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# Comparing Two Common Approaches to Public Transit Service Equity Evaluation

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**ABSTRACT**

Understanding the equity effects of transit service changes requires good information about the demographics of transit ridership. Both on-board survey data and census data can be used to estimate equity effects, though there is no clear reason these two sources will result in the same finding of impact. Guidance from the Federal Transit Administration (FTA) recommends using either of these data sources to estimate equity impacts. This article makes a direct comparison of the two methods for the public transit system in the Phoenix, Arizona metropolitan area. The results indicate that, although both sources are acceptable for FTA compliance, the use of one or the other can affect whether a proposed service change is deemed equitable. In other words, the outcome of a service change equity analysis can differ depending on the data source used. To ensure the integrity and meaning of the analysis, FTA should recommend the collection and use of ridership data for conducting service change analyses to supplement census-based approaches.

## INTRODUCTION

Public transportation systems serve at least two distinct groups of riders (*1*, *2*). They provide a basic level of mobility and accessibility for transit dependent populations – those without automobile access or convenient non-motorized options – and also provide alternatives for some commuters that have access to an automobile but choose to use transit. Luring commuters out of their cars and into public transportation is thought to reduce congestion and improve air quality. On the other hand, transit dependent populations are generally politically marginalized and find it difficult to muster public support for systems that meet their needs. Accordingly, public transit policy and finance has tended to favor the provision of commute alternatives over services for transit dependents over the past several decades (*1*).

Important differences exist in the transit technologies used to serve these two populations. Bus transit is typically used to meet the basic mobility and accessibility needs of the transit dependent. Since riders are few and destinations are not centralized, buses provide a flexible option for meeting existing needs and adapting to changes in the urban form and settlement patterns. Commute alternatives are generally provided by fixed-guideway infrastructure linking established residential (suburban) and job (central business district) locations.

Because rail commuters tend to be wealthier and whiter than transit dependents (*3*), and because of the higher expense of rail relative to bus, transit riders in cities across the US have increasingly been calling attention to *transit equity*. In many cases, lawsuits have alleged discriminatory funding policies, in violation of federal civil rights law, at public transit and regional transportation planning agencies (*4*-*6*).

To protect against discriminatory outcomes, since 2007, the Federal Transit Administration (FTA) has required fund recipients located in urbanized areas exceeding 200,000 in population to perform a service equity analysis whenever a “major service change” is undertaken (*7, 8*). Similarly, a fare equity analysis is required whenever a fare change is proposed. The analysis is intended to determine whether a proposed service or fare change will have a disparate impact on racial minorities or place a disproportionate burden on low-income people.

Legal challenges and popular opposition to certain transportation programs and projects have persisted despite this FTA requirement. Occasionally, this is because an agency foregoes its responsibility to analyze proposed changes as occurred recently in the San Francisco Bay Area (*9*) and Los Angeles. But even when the results indicate a non-discriminatory outcome, transit advocates are rarely appeased. This article investigates the importance of a key shortcoming in the FTA-prescribed analysis that may affect its ability to detect the actual equity impacts of transit decisions. Specifically, the FTA describes two methods for quantifying populations served by particular transit routes: population-based and ridership-based. Both are deemed acceptable, but the hypothesis of this article is that that they will provide different results. It is therefore possible that an analysis resulting in a null finding of discrimination would actually be found to discriminate under alternative, but entirely reasonable analytical assumptions. This work should be useful for FTA, its fund recipients, and bus riders and their advocates interested in ensuring non-discriminatory outcomes in their regions.

## LITERATURE REVIEW

The issue of public transit equity and the link to civil rights has generated substantial interest in the literature, dating back to the early 1980s (*4-6, 10, 11*). Much of this work describes the ridership of different transit modes in a region, illustrating important differences between the demographics of transit dependent local bus users, and relatively wealthier, whiter suburban residents using fixed guideway commute alternatives. Both the courts and executive agencies have, at turns, acknowledged that discrimination in service provision exists and have taken steps to rectify the situation. One of the most prominent cases involved the Los Angeles Metropolitan Transportation Authority in the 1990s (*4, 12, 13*). There, bus riders successfully argued that LA Metro had created a separate and unequal transit system for minority riders. The court-ordered consent decree demanded that the agency maintain then-current fare levels and acquire new rolling stock to reduce overcrowding.

Inspired in part by these differences in transit riderships, the literature contains many analyses that compare current transit service levels, access, or accessibility to census demographics (*14-19*). Regional agencies also routinely include transit level-of-service analyses in their regional plans (*20-22*). These studies invariably demonstrate that current arrangements are equitable – areas inhabited by low-income and minority populations tend to enjoy superior access to transit service or accessibility to transit. However, these results are mostly due to the concentration of transit service and minority and low-income populations in traditional central business districts. Recent work has shown that competition for low-skilled jobs in these areas is high (*23*). Further, operationalizations of accessibility, especially those based on traditional four step travel demand models are likely to suffer from issues of accuracy and scale, especially when transit travel times are used (*24*). Additionally, there is no *a priori* reason to prefer one metric over the other, and comparative assessments of different metrics, data, or approaches are rare (but see *25*).

