



A comparative analysis of the challenges in measuring transit equity: definitions, interpretations, and limitations

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ABSTRACT

In the study of equity in public transit service distribution to disadvantaged groups, there is often a desire for a concise and relatable quantitative measure of equity. This ambition has often pushed researchers to develop methods for combining (or aggregating) various dimensions of disadvantage into a single, multi-faceted metric of potential transit demand (or need) among the disadvantaged population. These metrics then enable a somewhat straightforward analysis of the transit needs of the aggregate disadvantaged population to the transit service supplied in order to arrive at a measure of transit equity.

More recently, it has been proposed that such aggregated transit equity analysis may introduce veiled judgments or bias through the specific interpretation of key definitions and through the particular choices in the construction of a combined metric. It may also be the case that such an aggregate metric may mask or convolute important disparities in transit equity experienced by the various disadvantaged populations aggregated into a combined metric.

This research studies these issues through a clear discussion of the ambiguity and implied judgments often found in transit equity literature and then provides recommendations to mitigate these issues. Also, two common equity analysis methods are compared through a case study of public transit service in the city of Corvallis, Oregon, and a new transit service metric construction is introduced. By comparing the results of both the aggregated and disaggregated forms of disadvantaged group transit need within each analysis method, this study provides further evidence that important information may be concealed or easily misinterpreted when using aggregated descriptions of transit need.

1. Introduction

Public transit in the United States is a subsidized transportation service and, as such, it is considered a service required to be open and available to the entire public (Walker, 2012). It is this understanding of transit that drives one of its fundamental goals, i.e., to provide mobility benefits to the population as a whole. Unfortunately, this notion of responsibility to the public has occasionally been narrowly interpreted by transit providers and governments to mean only a bare minimum level of access to transit needs to be offered to everyone. However, the idea of public responsibility has come to mean transit service should instead be distributed based upon ideas of equity and need (Walker, 2008). Since the operation of public transit is inherently a spatial problem, equity in public transit service (from a regulatory standpoint) has historically had spatial considerations as integral, core components.

General transportation equity to disadvantaged groups has been made a progressively more explicit requirement through legislation and

regulations such as Title VI of the 1964 Civil Rights Act, the 1994 Executive Order 12898, and the Transportation Equity Act for the 21st Century (TEA-21) (Marcantonio et al., 2017; Martens et al., 2012). These equity requirements have been carried over into recent legislation and guidelines, including the Fixing America's Surface Transportation (FAST) Act of 2015 and additional Federal Transit Administration (FTA) regulations, which require all federal funding recipients to distribute services equitably, mitigate disparate impacts, and conduct equity analysis if they service areas whose populations are larger than 200,000 (FTA, 2012a; 2012b). Often, these requirements are seen as too variable and vague because of the many definitions of equity used, the various analysis methods available, and the many possible subjective decisions and interpretations contained in the analysis methods (Karner, 2018; Karner and Golub, 2015; Marcantonio et al., 2017).

Therefore, the main goal of this research is to seek clarity in transit equity analysis by highlighting the many possible areas where degradations in clarity could be unwittingly introduced, and to offer

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mitigation suggestions. This is accomplished by 1) reviewing the manner in which quantitative methods are commonly applied for measuring and describing transit equity, 2) highlighting the qualitative issues that arise when using possibly ambiguous terminology (e.g., *equity*, *equality*, and *accessibility*), and 3) illuminating the assumptions inherent within a chosen methodological approach introduced through the transport disadvantage factors selected to include or exclude. It is also important to understand the benefits and limitations of two commonly used analytical methods in transit equity analysis, Lorenz curves with Gini coefficients and needs gaps, each coupled with the common practice of using aggregated depictions of disadvantaged group need. The hypothesis is that a lack of clear and explicit definitions, unacknowledged assumptions, biases, judgments, and aggregated measures of disadvantage group need, all combine to produce results which could be easily misinterpreted. These results could also obscure the unintentional (or intentional) judgements and values introduced by the methodological decisions (Brick, 2015; Walker, 2018). With support through literature, this hypothesis is explored by applying and comparing methods and their parameters in a case study.

The remainder of this manuscript is organized as follows. A review of relevant topics to this research study is presented, followed by a description of the methodology used for the case study. The results of the case study are discussed, and finally, the research findings, limitations, and opportunities for future work are presented in the conclusion.

2. Literature review

Transit-specific and equity-specific terminology can easily be misinterpreted as their common English usage lacks the specificity of meaning intended by researchers. This can lead to ambiguous statements or misinterpretation of results. In attempting to address any of the issues found in equity analysis, four key concerns arise from the literature:

- How is transit equity defined and understood (Garrett and Taylor, 1999; Kamruzzaman et al., 2016; Litman, 2016; Manaugh and El-Geneidy, 2012)?
- What are the set of factors chosen to represent some level of transport disadvantage (Al Mamun and Lownes, 2011b; Delbosc and Currie, 2011a; Fransen et al., 2015)?
- How are these definitions and factors then used to measure or quantify transit equity (Al Mamun and Lownes, 2011a; Grengs, 2015; Welch and Mishra, 2013)?
- What are the analysis methods used, and what are their accompanying assumptions and implications (Biba et al., 2010; Currie, 2010; Foda and Osman, 2010; Fransen et al., 2015)?

