Equity Analysis of Transit Service in Large Auto-Oriented Cities in the United States

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ABSTRACT

Recent studies on transit service through an equity lens have captured broad trends from the literature and national-level data, or analyzed disaggregate data at the local level. This study integrates these methods by employing a geostatistical analysis of new transit access and income data compilations from the Environmental Protection Agency. By using a national data set spanning variables including income as an equity variable and transit service frequencies and locations at the block group level, this study demonstrates a method for equity analysis and provides results spanning nine large auto-oriented cities in the United States. Results demonstrate variability among cities’ transit services to low-income populations, with differing results when viewed at the regional and local levels. Regional-level analysis of transit service hides significant variation through spatial averaging, while the new data employed in this study demonstrates a block-group scale equity analysis that can be used on a national-scale data set. The regions included in this study with extensive rail and bus service are most likely to provide low income and all workers served by transit equitably. The methods used can be adapted for evaluation of transit and other modes’ transportation service in areas to evaluate equity at the regional level, and at the neighborhood scale, while controlling for spatial autocorrelation. Transit service equity planning can be enhanced by employing geostatistics to improve local analysis.
1. INTRODUCTION

Public transportation serves the important role of providing transportation across the social and economic spectrum, particularly for the largest cities in the United States (1, 2). The recent federal emphasis on evaluating transportation investments with performance measures provides an opportunity for transportation agencies to employ new data sources and methods to evaluate transit service (3). Since this responsibility for measuring performance is most often attributed to individual transportation agencies (4, 5), most previous studies of transit service equity approach the problem as either a qualitative overview within a region, or as case studies (2, 6–8), rather than comparing service equity details among peer agencies. Transportation agencies can analyze equity from multiple perspectives and time frames, and additional methods are needed to improve planning (7).

Transit accessibility is an equity issue because buses, trains, and other transit services provide the motorized transport necessary to access jobs needed for social mobility (9–12). Low-income populations that may not have access to a car are put at a disadvantage in competing for jobs located more than a few blocks from home, even if they are fully qualified. Slower transit services also compound challenges on low income families who need to chain trips to stores with work and transporting children to school and other activities (12–16).

This study takes a step back from traditional approaches and uses current techniques to evaluate transit service levels in respect to low-income communities with a geographic perspective using a standardized data set. This data-driven approach serves to extend the methods used by planners with objectivity in a current dominant planning paradigm rooted in communicative rationality, which attempts to place language and discourse at the core of decision making, rather than expert-driven data analysis (17). Employed properly, new geographic data analysis methods can be used improve the discourse of transportation planning by evaluating equity at multiple scales.

The paper begins with a brief review of the challenges of transportation justice in the United States, along with current planning requirements, followed by a more detailed overview of the literature including social equity and environmental justice methods, and previous studies of transit service. We then describe recent transit service among 10 large cities in the United States, with an emphasis on those that have been considered traditionally auto-oriented. Finally, we propose a geostatistical method to provide a stronger methodological bridge between the understanding of geodemographics and transit services, offering conclusions linking this study for use at the sub-national level and in other countries.

2. SYNTHESIS OF EQUITY AND TRANSPORTATION PLANNING

2.1. Social Justice and Ethics

There is little debate on the role of transportation planners and governments to provide infrastructure enabling mobility to as many people as possible, but the challenges involve the decisions involved with spreading limited resources over a finite population geography (18). This responsibility is alluded to within the code of ethics of planners: “... seek social justice by working to expand choice and opportunity for all persons, recognizing a special responsibility to plan for the needs of the disadvantaged and to promote racial and economic integration” (19). Civil engineers have a similar code of ethics, repeatedly mentioning an engineer’s responsibility
to the public, and also the principles of sustainable development, which they define as including responsibility “…to enhance the safety, welfare, and quality of life for all of the society…” (20).

Transportation professionals’ codes of ethics can provide some guiding directions, but do little in terms of describing how social justice is achieved through their work. Equity evaluation of plans typically takes place during the planning process using multiple scenarios that do not yet exist. Fainstein argues that tensions between democratic processes, equity, and diversity are difficult to address in the real world, where the sentiment of the majority does not necessarily promote values rooted in justice (21).