The Federal Transit Administration (FTA) has promulgated guidance in this area, and recent experience illustrates their willingness to enforce civil rights law (*9*). Despite FTA activity, transportation researchers have engaged very little with federally-required analyses. One method, required in various forms by FTA since at least 2007 (*8*) involves an explicit assessment of the equity of proposed service and fare changes. Because of the ubiquity of this approach, but a lack of systematic investigation of its meaning or theoretical foundations, it is the subject of the remainder of this paper.

### *FTA service and fare changes*

The FTA-required fare and service equity analysis methods are described in 2012 FTA Circular 4702.1B (*7*), and update of similar methods outlined in a 2007 circular (*8*). As of late 2013, FTA was still engaged in reviewing and approving the analytical approaches of and proposals from transit agencies across the nation (*26*, p. 7). The stated purpose of the analysis as described by the circular is to “determine whether the planned changes will have a disparate impact on the basis of race, color, or national origin” or whether low-income populations will bear a disproportionate burden resulting from the change (*7*, p. IV-11).

Only operators that provide a peak service consisting of 50 or more vehicles and that are located in an urbanized area exceeding 200,000 in population are required to conduct the analysis when considering a “major service change”; the definition of same is left to the discretion of the agency (*7*, p. IV-12). The determination of either disparate impact or disproportionate burden involves the creation of a “comparison population” described by the FTA as follows, “all persons who are either affected by the service or fare changes or who could possibly be affected by the service or fare change” (*7*, p. IV-11).

The agency must establish a threshold for determining whether disparate impacts or disproportionate burdens are likely to occur as a result of a proposed change. The minority/low-income proportion in the comparison population (i.e. those actually or likely to be affected by the proposed change) is compared to the system-wide minority/low-income proportion. If the percentage point difference exceeds the threshold the agency must either justify their decision or consider other options.

The distinction between "possibly" affected persons and affected persons is important and results from the existence of two types of data sources for analyzing transit demographics: ridership and census data. Ridership data must be collected from relatively expensive and time consuming on-board surveys. Census demographics are thought to represent potential ridership and can serve as a less expensive proxy where detailed ridership data are not available. Although FTA recommends the use of one data source over the other in certain instances, in practice data availability will drive this decision. FTA does not discuss whether a different determination of equity could be reached based on the type of data used, nor do they recommend using both and interpreting any differences in results.

The typical service analysis proceeds as follows, based on a review of publicly available presentations given by FTA to fund recipients, and some publicly available service equity analyses (*27, 28*):

1. Establish demographics of the service area. Either census demographics or ridership can be used for this purpose. Whichever is used should be employed in the remainder of the analysis (*7*, p. IV-15). The service area can be defined as the city/cities or statistical area in which the transit service operates. These demographics provide a baseline against which to compare the demographics of individual line or aggregate service changes.
2. Establish demographics of affected populations. For proposed service reductions and enhancements, determine the affected demographics using buffers around transit terminals (census data) or ridership data.
3. Compare the population proportion of minority and low-income riders to the service area population. If the difference in proportions between the affected population and the service area population exceeds the threshold amount, there is likely to be a disparate impact or disproportionate burden.
4. (If necessary) Alter or cancel the offending service change.

The requirements for the fare change analysis are similar in concept, but require data on the fare media use by demographic group since they, by definition, form the affected population. FTA specifically notes that census data are not appropriate for this purpose (*7*, p. IV-19). Additionally, all fare changes must be analyzed for equity – there is no "major" fare change. Because of this explicit guidance regarding fare equity data, the remainder of this paper focuses on service equity analysis.

## DATA AND METHODS

The methods and data used in this study are designed to compare alternative methods for assessing the equity implications of transit service changes. To this end, data were assembled that facilitate a comparison between census demographics and ridership in the Phoenix, Arizona metropolitan area in the southwestern United States. Phoenix is the sixth largest city by population and the metropolitan area is the 13th largest in the US as of mid-2014. The regional transit operator, Valley Metro, maintains a multimodal public transportation system, with recently implemented light rail.

In addition to comparing ridership and census demographics, this article simulates the effect of a service change scenario on public transit equity, demonstrating how different data lead to different equity outcomes. These types of data comparisons could be built into the requirements promulgated by the FTA and/or adopted in analyses conducted by transit providers.

***Transit data***

The location of transit stops and information on the stops served by each route were taken from Valley Metro's General Transit Feed Specification (GTFS) data, current as of May, 2014. Although Valley Metro does not make their data openly available to the public, it is possible to register as a developer with the agency and download the feed. Because the GTFS data were from mid-2014 and the ridership survey was conducted over 2010-2011, there were discrepancies in the routes included within each. In additional to light rail, 91 bus routes were identified in both datasets, 10 were in the ridership data but not in the GTFS feed and eight were in the GTFS feed but not in the ridership data. Although the possibility exists that individual stops were changed on positively identified routes, it is likely that the route number would have been changed if stops were changed so substantially as to alter the ridership of the route. Most of the routes no longer included in the feed were cancelled, merged, or otherwise underwent substantial service changes and were renumbered.

