Comparison of Two Common Approaches to Public Transit Service Equity Evaluation

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Understanding the equity effects of transit service changes requires good information about the demographics of transit ridership. Onboard survey data and census data can be used to estimate equity effects, although there is no clear reason to conclude that these two sources will lead to the same findings. Guidance from the FTA recommends the use of either of these data sources to estimate equity impacts. This study made a direct comparison of the two methods for the public transit system in the Phoenix, Arizona, metropolitan area. The results indicated that although both sources were acceptable for FTA compliance, the use of one or the other could affect whether a proposed service change was deemed equitable. In other words, the outcome of a service change equity analysis could differ as a result of the data source used. To ensure the integrity and meaning of such analyses, FTA should recommend the collection and use of ridership data for conducting service change analyses to supplement approaches that are based on census data.

Public transportation systems serve at least two distinct groups of riders (*1, 2*). They provide a basic level of mobility and accessibility to transit-dependent populations without automobile access or convenient nonmotorized options. They also provide alternatives to some commuters that have access to an automobile but choose to use transit. To lure commuters out of their cars and into public transportation is thought to reduce congestion and improve air quality. However, transit-dependent populations in general are politically marginalized and find it difficult to muster public support for systems that meet their needs. Accordingly, public transit policy and finance have 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. Typically, bus transit is used to meet the basic mobility and accessibility needs of the transit dependent. Buses provide a flexible option to meet existing needs and to adapt to changes in urban form and settlement patterns: riders are relatively few and destinations are not centralized. Commute alternatives in general are provided by fixed guideway infrastructure that links 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 United States increasingly have called 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, the FTA has required since 2007 that fund recipients in urbanized areas with populations that exceed 200,000 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 described here was intended to determine whether a proposed service or fare change would 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, an agency that foregoes its responsibility to analyze proposed changes has been the target of such challenges and opposition, as occurred recently in the San Francisco Bay Area and city of Los Angeles in California (*9*). Yet even when the results indicate a nondiscriminatory outcome, transit advocates are rarely appeased. The present study reported here investigated the importance of a key shortcoming in the FTA-prescribed analysis that might affect its capability to detect the equity impacts of transit decisions. Specifically, the FTA describes two methods to quantify populations served by particular transit routes on the basis of (*a*) census data and (*b*) ridership data. Both types of data are deemed acceptable, but the hypothesis of this study was that they provide different results. Thus it was possible that an analysis that resulted in a null finding of discrimination would actually be found to discriminate under alternative, but entirely reasonable, analytical assumptions. To investigate this possibility, this study compared census and ridership demographics and simulated the effect of a service change on public transit equity, which demonstrated how different data could lead to different equity outcomes. This work should be useful to FTA, its fund recipients, and to bus riders and their advocates, who wish to ensure nondiscriminatory 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, and dates back to the early 1980s (*4–6, 10, 11*). Much of this work described the ridership of different transit modes in a region, which illustrated important differences between the demographics of transit-dependent local bus users, and relatively wealthier, whiter suburban residents, who used fixed guideway commute alternatives. Courts and the executive agencies, by turns, have 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

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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 ridership, the literature contains many analyses that compared current transit service levels, access, or accessibility with census demographics (*14–19*). Regional agencies also routinely included transit level-of-service analyses in their regional plans (*20–22*). These studies invariably demonstrated that current arrangements were equitable: areas inhabited by low-income and minority populations tended to enjoy superior access to transit service or accessibility to transit. However, these results were mostly the result of a concentration of transit service and minority and low-income populations in traditional central business districts. Recent work showed that competition for low-skilled jobs in these areas was high (*23*). Further, operationalization of accessibility, especially for traditional four-step travel demand models, was likely to suffer from issues of accuracy and scale, especially when transit travel times were used (*24*). In addition, there was no a priori reason to prefer one metric over the other, and comparative assessments of different metrics, data, or approaches were rare [but see Horner and Murray (*25*)].

