant contribution of this study. The fact that a robust transit system can affect regional economic outcomes is notable because it offers a new possible lever for policy makers. Policies aimed at lifting economies and limiting the effects of economic hardship are numerous, wide-ranging, and often esoteric. However, this study give credence to the long-held but mostly unproven theory that transportation spending, specifically spending on transit systems, can help to boost regional economies. The empirical connection established in this paper between transit service and regional economies strengthens the case for policy makers to support spending on transit with the purpose of improving economic opportunities can use reductions in unemployment and poverty.

When we model transit's effect on unemployment directly, we see models with poorer fit, and a non-significant relationship between transit and unemployment. This indicates that it is unlikely that transit affects unemployment directly, or if it does, its effects are not measureable at the regional level. In a conversation with an academic leader in transit and equity, he suggested that our models would not be able to detect a relationship between transit and unemployment because the majority of transit systems in the US are too small to be able to observe common variation between transit and economic outcomes. The lack of a direct effect of transit on unemployment vindicates this assertion, but only to some degree. We find that even if the direct variation between the two variables is too small to detect or non-existent, an indirect effect of transit on unemployment is, in fact, measurable and noteworthy.

Another important result of our models is the discovery that while transit affects unemployment and poverty only indirectly through compactness, it affects income inequality directly. Similar to what we describe above, when we model the effect of transit on income inequality indirectly through compactness, as it is done in the unemployment and poverty model, we observe poorer model fit and an insignificant relationship with the incorrect sign. However, when the relationship of transit on income inequality is modeled directly, the model fit improves. The direct effect of transit on income inequality is small, with an elasticity of only -0.07, however, when the indirect effect is included, the total effect is -0.16. This is still a relatively small elasticity, but it is not trivial. Transit's elasticity of -0.16 with respect to income inequality indicates that as transit service increases, we can expect to see a small reduction in regional income inequality.

This paper also suggests that land use planning can have an effect on regional economic outcomes. Job-population balance has been associated with transportation behavior and income matching in the past, but it has yet to be tied to unemployment and poverty. We find that job-population balance is highly influential on these outcomes. This advances the notion that successful land use planning in which a proper balance of jobs and population is achieved can have an impact on unemployment and poverty. This suggests that planners can have lasting effects on economic development. Additionally, we also see further evidence for the theory of spatial mismatch. A proper balance of jobs and population would create more opportunities for jobs to be located near the residences of workers, and the results of our models support this theory.

LIMITATIONS

This paper represents a major step forward in empirically understanding the theory of transit service's effects on spatial mismatch. Using data from a national sample of the largest US cities helps us to understand how quality transit relates to regional economic outcomes. However, we must briefly discuss how the study design limits how we can interpret the results. The cross-sectional nature of the dataset offers a degree of generalizability of the results, but it also limits our ability to attribute causality to the relationships we modeled. An assumption of inferential association in cross-sectional study design is that the difference observed between observations is random. This means that the difference in attributes associated with a specific location are related to the that locations attributes alone, and not associated with its location itself. Geography is inextricably linked to urban phenomenon, and as such, there are limitations to cross-sectional study designs in this field.

An additional limitation to our study is the inherent issue of ecological fallacy associated with explaining phenomena that are experienced at the individual or household level but measured at an aggregated level. We can say that regions with higher quality transit and more compactness are likely to experience lower unemployment and poverty rates, but not that a certain level of transit provision will provide the requisite level of economic opportunity for a specific household or individual. Finally, there is the unavoidable issue of endogeneity associated with modeling complex relationships using interrelated variables. We have constructed our models in a way that is theoretically justifiable, but one could certainly make arguments against whether any of the variables said to be exogenous in our models are, in fact so. Structural equation modeling requires the organization of variables in this fashion, and we also believe that our models represent relationships that are structured in a logical and theoretically defensible way.

REFERENCES

Achia, T., Wangombe, A., and Khadioli N. (2010). A Logistic Regression Model to Identify Key Determinants of Poverty Using Demographic and Health Survey Data, European Journal of Social Sciences,13 (1) 38-45

Badinger, H., & Url, T. (2002). Determinants of regional unemployment: some evidence from Austria. Regional studies, 36(9), 977-988.

Bakija, J., Cole, A., & Heim, B. T. (2012). Jobs and income growth of top earners and the causes of changing income inequality: Evidence from US tax return data. *Unpublished manuscript, Williams College*.

Berechman, J., Ozmen, D., & Ozbay, K. (2006). Empirical analysis of transportation investment and economic development at state, county and municipality levels. *Transportation*, *33*(6), 537-551.

Blanden, J. (2013). Cross‐country rankings in intergenerational mobility: a comparison of approaches from economics and sociology. *Journal of Economic Surveys*, *27*(1), 38-73.

Bratberg, E., Davis, J., Mazumder, B., Nybom, M., Schnitzlein, D. D., & Vaage, K. (2017). A Comparison of Intergenerational Mobility Curves in Germany, Norway, Sweden, and the US. *The Scandinavian Journal of Economics*, *119*(1), 72-101.

Cervero, R., & Duncan, M. (2006). 'Which Reduces Vehicle Travel More: Jobs-Housing Balance or Retail-Housing Mixing?. *Journal of the American planning association*, *72*(4), 475-490.

Cervero, R. (1989). Jobs-housing balancing and regional mobility. *Journal of the American Planning Association*, *55*(2), 136-150.

Cervero, R., Sandoval, O., & Landis, J. (2002). Transportation as a stimulus of welfare-to-work: Private versus public mobility. *Journal of Planning Education and Research*, *22*(1), 50-63.

Chetty, R., Hendren, N., Kline, P., & Saez, E. (2014). Where is the land of opportunity? The geography of intergenerational mobility in the United States. *The Quarterly Journal of Economics*, *129*(4), 1553-1623.

Corak, M. (2013). Income inequality, equality of opportunity, and intergenerational mobility.

The Journal of Economic Perspectives, *27*(3), 79-102.

Cingano, F. (2014). Trends in income inequality and its impact on economic growth.

Dabla-Norris, M. E., Kochhar, M. K., Suphaphiphat, M. N., Ricka, M. F., & Tsounta, E. (2015). *Causes and consequences of income inequality: a global perspective*. International Monetary Fund.

Ellwood, D. T. (1986). The spatial mismatch hypothesis: Are there teen-age jobs missing in the ghetto? In R. B. Freeman & H. J. Holzer (Eds.), The black youth employment crisis (pp. 147– 190). Chicago: University of Chicago Press.

Ewing, R., Hamidi, S., Grace, J. B., & Wei, Y. D. (2016). Does urban sprawl hold down upward mobility?. *Landscape and Urban Planning*, *148*, 80-88.

Ewing, R., Meakins, G., Hamidi, S., & Nelson, A. C. (2014). Relationship between urban sprawl and physical activity, obesity, and morbidity–update and refinement. *Health & place*, *26*, 118-126.

Ewing, R., Hamidi, S., Tian, G., Proffitt, D., Tonin, S., & Fregolent, L. (2018). Testing Newman and Kenworthy’s theory of density and automobile dependence. *Journal of Planning Education and Research*, *38*(2), 167-182.

Filiztekin, A. (2009). Regional unemployment in Turkey. Papers in regional science, 88(4), 863-878.

Förster, M. F., & Pellizzari, M. (2000). Trends and driving factors in income distribution and poverty in the OECD area.

Harper, C., Marcus, R., & Moore, K. (2003). Enduring poverty and the conditions of childhood: lifecourse and intergenerational poverty transmissions. *World development*, *31*(3), 535-554.

Horrell, S., Humphries, J., & Voth, H. J. (2001). Destined for deprivation: Human capital formation and intergenerational poverty in nineteenth-century England. *Explorations in Economic History*, *38*(3), 339-365.

Ihlanfeldt, K. R. (1993). Intra-urban job accessibility and Hispanic youth employment rates. *Journal of Urban Economics*, *33*(2), 254-271.

Kain, J. H., & Persky, J. J. (1969). Alternatives to the gilded ghetto. *The Public Interest*, (14), 74.

Kain, J. F., & Meyer, J. R. (1970). Transportation and poverty. *The Public Interest*, *18*, 75.

Kaplan, G. A., Pamuk, E. R., Lynch, J. W., Cohen, R. D., & Balfour, J. L. (1996). Inequality in income and mortality in the United States: analysis of mortality and potential pathways. *Bmj*, *312*(7037), 999-1003.

Kasarda, J. D. (1983). Entry-level jobs, mobility, and urban minority unemployment. *Urban Affairs Quarterly*, *19*(1), 21-40.

Kuznets, S. (1955). Economic growth and income inequality. *The American economic review*, 1-28.

Landersø, R., & Heckman, J. J. (2017). The scandinavian fantasy: The sources of intergenerational mobility in denmark and the us. *The Scandinavian Journal of Economics*, *119*(1), 178-230.

Moller, S., Huber, E., Stephens, J. D., Bradley, D., & Nielsen, F. (2003). Determinants of relative poverty in advanced capitalist democracies. American sociological review, 22-51.

Moore, K. (2005). Thinking about youth poverty through the lenses of chronic poverty, life-course poverty and intergenerational poverty.

Piachaud, D. (2002). Capital and the determinants of poverty and social exclusion.

Reed, D. (1999). *California's rising income inequality: Causes and concerns*. San Francisco: Public Policy Institute of California.

Rupasingha, A., & Goetz, S. J. (2007). Social and political forces as determinants of poverty: A spatial analysis. The Journal of Socio-Economics, 36(4), 650-671.

Sanchez, T. W. (1999). The connection between public transit and employment: the cases of Portland and Atlanta. *Journal of the American Planning Association*, *65*(3), 284-296.

Sanchez, T. W. (2008). Poverty, policy, and public transportation. *Transportation Research Part A: Policy and Practice*, *42*(5), 833-841.

Stoker, P., & Ewing, R. (2014). Job–worker balance and income match in the United States. *Housing Policy Debate*, *24*(2), 485-497.

Tian, G., Ewing, R., White, A., Hamidi, S., Walters, J., Goates, J. P., & Joyce, A. (2015). Traffic generated by mixed-use developments: Thirteen-region study using consistent measures of built environment. *Transportation Research Record: Journal of the Transportation Research Board*, (2500), 116-124.

Weitz, J. (2003). Jobs-Housing Balance'Planning Advisory Service Reports. *Chicago, IL:*

American Planning Association, Planning Advisory Service.

Wolf, J. P. (2007). Sociological theories of poverty in urban America. *Journal of Human Behavior in the Social Environment*, *16*(1-2), 41-56.

Zenou, Y. (2000). Urban unemployment, agglomeration and transportation policies. *Journal of Public Economics*, *77*(1), 97-133.

Zhao, P., Lü, B., & De Roo, G. (2011). Impact of the jobs-housing balance on urban commuting in Beijing in the transformation era. *Journal of transport geography*, *19*(1), 59-69.

CHAPTER 3:
TRANSIT ECONOMIC EQUITY INDEX: DEVELOPING A COMPREHENSIVE MEASURE OF TRANSIT SERVICE EQUITY

ABSTRACT:

In this study we develop an index that we call the Transit Economic Equity Index to quantitatively assess transit service equity. The index measures convenience of travel for advantaged and disadvantaged work trips based on travel speed using a multimodal network that includes transit lines, stop locations, transit schedules, and pedestrian connections via the street network. Non-peak hour service is compared with peak-hour service to determine the degree to which operating resources are concentrated in times that might have greater benefits to advantaged populations. Finally, we compare accessibility to the transit system in terms of the number of transit stops in neighborhoods and employment centers and compare these figures between advantaged and disadvantaged locations. The scores for these three components are combined to create a single measure of transit economic equity. We define disadvantage using criteria established in Title VI of the Civil Rights Act of 1964. We have constructed the index in a way that balances a robust and meaningful measure of transit equity with the ability to be replicated relatively easily so that transit agencies can reasonably use this metric to assess the equity of their systems as well as how potential service changes affect equity.

INTRODUCTION:

Transit agencies and other public institutions use performance measures to assess their ability to successfully provide services and achieve their goals and objectives. The most common performance measurement of transit agencies is transit ridership. This measure is of the utmost importance to transit agencies as it is an effective proxy for the ability of a transit system to provide mobility and access to opportunities for travelers not using private vehicles. However, with the supremacy of this measure comes the potential to make decisions that are favorable in terms of their effects on ridership, but possibly not beneficial in terms of equity. While equity and ridership are not necessarily competing goals, measuring just one of these performance measures demonstrates a priority that may not accurately reflect the goals and objectives of a transit agency. Measuring equity as well as ridership will help transit agencies to make better decisions that find a balance of these two goals.

Transit agencies are required to analyze the effects of service changes on equity through Title VI of the Civil Rights Act of 1964. Changes in service that are found to have a disparate impact on disadvantaged populations, defined by race and income, are determined to be inequitable. This analysis is required of agencies serving populations greater than 200,000 receiving federal transportation funds. The spirit of the regulation is to ensure that federal transportation spending is not being unfairly allocated to already advantaged groups.

Researchers have indicated that the method prescribed by Title VI is inadequate (Karner, 2018). Many studies have proposed methods that analyze transit accessibility and create synthesized measures of transit accessibility to opportunities such as employment (Welsh & Mishra, 2013; Mamun et al., 2013; Foth et al., 2013; Manaugh & El-Geneidy, 2010; Karner, 2018). These methods offer more robust measures of transit equity than can be accomplished with the Title VI service change equity analysis, but there continues to be a need for a comprehensive methodology that is also accessible to transit planners.

While most previous efforts have applied their analyses to single North American regions, we have applied our Transit Economic Equity Index (TEEI) to six US regions. We use an expert panel to validate our methods and have created an index that we believe to be compendious, measuring temporal and spatial allocation of service as well as system accessibility at origins and destinations. Our TEEI uses public data to compare the convenience of transit service connections from advantaged and disadvantaged neighborhoods to their respective employment centers in terms of travel speeds, non-peak hour service, and number of stops per population and employment. A three factor index rates transit systems in terms of their equity, with a score of one representing a system that serves advantaged and disadvantaged populations equally, greater than one representing a system that serves disadvantaged populations better than their advantaged counterparts, and less than one representing a system that serves advantaged populations best. We believe that this simple metric can help transit agencies to evaluate the equity of their systems in their current form, as well as to assess how changes to service will impact the equity of their system. The intention of the index is to provide an accessible tool for measuring economic equity in transit service so that transit agencies can find an appropriate balance in achieving their goals of both ridership and equity.

LITERATURE REVIEW:

Hundreds of billions of dollars are spent annually in the US on transportation capital projects, maintenance, safety monitoring, subsidies, and countless other transportation-related expenditures (Dittmar, 1995; Puentes & Prince, 2005; Cohen et al., 2012). The majority of this spending, however, is focused on automobile infrastructure. The most obvious issue is that of the environmental impacts of the resource consumptive and highly polluting model of personal vehicle travel. Allocating public funds primarily on automobile infrastructure can be problematic, specifically related to the environmental concerns, public health, and social equity (Freund & Martin, 1996; Pucher & Dijkstra, 2003; Sanchez & Wolf, 2005). Researchers have studied the benefits and tax burdens of transit subsidies among income classes, finding that such subsidies have not been effective at transferring benefits to the most disadvantaged travelers (Pucher & Hirschman, 1981; Sanchez et al., 2003).

Although subsidy and infrastructure investment make driving artificially cheap in the US, it still can be beyond the means of the poorest and most disadvantaged populations (Hanson, 1992). The close relationship between transportation and the built environment means that living within the context of an auto-oriented urban fabric makes living without a car very challenging. Poor individuals have the same necessity for travel as everyone else but may not be able to achieve the same levels of accessibility without access to a vehicle (Lei et al., 2012; Grengs, 2010; Handy & Niemeier, 1997; Sanchez et al., 2004). Boschmann & Kwan (2008) define the social component of conventional sustainability as “The *social* concern for eradicating widespread poverty and hunger, meeting basic human needs, and addressing the growing social and economic disparities." Transportation, particularly public transit, has the occasion to address many of these concerns by affording economic opportunity to those short on it with increased accessibility to jobs.