After loading the stop data into a geographic information system, buffers around stops were produced with radii differing depending on mode, following the FTA guidance. All bus stops were buffered at 1/4 mile. Buffers were dissolved at the route level to avoid double counting. Similarly, when presenting results by mode and service area, all buffers were dissolved so that persons were only counted once.

***Ridership data***

Data on transit ridership come from the Valley Metro 2010-2011 Transit On-Board Survey. Full details of the survey design and administration are described elsewhere (*29*). In brief, the survey was conducted during weekdays spanning an approximately five month period from October, 2010 to February, 2011. The survey was extensive and was intended to quantify changes in ridership resulting from the implementation of light rail in the region. Sampling targets were established by mode and by route, to ensure that a 5% sample was achieved, even on small routes. Random samples were drawn within particular transit vehicles operating on each route. In addition, light rail was sampled heavily, with goals established for each station location. The overall response rate was 90% and sampling targets were met on all routes.

Two types of weights were used to expand the sample to the population of transit riders: unlinked and linked trips. Weighting factors were developed based on time of day and direction of travel for all modes. Light rail trips were additionally controlled for between station movements and high-volume bus routes accounting for 50.3% of average weekday bus ridership were controlled for total boardings at the route-segment level. The practical result is an estimate of average weekday transit ridership demographics at least at the level of the route, and often at the level of a stop. Unlinked trip weighting factors that count each trip separately were used in this study since the interest was in route-level ridership. On routes with low ridership, the 5% sample employed is likely to result in relatively large standard errors. However, neither the survey consultants nor FTA provide guidance on the consideration of error in equity analyses. We therefore employ the route-level estimates, assuming that the same would be done in practice.

### *Census data*

Census data on total population, households, and population race/ethnicity were assembled from 2010 Summary File 1. Data on income were assembled from the American Community Survey (ACS) 2008-2012 five year estimates. Summary File 1 data were tabulated at the block level while ACS data were tabulated at the block group level. Because of the arbitrary nature of transit stop-level buffers, areal interpolation – transferring data from one set of geographic zones to another – seemed appropriate (see, e.g., ref. *30*). FTA guidance states that data from an entire census unit can be used if a transit buffer intersects it (*8*, p. IV-14), but this may introduce additional error, especially considering the relatively small buffer size recommended for local bus routes (1/4 mile around transit stops). To correspond census blocks to transit route buffers, we area-weighted based on the proportion of block area that overlapped the buffer. This approach assumes that populations are evenly distributed throughout blocks.

Researchers have lamented the loss of income data from the census summary file, and for good reason. The income data available in the ACS are not of the quality of prior decennial census estimates and present important limitations that must be addressed. In order to determine income demographics for transit buffers, data on household income from the ACS block group data were adjusted to create “pseudo” ACS blocks. First, ACS block group households were allocated to 2010 census blocks according to the proportion of block households within block groups. The resultant weighting factor was applied to ACS 2008-2012 households, and the areal interpolation method followed for census blocks described above was applied.

## RESULTS AND DISCUSSION

The Phoenix metropolitan area and its transit services are shown in Figure 1. The history of transportation policy and planning in Phoenix echoes many other southwest US cities and is dominated by automobile infrastructure even though a modest electric streetcar system did serve downtown Phoenix throughout the first half of the 20th century. From the 1950s until the mid-2000s, however, the bus system grew and remained the main form of public transportation. As of mid-2014, there are approximately 98 bus rapid transit, local, rapid, express, rural, and local circulator bus routes carrying approximately 170,000 passengers per day. The 20-mile, 28-station light rail transit (LRT) line opened in December, 2008 and passes through central and east Phoenix before connecting to the neighboring cities of Tempe and Mesa. Only 2.4% of Maricopa County workers commute regularly by public transit, less than half the average rate for the United States. It is therefore not surprising that, as of the most recent on-board survey, most of the bus and LRT riders would be characterized as transit dependent; about half have no access to a vehicle, and 70% had annual incomes below $35,000 (*29*). On the other hand, there are important demographic differences between modes. Transit users that only took LRT tended to have higher household incomes than users that only took the bus (the proportion of riders with household incomes greater than $50,000 was 29% for LRT and 17% for bus) (*29*). Because the rapid and express service operated by Valley Metro primarily serves suburb – central city commuters, there are likely to be additional demographic differences as well. These are investigated further below.