FTA promulgated guidance in this area, and recent experience illustrated its willingness to enforce civil rights law (*9*). Despite FTA activity, transportation researchers have engaged in little research on federally required analyses. One method of analysis, required in various forms by FTA since at least 2007 (*8*), involves an explicit assessment of the equity of proposed service and fare changes. Given the ubiquity of this approach but the lack of systematic investigation of its meaning or theoretical foundations, it was chosen as the subject of the study described in the remainder of this paper.

FTA Service and Fare Changes

FTA-required fare and service equity analysis methods were described in 2012 FTA Circular 4702.1B (*7*), and an update of similar methods was outlined in a 2007 circular (*8*). As of late 2013, FTA was still engaged in the review and approval of analytical approaches and proposals from transit agencies across the nation (*26,* p. 7). The stated purpose of the analysis as described by the circular was 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 would bear a disproportionate burden as a result of the change (*7,* p. IV-11).

Only operators that provide peak service that consists of 50 or more vehicles located in an urbanized area with a population that exceeds 200,000 are required to conduct the analysis when they consider 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 to determine whether disparate impacts or disproportionate burdens are likely to occur as a result of a proposed change. The minority and low-income proportion in the comparison population (i.e., those actually or likely to be affected by the proposed change) is compared with the systemwide minority and low-income proportion. If the percentage point difference exceeds the threshold, the agency must either justify its 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 to analyze transit demographics: ridership and census data. Ridership data must be collected from relatively expensive and time-consuming onboard surveys. Census demographics are thought to represent potential ridership and can serve as a less expensive proxy in which 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 drive this decision. FTA does not discuss whether a different determination of equity may be reached on the basis of the type of data used, nor do they recommend the use of both types and the interpretation of any differences in results.

Service Analysis Procedures

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

1. Establish the demographics of the service area. Either census demographics or ridership data may be used for this purpose. Whichever data are used, they should be employed in the remainder of the analysis (*7,* p. IV-15). The service area may be defined as the city (or 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 the demographics of the affected populations. For proposed service reductions and enhancements, determine the affected demographics through the use of buffers around transit terminals (census data) or ridership data.
3. Compare the population proportion of minority and low-income riders with the service area population. If the difference in proportions between the affected population and the service area population exceeds the threshold amount, a disparate impact or disproportionate burden is likely.
4. If necessary, alter or cancel the offending service change.

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

DATA AND METHODS

The methods and data used in this study were designed to compare alternative methods used to assess the equity implications of transit service changes. To this end, data were assembled that facilitated a comparison between census demographics and ridership in the Phoenix, Arizona, metropolitan area in the southwestern United States.

Transit Data

The location of transit stops and information on the stops served by each route were taken from the general transit feed specification

(GTFS) data, current as of May 2014, of Valley Metro, the regional transit system in the Phoenix metropolitan area. Although Valley Metro does not make its 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 during 2010 and 2011, discrepancies in the routes were included within each. In addition to light rail, 91 bus routes were identified in both data sets: 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 existed that individual stops were changed on positively identified routes, it was 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 canceled, merged, or otherwise underwent substantial service changes and were renumbered.

After the stop data were loaded into a geographic information system, buffers around stops were produced with radii that differed with the mode, in accordance with FTA guidance. All bus stops were buffered at ¼ mi. Buffers were dissolved at the route level to avoid double counting. Similarly, when the results were presented by mode and service area, all buffers were dissolved so that persons were counted only once.

Ridership Data

Data on transit ridership came from the Valley Metro 2010–2011 Transit On-Board Survey. Full details of the survey design and administration are available elsewhere (*29*). In brief, the survey was conducted during weekdays that spanned an approximately 5-month period from October 2010 to February 2011. The survey was extensive and was intended to quantify changes in ridership that resulted 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 that operated 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 on the basis of time of day and direction of travel for all modes. Light rail trips also were controlled for between station movements. High-volume bus routes, which accounted for 50.3% of average weekday bus ridership, were controlled for total boarding at the route-segment level. The practical result was 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 counted each trip separately were used in this study, given that the interest was in route-level ridership. On routes with low ridership, the 5% sample employed was 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. Thus the study employed the route-level estimates, with the assumption that the same would be done in practice.

