



Assessing public transit service equity using route-level accessibility measures and public data

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ABSTRACT

The benefits and burdens of public transit service changes can be quantified using many different metrics. In the United States, the Federal Transit Administration requires transit agencies to assess the equity of proposed service changes using the demographic shares of affected riders. The purpose of the work presented here is to inform the development of more robust transit equity analyses than are currently conducted by integrating measures of accessibility – the ease with destinations can be reached – into FTA-required analyses. The measures are calculated using publicly available data, including the US Census Bureau's Longitudinal Employer-Household Dynamics dataset and transit route and schedule information in the General Transit Feed Specification (GTFS) format. The results demonstrate that relying on a single measure (e.g. population shares or accessibility) to associate a route with a particular demographic group is likely to be deficient. Previous academic work on accessibility has not translated well to practice in part because the calculation of accessibility relied upon regional travel demand model outputs that were difficult to obtain. This work thus fills an important gap in the literature and practice by tying advances in the academic literature to FTA-mandated analysis with publicly available data.

1. Introduction

Achieving equity in the provision of public transit service has been a transportation policy goal in the US since at least the 1970s (e.g., Krumholz and Forester, 1990; Pucher, 1982). Differences in access to and accessibility by public transit according to geography and demographics have been extensively studied (e.g., Currie, 2010; Sanchez, 1999; Shen and Sanchez, 2005; Taylor and Ong, 1995). At the same time, changing urban forms and decentralizing employment have made automobile ownership a necessity in most areas across the US, reducing public transit's relevance for accessibility provision (Blumenberg and Manville, 2004; Blumenberg and Ong, 2001).

Despite transit's limitations, substantial public funds continue to be allocated to its construction and operation and disputes have routinely arisen between the transportation disadvantaged and more affluent populations regarding the types of systems that should be funded and built (Golub et al., 2013; Grengs, 2002). Additionally, access to reliable and affordable transportation options, whether public or private, is vital to ensuring the full participation of individuals in societies across the globe (Lucas, 2004, 2012). Achieving transportation equity requires addressing each of these concerns simultaneously, but barriers include issues of data availability, scale, and scope, the absence of standard

methods of equity assessment, weak guidance from agencies on analytical methods, and disagreement over appropriate definitions (Karner and Niemeier, 2013; Lei et al., 2012; Martens, 2012; Rowangould et al., 2016; Sanchez et al., 2003; Truelove, 1993).

In the United States, the Federal Transit Administration (FTA) requires its fund recipients located in urbanized areas exceeding 200,000 in population to perform a service equity analysis whenever a “major service change” is undertaken (Federal Transit Administration, 2012a). The purpose of the analysis is to guard against discrimination in the distribution of federal funds, as required by Title VI of the 1964 Civil Rights Act (Federal Highway Administration, 2012; Federal Transit Administration, 2012a, 2012b). The goal of the service equity analysis is to determine whether a proposed change will have a disparate impact on racial minorities and/or place a disproportionate burden on low-income populations.

The analysis as prescribed is inherently spatial—it relies upon comparing the demographic shares of the population likely to be affected by a service change (e.g. the population living near affected transit stops or stations) to that in the greater service area. If the burdens of a service cut fall disproportionately on people of color or low-income or if the benefits of a service improvement accrue disproportionately to whiter and more affluent populations, a service

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change may be judged to be discriminatory.

Such an analysis is undoubtedly necessary, but the data and methods prescribed by FTA are limited (Karner and Golub, 2015); no consideration is given to changes in public transit accessibility or level of service. Yet for decades, transportation scholars have identified the ability to access destinations dispersed across space as the primary benefit conferred by a transportation system (e.g., Martens, 2012; Wachs and Kumagai, 1973). Work is needed to integrate methods, findings, and best practices from transportation geography into public agency practices. The purpose of this study is to inform the development of robust transit equity analyses, consistent with the spirit of FTA's prescribed methods. Specifically, indicators of accessibility and equity are developed and applied to the Phoenix, Arizona metropolitan area's multimodal transit system. In contrast to many prior measures, those developed here link together both the opportunities available at the destination end of a trip and the characteristics of employed residents located at the origins.

The results demonstrate how a service equity analysis could incorporate broader conceptions of accessibility and the consequences of relying on demographic approaches alone. Some routes with relatively low proportions of low-income riders, for example, evidence relatively high accessibility to low-wage jobs, meaning that the share of a route's ridership that is low-income is a relatively poor indicator of the substantive importance of a route to low-income people. Additionally, measures that consider where workers live as well as the location of suitable employment opportunities demonstrate greater equity than those that consider only the location of opportunities. These combined results suggest that relying on a single measure to associate routes with particular demographic groups is likely to be deficient.