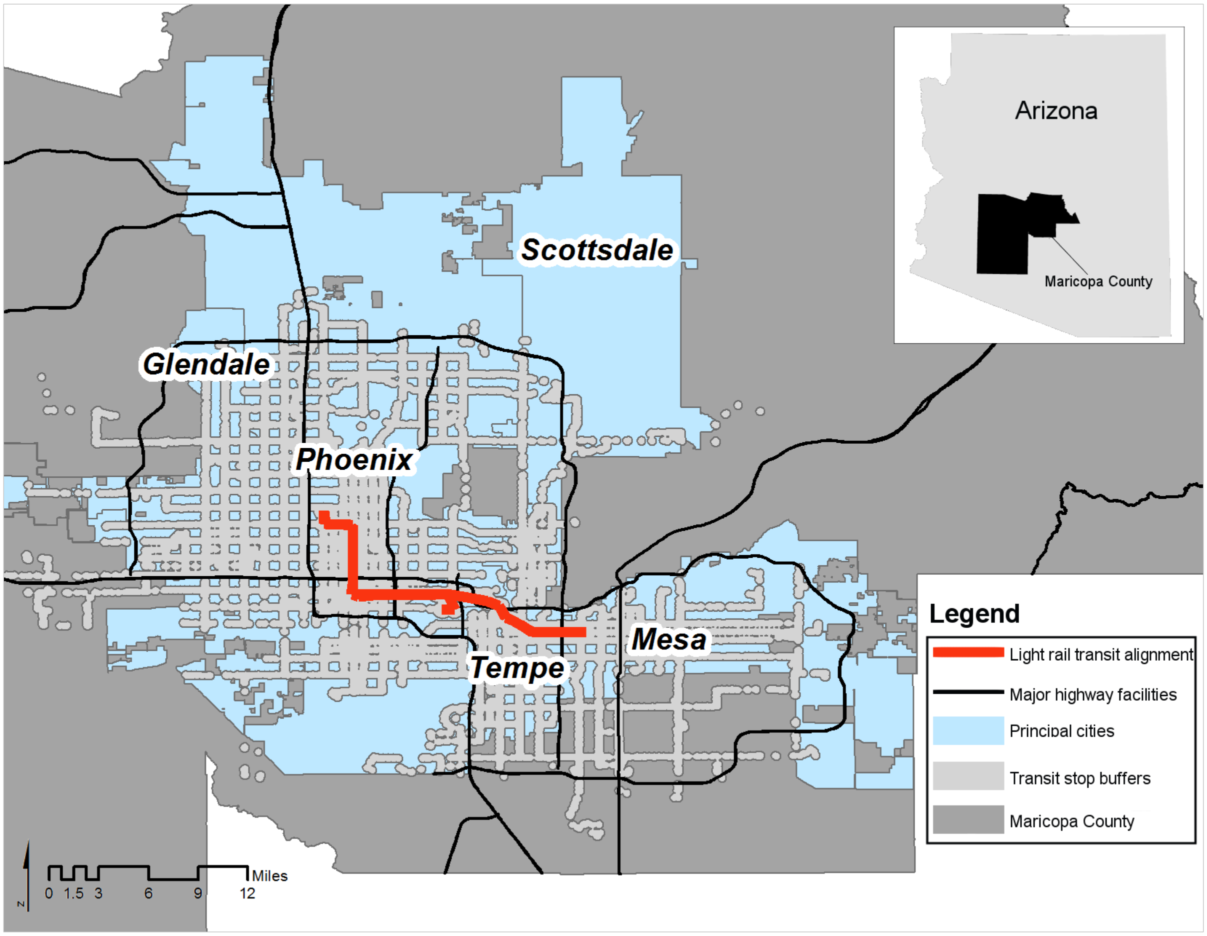


**FIGURE 1 Phoenix metropolitan region. Principal cities of the Phoenix-Glendale-Mesa Metropolitan Statistical Area, major highway facilities (Interstate freeways and state highways), LRT alignment, Valley Metro stop-level buffers for all transit and location of Maricopa County within Arizona shown.**

Key demographics relevant to transit service equity are summarized in Table 1. These include demographics for all route-level buffers, the city of Phoenix, the metropolitan statistical area, and the ridership of Valley Metro. Because the census asks separate questions regarding race and ethnicity, we have followed established practice and used only non-Hispanic or Latino respondents in each racial category. Hispanic or Latino population counts are grouped under the heading “Latino.” The people of color category is constructed by subtracting the non-Hispanic white population from the total population. Table 1 shows that the city of Phoenix demographics closely track the demographics indicated by the Valley Metro system but that both have higher proportions of people of color and low-income people than the greater metropolitan region. Additionally, the actual ridership of the transit system as measured using on-board surveys is substantially poorer and less white than indicated by any of the other demographic summaries. Indeed, black people disproportionately compose transit ridership in Phoenix, much as in other areas of the country. This finding is either due to different tastes for public transit among black people, superior service provided to black neighborhoods, or a poverty effect wherein black people are more likely to be poor and transit dependent. Somewhat surprisingly, Latinos are under-represented among transit users, relative to their population share. This may be due to stronger social networks and generally stronger propensity to share rides relative to non-Latinos.