The following sections present the relevant prior work that was reviewed and synthesized to elucidate these questions.

2.1. Definition of equity

The term *equity* is often used interchangeably with the term *equality* which can lead to confusion. Therefore, it is critical to explicitly state the meanings of these two terms in transit research, and to acknowledge the possibility of ambiguity due to unclear use in prior literature. Generally, the concept of equality is understood to suggest that people or groups have the same rights and opportunities and should therefore be treated equally. It is helpful to think of equality as being related to “equal” or “sameness”. In the context of public transit, a goal of service equality would mean that all groups should be provided the same level of service. Therefore, equality is impractical and rarely the goal in practice or research.

In contrast, the concept of equity is understood to mean that, since people or groups may not have the same opportunities, they should be provisioned differently to address the disparities in opportunity (Brick,

2015). Thus, equity is more related to “fairness” or “justice”. With this definition of equity, inequity is then understood to refer to a lack of equity. In more recent transit equity analysis research, equity is further distinguished as either *horizontal equity* or *vertical equity* (Bandegani and Akbarzadeh, 2016; El-Geneidy et al., 2016; Pyrialakou et al., 2016; Welch, 2013). With these understandings of the terms, it is important to note that in transit equity research, it is the levels of equality which are measured directly. In order for a researcher to make claims of equity, subsequent analyses are required, or an explicit statement of the values and priorities used to relate equality to equity is needed. In other words, equality is not a subjective measure, but equity is always value based.

As opposed to horizontal equity (i.e., equity under the assumption of equally abled groups or individuals), the majority of transit equity literature focuses on the concept of vertical equity, which is concerned with situations where there is inequity experienced by disadvantaged individuals or groups. The latter are sometimes referred to as vulnerable groups, Environmental Justice (EJ) communities, or communities of concern (Rowangould et al., 2016; Welch, 2013). The drive is to then provide greater accessibility to these groups (e.g., minorities, poor, elderly, disabled, etc.) in order to achieve equity of opportunity.

Vertical equity is further divided with increasing specificity by Litman (2002), who uses “Vertical Equity with Regard to Income and Social Class” to refer to what generally may be understood as *socio-economic equity*. The concept of socioeconomic equity is often the concern of those performing transit equity research. The terms social disadvantage, social exclusion, social justice, social sustainability, etc., as they relate to transportation, while distinct, are highly interrelated and are found addressing concerns similar to socioeconomic equity in the transit equity literature (Bennett and Shirgaokar, 2016; Dodson et al., 2004; Fransen et al., 2015; Kamruzzaman et al., 2016; Martens et al., 2012).

Litman (2002) uses the term “Vertical Equity with Respect to Need and Ability” to refer to the concept of *equity in mobility*. While factors of disadvantage often overlap, the concept of equity in mobility can be thought of as equity concerns for those who are disadvantaged by limited personal or transportation mobility (e.g., youth, seniors, spatially isolated, unlicensed, walkers, disabled, tourists, etc.). Most transit equity literature concerning equity in mobility is done in conjunction with analysis also containing factors of socioeconomic equity (Brick, 2015; Kaplan et al., 2014; Ricciardi et al., 2015).

2.2. Factors of transport disadvantage

When conducting research on vertical equity in transit, it is necessary to specify which set of factors will be used to define potentially disadvantaged groups. Since this set of factors then becomes the basis of the analysis into whether transit inequities exist between groups, their selection is considered one of the most critical steps in transit equity analysis (Foth et al., 2013). Within the transit equity literature, researchers often choose several factors to study. However, the factor of spatial location is always inherently included in transit research, predominantly through the relative location of domiciles to other locations of interest within a defined area.

The factors of disadvantage which can be broadly categorized as socioeconomic are those which stratify groups of people based on socially constructed concepts and delineations, as opposed to a physical or logistical disadvantage. The most commonly found socioeconomic factors in the transit equity literature are those that are also found across general social equity literature, and those mentioned in laws and regulations. They include race and ethnicity (Karner and Niemeier, 2013), income (El-Geneidy et al., 2016; Ricciardi et al., 2015), and employment status (Pyrialakou et al., 2016; Wixey et al., 2005). Less commonly seen factors include gender (Dobbs, 2005; Rogalsky, 2010), local language fluency (Litman, 2016), immigrant status (Bennett and Shirgaokar, 2016; Heisz and Schellenberg, 2004; Manaugh and El-Geneidy, 2012), and single parent status (Kramer and Goldstein, 2015);

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