Transit agencies are charged with efficiently providing accessibility for riders and doing so with limited resources. Ridership is the most common way that agencies and regulators determine their effectiveness in achieving this goal. However, focusing solely on ridership can be problematic if service resources are concentrated on choice riders (Karner, 2018). Researchers have identified two categories of transit riders with distinct needs and characteristics. Choice riders are those with access to an automobile that choose high-quality transit options for convenience or other reasons (Garrett & Taylor, 1999; Grengs, 2002; Taylor & Morris, 2015). Transit-dependent riders, on the other hand, are often lower income than choice riders and do not have access to an automobile, demanding that they use transit or other modes for their daily travel needs. Recent research has claimed that increased attention to choice riders at the expense of transit-dependent riders creates a situation where transit equity might be overlooked (Grengs, 2005; Karner, 2018).

The standard process for measuring transit equity in the US is prescribed by Title VI of the 1964 Civil Rights Act. Title VI requires that transit agencies of a certain size measure the impacts of major service changes to assess whether they have a disparate impact on disadvantaged populations (Utah Transit Authority, 2016). Title VI defines disadvantaged populations as people of color and low income individuals. Impacts of service changes are considered when routes are eliminated, headways are substantially reduced, or fare prices are changed. The Title VI equity analysis requires that transit agencies measure the demographic makeup of populations at a distance from the eliminated or changed line. This socioeconomic makeup is compared against the region-wide average, and if the population is significantly more disadvantaged than the average, this change is considered to have a disparate, inequitable impact. Unjustified changes having inequitable impacts can jeopardize an agency's ability to qualify for federal funds, which often constitute a large proportion of their budget (Parry & Small, 2009).

It is laudable for the Federal Transit Administration (FTA) to require that federal money be allocated in a manner that does not discriminate on the basis of race, national origin, or income. However, the above method of analysis seems to fall short of adequately measuring the equity of a system by simply measuring the shares of population near service changes. While residents living close to transit services are more likely to use those services, this analysis does not capture the actual utility of these services for nearby residents. Researchers have attempted to create more robust measures of transit equity, and this subfield has grown in recent years.

Much of the work on transit equity has focused on gaps between the need or likelihood to use transit of certain populations and the actual services available (Debolsc & Currie, 2011; Manaugh & El-Geneidy, 2010; Foth et al., 2013; Mamun et al., 2013). Welsh & Mishra (2013) propose a methodology for measuring transit equity using frequency, speed, capacity, and the built environment. This study utilizes a comprehensive list of factors influencing transit equity, including frequency, speed, capacity, and the built environment. The best effort to date in establishing a meaningful measure of transit equity was recently completed by Karner (2018). Karner utilizes Google Transit Feed Specification (GTFS) data and an extension of ESRI software to determine travel times between origins and destinations. This method has informed our approach to determining transit equity.

Although the above studies represent significant advancements in academic understanding and measurement of transit equity, there are still barriers to broad implementation of their methods. Most studies have only examined a single North American region and require highly advanced techniques to execute. The method proposed in this paper seeks to find a balance between comprehensively measuring equity while also being accessible to transit planners with common spatial analysis skills. We believe that we demonstrate the replicability of our method by applying it to six US case studies of varying sizes.

METHODOLOGY:

The purpose of this study is to improve upon existing methodologies for measuring equity in transit service. We seek to develop a method that can be easily replicable, and therefore have the potential to be widely utilized. We use public data, straight-forward measures, and common geographic units of analysis in an attempt to make our index practical, comprehensive, and accessible. Current practice in transit equity analysis is to evaluate how major service changes affect equity by measuring how the demographics (race and income) of the population affected by the service change compare to system-wide averages. Beyond the incomplete and narrow focus of this estimation technique, another shortcoming is the fact that it does not attempt to address the equity of the system as a whole. Researchers have suggested ways to do this, mostly through gap analyses. However, our method allows transit agencies to also be able to measure how potential service changes could affect the equity of the system by comparing an objective and easy to interpret index score changes. Additionally, this index score creates a quantifiable measure of equity that can assess an agency's ability to provide economic opportunity to disadvantaged populations. Finally, this measure also allows for transit agencies, planners, and decision makers to compare equity among multiple different transit systems. We will highlight these applications of the Transit Economic Equity Index (TEEI) in more detail below.

EXPERT PANEL

The first step in the creation of the TEEI was to conduct an expert panel. We interviewed 16 experts in transit equity to ensure that we were creating an index that satisfied the goals of this method: an objective, comprehensive measure that is robust while still accessible to practicing transit planners. In order to guide and validate our method we spoke to leading academics on transit equity, transit service planners, metropolitan planning organizations, civil rights compliance officers, transit advocacy group representatives, and political leaders. We believe that this effort, consisting of over twelve hours of in-person and phone interviews, greatly strengthens the validity of the TEEI.

The initial conceived purpose of the expert panel was to help identify appropriate weighting of the TEEI components. However, early in the process, it became clear that the experts did not feel comfortable assigning weights to the components. Brian Taylor of UCLA, in fact, suggested that instead of prescriptively assigning weights, the paper should allow potential users of the index to assign weights themselves with understanding of the particular needs or constraints of their agencies. Subsequent to this repurposing, experts directed us in the way we operationalized constructs of transit equity, suggested which tools to use for our analysis, and clarified how transit agencies and regional planners use equity in their decision making. Instead of using the expert panel to assign weights, we instead used their knowledge to “ground truth” our index. Table 3.1 identifies experts, classifies their sector, and indicates their area of expertise.

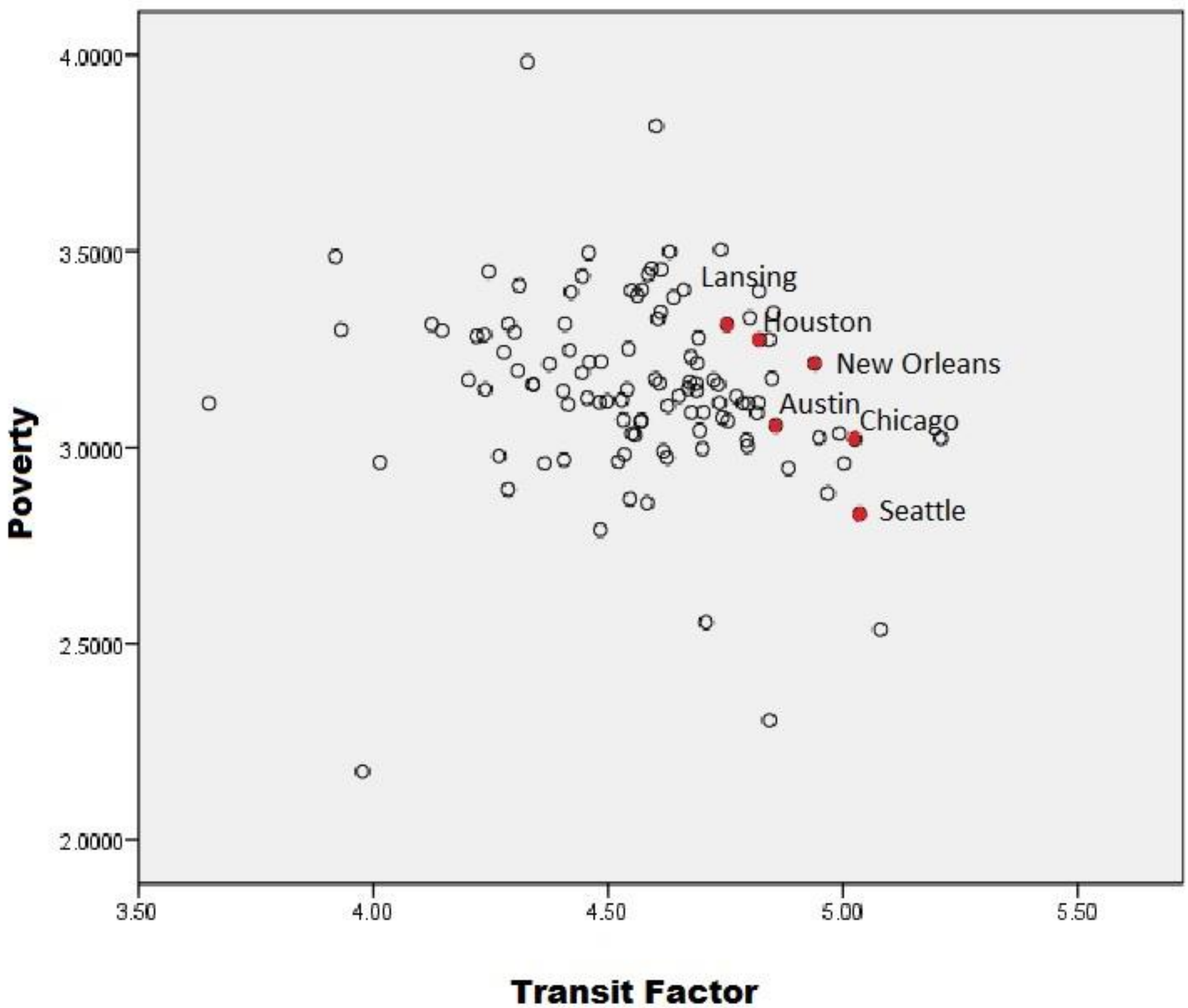
TABLE 3.1 Unemployment and Poverty Model Covariance Estimates

Expert	Sector	Institution	Area of Expertise
Brian Taylor	Academic	University of California Los Angeles	Public Transit
Roger Borgenicht	Advocacy	ASSIST Inc	Community Design
Ellen Reddick	Advocacy	Utah Transit Riders Union	Public Transit
Alex Karner	Academic	University of Texas Austin	Social Equity in Transit
Andrew Golub	Academic	Portland State University	Public Transit
Ted Knowlton	Government	Wasatch Front Regional Counsel	Regional Planning
Ali Oliver	Public Transit	Utah Transit Authority	Social Equity
Andrew Gray	Public Transit	Utah Transit Authority	Title VI
Focus Group Participants	Public Transit	Utah Transit Authority	Varying
Ralph Becker	Government	Salt Lake City Corporation (formerly)	Urban Planning, Government

SCOPE

This study examines six US case studies. The case studies were selected based on their position on a plot of transit quality and poverty. The transit variable that we used is the result of a principal component analysis which finds common variation among five measures of transit service and creates a single variable from that common variation. Generally, regions with higher transit quality demonstrate lower levels of poverty (Lyons, 2019). We select regions along the continuum, with regions demonstrating high quality transit and low poverty, regions demonstrating average levels of transit and poverty, and regions demonstrating low levels of transit and high levels of poverty. Figure 3.1 plots transit service and poverty, identifying the position of the six case studies on the plot. Table 3.1 describes additional characteristics of the six case studies. Table 3.2 shows the different transit modes available in each region’s transit system.

Figure 3.1 - Case Selection Based on Transit



The sample is clearly skewed to the right, meaning that the case studies represent areas with better than average transit service. Another factor in selecting our case studies was the availability of GTFS data. We found that smaller transit agencies with fewer staff and resources were less likely to maintain GTFS feeds. This is why the sample is skewed toward higher quality transit systems. However, the sample indicates less bias in terms of poverty.

Table 3.2 - Case Study Select Descriptive Statistics

Region	Agency Name	No Vehicle	Percent White	Population	Land Area	Unemployment 2010	Transit Factor	Poverty
Austin	Cap Metro	5.86	76.36	1254769	717	12.51	4.82	22.51
Chicago	CTA	12.56	64.43	8674561	3316	14.89	5.02	20.52
Houston	Metro	6.68	61.80	4796260	1798	15.57	4.84	26.44
Lansing	CATA	8.76	74.11	319016	209	15.25	4.75	27.46
New Orleans	NORTA	11.60	52.48	859842	286	17.10	4.80	27.96
Seattle	King County Metro	6.87	70.30	3062739	1084	13.07	5.04	16.97

Table 3.3 – Case Study Transit Modes Available

Region	Agency Name	Bus	BRT	Streetcar	Light Rail	Commuter Rail	Heavy Rail
Austin	Cap Metro	✓				✓	
Chicago	CTA	✓				✓	✓
Houston	Metro	✓	✓		✓		
Lansing	CATA	✓					
New Orleans	NORTA	✓		✓			
Seattle	King County Metro	✓		✓	✓	✓	

Table 2 shows that all regions have bus service while there is a great deal of variability in terms of the existence of other transit modes. Chicago is the only region with heavy rail transit, and Houston is the only with true bus rapid transit (BRT) in our sample.

UNIT OF ANALYSIS

We chose census block groups to represent neighborhoods. Census block groups are a very common unit of analysis for combining demographic, built environment, and transportation variables (Sanchez, 1999; Shiftan, Outwater & Zhou, 2008; Lachapelle et al., 2016). Some studies have used smaller geographies like transit station buffers (Karner, 2018). We have chosen to utilize a larger unit of analysis because we believe that this method will allow transit agencies to gain more meaningful conclusions from this equity analysis; highlighting neighborhoods that could benefit from better service as opposed to blocks or segments of buffers. For the purpose of conducting a network analysis, origins and destinations were reduced to centroid points of block groups. This is similar to the process used travel demand modeling where traffic analysis zones are represented by centroid points. This reduction of the complexity of trip origins and destinations, street network, and built environment is necessary for modeling complex travel patterns in a manner that can produce findings that are meaningful and actionable for transit agencies.

DATA

We assessed demographic data for block groups using publicly available American Community Survey (ACS) data accessed via the National Historic Geographic Information System (NHGIS) portal. These data provide estimates for median household income and race for block groups. We used Longitudinal Employer-Household Dynamics (LEHD) Workplace Area Characteristics (WAC) data to identify the location of high employment density block groups.

We utilized Open Mobility Data's portal for GTFS feeds. There are several different websites that provide these data. GTFS feeds are repositories for text files that can be maintained and uploaded by transit agencies to describe transit lines, stops, and schedules.

MEASURES

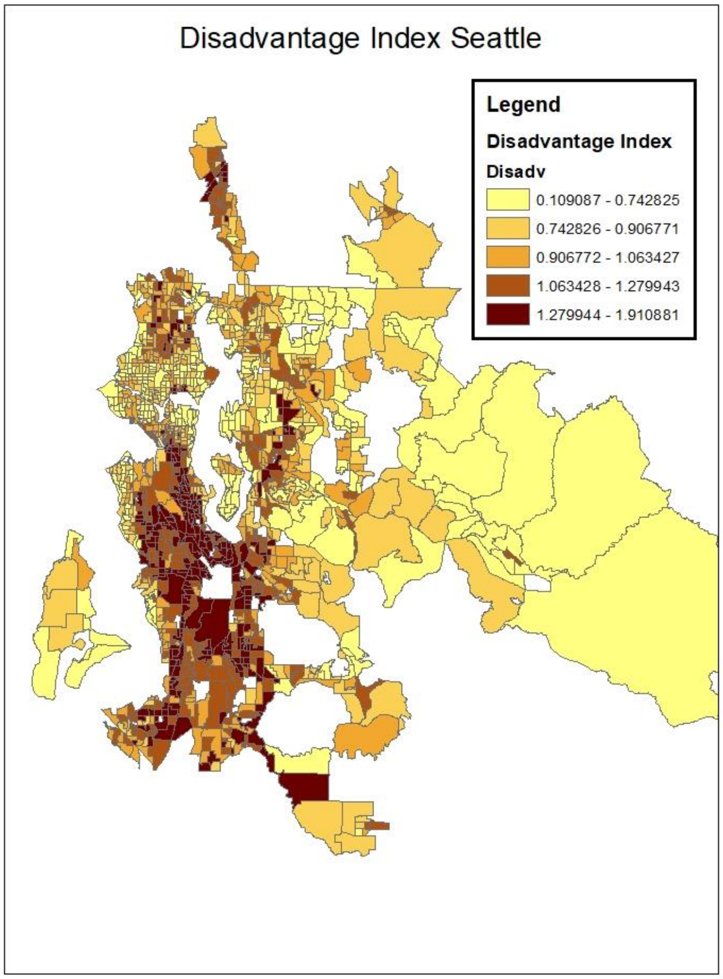
Disadvantage Index – We use race and income to place block groups on a scale of disadvantage. We measure these variables at the block group level. We measure race as the percent of the population that is white. Finally, we use median household income as our measure of income. In order to create a meaningful and normally distributed scale, we normalize race and income measures using minimum-maximum normalization. After normalizing race and income, we index these figures so that they can be aggregated to produce the disadvantage index. Block groups with low proportions of white residents and low household incomes score higher on the disadvantage index. The equation for calculating the disadvantage index of block group *x* is depicted below:

$$DI = \left(1 - \frac{Ix - \bar{I}}{\bar{I}}\right) + \left(1 - \frac{Rx - \bar{R}}{\bar{R}}\right)$$

where *DI* is disadvantage index; *Rx* is percent white of block group *x*; $\bar{R}$ is average percent white of all block groups in service area; *Ix* is median income of block group *x*; $\bar{I}$ is average median income of all block groups in service area.