Census Data

Census data on total population, households, and population race and ethnicity were assembled from the 2010 Summary File 1. Data on income were assembled from the 2008–2012 American Community Survey (ACS) 5-Year Estimate. 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 (i.e., transfer of data from one set of geographic zones to another) seemed appropriate (*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 use may introduce additional error, especially given the relatively small buffer size recommended for local bus routes (i.e., ¼ mi around transit stops). To equate census blocks to transit route buffers, area weighting was done on the basis of the proportion of block area that overlapped the buffer. With this approach it was assumed that populations were 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 earlier decennial census estimates and present important limitations that must be addressed. 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 households for 2008 to 2012, and the areal interpolation method used for census blocks (described earlier in the paper) 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 is similar to that of many other cities in the U.S. Southwest 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, approximately 98 bus rapid transit, local, rapid, express, rural, and local circulator bus routes carried approximately 170,000 passengers per day. The 20-mi, 28-station light rail transit (LRT) line, which opened in December 2008, passes through central and east Phoenix before it connects to the neighboring Arizona cities of Tempe and Mesa. Only 2.4% of Maricopa County workers commute regularly by public transit, which is less than half the average rate for the United States. Thus it was not surprising that, as of the most recent onboard survey, most of the bus and LRT riders were characterized as transit dependent; about half had no access to a vehicle, and 70% had annual incomes below $35,000 (*29*). However, important demographic differences were observed between modes. Transit users that took only the LRT tended to have higher household incomes than users that took only 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 to central city commuters, there are likely to be additional demographic differences as well. These are investigated here further.

Key demographics relevant to transit service equity are summarized in Table 1. These included demographics for all route-level buffers, the city of Phoenix, the metropolitan statistical area (MSA), and the ridership of Valley Metro. Census racial–ethnic categories were matched to those contained in the Valley Metro ridership survey. Because the census asks separate questions about race and ethnicity, this study followed established practice and used only non-Hispanic or Latino respondents in each racial category. Hispanic or Latino population counts were grouped under the heading "Latino." To