Some recent research has identified that the scale of evaluation is important. “By shifting the scale of sustainability research to the locality, social sustainability concerns of meeting human needs and satisfying aspirations for a better life can more appropriately be addressed and researched within context” (22). This begins to direct questions of the ‘where’ of transportation equity, but actionable ethics also relate to answering ‘who.’ Current legislation discussed in the next section refers to low-income and minority communities, and most research in the area focuses on these specific communities. “African Americans and the urban working poor, for example, suffer from a lack of transportation options not unlike their disproportionately poor access to affordable housing and other basic daily goods and services, such as neighborhood grocery stores” (23). Here, Furness references transportation equity as not only an infrastructure issue, but one that involves land use planning as well. Finally, the timing of transportation is important, reflecting a ‘when’ dimension of equity: “People of color tend to work more swing shifts, so they rely on their feet or bicycles to get to and from transit, often in areas with no sidewalks and poor lighting” (24).

Although transit is considered as an important mode of transportation, access to an automobile has been shown to significantly increase opportunities for employment (11). However, a study from the same year (10) found that demographics, geographic factors, and access to multiple transportation modes affect access to employment in complicated ways, so improving the transportation network cannot be expected to fix all employment access problems for all people.

2.2. United States Legal Planning Requirements

In 1994, the United States’ Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations (25), the 2012 updated Environmental Justice Order 5610.2(a) (26), which advised transportation planners to avoid disproportionate adverse impacts on minority and low-income groups, and the research community responded with diverse solutions for improving transportation equity. However, most of the methods address only automobile traffic, either regarding network efficiency (27), tolling impacts (28, 29), or negative impacts such as air and noise pollution (8). Metropolitan planning organizations (30) and states (31) have considered environmental justice criteria as part of the multimodal project prioritization, but no known studies have systematically analyzed transit services offered in the United States from an environmental justice perspective.

2.3. Environmental Justice: Definition and Methods

Environmental justice has been defined as “a public policy goal of ensuring that the adverse human health or environmental effects of government activities do not fall dis-proportionately upon minority populations or low-income populations” (8). Environmental justice analysis of
transport projects can involve evaluation of impacts on specific communities with economic, health, job access, and other factors. Local and regional planning bodies often face challenging choices on which aspects to focus on given resource and time constraints (7), and the reality that adequate information may not be readily available (32). Information needed for these analyses comes from modeling, geographic information systems, and qualitative methods.

Environmental justice analyses typically identify protected populations, which often include low income and racial or ethnic minorities, then evaluate transportation system effects on transportation users and many other perspectives such as noise, land prices, and air quality (2). Evaluation of transportation user effects include methods to evaluate the ability to reach desired destinations and choices in terms of quantity and quality of transportation options, typically involving travel demand models.

Geographic information systems (GIS) have become instrumental to integrate existing socio-demographic community data with planning scenarios developed in a modeling framework. GIS tools are used to overlay population characteristics with anticipated planning outcomes (such as changed mobility or air quality) to identify potential environmental in-justice. GIS platforms have the particular strengths to geographically organize data for analysis of numerical data, and more recently for information gleaned from affected persons of a qualitative nature (33, 34).

Qualitative methods can be a useful alternative or supplement to numerical evaluation of environmental justice, even though transport planning may be steeped in empiricism through its growth during a philosophical era dominated by logical positivism (35). Use of surveys, personal interviews, and analysis of public meetings have been useful to understand the often-complicated relationships of the actors in a planning process, and the outcomes implied by plans as they are developed (2, 36). For instance, McCray and Brais performed a spatial analysis of focus groups and interviewed concerning challenges in bus service for women in low income communities (33). The insight reached through personal discussions offered knowledge that cannot be found in the more traditional quantitative data sets used by transportation planners.

Many of these methods were developed by researchers and planners with their peers in mind, rather than providing tools understandable or usable by a wider population (37, 38). One recent advancement to make transportation equity analysis more accessible involved the development of a proof-of-concept website that arrays various regional transportation scenarios in a planning effort, vis-à-vis demographic groups such as income and race (39). Although this effort provides a new method to expand the availability of information to the public with an environmental justice perspective, the authors noted it may be complicated for some users and lead to misinterpretation.
3. THE STUDY IN THE CONTEXT OF LARGE CITIES

Though transportation equity is a concern over all populations and places, this study focused on the challenges of transit service in large cities. This emphasis combines an interest in both the unique challenges of more auto-oriented growing cities and the presence of newly-developed data. The availability of the Environmental Protection Agency’s (EPA’s) new Access to Jobs and Workers via Transit promotes efficient geographic analysis, while covering 88 percent of all transit ridership in the United States (40). This emphasis seizes an opportunity to leverage new data to support equity analysis in cities with expanding and changing transit systems.