Below, Figure 3.2 demonstrates the geographic distribution of block groups on the disadvantaged scale.

Figure 3.2 – Disadvantage Index Seattle



There are a few block groups without disadvantage index values. This is a result of either missing race or income data or due to the block group not being intersected by a transit line. We create a service area of block groups intersected by transit lines to allow for more streamlined data processing.

We only include measures of race and income for two reasons. First, we hope to make the analysis simple and straight-forward. The construct of "disadvantaged populations" is quite complex and multi-faceted. An index could be created that includes many indicators of disadvantage, but this would could quickly become unwieldy and cumbersome. As it is, the process of creating the index requires a significant portion of the time involved in executing our methodology. Second, Title VI uses race and income as its definition of discrimination. We believe that working within the framework of federal guidelines on transit equity helps to make our method more approachable for transit planners. The law has operationalized disadvantaged populations this way, and thus our methodology follows suit. Furthermore, other academic efforts to create improved methodologies for measuring equity in transportation have limited the dimensions of their measures of disadvantage similarly (Karner, 2018; Forkenbrock & Schweitzer 1999).

Employment – We establish block groups with high low-wage employment density as well as overall employment density. Density is measured by the number of jobs per block group. This is not a uniform measure, as each block group has a different area. However, as we stated earlier, block groups are our unit of analysis, and therefore a simple count of jobs is a sufficient proxy for employment activity within this framework.

NETWORK ANALYSIS

We use network analysis to calculate travel times and distances between origins and destinations.

Origin and Destination Selection – Disadvantaged origins are represented by centroids of block groups that are in the top quintile of our disadvantage index, a combination of normalized values of race and income. Advantaged origins are represented by centroids of block groups in the bottom quintile of our disadvantage index. Disadvantaged destinations are represented by centroids of the 20 block groups with the largest count of low-wage jobs. LEHD WAC data classify jobs in three categories: jobs with earnings $1,250/month or less; jobs with earnings $1,251/month to $3,333/month; and jobs with earnings greater than $3,333/month. We choose low-wage job hotspots as destinations for our disadvantaged population as these are the areas where this population is most likely to need to go for employment (Kain, 1992; Gobillon et al., 2007; Ihlanfeldt & Sjoquist, 1998). Advantaged destinations are represented by centroids of the 20 block groups with the largest counts of all jobs. We choose overall employment density to represent advantaged destinations based on the assumption that this population has a greater level of choice with respect to their employment opportunities.

Add GTFS to a Network Dataset –A recent development in Esri's Arcmap software allows users to utilize GTFS transit data to create a multi-modal network dataset for network analyses. An extension to Arcmap called "Add GTFS to a Network Dataset" reads GTFS text files to generate traversable polylines that represent transit lines and points that represent stops. Additionally, the extension allows schedule data to be incorporated into the analysis. This addition of a temporal element is crucial in evaluating travel time costs for origins and destinations. In a three step process the extension creates transit stops and lines, connects stops to the street network, and then creates network ID's for the stops that contain schedule information. The user finally creates a multimodal network dataset that can be used to create cost matrices for connecting origins and destinations.

Transit Service Convenience Score – The first component of our TEEI is the transit service convenience score. With this index we compare the convenience of traveling via the transit network from disadvantaged neighborhoods to their assigned employment destinations with that same trip for our advantaged population. We operationalize convenience in terms of speed. Speed is a measure of the amount of time it takes to make the multimodal trip divided by the trip distance. We include distance to account for the geographic distribution of wealth; we assume that neighborhoods are segregated by socioeconomic status. We create an origin-destination cost matrix for disadvantaged work trips at the 8 AM transit peak hour (Cervero, 2006) and compare the average speed of these trips against the average for advantaged work trips. The index score is calculated with the following equation:

$$TSCS = 1 - \frac{Sd - Sa}{Sd}$$

where *TSCS* is the transit service convenience score; S_d is disadvantaged travel speed; S_a is advantaged travel speed.

This equation will generate a figure of one if the two speeds are identical, greater than one if the disadvantaged speed is greater than the advantaged speed, and less than one if the advantaged speed is greater than the disadvantaged speed. We set the measure to where a value of one represents a system where transit service convenience is equal between advantaged and disadvantaged populations. This makes the index score easy to interpret: greater than one is equitable, less than one is inequitable.

Non-Peak Hour Service Score –The second component of the TEEI is the non-peak hour service score. The theory in measuring the proportion of service that is provided outside of the typical peak hour service based on the conventional 9:00-5:00 work schedule is that low-wage service jobs may not fall within that temporal framework. If transit service is favors traditional peak hours, at the expense of the non-peak hours, this can be considered an inequitable allocation of transit resources. We recognize, however, that allocating transit service during these times might make the most sense in terms of efficient use of resources; maximizing occupancy and producing a greater revenue return for operating costs.

To generate the non-peak hour service score we first run a network analysis of the multimodal network for each hour of the 24-hour day. Peak period is considered between 7:00 AM and 9:00 AM and between 4:00 PM and 6:00 PM (Karner, 2018). All other hours represent non-peak hour service. From the resulting O-D cost matrix for each hour we calculate the average travel time for disadvantaged work trips. The average travel times are then compared to generate the non-peak hour service score with the following equation:

$$NPSS = 1 - \frac{\bar{x} - \bar{y}}{\bar{y}}$$

where *NPSS* is non-peak hour service score; $\bar{x}$ is the average non-peak hour travel time; $\bar{y}$ is average peak hour travel time.

We calculate OD cost matrices for only disadvantaged work trips as, in theory, this is where the need exists for non-peak hour service. Another reason for only calculating this score for one of our two populations is that this is the most time consuming portion of the index calculation, as one is required to execute 24 separate network analyses. The time necessary to generate an OD cost matrix depends on the size of the region; the number of connections the network analysis is calculating is a function of the number of origins times the number of destinations.

System Access Score – Another way that we operationalize the convenience and distribution of transit service across the transit system is system accessibility. This is a simple measure of transit stops per population and jobs. We calculate four separate scores to compare system accessibility between our two populations. First, we measure origin accessibility for disadvantaged and advantaged block groups. To do this we spatially join transit stop points to our disadvantaged block group layer. This creates a count of stops for each block group, which is then divided by the population of that block group (population/1000) to generate a disadvantaged origin access score. This process is repeated to create an advantaged origin access score. We then create an origin access score similar to the processes above with the following equation:

$$OAS = 1 - \frac{OAa - OAd}{OAd}$$

where *OAS* is origin access score; *OAa* is advantaged origin access score; *OAd* is disadvantaged origin access score.

We replicate this procedure for destination access score with one distinction: stops are divided by number of jobs/1000 instead of population. Finally, we average the origin access score with the destination access score to get the final system access score. Again, a figure of one represents a system in which access to transit stops is equal between advantaged and disadvantaged populations, a figure greater than one expresses better access for disadvantaged populations, and less than one demonstrates better access for advantaged populations.

Transit Economic Equity Index –Finally, calculating the TEEI simply requires averaging the three index components.

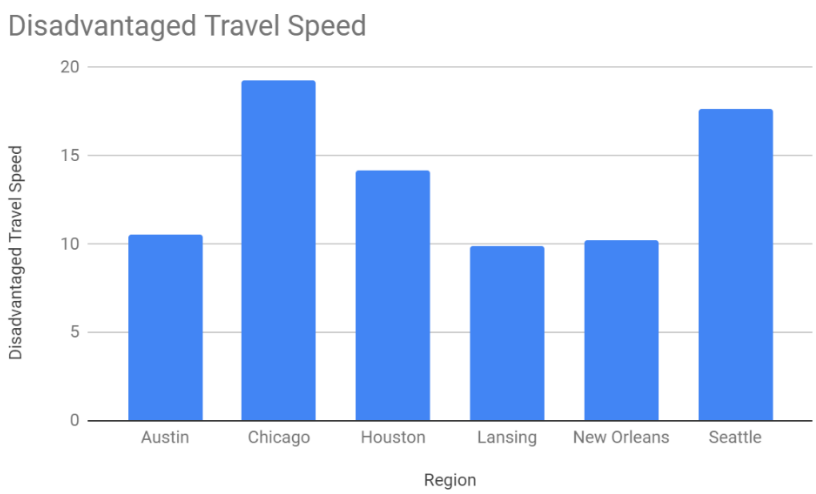
$$TEEI = average(TSCS, NPSS, SAS)$$

RESULTS:

TRANSIT SERVICE CONVENIENCE SCORE–

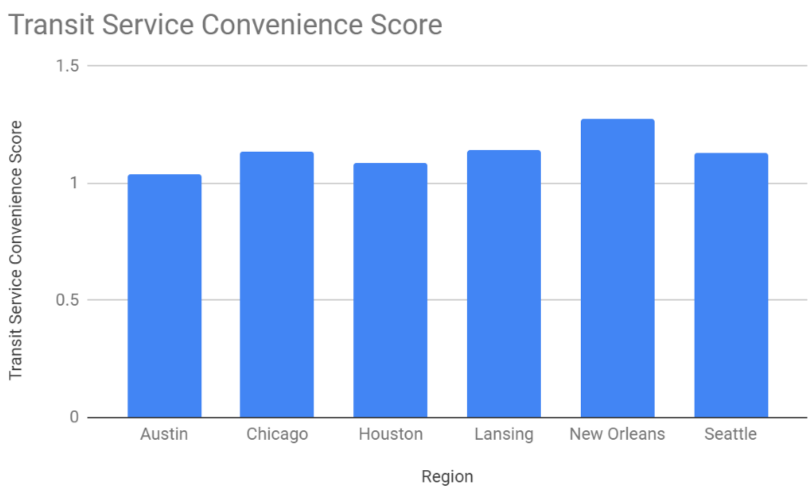
Our six case studies show variation in the 8 AM peak hour work trip travel speed. Figure 3.3 shows the average travel speed for disadvantaged work trips among the six regions.

Figure 3.3 – Average 8 AM Peak Disadvantaged Work Trip Travel Speeds



We see that Chicago and Seattle have significantly higher average travel speeds than the rest of the case studies. This can be attributed to the fact that these two regions have heavy rail components of their transit systems. Austin, Lansing, and New Orleans all have very similar travel speeds at around 10 Km/Hr. These regions rely mostly on bus service and are relatively small compared to the other three regions in terms of land area. Houston demonstrates an average travel speed higher than the bus-only regions, we assume, because their system has a light-rail component and trip distances are longer with greater space between stops. Below, Figure 3.4 shows transit service convenience scores for the six regions.

Figure 3.4 – Transit Service Convenience Score



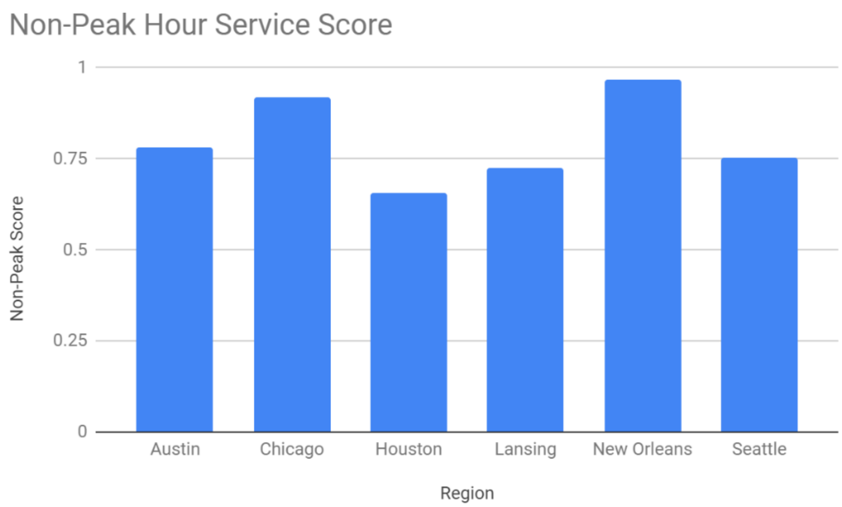
Here we see that every region produces transit service convenience scores that indicate equitable systems. This means that in terms of spatial and temporal distribution of transit service, such that it connects neighborhoods to employment centers, these systems do so in a way that is better for disadvantaged populations than advantaged populations. We believe that this component of the index is arguably the most important, as it expresses a measure of accessibility to jobs. This measure captures the allocation of service both in terms of frequency and coverage. It is heartening to see that all the regions in our sample are providing good access to employment for disadvantaged populations, at least when compared to their advantaged counterparts.

NON-PEAK HOUR SERVICE SCORE

An area in which all our sample regions struggled was non-peak hour service score.

Figure 3.5 shows this index component among the six regions.

Figure 3.5 – Non-Peak Hour Service Score

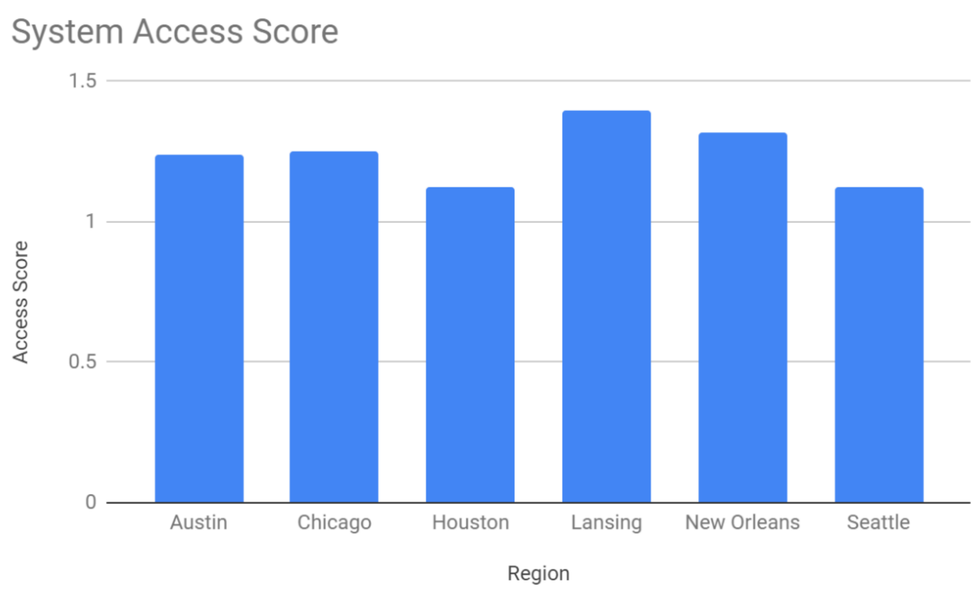


Here, we see that no transit agency is providing equity with respect to the temporal allocation of service. This means that transit service is concentrated in the peak times that coincide with the standard 9:00 to 5:00 work day. Although this is theoretically an inequitable distribution of resources, it also makes sense in terms of being prudent with those resources. If the peak hour times are those in which there is the most ridership, this would be when operating costs produce the greatest returns. Nonetheless, we find that all regions demonstrate inequity in this measure. Interestingly, New Orleans and Chicago receive scores that are close to one, meaning that the difference between the average travel times of non-peak and peak hour disadvantaged work trips is minimized in these regions.