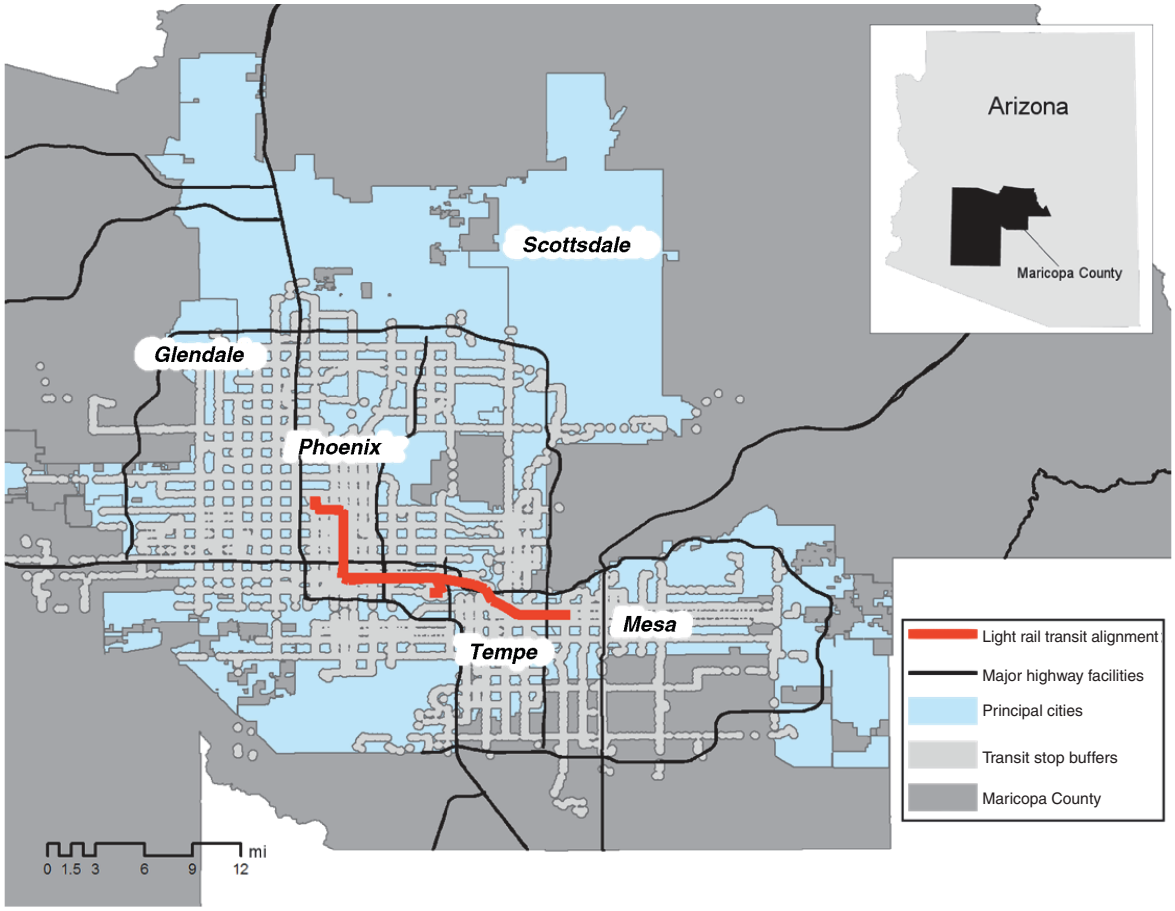

FIGURE 1 Phoenix metropolitan region showing principal cities of Phoenix–Glendale–Mesa MSA, major highway facilities (Interstate freeways and state highways), LRT alignment, Valley Metro stop-level buffers for all transit, and location of Maricopa County.

construct the category "people of color," the non-Hispanic white population was subtracted from the total population. For brevity, the census racial category of Black or African-American was shortened to "black." Table 1 shows that the city of Phoenix demographics closely tracked the demographics indicated by the Valley Metro system but that both had higher proportions of people of color and low-income people than the greater metropolitan region. In addition, the actual ridership of the transit system, measured through the use of onboard surveys, was substantially poorer and less white than indicated by any of the other demographic summaries. Indeed, black people disproportionately composed transit ridership in Phoenix, much as they did in other areas of the country. This finding may have resulted from (*a*) differences in taste in public transit among black people, (*b*) superior transit service provided to black neighborhoods, or (*c*) poverty (i.e., black people were more likely to be poor and transit dependent). Somewhat surprisingly, Latinos were underrepresented among transit users, relative to their population share, which may have reflected stronger social networks and a generally stronger propensity to share rides than was the case among non-Latinos.

Given earlier 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 differentiate between bus and rail only, Valley Metro operates several modes of bus service that clearly cater to different transit riders. Again, the census demographics told a different story than the ridership data. Modes that provided high levels of service to peak period commuters (i.e., bus rapid transit, express, rapid) showed disproportionate white ridership relative to the census. However, modes that provided local accessibility (i.e., light rail, local bus) served disproportionate shares of people of color overall, and black populations in particular. Again, Latino populations were underrepresented relative to their census demographics.

These patterns held in general for individual routes in the transit network. For each route, Figure 3 plots the proportion expected on the basis of ridership data versus the proportion expected on the basis of census demographics, disaggregated by race and ethnicity, and with a 1:1 line for comparison. In the figure, the points that plot above the line indicate a tendency for ridership to result in higher estimates than does the census and those that plot below the line indicate the opposite. The results for riders of color showed a generally even split on the 1:1 line, which indicated that there was no systematic propensity to over- or underpredict ridership on the basis of one data source or the other. However, the results for black riders showed that, in most cases, use of the census demographics would vastly understate ridership. For Latino populations, the use of census data would tend to overstate ridership. These results indicated a danger to view service equity analyses solely on the basis of a single data source. In addition, the results showed that the disaggregation of racial groups could reveal information about travel behavior that would be obscured if