**TABLE 1 Population Demographics**

| | total population | white | black | Latino | people of color | household income < $25K[c] |
|---|---|---|---|---|---|---|
| Valley Metro system demographics (buffers)[a] | 1,710,309 | 818,319<br>48% | 98,029<br>5.7% | 670,323<br>39% | 891,990<br>52% | 177,640<br>28% |
| City of Phoenix[a] | 1,445,632 | 672,573<br>47% | 86,788<br>6% | 589,877<br>41% | 773,059<br>53% | 131,563<br>25% |
| Phoenix-Mesa-Glendale MSA[a] | 4,192,887 | 2,460,541<br>59% | 193,497<br>4.6% | 1235,718<br>29% | 1,732,346<br>41% | 321,043<br>21% |
| Valley Metro system ridership[b] | 242,687 | 105,958<br>44% | 43,583<br>18% | 70,381<br>29% | 136,729<br>56% | 122,532<br>50% |

Note: The final column uses total number of households in the denominator. All other columns use the total population as the denominator. The final row (Valley Metro system ridership) counts total daily boardings, as opposed to members of the population.
[a]Census 2010, Summary File 1
[b]Valley Metro 2010-2011 On-Board Survey
[c]American Community Survey, 2008-2012 five year estimates

Because of prior evidence on differences in transit mode use by demographic group, Figure 2 illustrates the "comparison populations" for each mode operated by Valley Metro. Although the FTA guidelines only differentiate between bus and rail, Valley Metro operates several different "modes" of bus service that clearly cater to different transit riderships. Again, the census demographics tell a different story than the ridership data. Modes that provide high levels of service for peak period commuters – BRT, express, and rapid – show disproportionate white ridership relative to the census. On the other hand, modes providing local accessibility – light rail and local bus – show disproportionate shares of people of color overall, and black populations in particular. Again, Latino populations are underrepresented relative to their census demographics.

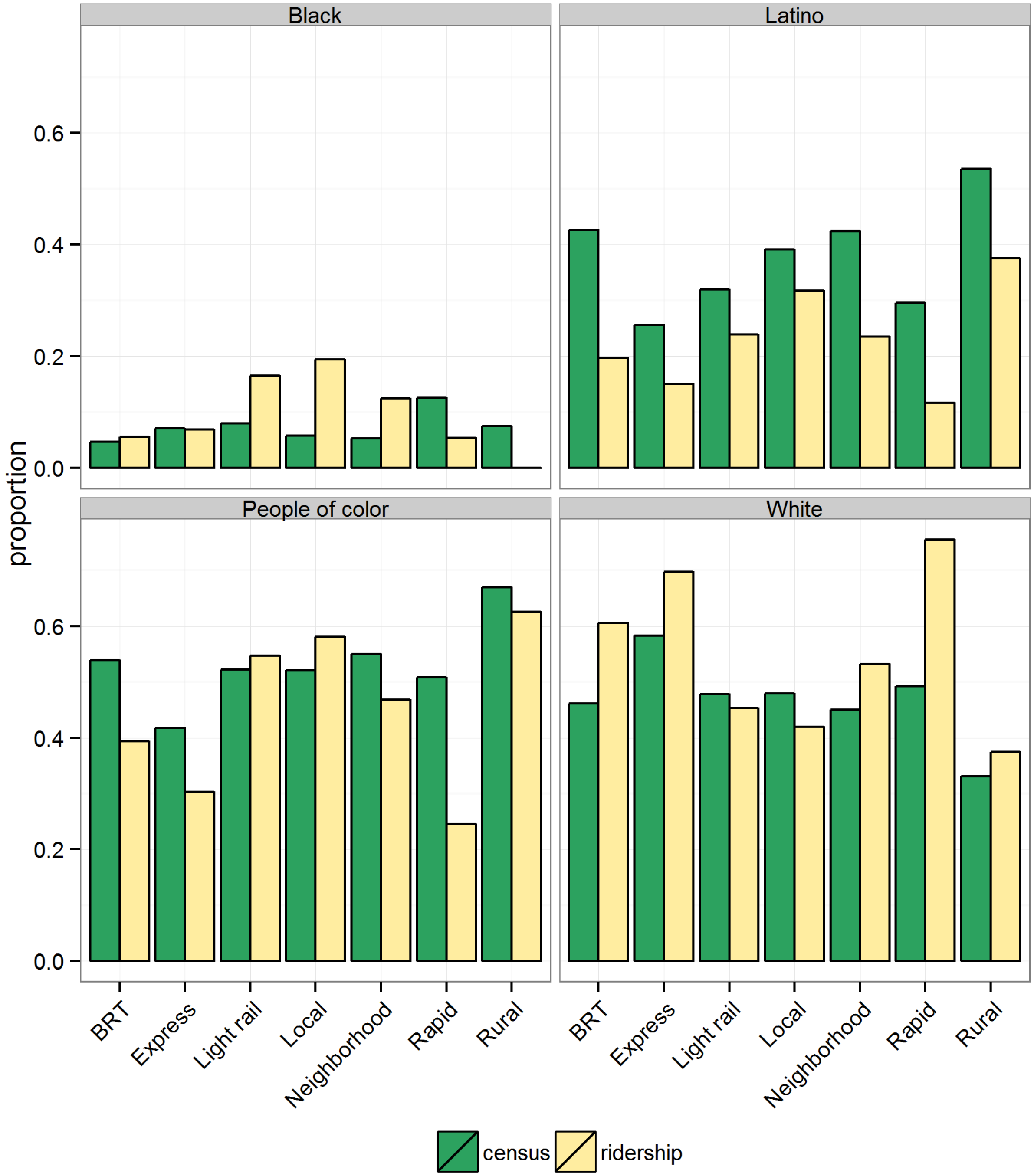


**FIGURE 2 "Comparison population" proportions for race and ethnicity based on census data and observed ridership. Data from 2010 US Census Summary File 1 and Valley Metro 2010-2011 On-Board Survey.**