3.1. Demographic Description of Large City Transit Service Areas

This study focuses on large cities in the United States that have not retained a robust transit system over several generations. New York City, Boston, Massachusetts, and to some extent, Washington, D.C., were largely developed before popularization of the automobile, and built out rail and bus transit systems concurrently with development. In terms of equity, more challenges are anticipated on cities developing in the midst of the challenges of suburban dispersal, limited transit funding, and growth in population and employment. An additional requirement for this study is the availability of transit operation data combined with income data for equity analysis, which is described later. The following nine cities meet these criteria and their regions comprise the focus of this study: Atlanta, GA; Austin, TX; Dallas, TX; Denver, CO; Houston, TX; Indianapolis, IN; Los Angeles, CA; Seattle, WA; and San Diego, CA.

Each of these large cities focused on in this study varies in its size, density, and transit service. Table 1 includes their basic characteristics based on the 2012 National Transit Database (41), with calculations performed by the authors. Though Atlanta, Georgia, is similar to the other cities in terms of its service area and population, it has a 96-mile heavy rail system with almost double the annual passenger miles of its bus system. Indianapolis, Indiana, has the lowest passenger kilometers per capita, with a straightforward bus system of 120 directly operated vehicles. Service area population densities vary from that of the urbanized area because transit services for the primary transit agency may extend well past municipal boundaries or can also be shared with multiple agencies.
**TABLE 1 Primary City Transit Service Area Characteristics (41)**

<table>
<thead>
<tr>
<th>Primary City</th>
<th>Primary Transit Agency</th>
<th>Service Area (sq. km)</th>
<th>Service Area Population (Census 2010)</th>
<th>Annual Passenger Kilometers per Capita</th>
<th>Population Density of Service Area (sq. km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlanta, GA</td>
<td>Metropolitan Atlanta Rapid Transit Authority</td>
<td>1,290</td>
<td>1,574,600</td>
<td>1,150</td>
<td>1,221</td>
</tr>
<tr>
<td>Austin, TX</td>
<td>Capital Metropolitan Transportation Authority</td>
<td>1,352</td>
<td>1,023,135</td>
<td>405</td>
<td>757</td>
</tr>
<tr>
<td>Dallas, TX</td>
<td>Dallas Area Rapid Transit</td>
<td>1,803</td>
<td>2,423,480</td>
<td>505</td>
<td>1,344</td>
</tr>
<tr>
<td>Denver, CO</td>
<td>Denver Regional Transportation District</td>
<td>6,024</td>
<td>2,619,000</td>
<td>583</td>
<td>435</td>
</tr>
<tr>
<td>Houston, TX</td>
<td>Metropolitan Transit Authority of Harris County</td>
<td>3,328</td>
<td>3,527,625</td>
<td>392</td>
<td>1,060</td>
</tr>
<tr>
<td>Indianapolis, IN</td>
<td>Indianapolis and Marion County Public Transportation</td>
<td>1,026</td>
<td>911,296</td>
<td>130</td>
<td>889</td>
</tr>
<tr>
<td>Los Angeles, CA</td>
<td>Los Angeles County Metropolitan Transportation Authority</td>
<td>3,919</td>
<td>8,626,817</td>
<td>681</td>
<td>2,201</td>
</tr>
<tr>
<td>Seattle, WA</td>
<td>King County Metro</td>
<td>5,527</td>
<td>1,957,000</td>
<td>763</td>
<td>354</td>
</tr>
<tr>
<td>San Diego, CA</td>
<td>San Diego Association of Governments</td>
<td>1,834</td>
<td>2,813,833</td>
<td>355</td>
<td>1,534</td>
</tr>
</tbody>
</table>

3.2. Transit Service in Nine Large Cities

The EPA’s Access to Jobs and Workers via Transit includes information on a range of transit and population-related statistics, both at the U.S. Census’ Core Based Statistical Area (CBSA) block group geographies. CBSAs include one or more counties with a core area containing at least one core of 10,000 population or more, together with adjacent communities having a high degree of economic and social integration with that core (42). One attribute related to transit service equity is the percent of low-wage workers that can reach block groups within each CBSA. Figure 1 shows this result in aggregate, with the Denver, CO, region having the highest percentage of low-wage workers that can reach block groups throughout the CBSA. This factor can be expected to have as much to do with the ability of a transit agency to serve low-income customers in the region as it does with the distribution of affordable housing, creating a problem explored in other studies (43–45).
4. DATA AND METHODS

The EPA’s new Access to Jobs and Workers via Transit database combines transit service and selected demographic variables to allow evaluation of the performance of neighborhoods in regard to their accessibility to destinations via public transit service (40). This study uses a small portion of the variables available related to transit access and income to evaluate equity.