TABLE 1 Population Demographics

Demographic	Total Population	White[a]		Black[a]		Latino[a]		People of Color[a]		Household Income < $25,000[b]	
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
Valley Metro system buffers[c]	1,710,309	818,319	48	98,029	5.7	670,323	39	891,990	52	177,640	28
City of Phoenix[c]	1,445,632	672,573	47	86,788	6	589,877	41	773,059	53	131,563	25
Phoenix–Mesa–Glendale MSA[c]	4,192,887	2,460,541	59	193,497	4.6	1,235,718	29	1,732,346	41	321,043	21
Valley Metro system ridership[d]	242,687	105,958	44	43,583	18	70,381	29	136,729	56	122,532	50

[a]Denominator = total population.
[b]American Community Survey, 2008–2012 5-year estimates. Denominator = total number of households.
[c]Census 2010, Summary File 1.
[d]Valley Metro 2010–2011 On-Board Survey. Total daily boardings, as opposed to members of the population.

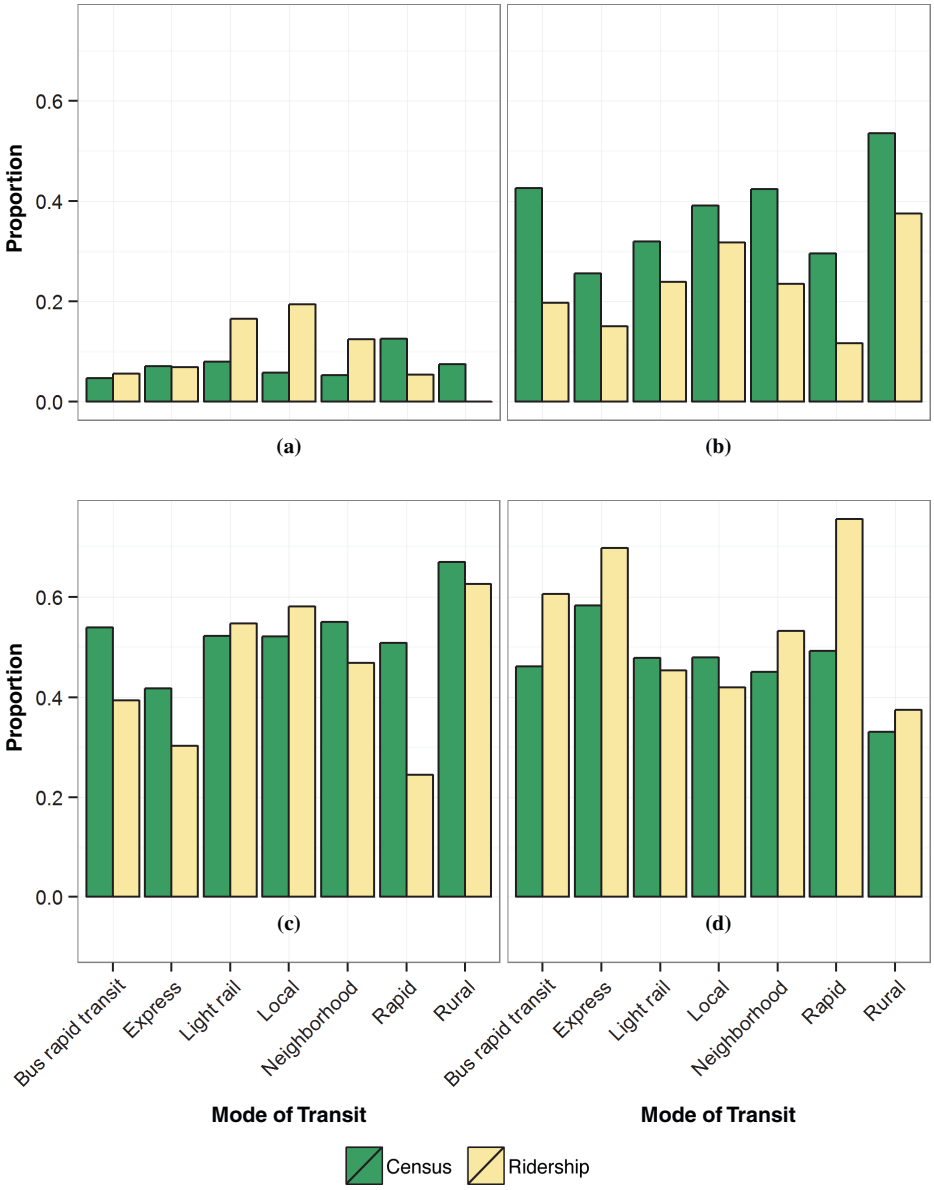

FIGURE 2 Comparison population proportions for race and ethnicity on basis of census data and observed ridership: (*a*) black, (*b*) Latino, (*c*) people of color, and (*d*) white. (Source: Data from 2010 U.S. Census Summary File 1 and Valley Metro onboard survey, 2010–2011.)