These patterns generally hold for individual routes in the transit network. For each route, Figure 3 plots the proportion expected based on ridership data versus the proportion expected based on census demographics, disaggregated by race and ethnicity, and a 1:1 line for comparison. Points plotting above the line indicate a tendency for ridership to result in higher estimates than the census and those plotting below the line indicate the opposite. The results for people of color riders show a generally even split about the 1:1 line, indicating that there is no systematic propensity to over- or under-predict ridership based on one data source or the other. However, the results for black riders show that, in most cases, using census demographics will vastly understate ridership. For Latino populations, the use of census data will tend to overstate ridership. These results indicate the danger of viewing service equity analyses based solely on a single data source. Additionally, they show that disaggregating racial groups can reveal information about travel behavior that would be obscured if a single, “minority populations” definition is used, as recommended by the FTA. Figure 4 demonstrates a similar split based on income. Higher income groups tend to have higher estimated proportions based on census demographics as opposed to ridership data. For lower income groups, the opposite is true.

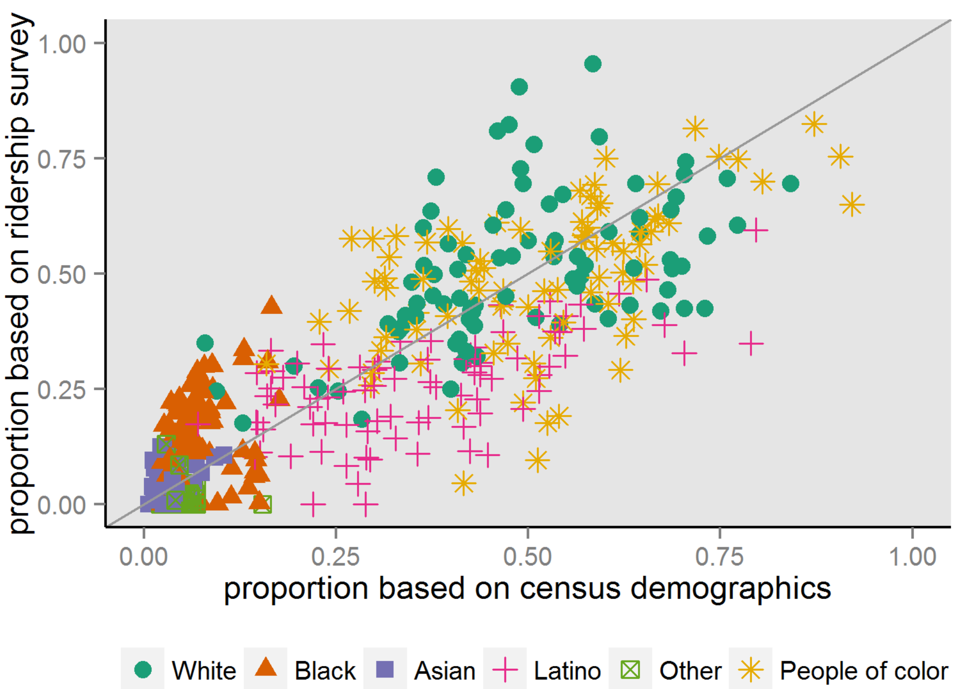


**FIGURE 3 “Comparison population” estimates based on observed ridership and census demographics calculated at the individual route level, race and ethnicity. Data from 2010 US Census Summary File 1.**

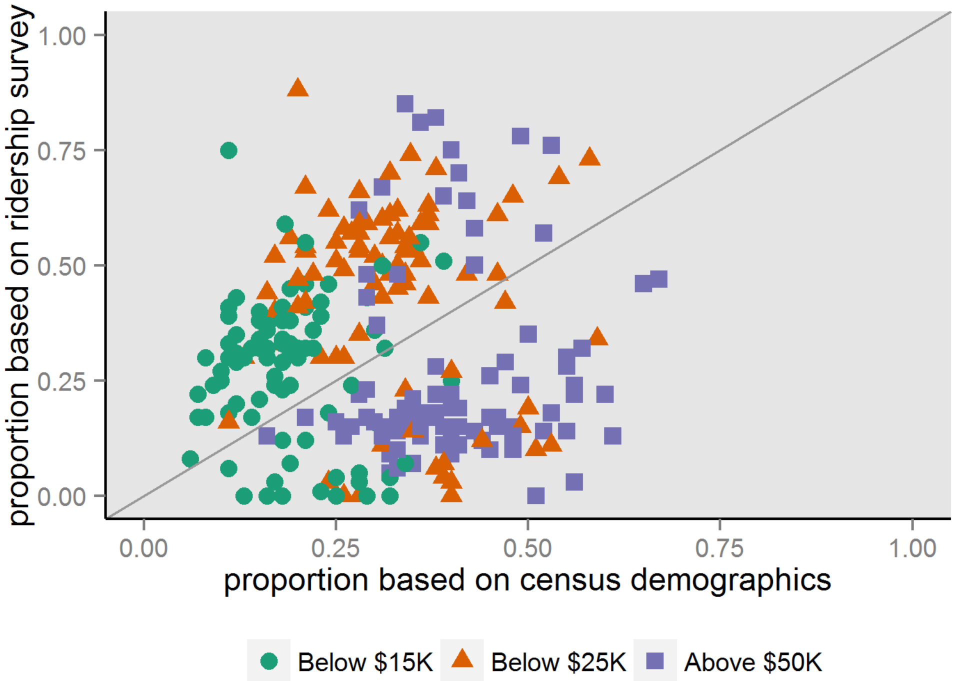


**FIGURE 4 "Comparison population" estimates based on observed ridership and census demographics calculated at the individual route level, income measures. Data from ACS 2008-2012 five year estimates.**