SYSTEM ACCESS SCORE

The system access score is the component of the TEEI in which our sample regions perform the best. The average score for system access was 1.243. This means that transit agencies are providing more transit stops per population in disadvantaged neighborhoods and more stops per jobs in disadvantaged employment centers. Below, Figure 3.6 indicates system access scores for our six case study regions.

Figure 3.6 – System Access Scores



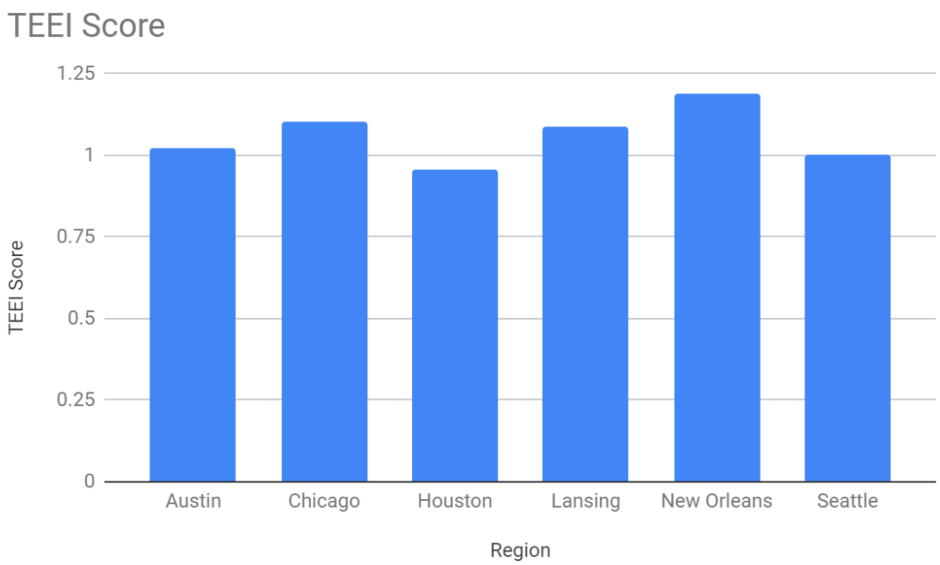
We see that all regions perform well with respect to system access. Interestingly, for the first time our smallest region, Lansing, demonstrates the best score compared to its peers.

A plausible explanation for the high scores in this component of the index might have to do with the nuanced difference between rail and bus service. Rail service is often considered a premium transit mode that is aimed at attracting choice riders. If this is the case, it would make the most sense to locate rail lines closer to more advantaged neighborhoods and connect to their respective employment centers to offer convenient transit service for choice riders. In such a scenario we would expect transit system access, in terms of the way this measure is constructed, to be lower for advantaged populations. If rail service is provided to advantaged neighborhoods (Grengs, 2002), and bus service is provided to disadvantaged neighborhoods, transit stop density would likely be higher in the disadvantaged neighborhoods. This is because rail vehicles typically travel faster than buses, and therefore stop less frequently. However, the only region without rail service scored the highest on the system access measure. That finding does not support the theory that rail service can lead to an inflated system access score that might mischaracterize equity. Additionally, if there are some ways that rail service might inflate a system's access score, the quality of that service being offered to advantaged populations would be captured in the transit service convenience score in the form of faster travel speeds for advantaged work trips.

TRANSIT ECONOMIC EQUITY INDEX

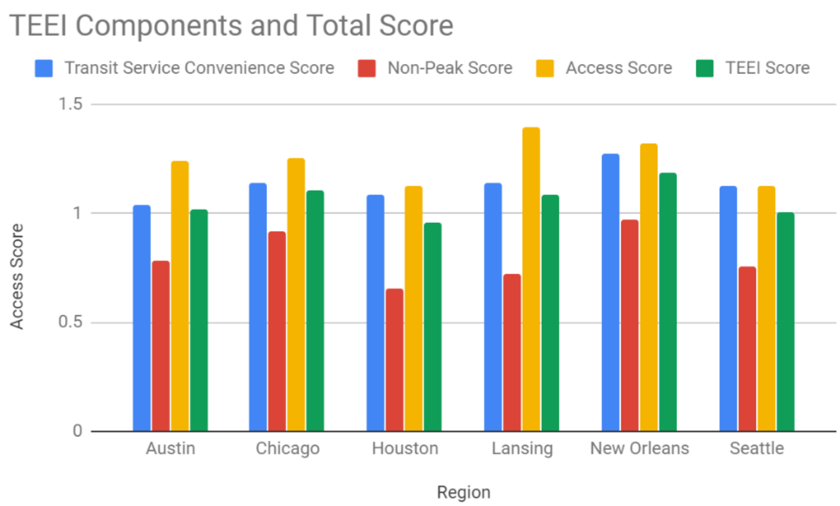
Generally, the findings with respect to the TEEI indicate that our sample regions are providing equitable transit systems. All but one of the regions score above 1 on the TEEI. Below, Figure 3.7 shows TEEI scores for all six regions.

Figure 3.7 – Transit Economic Equity Index Scores



We see that New Orleans scores the highest with 1.187, and Houston scores the lowest at 0.955. The finding that Houston scores below 1 is troublesome. This means that by our measure, Houston is actually serving advantaged populations better than they are serving disadvantaged populations with their transit system. Although it can be argued that two of the three index components showed equitable results for Houston, its exceedingly low value for non-peak hour service brought the total index score below 1. Below, Figure 3.8 shows all TEEI component and final index scores.

Figure 3.8 – All Index Component Scores



DISCUSSION

Our results suggest that almost all the transit agencies in our sample are providing equitable transit systems. Systems tended to rate highly on our transit service convenience score as well as our system access score. This means that all the transit systems in our sample are providing more convenient service for disadvantaged populations than advantaged populations in terms of travel speeds to employment centers and in terms of ease of access to the system. However, one measure consistently demonstrated that preference is being given to advantaged populations. This measure was our non-peak hour service score. We found that all agencies demonstrated preference for peak hour service, which we contend is a concentration of resources in a way that favors already advantaged populations. Although, when the three measures are combined to create an overall Transit Economic Equity Index score, we find that five out of six of our case study regions are providing equitable transit systems. The one exception to the this is Houston. Houston scored the lowest on the non-peak hour service score and was not able to recover from this deficit with its scores on the other two index components. This finding is troublesome for Houston Metro and warrants further investigation, especially considering that it is an outlier in its condition as inequitable, at least within the context of our sample.

This study has demonstrated the successful application of the new Transit Economic Equity Index (TEEI) to six US case studies. This method builds upon other efforts in the transit planning literature to enhance our understanding of equity in transit service. The prescribed analysis mandated by Title VI of the Civil Rights Act of 1964 has been widely criticized by academics as too narrowly focused and inadequately representative of the equity of transit systems as a whole. Title VI equity analysis focuses on demographics of populations within a given distance from affected routes. The purpose of the Title VI analysis is to determine if the route changes have disparate impacts on disadvantaged populations when compared to system-wide averages. While this method should be lauded for its effort in ensuring that federal funds are not allocated to agencies that are engaging in discriminatory practices, it clearly falls short of comprehensively measuring the overall equity of a system. Although other studies have attempted to fill this void by better assessing gaps in transit service with respect to need, and even by comparing accessibility offered to populations of different socioeconomic attributes, no study has been able to create a measure of system-wide transit equity that is both comprehensive and accessible. We believe that the TEEI is the best effort to date to achieve such a balance. We hope that the choices we have made to reduce complexity while maintaining the ability to accurately and objectively measure transit equity are effective in achieving this goal.

Another strength of the method that we propose in this paper is its versatility. The first application of the index, which is described above, is in assessing the equity of a system at a given point in time so that transit agencies can evaluate how well they are providing economic opportunity for disadvantaged populations. In addition, however, the index can also measure how changes in transit systems, both past changes and proposed future changes, affect the equity of the system. Applying this method to data from past, present, or future transit system configurations can help transit planners to evaluate how changes to their service affect equity. We have not applied the TEEI in this way to our case studies because the primary focus of this paper is to introduce the method and demonstrate its replicability. We are confident that future research that utilizes our method will be able to demonstrate this other useful application of the

TEEI.

The TEEI can also be used to measure other aspects of equity in transit. We have chosen to define disadvantaged populations in terms of race and income because this is the definition used by Title VI. We recognize, though, that disadvantage can be conceived of in a multitude of ways. Other considerations such as gender, age, disability, educational attainment, and other factors could be considered in a more multifaceted definition of disadvantaged populations. Refining the definition of disadvantage could help transit agencies to focus their efforts on an even more-broadly defined segment of the population that could potentially benefit from more convenient transit service. Also, we have decided to measure connections to employment opportunities in our focus on economic equity. Other necessities could be the focus of future research that utilizes this index or even a modification of the techniques described here. For example, it could be argued that employment is only a small part of the larger picture of opportunities necessary for economic mobility. Further research could use this method to connect disadvantaged populations to destinations such as educational institutions, arguing that it is educational opportunity that is truly impactful in helping to lift people from one socioeconomic segment to another. We contend that the applications of the techniques outlined in this paper are only limited by the questions to which they are applied.

LIMITATIONS

While there are many directions that future research can take the method described in this paper, we certainly recognize that there are also substantial limitations to the ways in which we have decided to measure and operationalize equity. First, as stated above, we have focused on a very narrow definition of disadvantaged populations. We define disadvantage in terms of race and income because this is the way that it is defined in federal law. However, this is certainly not an adequate definition, and there is no arguing that stopping at just two measures properly considers the complexity of factors contributing to structural inequality. We have limited our definition to work within the framework of existing laws, data, and constraints of transit agencies.

The decision to limit our destinations to just employment centers is also an intentional, but notable simplification of the construct of equity and connecting people to opportunities. Other crucial daily or essential services should, at some point, be considered in transit equity analyses as well. Connecting neighborhoods to places like healthcare facilities, educational institutions, public services, legal services, and other potentially influential elements of daily life could prove to be just as important in contributing to an equitable transit system as employment opportunities.

The choice to use relatively course spatial resolution is another potential limitation of this study. We use block groups to represent neighborhoods, assuming that demographic and socioeconomic factors remain relatively constant at this level of geography. The notion of ecological fallacy, however, reminds us that by using aggregate measures to model the behavior of individuals creates bias. This phenomenon is inescapable when modeling individual behavior with aggregate data. We believe that reducing the spatial scale would only prove to complicate the process, making the index less accessible and therefore less likely to be utilized by transit planners to facilitate service planning decisions based on a reasonable understanding of how those decisions will affect the equity of their system.

Another limitation of this study is evident in Figure 1, which was introduced early in the paper. The fact that all the regions in our sample score relatively high with respect to the transit variable in the plot is quite telling. GTFS feeds are not provided by all transit agencies, and our investigation suggests that larger transit agencies with more resources are more likely to provide GTFS data. Our method requires this data as it allows for an analysis that includes both the spatial distribution of routes as well as the temporal allocation of service resources in the form of headways. The ability to include schedule information in our network dataset creates a level of nuance to the network analysis that allows for more accurate estimates of the convenience of transit service. However, this level of detailed information is only provided, at least at this moment in time, by a certain subset of transit agencies. The fact that our sample showed that almost all transit agencies were providing equitable systems might not be generalizable across agencies of all sizes and resource levels. It might be that smaller transit agencies are less capable of providing equitable transit service. While theory on this question is limited, we also cannot know empirically, based on our method and the current lack of appropriate data for small transit agencies.

Finally, an interesting consideration that is important to understanding how this method can be applied to evaluating transit systems is that bad transit can still be found to be equitable by our measure. What we mean is that service that is poor for everyone, just not worse for the most disadvantaged, would still be equitable on the TEEI. It could be argued that poor transit service is not equitable even if it is serving the most disadvantaged as well or better than their advantaged counterparts. This argument is valid, but it misses the point of the research. Transit service planners work tirelessly to optimize their systems in a way that is most convenient, and thus most attractive to as many people as possible. A convenient system will be proven as such by returns in ridership. Transit practitioners and academics have been exploring methods for optimizing ridership and modeling the factors influencing ridership for decades, and that focus is part of the motivation for this research. We believe that by creating an objective measure of equity in transit, transit service planners can evaluate how potential service changes will affect the equity of their system and compare potential ridership gains against potential changes to equity.

REFERENCES

Boschmann, E. E., & Kwan, M. P. (2008). Toward socially sustainable urban transportation: Progress and potentials. *International Journal of Sustainable Transportation*, *2*(3), 138-157.

Cervero, R. (2006). Alternative approaches to modeling the travel-demand impacts of smart growth. *Journal of the American Planning Association*, *72*(3), 285-295.

Cervero, R. (2006). Office development, rail transit, and commuting choices. *Journal of Public Transportation*, *9*(5), 3.

Delbosc, A., & Currie, G. (2011). Exploring the relative influences of transport disadvantage and social exclusion on well-being. *Transport Policy*,*18*(4), 555-562.

Dittmar, H. (1995). A broader context for transportation planning: not just an end in itself. *Journal of the American Planning Association*, *61*(1), 7-13.

Foth, N., Manaugh, K., & El-Geneidy, A. M. (2013). Towards equitable transit: examining transit accessibility and social need in Toronto, Canada, 1996–2006. *Journal of transport geography*, *29*, 1-10.

Forkenbrock, D. J., & Schweitzer, L. A. (1999). Environmental justice in transportation planning. Journal of the American Planning Association, 65(1), 96-112.

Garrett, M., & Taylor, B. (1999). Reconsidering social equity in public transit. *Berkeley Planning Journal*, *13*(1).

Gobillon, L., Selod, H., & Zenou, Y. (2007). The mechanisms of spatial mismatch. *Urban studies*, *44*(12), 2401-2427.

Grengs, J. (2010). Job accessibility and the modal mismatch in Detroit. *Journal of Transport Geography*, *18*(1), 42-54.

Grengs, J. (2005). The abandoned social goals of public transit in the neoliberal city of the USA. *City*, *9*(1), 51-66.

Grengs, J. (2002). Community-based planning as a source of political change: The transit equity movement of Los Angeles' Bus Riders Union.*Journal of the American Planning Association*, *68*(2), 165-178.

Handy, S. L., & Niemeier, D. A. (1997). Measuring accessibility: an exploration of issues and alternatives. *Environment and planning A*, *29*(7), 1175-1194.

Hanson, M. E. (1992). Automobile subsidies and land use: estimates and policy responses. *Journal of the American Planning Association*, *58*(1), 60-71.

Ihlanfeldt, K. R., & Sjoquist, D. L. (1998). The spatial mismatch hypothesis: a review of recent studies and their implications for welfare reform. *Housing policy debate*, *9*(4), 849-892.

Kain, J. F. (1992). The spatial mismatch hypothesis: three decades later. *Housing policy debate*, *3*(2), 371-460.

Karner, A. (2018). Assessing public transit service equity using route-level accessibility measures and public data. *Journal of Transport Geography*, *67*, 24-32.

Lachapelle, U., Frank, L. D., Sallis, J. F., Saelens, B. E., & Conway, T. L. (2016). Active transportation by transit-dependent and choice riders and potential displacement of leisure physical activity. *Journal of planning education and research*, *36*(2), 225-238.

Lei, T. L., Chen, Y., & Goulias, K. G. (2012). Opportunity-based dynamic transit accessibility in Southern California: measurement, findings, and comparison with automobile accessibility. *Transportation Research Record*, *2276*(1), 26-37.

Lyons, T. (2019) The Effects of Transit and Compact Development on Unemployment and Poverty. Working paper.

Mamun, S. A., Lownes, N. E., Osleeb, J. P., & Bertolaccini, K. (2013). A method to define public transit opportunity space. *Journal of Transport Geography*, *28*, 144-154.

Manaugh, K., & El-Geneidy, A. (2012). Who benefits from new transportation infrastructure? Using accessibility measures to evaluate social equity in transit provision. *Accessibility and Transport Planning: Challenges for Europe and North America*, 1035-1053.