a single definition of minority populations was used, which FTA had recommended. Figure 4 illustrates a similar split on the basis of income. Higher-income groups tended to have higher estimated proportions on the basis of census demographics as opposed to ridership data. For lower-income groups, the opposite was true.

Figure 5 summarizes differences observed between census demographics and ridership for race and ethnicity and income. It plots empirical histograms for three race and 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 (i.e., low-income and black populations are underrepresented in census counts, whereas white, Latino, and high-income populations are overrepresented). The implications for FTA analysis follow.

Sample FTA Analysis

To demonstrate how discrepancies between ridership estimates and census demographics can materially affect the outcomes of FTA service equity analysis, this section illustrates a typical analysis with the use of the data assembled and described in earlier sections of this paper. The first step is to define the reference population. FTA guidance is clear: either census demographics or ridership data should be

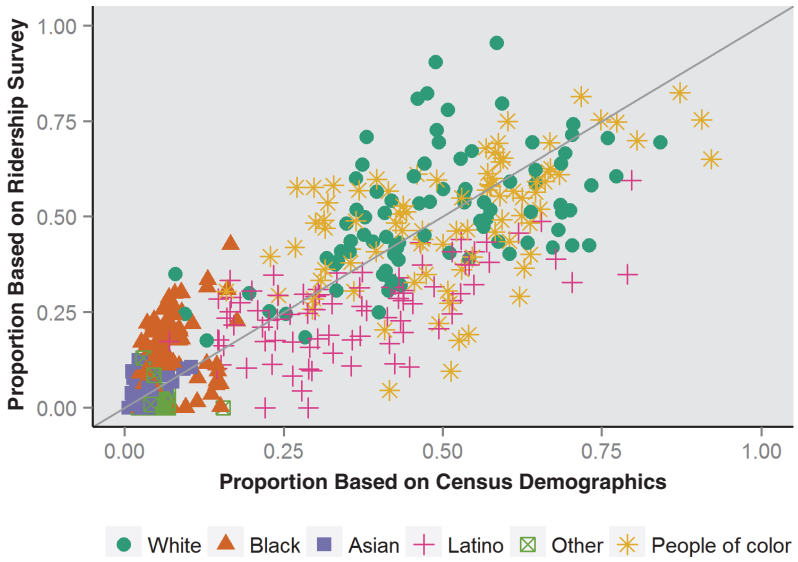

FIGURE 3 Comparison population estimates on basis of observed ridership and census demographics calculated at individual route level and for race and ethnicity. (Source: Data from 2010 U.S. Census Summary File 1.)

used but not both. The reference population on the basis of ridership is unambiguous and can be determined with the weighted onboard survey data. To determine the reference population on the basis of census figures is less straightforward, because multiple candidate geographies are possible (Table 1). Because members of the population who live outside the buffer areas also can access the transit system, there is some merit in the use of a geographic definition that is more inclusive.

Table 2 shows the trade-offs inherent in different reference population definitions. Each of the 91 common bus routes between 2010 and 2011 (onboard survey) and in 2014 (GTFS) are compared with the three reference populations. The table shows how many routes exceed the reference population in terms of demographic proportion (i.e., indicates possible disproportionate impact under proposed service cuts) and how many routes fall below the reference population in terms of demographic proportion (i.e., indicated possible disproportionate impact under proposed service improvements). This analysis is equivalent to the envisioning of a hypothetical service change on each individual route.