Figure 5 summarizes differences observed between census demographics and ridership for both race/ethnicity and income. It plots empirical histograms for three race/ethnicity categories and three income categories. The quantity represented is the difference in percentage points between the census demographics and ridership data for each route. Positive values indicate that census proportions are higher than ridership proportions. Histograms that are positively skewed show that, for a particular demographic group, ridership is higher than indicated by the census. Negatively skewed histograms show the opposite. The histograms confirm the results discussed above. Namely, that low-income and black populations are under-represented in census counts and white, Latino, and high-income populations are over-represented. The implications for FTA analysis are described below.

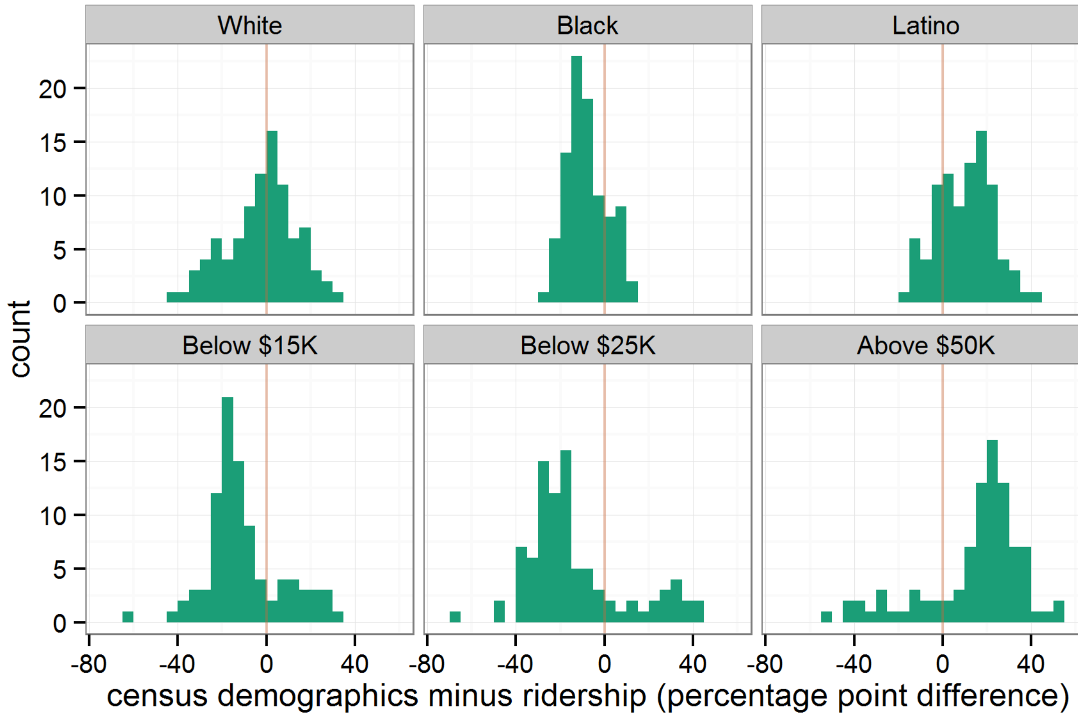


**FIGURE 5 Empirical histograms illustrating difference in census demographics and measured ridership by demographic group (positive numbers indicate that census data over-predicts ridership). Data from 2010 US Census Summary File 1, ACS 2008-2012 five year estimates, and Valley Metro 2010-2011 On-Board survey.**

### *Sample FTA analyses*

In order to demonstrate how discrepancies between ridership estimates and census demographics can materially affect the outcomes of an FTA service equity analysis, this section illustrates a typical analysis using the data assembled above. The first step is to define the reference population. FTA guidance is clear that either census demographics or ridership data should be used, but not both. The reference population based on ridership is unambiguous and can be determined using the weighted on-board survey data. Determining the reference population based on census figures is less straightforward as multiple candidate geographies are possible (Table 1). Since members of the population living outside of the buffer areas can also access the transit system, there is some merit in using a geographic definition that is more inclusive.

Table 2 illustrates the tradeoffs inherent in different reference population definitions by comparing each of the 91 common bus routes between 2010/2011 (on-board survey) and 2014 (GTFS) to three reference populations. The table shows how many routes exceed the reference population in terms of demographic proportion (indicating a possible disproportionate impact under proposed service *cuts*) and how many routes fall below the reference population in terms of demographic proportion (indicating a possible disproportionate impact under proposed service *improvements*). This analysis is equivalent to envisioning a hypothetical service change on each individual route.