Parry, I. W., & Small, K. A. (2009). Should urban transit subsidies be reduced?. *American Economic Review*, *99*(3), 700-724.

Pucher, J., & Dijkstra, L. (2003). Promoting safe walking and cycling to improve public health: lessons from the Netherlands and Germany. *American journal of public health*, *93*(9), 1509-1516.

Pucher, J., & Hirschman, I. (1981). DISTRIBUTION OF THE TAX BURDEN OF TRANSIT SUBSIDIES IN THE UNITED-STATES. *Public Policy*, *29*(3), 341-367.

Puentes, R., & Prince, R. (2005). Fueling Transportation Finance. *Taking the high road: A metropolitan agenda for transportation reform*, 45-76.

Sanchez, T. W., Shen, Q., & Peng, Z. R. (2004). Transit mobility, jobs access and low-income labour participation in US metropolitan areas. *Urban Studies*, *41*(7), 1313-1331.

Sanchez, T. W. (1999). The connection between public transit and employment: the cases of Portland and Atlanta. *Journal of the American Planning Association*, *65*(3), 284-296.

Sanchez, T. W., & Wolf, J. F. (2005). Environmental justice and transportation equity: A review of metropolitan planning organizations. *Cambridge, MA: The Civil Rights Project at Harvard University*.

Sanchez, T. W., Stolz, R., & Ma, J. S. (2003). Moving to equity: Addressing inequitable effects of transportation policies on minorities.

Shiftan, Y., Outwater, M. L., & Zhou, Y. (2008). Transit market research using structural equation modeling and attitudinal market segmentation. *Transport Policy*, *15*(3), 186-195.

Taylor, B. D., & Morris, E. A. (2015). Public transportation objectives and rider demographics: are transit's priorities poor public policy?. *Transportation*, *42*(2), 347-367.

Utah Transit Authority, 2016. Title VI Program, Salt Lake City, UT. https://www.rideuta.com/-/media/Files/About-UTA/Title-Six/Title_VI_Program_2016_fffFull.ashx?la=en

Welch, T. F., & Mishra, S. (2013). A measure of equity for public transit connectivity. *Journal of Transport Geography*, *33*, 29-41.

CHAPTER 4:

BEYOND TITLE VI: HOW TRANSIT AGENCIES PLAN FOR EQUITY

ABSTRACT

Title VI of the Civil Rights Act of 1964 plays an important role in the way that transit agencies address equity. Much of the literature on the subject highlights the shortcoming of this framework for measuring transit equity. Most scholars focus on accessibility in transit, claiming that access to opportunity is lacking from the Title VI requirements. While this is certainly true, a singular focus on accessibility neglects many other elements of how transit agencies contribute to and plan for equity. Title VI requires many other practices that facilitate more equitable transit systems, and this framework is influential on the way that transit planners think about equity. In this study we interview transit planners from five different US case regions to determine how transit agencies plan for equity. We find that Title VI is an important and somewhat comprehensive paradigm for considering equity in transit. We discuss common and exemplary policies used by transit agencies to facilitate equity, and we hypothesize ways that academic study of equity in transit can better conform to the frameworks in which transit agencies operate.

INTRODUCTION

Transportation planning has a long and fraught history of creating social and environmental injustices. Disadvantaged populations often bear the burdens of transportation projects while being left without any of the benefits. Scholars have discussed the issue of varied levels of access to opportunity, and often suggest that accessibility is the best framework with which to consider equity in transportation. Transit planners, and even federal regulation, however, work within a broader framework of justice to assess how well transit agencies are facilitating equity through transit service.

With the work of Karner, Golub, Taylor, Martens, and other prominent scholars in transit equity, we are very aware of the shortcomings of Title VI with respect to measuring transit agencies' efficacy in promoting social equity. This study seeks to understand how transit planners think of equity in transportation. We interview transit planners to establish the ways that they plan for equity, determine what policies and programs are most effective in promoting equity, and identify barriers to the implementation of equitable transit systems. This study synthesizes political theory of justice in transportation, academic efforts to improve upon how we think of and measure equity in transit, and practice in planning for equity. We work to rectify these somewhat divergent arenas and propose ways that academic effort can be more reflective of the needs of transit agencies and practicing planners.

WHY DO WE PROVIDE PUBLIC TRANSPORTATION?

Economists, engineers, and planners are just part of a broad group of scholars that have considered the most efficient and just distribution of transportation services across society. Transportation spending is considered by most economists, and even by politicians from a wide spectrum of ideologies, to be a prudent use of tax revenue (Winston, 1991). However, the way in which those funds are spent is less unanimously agreed upon. Roadways have proliferated to an unfathomable extent in the modern era (Weiner, 2016; Engel et al., 2006). While the use of automobiles can be considered a private (somewhat) market-based system of allocating transportation goods, another model for the provision of transportation services is public transit. Public transit can be considered a government intervention in the distribution of transportation goods. There are many debates as to the level or amount to which the public model of transportation service provision should be funded, but generally, the fact that public transportation should be provided at all is seldom questioned. This notion that government intervention is warranted for the just distribution of transportation goods requires further investigation.

Walzer (1983) defines a construct he calls “distributive spheres” through which society determines meaning, value, and distribution of goods. The value of each good is based on societal norms and expectations, and the way that these goods are distributed is determined by this value. However, some goods are valued in a way that is problematic and can influence other distributive spheres, i.e. money and power. Walzer claims that when distributive spheres are not autonomous, injustice occurs. Goods that are influenced by the distributive sphere of another superior good, thus, must be removed from the market and distributed equally or in a way that ensures the good’s autonomy (Trappenburg, 2000). This theoretical foundation for justifying redistribution of transportation resources through public transit was originally applied by Martens et al. (2012). They claim that "If the benefits of transportation can be defined as having a distinct social meaning, then a distributive approach, distinct from market exchange, to transport benefits can be justified."

The conceptualization of a free market with respect to transportation goods is fraught, however. First, free markets can be inefficient and unfair with the existence of market failures (Hausman & McPherson, 2006). Market transactions also insufficiently represent justice, as power imbalances limit consent and discretion (Sandel, 2010). Beyond the well-documented shortcomings of markets, to consider transportation goods as existing on a free market devoid of government intervention would be naive. If transportation is provided on a free market, then the market itself is almost entirely facilitated by government. Although private contractors are ultimately tasked with the construction of most road infrastructure, the funding for these projects comes from government agencies at many levels. Private toll roads are the exception to this paradigm, but they are uncommon in the US and play a miniscule role in the overall transportation system (Engel et al., 2006). The need for public expenditure to facilitate private transportation weakens the argument that funding public transit is a distinctly interventionist policy. However, if we concede that the provision of public transit needs justification beyond what is necessary in defense of the private vehicle system, more evidence must support the necessity for transit.

SOCIAL EQUITY AND ENVIRONMENTAL JUSTICE IN TRANSPORTATION

Pereira et al. (2017) synthesize political theory of justice to better place transportation within this construct. They identify four theories of justice from political philosophy relevant to transportation policy: Utilitarianism; Libertarianism; Institutionism; and Rawls' egalitarianism. Rawls' egalitarianism is a theory that starts with the primacy of freedom and individual choice; individuals should have as much freedom as possible without impinging on those of others. The second principle of Rawls' theory is that inequalities can be fair, but only so long as they arise from conditions of equality of opportunity and work to benefit disadvantaged members of society (Rawls, 1999; Rawls, 2001). Critics of this theory suggest that it does not account for the effects of innate abilities or personal preference (Kymlicka, 2002; Dworkin, 1981; Nussbaum, 2011; Sen, 2009).

Another effective framework for evaluating justice in transportation is the "capabilities approach". This framework was developed by Amartya Sen (1979; 2005; 2009) to supplement the deficiencies of Rawls' egalitarianism. Sen frames fairness in terms of capabilities, or in other words, as freedoms and opportunities from which individuals can choose. Elaborating on the applicability of Sen's capabilities approach to justice, Pereira et al. (2017) say "Although the Capability Approach (CA) is not intended to be a full theory of justice, human capabilities are at the heart of justice concerns, which essentially deal with the opportunities and substantive freedoms that enable individuals to achieve things they have reason to value."

These frameworks help us to view justice within the context of political theory, but it is also necessary to elucidate how transportation, specifically, relates to social equity and environmental justice. Schweitzer & Stephenson (2007) provide an excellent definition for environmental justice in urban planning: the pursuit of a just distribution of collective urban goods in a democratic society. Transportation, unfortunately, has a problematic history with respect to environmental justice in urban settings. Bullard & Johnson (2004) aptly describe this history as being disparate in terms of how some benefit from the fruits of transportation investment while others bear the costs of that same investment. In fact, one of the first lessons taught in any urban history course is the story of Robert Moses in New York City. Moses was an influential figure in New York in the early age of highway expansion. He proposed many grand highways to connect the economic centers of New York City to the affluent residential enclaves. However, in the process of connecting these places, Moses proposed the demolition of low-income neighborhoods that he saw as simply a surmountable barrier to his vision for an improved city. This plan was famously met with opposition from Jane Jacobs who advocated for the rights of the residents of these neighborhoods slated for demolition (Gratz, 2010). This conflict is an early example of how transportation projects can have positive impacts for some in terms of accessibility to opportunities while simultaneously having negative impacts for those with less political power (Whitt, 2014).

ISSUES OF INJUSTICE IN TRANSPORTATION

Beyond the infamous example of Robert Moses' grand, socially disastrous transportation projects in New York City, the pattern of compromising the well-being of disadvantaged populations for the sake of improved accessibility for more powerful suburban residents has been widely recognized by transportation scholars. Researchers have identified three areas of concern with respect to equity in transportation planning: process-based or participation; costs or burdens; and benefits (Marcantonio et al., 2017; Sweitzer & Valenzuela, 2004). Process-based claims are those that find that there was a lack of public involvement in the decision-making process. Marcantonio et al. suggest that both the level of participation by citizens in general, and also *who* participates should be considered. The authors report that progress has been made since the infancy of transportation planning when there were no requirements for public participation, and thus there was no effort to incorporate public feedback in practice. Procedural justice, it is argued by Schlosberg (2004), is an important component to planning processes that contribute to a just distribution of outcomes. Procedural justice, in this context, refers to access to process in such a manner that one's concerns can be heard. For transportation outcomes to be fair, citizens must have the opportunity to participate and comment on the process. In addition to broad inclusion in the decision-making process in general, it is also necessary that the right people be given the opportunity to participate. This is part of the distinction between "public involvement" and "meaningful involvement," according to Aimen and Morris (2012).

Cost or burden concerns in transportation justice refer to the ways in which investments in transportation projects affect disadvantaged populations. One manner in which the burdens of transportation improvements are carried by the poor is through the siting of infrastructure (Bullard & Johnson, 1997; Lee, 1997; Wright, 1997; Checker, 2011). In an urban setting, expansion of highways or road capacity projects often require the acquisition of right of ways and the exercise of eminent domain to make room (Freillich & Chin, 1986; Miceli & Sirmans, 2007). Often, the areas most affected by the need to make space are impoverished neighborhoods. Displacing poor residents for the sake of improved accessibility disproportionately applies the burdens of transportation infrastructure on disadvantaged populations. Another commonly cited claim of injustice in transportation burdens is the disproportionate exposure to environmental externalities associated with transportation infrastructure. Noise and pollution are externalities most often associated with transportation, and have been related to negative health outcomes like hypertension, heart disease, and asthma (Forkenbrock & Schweitzer, 1999; Clark & Stansfeld, 2007; Vienneau et al., 2015; Wright, 1997; Morello-Frosch et al., 2001; Gwynn & Thurston, 2001; Brainard et al., 2002).

Disproportionate benefits are also a concern in transportation justice. The primary benefit of transportation infrastructure is access to social and economic opportunity (Sweitzer & Valenzuela, 2004). Instances in which this access was prioritized for residents with greater political power are well documented. Grengs (2002) describes a case in Los Angeles where a proposed light rail expansion was met with fierce opposition, as its completion required the reduction of bus service that provided access for low-income and minority neighborhoods. Similar cases in New York and Philadelphia support the assertion that it is common for improvements to high-quality transit service for affluent transit riders to come at a cost to disadvantaged transit riders (Korb, 2011; Highsmith, 2009). Not only is the disproportionate benefit of transit service allocation an issue for justice in transportation, but the disparity in benefits from the automobile-oriented transportation system is also a major cause for alarm. Access to social and economic opportunity is relatively ubiquitous with a personal vehicle and endless roadways. However, there are economic barriers to this system, and those barriers have significant impacts on the freedom and quality of life for disadvantaged populations (Johnston, 1998; Pucher et al., 1998; Taylor and Ong, 1995; Wachs & Taylor, 1998; Sawicki & Moody, 2000).

TRANSPORTATION JUSTICE AND EQUITY IN PRACTICE

The legal framework for addressing environmental or social injustice in transportation originates from the Civil Rights Act of 1964. This landmark legislation prohibits discrimination based on race, color, religion, sex, or national origin. Title VI of the Civil Rights Acts stipulates that agencies receiving federal funds cannot be discriminatory in their actions or in their use of those funds. The definition of discrimination was broadened by Executive Order 12898 in 1994, extending protections to low-income Americans. Enforcement of Title VI with respect to transit planning is the purview of the Federal Transit Administration.

FTA requires that Title VI program documents be sent to an FTA regional civil rights officer once every three years. This documentation is necessary of all transit providers of fixed-route transit service that receive federal funding. Additional information is required of providers that have more than 50 fixed-route vehicles and are in an urbanized area with a population greater than 200,000. The Title VI program documentation that FTA requires of transit providers of this stature includes the following:

1) Title VI Notice to the Public
2) Title VI Complaint Process
3) Public Participation Plan
4) Language Assistance Plan
5) Membership of Non-Elected Committees and Councils
6) Title VI Equity Analysis of Constructed Facilities
7) Title VI Certifications and Assurances
8) Service Standards and Policies

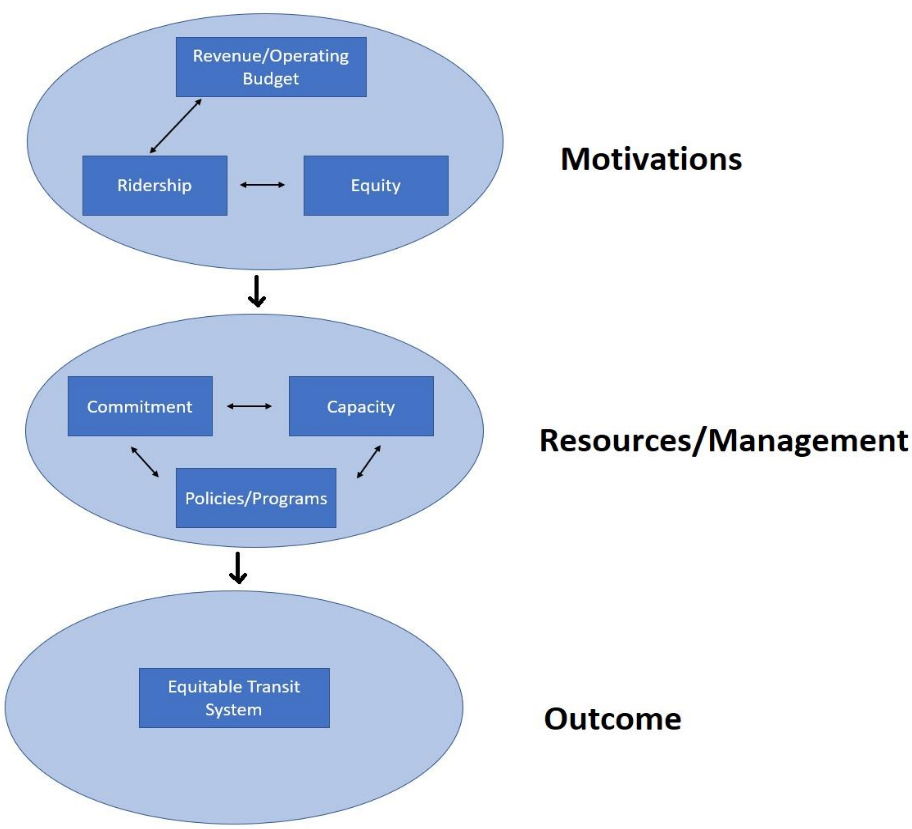
9) Demographic Service Profile Maps and Charts
10) Demographic Ridership and Travel Patterns
11) Description of the Public Engagement Process
12) Results of Service and/or Fare Equity Analyses
13) Evidence of Governing Officials Approval

The above documentation is required by the Title VI process per FTA's Circular 4702.1B, updated in 2012. We will not detail the requirements of each individual requirement, but rather we will discuss the elements of the document that were highlighted by the participants of our survey of transit planners. However, we see that the Title VI process is relatively comprehensive, requiring careful analysis, or at least reporting, of the ways that transit agencies affect equity in transportation.