As illustrated in Table 2, comparison populations that had their basis in census data were more likely to result in discriminatory

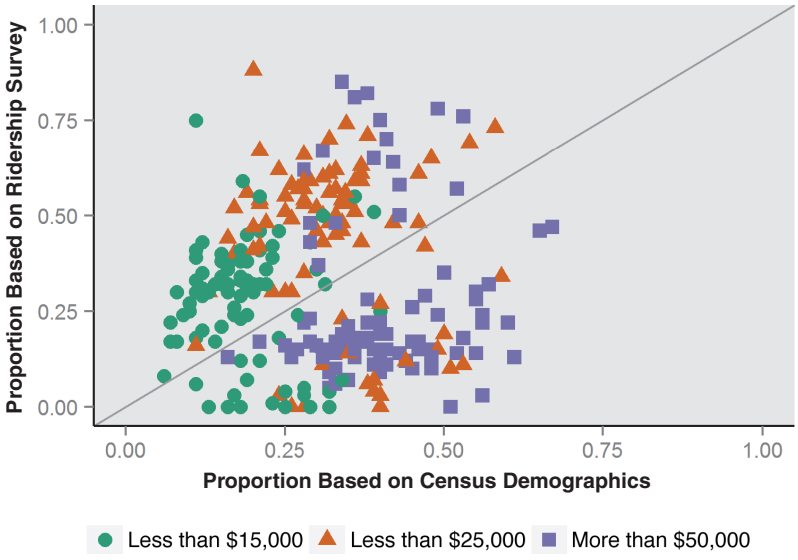

FIGURE 4 Comparison population estimates on basis of observed ridership and census demographics calculated at individual route level for income measures. (Source: Data from ACS 5-year estimates, 2008–2012.)

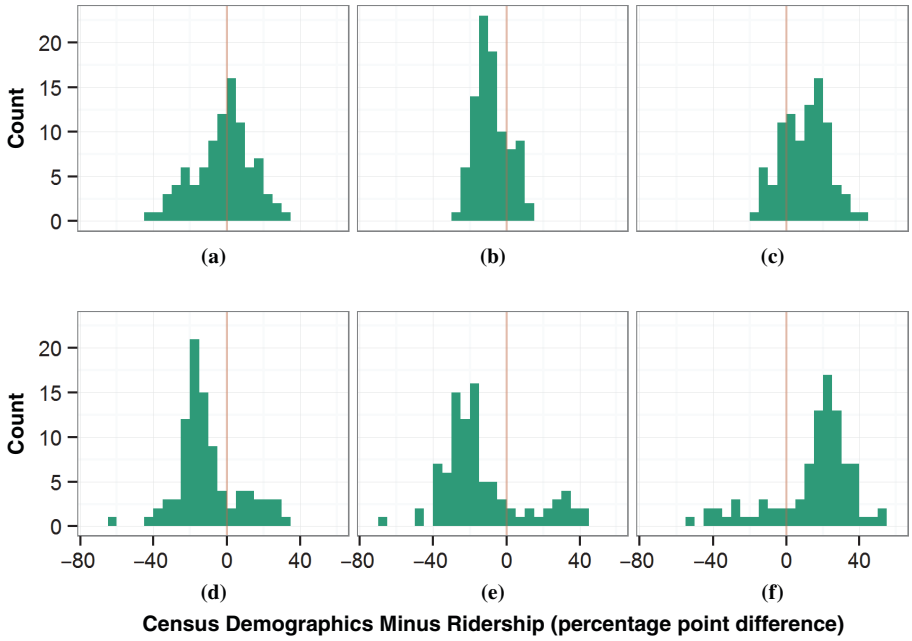

FIGURE 5 Difference in census demographics and measured ridership by demographic group (positive numbers indicate that census data overpredict ridership): (*a*) white, (*b*) black, (*c*) Latino, (*d*) less than $15,000, (*e*) less than $25,000, and (*f*) more than $50,000. (Source: Data from 2010 U.S. Census Summary File 1, ACS 5-year estimates, 2008–2012, and Valley Metro onboard survey, 2010–2011.)

findings when service was being cut and less likely to result in discriminatory findings when service was being improved. The greatest difference between ridership and demographics was observed when the MSA population was used as a reference. Because of historic patterns of residential and commercial location decisions, MSA populations tended to be whiter and wealthier than a more spatially constrained reference population or ridership. This result showed that the reference population definition could affect whether a particular transit planning decision (i.e., cut or improve service) was flagged for potential discriminatory impact.