**TABLE 2 Comparison of All Common Routes to Various Reference Populations**

| Reference population | people of color | black | Latino | household income < $25K |
|---|---|---|---|---|
| *Number of routes where minority population > reference population (possible discriminatory impact under service cuts)* | | | | |
| Service area (buffers) | 45 | 51 | 36 | 62 |
| Service area (MSA) | 66 | 68 | 55 | 79 |
| Ridership | 34 | 36 | 36 | 47 |
| *Number of routes where minority population < reference population (possible discriminatory impact under service improvements)* | | | | |
| Service area (buffers) | 46 | 40 | 55 | 29 |
| Service area (MSA) | 25 | 23 | 36 | 12 |
| Ridership | 57 | 55 | 55 | 44 |

As illustrated in Table 2, comparison populations based on census data are more likely to result in discriminatory findings when service is being cut and less likely when service is being improved. The greatest difference between ridership and demographics is observed when using the MSA population as a reference. Because of historic patterns of residential and commercial location decisions, MSA populations will tend to be whiter and wealthier than a more spatially constrained reference population or ridership. This result shows that the reference population definition can affect whether a particular transit planning decision (cut or improve service) is flagged for potential discriminatory impact.

The implications of these findings become clear when evaluating the equity implications of a specific service change. Valley Metro operates "Rapid" buses during peak periods between suburban park-and-ride locations and downtown Phoenix. The rolling stock is different from that used on local routes and has distinct livery. The 2010-2011 onboard survey only collected detailed ridership data on two out of four Rapid routes. Table 3 shows the results of a standard service equity analysis, assuming service improvements are proposed for both Rapid routes without simultaneous changes elsewhere. The analysis based on census demographics shows no evidence of disparate impact. Required measures for the comparison populations (proportion people of color and proportion low-income) equal or exceed those in the general population using both buffers and MSA reference populations. This means that people of color and low-income appear to disproportionately benefit from the service change. Ridership data, however, show the opposite. The people of color and low-income riderships are much lower than would be predicted by the census data. As a result, they are much lower than the reference population of system-wide ridership.

**TABLE 3 Sample FTA Analysis for Hypothetical Change to Rapid Service**

**Comparison populations**

| | white | people of color | black | Latino | household income < $25K |
|---|---|---|---|---|---|
| census | 6,524<br>48% | 7,158<br>52% | 2,008<br>15% | 3,975<br>29% | 1,396<br>48% |
| ridership | 1,337<br>76% | 434<br>24% | 96<br>7% | 205<br>12% | 205<br>11.5% |

**Reference population**

| | | | | | |
|---|---|---|---|---|---|
| Service area (buffers) | 48% | 52% | 6% | 39% | 28% |
| Service area (MSA) | 59% | 41% | 5% | 29% | 21% |
| Ridership | 44% | 56% | 18% | 29% | 50% |

A transit agency would not be able to proceed with these changes without further justification when using ridership data. It may be the case that Rapid service should never be improved on the grounds of providing enhanced service to commuters and an agency should improve service if there is a substantial legitimate justification to do so. However, with one data source, the agency would not have to justify the action and with another, they would. Additional standards and guidance from FTA could alleviate this problem.

## CONCLUSION

This article has shown that the outcome of an FTA-required service equity analysis can vary depending on the data used to characterize transit ridership. If census data are used, the analysis is more likely to show discriminatory impacts under service cuts and if ridership data are used, the analysis is more likely to show discriminatory impacts under service improvements. This result occurs because transit is likely to draw users from the surrounding area that are poorer and less white than the surrounding census demographics would suggest. As the proportion of low-income people and people of color in the reference population increase, it becomes more likely that the demographics of individual routes will fall below the reference population. Although it can be cost prohibitive to conduct a detailed, on-board ridership survey, the non-monetary cost of not obtaining detailed data on transit ridership appears to also be substantial. To ensure the integrity and meaning of the analysis, FTA should recommend the collection and use of ridership data for conducting service change analyses to supplement census-based approaches.

In the absence of detailed ridership information, extensive public outreach could also be conducted. Interviews with transit users, public meetings, and other public outreach activities would go a long way towards ensuring nondiscrimination in transit planning. It may also be possible to estimate ridership models for civil rights compliance that are applicable across jurisdictions. Future work by the authors will ascertain whether it is possible to represent route-level ridership using census data.

There are many additional studies that follow from this work and would serve to improve FTA-required equity analyses. All analyses proposed so far are based on the concept of a single transit boarding, yet other work has shown that different demographic groups not only use transit for different purposes, but have significantly different travel distances by transit (*31, 32*). A distance-based approach to equity would be likely to reveal rather different equity implications than those based on boardings alone.

New data and technology are becoming available that allow determinations of transit service equity based on accessibility. As noted by Bhat et al. (*33*), "ultimately [transit] service must provide convenient connectivity between origins and destinations of interest to the user in order to be 'accessible'" (emphasis added, p. 1). The use of accessibility metrics for assessing service equity would provide this insight and potentially lead to equity determinations much more grounded in the user's experience of a transit system.

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