CONCEPTUAL FRAMEWORK AND RESEARCH DESIGN

We design our study and base our research questions on the following conceptual framework. We developed the framework through an iterative process of reviewing the literature, conducting interviews of key informants, and developing theories based on an evolving synthesis of these data.

Figure 4.1 Conceptual framework of planning for equity in transit



The above framework depicts our hypothesized framework of the process by which transit agencies create equitable transit systems. We developed the framework based on interviews with key informants, years of discussions with transit planners and managers, and a comprehensive review of the public administration, public policy, and public health literature relating to organizational management and decision making.

The motivations of transit agencies are both diverse and singularly focused. As publicly funded governmental or quasigovernmental agencies they are charged with prudently using public funds to provide a service. The dominant performance measurement of their effectiveness in providing that service is transit ridership. We assume, however, that when asked what the role of a transit agency is, we might receive some responses that relate to equity. While we hypothesize that ridership and the revenue that riders bring are the primary motivations of transit agencies, our interviews will inform us to what degree equity is also a motivation.

Next, we assert that it is organizational resources and management that determine the outcome of equity in transit. We advance three elements of organizational resources and management: commitment, capacity, and programs and policies. These classifications come from an extensive review of the literature which we will briefly synthesize below. The outcome of our theoretical framework is an equitable transit system. This chapter does not seek to define an equitable system, as that was the essence of the previous chapter. With this theoretical framework we seek to understand how transit agencies think about planning for equity, and how they actually do so with commitment, capacity, and policy.

The ways that organizations and public agencies produce outcomes has been of interest to a diverse group of researchers for decades. Our review of the literature found that specifically, the fields of public health and public administration have the best insight into how we are understanding the resources and management of transit agencies. Our categorization of agency resources and management into commitment, capacity, and policies and programs is informed by this literature. Organizational capacity and its effect on outcomes is a focus of much of this literature. Gilbert & Howe (1991), for instance, go as far as to claim that capacity is a measure of an organization's ability to affect outcomes. Most, however, simply state that capacity has a persistent effect on an agency's ability to perform its charge and produce results from its policies and programs (Fleischmann & Green 1991; Scutchfield et al., 2004; Collins et al., 2007; McGuire & Silvia, 2010). Programs and policies are another focus of research on organizational strategy, and many agree that as well as capacity, the specific policies and programs that organizations choose to pursue is influential in their ability to generate desired outcomes (Koontz, 1999; Pitt et al., 1993; Robinsin & Berk, 2011). An additional factor that many have identified as important in the effectiveness of public agencies is the decisions made by managers and the environments they foster within an organization (Ford & Gioia, 2000; Wechsler & Backoff, 1986). Finally, it would be irresponsible to neglect to mention funding as an instrumental determinant of an organization's ability to affect desired outcomes. While there is a fair amount of debate as to which elements of organizational strategy and management are most effective, almost all agree that funding is paramount to generating intended outcomes (Scutchfield et al., 2004; Pedriana & Stryker, 2004; Collins et al., 2007; Pedriana & Stryker, 2004).

RESEARCH QUESTION

This study asks the following question:

How do transit agencies plan for equity?

We have many additional sub-questions that help to answer the broader research question and these will be apparent in the way we structure of our findings.

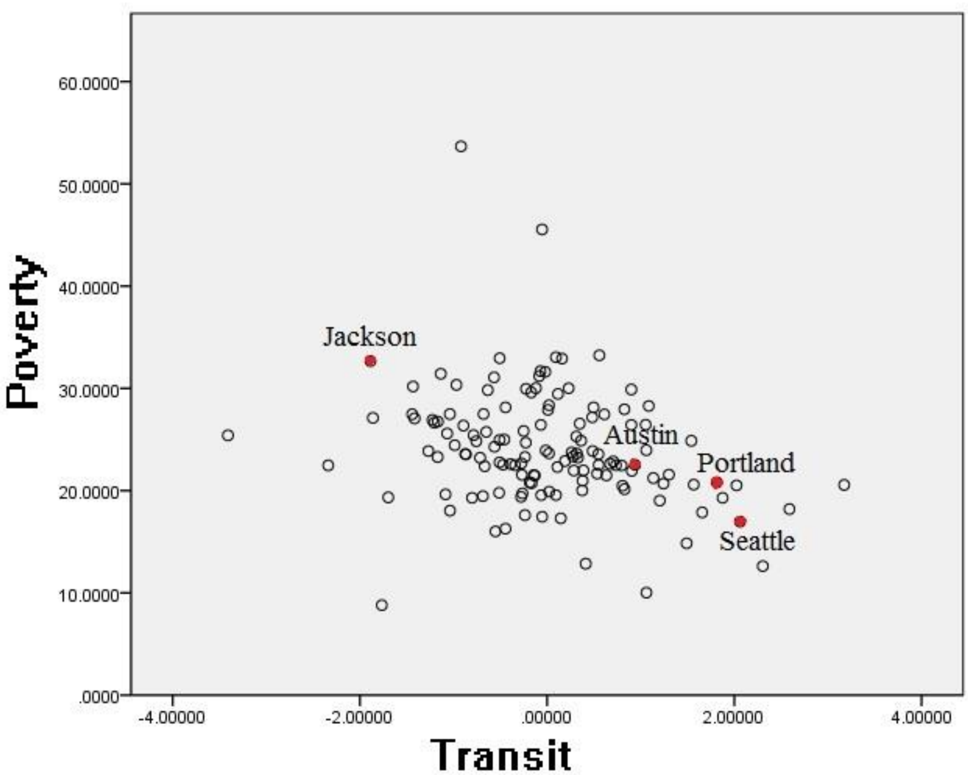
RESEARCH DESIGN

We use a case study approach to obtain an in-depth understanding of the ways that transit agencies plan for equity. We use interview data and document review to provide a detailed framework for how each case study agency considers and addresses equity. We selected five case studies using criteria developed in a concurrent study by the author; we will outline selection criteria below.

DATA COLLECTION AND ANALYSIS

We selected key informants to provide representation of the efforts of transit agencies with respect to equity. A snowball sampling method helped to identify additional key informants within case study agencies and regions. Key informants included transit service planners, general counsel, civil rights officers, diversity planners, and program managers. We conducted a pilot case study in Salt Lake City, UT to refine our data collection protocol. Further refinement of the protocol continued iteratively as new questions and theories developed. The number of informants varied between case studies and was reflective of agency size; transit agencies with fewer staff provided fewer key informants. Our pilot study region consisted of nine face to face interviews, typically lasting an hour. Our smallest region only provided a single interview, as there were only two administrative staff in the entire transit agency. In total, we conducted 16 interviews. We took notes of the interviews and supplemented the notes with audio recordings when possible. We conducted phone interviews for the non-pilot case studies and took notes of the conversations. We did not record phone interviews as this would require informed-consent documentation, and we concluded that this could limit participation in our study. Key informants also provided additional data through supplemental agency documents. We used supplemental documents to fill in gaps left by incomplete interview data.

Figure 4.2 Case study selection



We chose cases that were dispersed along a plot of transit (a principle component analysis of five transit variables) and poverty. A simultaneous study by the author examines the effects of transit and compactness on poverty, and the data used for that study helped in the selection of our case studies. We sought regions that had various sizes of transit systems and agencies with differing capacities. Our pilot study, Salt Lake City, UT, is not on the plot as that region was missing data and was not in the sample for the other study. However, based on our assessment of Salt Lake City's transit system and poverty levels, we would imagine the representative data point on the above plot would be found near the Austin point. Below, we will briefly introduce each case study with a description of the region, the transit agency, and the agency's organizational structure.

Salt Lake City, UT is the capital of the State of Utah in the Intermountain West. The city had a population of just over 200,000 as of 2017, but the greater Wasatch Front region has more than 2 million residents. The Utah Transit Authority (UTA) is the sole transit operator in the region and is considered a "special service district." UTA serves most of the Wasatch Front, including Box Elder, Davis, Salt Lake, Summit, Tooele, and Utah Counties. Annual ridership in 2016 was over 45 million trips. UTA has nearly 2,500 employees, including an administrative staff of 848. The transit system includes bus service, bus rapid transit, commuter rail, paratransit, light rail, and streetcar.

Portland, OR is a city in the Pacific Northwest that is well known to planners. Portland had a population of just under 650,000 in 2017. The region is served by a single transit agency, TriMet.

TriMet operates in three counties: Multnomah, Washington, and Clackamas. TriMet boasts an annual ridership figure just shy of 100 million trips. TriMet offers light rail, bus service, paratransit, and commuter rail. TriMet has an annual operating budget of $526 million and employs approximately 3,000 people.

Austin, TX is the capital of Texas and is located in the South Central part of the state. Austin had a population of over 950,000 in 2017. The region is served by Capital Metro, which extends service to municipalities in Travis and Williamson Counties. The agency has an annual operating budget of $250 million, allowing for bus, bus rapid transit, light rail, commuter rail, and paratransit service. 29 million riders used the Capital Metro system in 2018.

Seattle, WA is a coastal city in the Pacific Northwest and is the largest region in our sample. Seattle is served by King County Metro. King County Metro Transit Department is part of the King County government. King County Metro serves only King County, which contains Seattle and other municipalities. The county's population was 2.17 million in 2017. King County Metro's operating budget in 2012 was $635 million, and this was used to provide service to 115 million riders that year.

Jackson, MS is the smallest region in our sample, with a population of 167,000 in 2017. Jackson is served by JATRAN, which is a division of the City of Jackson. There are only two administrative staff working in the division. JATRAN serves only the City of Jackson and provides the city with bus and paratransit service. Annual ridership of the JATRAN system was just under 450,000 passenger trips in 2017.

We conducted semi-structured interviews of key informants with open ended questions. In some cases where key informants were not available for phone interviews, they filled out our semi-structured interview document independently, then answered follow-up questions via email. Data analysis involved thematic content analysis of interview notes and transcripts as well as of supplemental documents. We consistently returned to our conceptual framework to synthesize the data as well as to adjust our framework. The presentation of our results is representative of how we organized themes that arose from our data analysis.

FINDINGS

HOW DO TRANSIT PLANNERS THINK ABOUT EQUITY?

We started interviews by asking our informants what they thought the charge of a transit agency to be. Very consistently we found that transit planners think of their role as providing access to opportunities, particularly for those that do not benefit from access granted by a personal vehicle. This common understanding was relatively ubiquitous regardless of the role of the informant. Possibly influenced by the context of the interview, we received a few responses that included equity in their description of the role of transit providers. Below, a planner from a small transit agency provided a very comprehensive description of the charge of a transit agency.

> *"[The role of a transit agency is to] provide affordable, equitable access to everything people need; not limited to a certain group. [Transit should be] universal in access, a good alternative to the automobile, and make riders comfortable not owning cars. People should be able to depend on a transit system."*

We followed the role of transit agencies with a question on how transit can affect equity. Responses to this question were more varied, and this began to give us an understanding of the breadth of ways that transit planners think about equity. Our literature review and conceptual framework focus largely on equity in terms of access. Here we will refer to this way of thinking of equity as the "accessibility framework." However, our interviews suggest that transit planners are considering equity within a broader framework that we have defined as the "justice framework." Examples of equity considerations that fall outside the accessibility framework, and thus are better suited for the justice framework include discussions of fare price or structure, business practices that stress diversity and inclusion, and prudency with public resources. Below is a succinct response to the question of how equity can be provided within the context of transit.

> *"[We provide equity by] insuring access to opportunity to those who have been historically oppressed or have been denied access to opportunity."*

We found that the lens with which planners view equity is related to their role in the agency. For example, planners that are involved in Title VI reporting such as diversity officers, service planners, and program managers, describe equity planning in a way that is reflective of Title VI. This means that those who are engaged in Title VI administration describe contributing to equity by providing equal access to opportunity, offering fare prices or structures that benefit disadvantaged populations, and offering contracts to businesses owned by women and minorities. These ways of planning for equity are more-broadly conceived than simply accessibility and indicate that Title VI might contribute to a more comprehensive conceptualization of equity in transit.

Another influence of how transit planners think about equity are agency policies and programs related to equity. In the initial stages of interviews, we would ask planners to define equity and then describe how the concept fits within the context of transit. Planners had very similar ways of defining equity, then would often move straight into the programs that their agencies managed to describe how they thought equity relates to transit. We see that in multiple ways, transit planners are influenced by the frameworks in which they operate. If an agency has policies or programs related to equity, often it is through that programmatic lens that planners at that agency will view equity. This supports the notion that agency commitment to equity through the establishment of policies and programs will influence the way that transit planners think about equity.

A surprising consideration that some transit planners associated with equity was prudency of public resources. These planners felt that the responsible handling of public money in a way that was efficient and effective is an important role of a transit agency with respect to equity. Although this does not necessarily conform with the frameworks of justice and accessibility discussed above, it is a way that some planners consider equity, nonetheless. Interestingly, again, we might be able to contribute this manner of thinking of equity to agency policies. Many agencies have policies that require an analysis of the proportion of service that is allocated to different jurisdictions based on those jurisdictions' contribution to agency funding. To this point, one interviewee, in an attempt to highlight their agency's singular dimension of equity consideration as simply being related to how tax dollars are allocated to service, stated:

> "*Equity is financial equity. Regional economic and social context limits [decision makers'] willingness to take equity seirously.*"

Again, it may be that the requirement to analyze fairness in this way contributes to planners' propensity to think of equity in terms this fiscal component of transit service provision.

COMMON POLICIES AND PROGRAMS FOR EQUITY IN TRANSIT

Fare Pricing

One way that transit agencies increase access to transportation is through their fare pricing. Fare pricing was the most common policy related to equity that was discussed by our key informants. Title VI mandates that an equity analysis be conducted any time that there is a change to fare price to ensure that the change does not have a disparate impact on disadvantaged riders. Many agencies have fare pricing policies that go beyond the Title VI analysis. Most agencies have reduced fares for seniors and persons with disabilities, as this is an FTA requirement for at least off-peak travel times. Other groups that are sometimes extended reduced fares include students, military personnel, and low-income individuals. The way that agencies administer reduced fares is highly variable and is often quite complicated. Reduced fare pricing requires an electronic pass card, and recipients of the reduced rate must prove their eligibility in some way. We will discuss the issues related to administering reduced fare programs later in the paper.

Other fare policies that transit agencies employ to offer easier access to their systems include dynamic structures where different modes, routes, or times are priced differently. Bus service is considered a less desirable transit mode and has been shown to be utilized by riders of lower incomes (Iseki & Taylor, 2010). Pricing bus fares lower than other transit modes is an example of a dynamic fare structure targeted toward equity. Offering lower fares in off-peak hours can also be considered an equitable fare strategy that could benefit lower-income transit riders. Service sector workers often have different travel needs in terms of temporal demand. Pricing off-peak trips lower than peak trips benefits these workers by reducing the burden of commuting to work via transit.

While a large majority of the literature on transit equity focuses on accessibility in terms of access to opportunity, we found that fare price was arguably the most commonly discussed facet of equity in transit by transit planners. Transit planners with many different roles within the agency consistently referred to fare pricing as a paramount focus for planning for equity.