TABLE 2 Comparison of All Common Routes to Various Reference Populations

Reference Population	Number of Routes by Demographic			
	People of Color	Black	Latino	Household Income < $25,000
Minority Population > Reference Population[a]				
Service area (buffers)	45	51	36	62
Service area (MSA)	66	68	55	79
Ridership	34	36	36	47
Minority Population < Reference Population[b]				
Service area (buffers)	46	40	55	29
Service area (MSA)	25	23	36	12
Ridership	57	55	55	44

[a]Possible discriminatory impact under service cuts.
[b]Possible discriminatory impact under service improvements.

Implications of Sample Analysis

The implications of these findings became clear when the equity implications were evaluated of a specific service change. Valley Metro operated rapid buses during peak periods between suburban park-and-ride locations and downtown Phoenix. The rolling stock was different from that used on local routes and had distinct livery. The onboard survey conducted for 2010 to 2011 collected detailed ridership data only on two out of four rapid routes. Table 3 shows the results of a standard service equity analysis that assumed that service improvements were proposed for both rapid routes without simultaneous changes elsewhere. The analysis with its basis in census demographics showed no evidence of disparate impact. The required measures for the comparison populations (i.e., proportion of people of color, proportion of low-income people) equaled or exceeded those in the general population with the use of buffers and MSA reference populations. Apparently, this finding meant that people of color and of low income appeared to disproportionately benefit from the service change. Ridership data, however, showed the opposite. The ridership numbers of people of color and low income were much lower than would be predicted by the census data. As a result, they were much lower than the reference population of systemwide ridership.

A transit agency would not be able to proceed with these changes without further justification when it used ridership data. It may be that the rapid service should never be improved on the grounds to provide enhanced service to commuters, and an agency should improve

TABLE 3 Sample FTA Analysis for Hypothetical Change to Rapid Service

Data Source	White	People of Color	Black	Latino	Household Income < $25,000
Comparison Populations					
Census					
Number	6,524	7,158	2,008	3,975	1,396
Percentage	48	52	15	29	48
Ridership					
Number	1,337	434	96	205	205
Percentage	76	24	7	12	11.5
Reference Populations					
Service area (buffers) (%)	48	52	6	39	28
Service area (MSA) (%)	59	41	5	29	21
Ridership (%)	44	56	18	29	50

service if there is substantial, legitimate justification to do so. However, with one data source, the agency would not have to justify the action; with another source, it would. Additional standards and guidance from FTA could alleviate this problem.

CONCLUSION

This study showed that the outcome of an FTA-required service equity analysis could vary, given the data used to characterize transit ridership. When census data were used, the analysis was more likely to show discriminatory impacts under service cuts. When ridership data were used, the analysis was more likely to show the discriminatory impacts of service improvements. This result occurred because transit was likely to draw users from the surrounding area, which was 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 increased, it became more likely that the demographics of individual routes fell below the reference population. Although it could be cost prohibitive to conduct a detailed, onboard ridership survey, the nonmonetary cost not to obtain detailed data on transit ridership appeared to be substantial also. To ensure the integrity and meaning of the analysis, FTA should recommend the collection and use of ridership data to conduct service change analyses to supplement census-based approaches.

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

Many additional studies that followed from this present work would serve to improve FTA-required equity analyses. All analyses proposed thus far have their basis in the concept of a single transit boarding. Yet other work has shown that different demographic groups not only use transit for different purposes but travel significantly different distances by transit (*31, 32*). A distance-based approach to equity would be likely to reveal different equity implications than those that arose on the basis of boarding alone.

New data and technology are becoming available to allow the determination of transit service equity on the basis of accessibility. As noted by Bhat et al., "ultimately [transit] service must provide convenient connectivity between origins and destinations of interest to the user in order to be accessible" (*33,* p. 1). The use of accessibility metrics to assess 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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