The data and methods presented here are based on publicly available data in the US that, with minor modifications, could be used in other contexts to address transit equity-related questions. These data are being continuously updated, making it possible to track accessibility changes over short time periods. Previous academic work on accessibility has not engaged deeply with the types of service equity analyses that US transit agencies must conduct day-to-day. This work thus fills an important gap by tying advances in the academic literature to FTA-mandated analysis using publicly available data.

2. Literature and practice review

In the literature on transit ridership, two groups have been identified: choice and transit dependent riders (Garrett and Taylor, 1999; Grengs, 2005; Taylor and Morris, 2015). Choice riders typically have an automobile available but choose high-level-of-service transit modes during the commute (e.g., commuter rail or express bus). Transit dependents lack access to an automobile and must rely on transit, ride-sharing, or other means to access desired destinations. Prior work has revealed important demographic differences between these two groups; namely, that transit dependent populations are more likely to be people of color and low-income than choice commuters (Garrett and Taylor, 1999). This market segmentation creates challenges for transit planners and civil rights enforcement. Without even considering the vast differences in accessibility afforded by the automobile versus public transit (Golub and Martens, 2014; Grengs, 2010), a single transit agency responsible for a multimodal system has to make choices regarding relative service levels subject to limited funding. Investing in choice modes and routes is seen as an important strategy to reduce congestion and vehicle-miles traveled, but can draw funding away from serving transit dependents. Recent history has seen a de-emphasis of transit dependents and re-emphasis on choice riders due to the vagaries of US transportation policy and finance and other political-economic factors (Grengs, 2005).

This shift in emphasis increases the likelihood that the civil rights of transit dependents will be violated. Appropriate care must be exercised to determine whether an equitable level of service is being provided to

this population relative to choice riders. In the US context, under Title VI of the 1964 Civil Rights Act, agencies receiving federal funding cannot discriminate in the distribution of those funds. According to environmental justice guidance, those agencies must also avoid disproportionately burdening populations of color and low-income populations while ensuring that they receive a fair share of the benefits of federal investments (Marcantonio et al., 2017). Measuring discrimination and disproportionality is challenging. How they are operationalized can determine whether and the extent to which problems are identified (Rowangould et al., 2016; Talen and Anselin, 1998; Truelove, 1993). Regulations and other guidance promulgated by executive agencies seek to provide structure to such analyses.

FTA has produced guidance aimed at determining whether the distribution of benefits and burdens resulting from proposed fare and service changes are equitable (Federal Transit Administration, 2012a). For the service equity analysis, a public transit agency establishes the demographics of their entire service area (i.e. shares of specific groups) as a basis for comparing the demographic shares of those routes affected by a service change (either a cut or addition). If the share of people of color or low-income people in the total affected population facing a service cut is substantially greater than that in the overall service area, the proposed service change may need to be altered or abandoned (e.g., CDM Smith et al., 2014; Los Angeles County Metropolitan Transportation Authority, 2013). The opposite is true for service improvements.

Although the methods prescribed by FTA for this analysis are very specific (see, e.g., Federal Transit Administration, 2012c, 2018), they are based entirely on rider demographics. FTA's guidance does not recommend or endorse the use of measures of service quality, including travel time, accessibility, or rider comfort, which may be more meaningful indicators of transit system performance and equity than proximity or demographics.

The literature on public transit equity offers some guidance for the selection of superior measures. There is a substantial body of work related to transit equity that quantifies a measure of transit supply in relation to demand as captured by population demographics. The goal of these studies is to determine whether areas that experience concentrated disadvantage have either adequate access to transit service or have equitable transit service relative to areas that are not disadvantaged. In other words, it seeks to determine whether there is a "needs gap" between populations likely to use public transit and transit service (Currie, 2004). Typical studies in this tradition employ transit supply measures based on available data and demographics as a proxy for transit demand. Commonly employed measures of supply operationalize access to the transit system using one or more measures calculated for a small geographic area, including, for example, average proximity to transit stops, average headway, service coverage, and network density (e.g., Al Mamun and Lownes, 2011; Currie, 2010; Mavoa et al., 2012; Minocha et al., 2008; Wu and Hine, 2003).

Although they are often straightforward to calculate, such measures of access to the system tell us little about how well transit links people to destinations. For this reason, measures of accessibility are generally preferred. Indeed, accessibility – the ease with which destinations can be reached for a given transportation-land use configuration – has been identified as a fundamental metric of transportation system performance (Golub and Martens, 2014; Grengs, 2015a; Martens, 2012). Accordingly, it has seen widespread application in both the literature and practice of transportation equity analysis (e.g., Páez et al., 2010; SCAG, 2012) and is an ideal measure upon which to base a public transit equity evaluation. Calculating true accessibility requires linking measures of the opportunities available across space (e.g. employment, healthy food, education) with general measures of travel cost. Because of the importance of employment to well-being, job accessibility is commonly used (e.g., Golub and Martens, 2014; Hu, 2015; Manaugh and El-Geneidy, 2012). When assessing the employment accessibility landscape faced by different demographic groups, it is important to use

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