Interestingly, transit planners typically brought up the topic of fare pricing without reference to Title VI. Title VI does require an equity analysis when fare prices are changed, but this was not the context with which fare pricing was brought up in our interviews. Planners consistently viewed fare pricing as an integral part of their agency's levers for affecting equity.

Equity Analysis

The most widely discussed transit equity policy in both literature and practice is the Title VI equity analysis. An equity analysis is required any time that there is a significant change to a route in terms of a reduction in service or realignment. A reduction in service can include either the geographic extent or temporal frequency of service. The equity analysis involves an assessment of the demographic makeup of "affected" populations. Affected populations are those within a specific buffer of the transit line. Planners are required to determine if the affected population differs in terms of race or income from the aggregate population of the entire service area. If there is, in fact, a greater proportion of disadvantaged residents within the affected area, then the change is considered to be discriminatory. Such a finding, without adequate justification, can jeopardize federal funding for a transit agency.

This process is very prevalent in the way transit planners think of equity. Many agencies have full time positions devoted to dealing with this analysis or Title VI processes in general, and service planners are also very aware of equity analyses. However, our interviews suggested a somewhat disjointed process where service planners consider equity broadly, but do not interact with Title VI officers until after changes have been proposed or enacted. Many of our key informants described the equity analysis as an "afterthought." For example, one transit planner that we spoke to suggested that This is problematic in that it suggests that while Title VI requirements affect the way that transit planners talk about equity, they might have less of an influence on the actual practices of service planners.

The problem might also lie in the Title VI guidelines themselves. If the requirements are such that service changes are tested against the protocol after being conceived, there is either an error in the construction of the analysis or in the way that planners use it. If the analysis inadequately captures the full extent of equity considerations that service planners are working with, then this might explain the disjointed process of planning and analysis. On the other hand, this “afterthought” paradigm might be the result of a lack of commitment or concern for equity in service planning. Based on our assessment, the latter scenario seems less likely, and we will discuss this further later.

Disadvantaged Business Enterprise Program

The Disadvantaged Business Enterprise Program (DBE) is an extension of the Civil Rights Act’s directive to avoid discrimination in the distribution of federal funds. The DBE program originally began in 1980 as a supplement to Title VI with a focus on businesses owned or operated by women or minorities. The modern iteration of the program works to ensure the participation of disadvantaged businesses in the procurement process. The three main objectives of the DBE program are: to ensure that disadvantaged business enterprises (DBE)s can fairly compete for federally funded transportation projects; to ensure that only legitimately eligible firms are able to compete with the classification of DBE; and to assist DBE firms outside of the federal procurement process.

Managing this program is often closely associated with other work related to Title VI compliance and reporting. Many planners that we interviewed worked with the DBE program as well as the equity analysis required by Title VI. This is another example of how Title VI requires a relatively comprehensive consideration of equity in the management of transit agencies.

Service Planning

Arguably one of the most important ways that transit agencies plan for equity is through service planning. Within the context of the accessibility framework, this is the single most essential function of transit planning with respect to equity. Transit service planners decide how routes are configured, weighing a multitude of factors to optimize efficiency, ridership, and equity.

The effects of route configuration, service coverage, and service frequency are not lost on transit planners. Service planners that we interviewed were very aware of their role in contributing to equity outcomes. Service planners seemed to be interested in balancing many of the goals and constraints of transit agencies like operating capacity, ridership and efficiency, and equity. We will discuss the tradeoffs between ridership and equity below. Much of the success of a transit agency in promoting equity has to do with the way that they allocate service. In our interviews, many informants referred to equity and coverage almost interchangeably. This connotes that an even distribution of service creates better accessibility, and therefore, more equity. This conceptualization of equity is more horizontal, meaning that equity in transit is a situation in which people have equal access to opportunity. Interestingly, service planners were often thought of by other agency staff to be those that are most involved with equity. As we worked to identify key informants for our study, we were typically directed first to customer service or secretarial staff. After explaining the purpose of our study and the questions that we might have, most often we were directed to service planners. In many cases, service planners were the people best-informed to participate in our interviews, particularly in smaller transit agencies. However, in larger agencies, there were staff that were more directly involved in equity planning. The fact that agency representatives think of service planners first when considering equity in transit is instructive in evaluating the role of service planning in transit equity.

THE EQUITY/RIDERSHIP CONUNDRUM

A foundational theory to our conceptualization of how transit agencies plan for equity has to do with the relationship between ridership and equity. Transit ridership is the most ubiquitous performance measurement of transit agency, and the measure dominates much of the discussion of how transit agencies are doing year over year or compared to each other. Ridership growth is synonymous with a successful, well-designed transit system. Some have argued, however, that in pursuit of ridership, transit planners can potentially be neglecting the needs of those that rely most heavily on the transit system (Karner, 2018). Many of our informants describe service with the intention of promoting equity as “coverage.” By coverage they mean transit lines that are not productive in terms of ridership, but rather are connecting far-flung neighborhoods to centers with greater opportunity. Connecting less central, often less dense neighborhoods to centers with more activity is inherently less productive in producing ridership. This is a common tradeoff discussed by transit service planners in our study. When one of our interviewees discussed the tradeoff between equity and ridership, they highlighted the difficulty of satisfying both needs:

> "*Our decisions are tailored to the choice rail commuter over the local bus passenger. Equity is not sexy. We're not being thoughtful enough about it."*

Another planner put it even more simply:

> *"Most of our decisions [in service planning] are based on ridership"*

There is another way that transit planners think about the tradeoff between equity and ridership, however. Service that is efficient with respect to ridership produces returns in the form of farebox recovery. Some of our informants described a paradigm in which this productive service is essential to generate revenue that can then be used to provide equity-based service. In this paradigm, it is ridership-based service that facilitates an agency's ability to provide less productive equity service. The planners that described these considerations highlighted the importance of finding a balance that allows for efficient routes that are highly productive so that the agency has the resources to "subsidize" less productive equity-based routes. Additionally, these planners said ridership-oriented routes can also be utilized by disadvantaged populations. They argue that a system that operates most efficiently provides a scenario in which revenue is generated, the main system functions at its highest possible capacity within the constraints of the resources available, and the funds generated by productive service can be used in part to pay for less productive equity routes.

EXEMPLARY POLICIES AND PROGRAMS FOR EQUITY IN TRANSIT

Reduced Fare Programs

Some of the case study regions in our sample have reduced fare programs that go beyond the typical FTA mandated schedules. TriMet in Portland, for example, offers a "HOP Fastpass" which is an electronic farecard that allows low-income Oregon residents the ability to ride for a 50% reduction in normal fare prices. Residents that are eligible for this pass are required to verify their income in one of two ways. First, if the resident is eligible for other public assistance such as Medicaid, SNAP, Temporary Assistance for Needy Families (TANF), or other select programs, simple documentation of participation in those programs qualifies them for a HOP Fastpass. Alternatively, a resident can verify their income with recent paystubs, unemployment paystubs, or other documentation deemed by the agency to verify income. Eligible participants are required to bring documentation to participating organizations to verify their eligibility. One of the most impressive elements of this program is that the locations that eligible participants can bring their documentation are convenient and broadly accessible to disadvantaged individuals. Public service providers are partners in the pass program, so individuals seeking other public services can take care of their transportation needs while simultaneously receiving services for other needs.

Enhanced Equity Analysis

TriMet has another program that contributes to the discussion of best practices in the provision of transit equity. The agency uses the analysis framework prescribed by Title VI for determining if service or fare changes have a disparate impact on disadvantaged populations, with two important distinctions. Title VI defines disadvantaged populations based on two criteria: race and income. Trimet, however, has a much more inclusive definition which includes a higher threshold for low-income, from 150% of the poverty level to 200%. This means that more people are considered to be low-income, essentially extending the federal protection to more people. Additionally, the disparate impact criteria are modified so that an impact on disadvantaged populations is considered inequitable at a lower threshold.

An even greater deviation from the norm in equity planning is their companion to the Title VI equity analysis that reports on accessibility impacts of proposed service changes. This analysis quantifies access to low/medium wage jobs, jobs held by minorities, educational institutions, health care service providers, and grocery stores and supermarkets. The consideration of this list of daily needs represents a more comprehensive assessment of accessibility than is required by Title VI. The analysis is even, in terms of what destinations are calculated, more encompassing than some academic methods for assessing equity in transit. We see that TriMet is surpassing the requirements of Title VI and evaluating the equity impacts of service changes in a way that is relatively thorough and multi-faceted.

Overarching Equity Policies

One important way that transit agencies or their managing organizations mandate the consideration of equity is through more overarching policies on equity. King County Metro in the Seattle region is part of the larger King County Government. King County has codified by ordinance an equity and social justice initiative that guides the work of all divisions within the county government. The county has developed an Equity and Social Justice Strategic Plan that shapes the work of their departments. The strategic plan mandates that all efforts of the county government be inclusive and collaborative, diverse and people-focused, responsive and adaptive, transparent and accountable, racially just, and focused upstream and where needs are greatest. Transit planners at King County Metro referenced this policy on multiple occasions, indicating that the county-wide policy has a large effect on the way that the agency thinks about and plans for equity. The planners also stressed the fact that this policy is codified, meaning that divisions of the county government are required by statute to work within the framework of the Equity and Social Justice Strategic Plan.

The plan directly addresses equity in transit in multiple ways. First, the plan suggests ways to target resources in a manner that can best benefit disadvantaged populations. The plan suggests that equitable transit-oriented development is an appropriate avenue for targeting resources so that low-income residents can find affordable housing that also has access to affordable transportation options. The strategic plan also recommends targeted investment in transit corridors for similar reasons. Importantly, the plan stresses the need to better understand how access to jobs, education, social services, healthcare, and healthy food differs between different segments of the population. The plan does not explicitly say how this should be measured, but the acknowledgement of its importance is significant. Broadly, the Equity and

Social Justice Strategic Plan is an impressive effort by the King County government, and it has the potential to have a positive effect on transportation equity in the region.

BARRIERS TO PROVIDING EQUITY IN TRANSIT

Our analysis of interview and supplemental data suggest that there are three barriers to planning for equity in transit: capacity constraints, political or public perception constraints, and cultural factors. In general, we find that the transit agencies with the largest operating budgets and largest numbers of administrative staff had the most comprehensive set of policies and programs for enhancing equity. Inversely, agencies with limited budgets and staff were the least capable of facilitating programs for equitable transit. Our smallest region was only able to identify two efforts through which the agency was contributing to equity, one being simply providing service with relatively widespread coverage. On the other end of the spectrum, TriMet in Portland reported devoting 12 planners to a department that was explicitly focused solely on equity. It is not surprising, then, that TriMet came up repeatedly in our discussion of exemplary policies and programs.

Political and public perception constraints were another commonly identified barrier to implementation of equitable programs. Many informants described precarious political situations that made them wary of designing systems in a way that favored equity. One common political concern was the prudent use of taxpayer money. Transit planners felt that providing service that was equitable, but possibly not particularly efficient in terms of filling transit vehicles, would contribute to a public perception that the agency was not spending public money in the most prudent manner.

Finally, it cannot be avoided that our two case studies that accounted for all of the exemplary policies and programs were located in the coastal Pacific Northwest. This area of the country, particularly Portland, is known for being progressive in a cultural and planning context. We believe that the fact that by many measures TriMet and its peer agencies in our sample have significantly different levels of success with respect to planning for equity indicates that there is something more special happening in Portland. We contend that a planning and political culture that is more supportive of equity concerns may be related to the fact that TriMet and King County Metro are so successful at promoting equity in transit through exemplary policies and programs.

DISCUSSION

This study finds that transit agencies use a variety of frameworks for understanding and thinking about equity. We define two ways of thinking about equity in transportation: the justice framework and the accessibility framework. Much of the literature on transit equity exists within the accessibility framework, working to establish improved ways of measuring how well transit agencies connect disadvantaged populations to opportunities. Simultaneously, many transit planners operate within the justice framework. This way of thinking about equity in transportation is more dynamic. Through the justice framework, transit planners consider more than just access to opportunities, but also the cost of service, efficient use of public resources, who transit agencies do business with, how other services beyond mobility are provided, and many other elements of equity. We contend that while these two frameworks are not necessarily competing, the justice framework is more comprehensive. Academic work on transit equity has focused heavily on accessibility, and unless the benefit of such a singular focus is better articulated, we argue that academic efforts to study equity should be broadened to better reflect the framework in which transit agencies and planners are operating.

Another essential finding of this study is the fact that Title VI plays a very important role in the ways that transit agencies think and plan for equity. While this might seem obvious, much of the literature, and even planners themselves, has downplayed the ability of Title VI to adequately promote equity in transit. However, through our interviews and analysis we find that Title VI plays a very important role in the way that transit planners conceptualize equity. In the very least, the efforts that are required of transit agencies to comply with this regulation affect the way their planners consider equity. We think that Title VI, especially when compared to the accessibility framework that is heavily relied upon in academic discussions of transit equity, is relatively comprehensive. Additionally, we find that the mandates from Title VI constitute a majority of work that transit agencies are doing to promote or document how their service affects equity. It could be argued that if the regulation did not exist, agencies might be able to refocus the effort they spend on Title VI compliance toward more targeted approaches to provide equitable service. However, given the limited extent to which even the most resourced and equity-minded agencies are surpassing the requirements of Title VI, we think that the federal program is very effective at producing at least a base-level of equity considerations by transit agencies.

REFERENCES

Aimen, D., & Morris, A. (2012). *Practical Approaches for Involving Traditionally Underserved Populations in Transportation Decisionmaking* (No. Project 8-72).

Brainard, J. S., Jones, A. P., Bateman, I. J., Lovett, A. A., & Fallon, P. J. (2002). Modelling environmental equity: access to air quality in Birmingham, England. *Environment and Planning A*, *34*(4), 695-716.

Bullard, R. D., & Johnson, G. S. (1997). *Just transportation: dismantling and class barriers to mobility*. New Society,.

Bullard, R. D., Johnson, G. S., & Torres, A. O. (Eds.). (2004). *Highway robbery: Transportation racism & new routes to equity*. South End Press.

Checker, M. (2011). Wiped out by the "greenwave": Environmental gentrification and the paradoxical politics of urban sustainability. *City & Society*, *23*(2), 210-229.

Clark, C., & Stansfeld, S. A. (2007). The effect of transportation noise on health and cognitive development: A review of recent evidence. *International Journal of Comparative Psychology*, *20*(2).

Collins, C., Phields, M. E., & Duncan, T. (2007). An agency capacity model to facilitate implementation of evidence-based behavioral interventions by community-based organizations. Journal of Public Health Management and Practice, 13, S16-S23.

Dworkin, R. (1981). The forum of principle. *Nyul Rev.*, *56*, 469.

Engel, E., Fischer, R., & Galetovic, A. (2006). Privatizing highways in the United States. *Review of Industrial Organization*, *29*(1-2), 27-53.

Fleischmann, A., & Green, G. P. (1991). Organizing local agencies to promote economic development. The American Review of Public Administration, 21(1), 1-15.

Ford, C. M., & Gioia, D. A. (2000). Factors influencing creativity in the domain of managerial decision making. Journal of Management, 26(4), 705-732.

Forkenbrock, D. J., & Schweitzer, L. A. (1999). Environmental justice in transportation planning. *Journal of the American Planning Association*, *65*(1), 96-112.

Freilich, R. H., & Chinn, S. P. (1986). Transportation Corridors: Shaping and Financing

Urbanization through Integratoin of Eminent Domain, Zoning and Growth Management Techniques. *UMKC L. Rev.*, *55*, 153.

Gilbert, J., & Howe, C. (1991). Beyond ‘state vs. society’: Theories of the state and New Deal agricultural policies. American Sociological Review, 56(2), 204-220.

Gratz, R. B. (2010). *The Battle for Gotham: New York in the Shadow of Robert Moses and Jane Jacobs*. Bold Type Books.

Grengs, J. (2002). Community-based planning as a source of political change: The transit equity movement of Los Angeles' Bus Riders Union. *Journal of the American Planning Association*, *68*(2), 165-178.

Gwynn, R. C., & Thurston, G. D. (2001). The burden of air pollution: impacts among racial minorities. *Environmental health perspectives*, *109*(suppl 4), 501-506.

Hausman, D., & McPherson, M. (2006). Utilitarianism and Consequentialism. *D. Hausman, & M. Michael, Economic Analysis, Moral Philosophy and Public Policy*, 99-116.

Highsmith, A. R. (2009). Demolition means progress: urban renewal, local politics, and state-sanctioned ghetto formation in Flint, Michigan. *Journal of Urban History*, *35*(3), 348-368.

Iseki, H., & Taylor, B. D. (2010). Style versus service? An analysis of user perceptions of transit stops and stations. Journal of Public Transportation, 13(3), 2.

Johnston, R. A., & Rodier, C. J. (1998). Regional simulations of highway and transit ITS: Travel, emissions, and economic welfare effects. *Mathematical and computer modelling*, *27*(9-11), 143-161.

Karner, A. (2018). Assessing public transit service equity using route-level accessibility measures and public data. *Journal of Transport Geography*, *67*, 24-32.

Koontz, T. M. (1999). Citizen participation: conflicting interests in state and national agency policy making. The Social Science Journal, 36(3), 441-458.

Korb, A. B. (2011). SEPTA, Philadelphia, and Transportation Equity in America. *Geo. JL & Mod. Critical Race Persp.*, *3*, 119.

Kymlicka, W. (2002). *Contemporary political philosophy: An introduction*. oxford: oxford University Press.

Lee, B. L. (1997). Civil rights and legal remedies: a plan of action. *Just transportation: Dismantling race & class barriers to mobility. Gabriola Island, BC: New Society Publishers*.

Marcantonio, R. A., Golub, A., Karner, A., & Nelson Dyhle, L. (2017). Confronting inequality in metropolitan regions: Realizing the promise of civil rights and environmental justice in metropolitan transportation planning. *Fordham Urb. LJ*, *44*, 1017.

Martens, K., Golub, A., & Robinson, G. (2012). A justice-theoretic approach to the distribution of transportation benefits: Implications for transportation planning practice in the United States. *Transportation research part A: policy and practice*, *46*(4), 684-695.

McGuire, M., & Silvia, C. (2010). The effect of problem severity, managerial and organizational capacity, and agency structure on intergovernmental collaboration: Evidence from local emergency management. Public Administration Review, 70(2), 279-288.

Miceli, T. J., & Sirmans, C. F. (2007). The holdout problem, urban sprawl, and eminent domain. *Journal of Housing Economics*, *16*(3-4), 309-319.

Morello-Frosch, R., Pastor, M., & Sadd, J. (2001). Environmental justice and Southern California's "riskscape" the distribution of air toxics exposures and health risks among diverse communities. *Urban Affairs Review*, *36*(4), 551-578.

Nussbaum, M. C. (2011). *Creating capabilities*. Harvard University Press.

Pedriana, N., & Stryker, R. (2004). The strength of a weak agency: Enforcement of Title VII of the 1964 Civil Rights Act and the expansion of state capacity, 1965–1971. American journal of sociology, 110(3), 709-760.

Pereira, R. H., Schwanen, T., & Banister, D. (2017). Distributive justice and equity in transportation. *Transport Reviews*, *37*(2), 170-191.

Pitt, M. M., Rosenzweig, M. R., & Gibbons, D. M. (1993). The determinants and consequences of the placement of government programs in Indonesia. The World Bank Economic Review, 7(3), 319-348.

Pucher, J., Evans, T. M., & Wenger, J. (1998). Socioeconomics of urban travel: evidence from the 1995 NPTS. *Transportation Quarterly*, *52*(3).

Rawls, J. (1999). A theory of justice (revised edition.). Cambridge, Mass.: Belknap Press of Harvard University Press.

Rawls, J. (2001). Justice as fairness : a restatement. Cambridge, Mass; London: Harvard University Press.

Robinson, L. W., & Berkes, F. (2011). Multi-level participation for building adaptive capacity: Formal agency-community interactions in northern Kenya. Global Environmental Change, 21(4), 1185-1194.

Sandel, M. J. (2009). *The case against perfection*. Harvard University Press.

Sandel, M. J. (2010). *Justice: What's the right thing to do?*. Macmillan.

Sawicki, D. S., & Moody, M. (2000). Developing transportation alternatives for welfare recipients moving to work. *Journal of the American Planning Association*, *66*(3), 306-318.

Schlosberg, D. (2004). Reconceiving environmental justice: global movements and political theories. *Environmental politics*, *13*(3), 517-540.

Schweitzer, L., & Stephenson Jr, M. (2007). Right answers, wrong questions: Environmental justice as urban research. *Urban Studies*, *44*(2), 319-337.

Schweitzer, L., & Valenzuela Jr, A. (2004). Environmental injustice and transportation: the claims and the evidence. *Journal of planning literature*, *18*(4), 383-398.

Scutchfield, F. D., Knight, E. A., Kelly, A. V., Bhandari, M. W., & Vasilescu, I. P. (2004). Local public health agency capacity and its relationship to public health system performance. Journal of Public Health Management and Practice, 10(3), 204-215.

Sen, A. K. (2009). *The idea of justice*. Harvard University Press.

Sen, A. (1979). Equality of what? *The Tanner lecture on human values*, *1*.

Sen, A. (2005). Human rights and capabilities. *Journal of human development*, *6*(2), 151-166.

Taylor, B. D., & Ong, P. M. (1995). Spatial mismatch or automobile mismatch? An examination of race, residence and commuting in US metropolitan areas. *Urban studies*, *32*(9), 1453-1473.

Trappenburg, M. (2000). In defence of pure pluralism: Two readings of Walzer's spheres of justice. *Journal of Political Philosophy*, *8*(3), 343-362.

Wachs, M., & Taylor, B. D. (1998). Can transportation strategies help meet the welfare challenge?. *Journal of the American Planning Association*, *64*(1), 15-19.

Walzer, M., & Dworkin, R. (1983). Spheres of justice: an exchange. *The New York Review of Books*, *21*, 43-6.

Wechsler, B., & Backoff, R. W. (1986). Policy making and administration in state agencies: Strategic management approaches. Public Administration Review, 321-327.

Weiner, E. (2016). *Urban transportation planning in the United States: history, policy, and practice*. Springer.

Whitt, J. A. (2014). *Urban elites and mass transportation: The dialectics of power* (Vol. 526).

Princeton University Press.

Winston, C. (1991). Efficient transportation infrastructure policy. *Journal of Economic Perspectives*, *5*(1), 113-127.

Wright, B. (1997). New Orleans neighborhoods under siege. *Just Transportation: Dismantling race and class barriers to mobility*.

Vienneau, D., Schindler, C., Perez, L., Probst-Hensch, N., & Röösli, M. (2015). The relationship between transportation noise exposure and ischemic heart disease: a meta-analysis. *Environmental research*, *138*, 372-380.

CHAPTER 5: CONCLUSION

This dissertation explores the concept of social equity and environmental justice in public transit. The three chapters used various methods to bring our understanding of equity in transit to a place of finer resolution. The general aim is to first determine how public policy and transit service can affect regional economic outcomes, then to put forward a novel method for measuring equity in transit service, and finally to determine how these concepts are implemented in practice.

A longstanding, yet scarcely explored assumption of public transit is that it works to reduce the effects of spatial mismatch by nullifying or minimizing the effects of geographic distance between where disadvantaged people and where they must seek employment. This assumption, however, has not been satisfactorily been proven using empirical study. The best effort to date was made by Sanchez (1999) when he related job accessibility by transit to employment rates in block groups in two US regions. Sanchez finds that block groups with greater levels of accessibility to jobs via transit experience higher employment rates. This finding is what we might expect, and supports the common assumption that transit limits the effects of spatial mismatch. The obvious shortcoming of this study is the lack of generalizability of the findings given its limited scope of just two case studies.

In the first chapter of this dissertation we determine whether Sanchez' findings persist with a more robust study design. We create a cross section of 113 US cities and apply structural equation modeling to identify relationships between regional economic outcomes and transit quality and compactness. Our findings support those of Sanchez' study: we find that higher quality transit service and compactness are, in fact, associated with lower levels of unemployment and poverty. These findings give credence to the assumption that transit moderates the effect of spatial mismatch on poverty and unemployment. Furthermore, the finding that transit service can affect poverty and unemployment arms local and regional policy makers with tools to promote economic opportunity for disadvantaged populations. The association of quality transit with lower unemployment and poverty suggests that investment in transit service, particularly in service that provides job accessibility for disadvantaged neighborhoods, can have a measurable effect on regional economic measures.

One clear limitation to this study design is its use of aggregate measures of regional characteristics, transit service provision, and economic outcome variables. We see this as a trade off to the more disaggregated but smaller geographical scope of earlier efforts to explore the relationship between transit and spatial mismatch. While we can say that quality transit service is associated with lower levels of unemployment and poverty, we cannot say which people or neighborhoods are most affected. Additionally, with our aggregated measures of quality transit service, we cannot say *how* transit service limits the effects of spatial mismatch or prescribe certain patterns or ways of providing effective service for disadvantaged neighborhoods. In the second paper of this dissertation, however, we create a new way to measure transit agencies' efficacy in providing equitable transit systems.

Chapter two of this dissertation creates a novel method for measuring how well transit systems are working to provide economic opportunity for disadvantaged populations. Again, we build on work that has already been advanced by previous scholars on the topic of social equity in transit service. Researchers such as Karner, Taylor, Golub, and others have worked for some time to create means for analyzing how effectively transit agencies are contributing to accessibility for disadvantaged neighborhoods. The bulk of these efforts has been primarily focused on creating measures of accessibility to jobs and analyzing how accessibility levels vary between neighborhoods of differing levels of disadvantage. These are important contributions to our understanding of how well transit agencies are serving those that have the direst need for their services. However, we argue that they are not comprehensive in their construction of how transit agencies affect equity in their regions.

In the second chapter of this dissertation we create a new method for analyzing equity in transit service that incorporates a more robust operationalization of equity in transit. We create what we refer to as the Transit Economic Equity Index, or TEEI, which utilizes three components of transit equity. The first component, transit service convenience, incorporates route frequency, route distribution, and number of connections to estimate and compare the transit travel speeds between advantaged and disadvantaged neighborhoods and their respective employment centers. This multifaceted measure of transit convenience is, in and of itself, an improvement to the accessibility measures employed by previous academic efforts. We continue to make our measure of transit equity increasingly robust comprehensive by adding two additional components to the TEEI. The second component, non-peak hour service, measures the proportion of transit service hours dedicated to serving the typical 9-5 work day commuters. We include this measure because the focusing of service on the typical 9-5 work day commuters potentially represents an allocation of resources that favors advantaged populations working moderate to high-paying white collar jobs. Service sector jobs often require that employees work outside of the typical 9-5 schedule, and these more disadvantaged populations might require transit service at odd hours, either very early in the morning or late at night. The third component of the index, system access, measures the availability of stops at origins and destinations and compares that access for advantaged and disadvantaged neighborhoods. The ease of access to the system is an important component of how a transit agency facilitates connections to economic opportunity, and as such, is included in our index. Finally, the scores from the three components are averaged to produce an overall TEEI score, which indicates the degree to which a transit system is prioritizing economic opportunity for disadvantaged neighborhoods as compared to their advantaged counterparts.

We find that among our six case study regions all but one region demonstrates what would we consider an equitable transit system. Again, this means that five of the six study regions are providing transit service that serves disadvantaged neighborhoods better than it serves advantaged neighborhoods. This is a heartening result and suggests that transit agencies are appropriately focused on the needs of the disadvantaged populations of their regions. While it is useful to compare regions in terms of their score on the TEEI at a given point in time, the index can also be used to see how single agencies have changed with respect to equity over time, or how changes to service can affect equity. A different study design might be able to identify how specific changes to service affect the relative equity of a single transit system. This is one of the intended uses for the index; a tool for transit agencies to evaluate of proposed service changes will affect the equity of their system. We see this use of the index as a way for transit agencies to weigh the equity implications of service changes against the potential effects on ridership of the same changes.

Forecasting for ridership and providing prescriptive guidelines for creating systems that enhance convenience in a way that entices discretionary riders has been a focus of transit researchers and consultants for some time. Tools for analyzing how changes to service will affect equity, however, have received less attention. We believe that the TEEI can be used by transit agencies in tandem with ridership forecasting to help to facilitate the creation of transit systems that are both efficient in terms of their returns on ridership and equitable in terms of their ability to provide economic opportunity for disadvantaged populations.

The third chapter of this dissertation qualitatively explores the question of how transit agencies plan for equity. In the other chapters we have seen evidence that suggests transit-supportive policies might decrease unemployment and poverty. We also provided a tool that can help transit agencies and regional governments evaluate their efficacy in promoting economic equity. However, these policy and measurement considerations must be rectified with the practice of planning for equity in transit to determine how these advances might actually be put to practice.

One of the important contributions of the third chapter is to synthesize the theoretical frameworks for conceptualizing equity in transit. We identify how academics and theorists have explained the need for public transit as an intervention of the disproportionate influence and power of the personal vehicle. We go on to discuss political economic theories of justice that apply to transportation policy as described by authors like Pereira, Rawls, and Sen. We identify the concepts of Utilitarianism, Libertarianism, Institutionis, and Rawls' Egalitarianism as useful political theories for thinking of equity in transportation policy.

A common theme in the academic literature and in the interviews we conducted is the deficiency of the federally mandated process of Title VI of the Civil Rights Act of 1964. In particular, scholars and interviewees have pointed to the equity analysis required by the law and its inadequacy in identifying the true impacts of service changes on accessibility. Accessibility has been the focus of academics in their attempts to improve methods for assessing equity in transit. With this study, however, we sought to determine if such a narrow view of what is important in the provision of equity through transit service was in line with the ways that transit practitioners conceive of and plan for equity. We found that transit planners conceptualize equity in a much broader sense than how it is commonly considered in the planning literature. Transit practitioners tend to think about equity in terms of how the agency conducts business within their community, how they operate internally, and how they provide transit service to disadvantaged residents.

This broad, more wholistic construction of the notion of equity in transit is, in part, a function of Title VI. I argue that there is evidence suggesting that policies and programs affect the way transit planners think about equity. This idea comes from the fact that interviewees often describe how they plan for equity by outlining the related programs and policies of their agencies. Furthermore, I find that when asked to describe what equity means, there is congruence in their definition of the concept with these policies, almost as if they shape planners' very understanding of the concept. The result of this broader way of looking at equity leads transit agencies to carry out an array of measures for promoting equity. As a result, we are left with a much less pessimistic impression of Title VI than is typical of the academic literature. We find that Title VI contributes to a long list of additional policies and programs consistently executed by transit agencies.

In addition to setting a framework for thinking about equity, Title VI also provides a baseline standard for equity considerations in transit regardless of the size or capacity of the agency. For this study we interviewed transit planners from large and small transit agencies, and we find that Title VI requirements factor into planners' equity strategies in similar ways regardless of agency capacity. The uniform application of Title VI requirements across all transit agencies has the benefit of maintaining a status quo that includes the consideration of equity.

While one transit agency that we interviewed was so constrained by their capacity that they were very limited in their ability to plan for equity, we can be assured that they are at least meeting the minimum requirements set by the national policy.

Beyond simply filling gaps in the literature, the three chapters of this dissertation work to collectively provide a more comprehensive understanding of the relationship between public transit and equity. First, we test the underlying assumption that transit helps to provide economic opportunity for disadvantaged populations. With the confirmation of this assumption from the findings of the first chapter, the second chapter then explores a new way to measure equity provision by transit agencies. Adding this to the first chapter, we can move from theory towards something that can help prescriptively. This tool can be used to help transit planners and policy makers to evaluate agencies' efficacy in promoting economic equity. With the theory supported, the methods for evaluation improved, we finally move to policies and programs that transit agencies use to affect equity. In investigating how transit agencies actually plan for equity the picture becomes relatively complete.