4.1. Integration of Transit Access and Income Class

This study focuses on two attributes of interest from the EPA’s Access to Jobs and Workers via Transit database: the percent of all workers accessible by transit and the percent of all low-wage workers accessible by transit (40). The first variable is defined as the “employed population able to access the block group within a 45-minute transit commute from their home location as a percentage of total regional employed population” (40). The low-wage classification for the second attribute is defined as workers earning $1,250 per month or less.

Transit service information includes calculations of travel time from each U.S. census block group to all other census block groups accessible via transit. Census 2010 data were integrated to tabulate how many people live and work in those accessible block groups, using a 45-minute travel time limit that includes wait times, transfers, and walking to and from transit stops. The 45-minute transit travel time restriction imposed by the EPA data source may not
Griffin and Sener (2014)

Griffin and Sener (2014) represent all trips well, since the 2009 National Household Travel Survey reports an average commute time of 53 minutes (46). This could be expected to restrict destination accessibility represented in these data more in suburban areas than city centers, but any bias in this regard is applied equally among the cities through these data, therefore not restricting aggregate city comparison. The data only cover metropolitan regions and counties served by transit agencies that provide their service data using a standard data format called General Transit Feed Specification, which includes stops, routes, trips, and other schedule data (47).

4.2. Transit Access Equity by Income Class

Due to the costs, locations and levels of transit service, there are inevitable populations with better services than others. One way to evaluate transit service equity is by understanding the difference between accessibility by low-income classification versus the remainder of the transit-accessible population. For each block group in each of the nine CBSAs, equity was evaluated as the arithmetic difference between the percent of low wage, transit-accessible workers and the total of transit-accessible workers. This method is similar to travel time measures commonly incorporated in environmental justice analyses (27).

4.3. Local Spatial Autocorrelation

In his article describing simulation of urban growth over time, Tobler invoked the first law of geography: “…everything is related to everything else, but near things are more related than distant things” (48). The degree to which each block group is influenced by its neighbor can be described with spatial statistics. Anselin developed a local Moran’s I statistic to describe this relationship:

\[ I_i = \sum_j w_{ij} z_j \]

where “the observations \( z_i, z_j \) are in deviations from the mean, and the summation over \( j \) is such that only neighboring values \( j \in J_i \) are included” (49). The local analysis of clustering of each block group with its neighbors prevents global statistics’ tendency to hide issues of significance when averaged as a whole. Since we are interested in understanding the effects of transit service levels in different locations, the local Moran’s I helps explain the likelihood of transit service being similar in locations close to each other.

Variances in transit access by income are expected to follow Tobler’s Law, in that observations in one location are more likely influenced by their geographic neighbors than other locations. Therefore, local Moran’s I is calculated using an inverse distance weighted conceptualization of spatial relationships, using a Euclidean distance calculation on data with coordinates in the Albers projection. Like other local indicators of spatial autocorrelation, the local Moran’s I “…gives an indication of the extent of significant spatial clustering of similar values around that observation” (49).

5. RESULTS

Each of the nine large cities varies in the difference between workers’ transit access by income class. Observed at the core based statistical area level, the Atlanta, GA, region has the least
average difference between the percentage of low wage workers and all transit-accessible workers. The minimum, maximum, and standard deviation indicate the lowest variation between block groups in the Atlanta, GA, region as well, with the greatest deviation in the Denver, CO, region. Though the Denver, CO, region provided the highest percentage of low-wage workers able to reach work destinations from their home location, it also had the highest standard deviation of block groups within the region, indicating disparity in local service.

Overall, this method helps answer questions of difference in transit accessibility between large cities and within neighborhoods. This regional view provides the first known analysis of these cities in terms of the income equity of transit service.

**TABLE 2 Percent Difference in Transit Accessibility between Low Wage and All Transit Accessible Workers**

<table>
<thead>
<tr>
<th>CBSA</th>
<th>Average Percent Difference</th>
<th>Minimum Percent Difference</th>
<th>Maximum Percent Difference</th>
<th>Standard Deviation Percent Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlanta-Sandy Springs-Marietta, GA</td>
<td>-0.546411</td>
<td>-1.19108</td>
<td>8.35001</td>
<td>1.360138</td>
</tr>
<tr>
<td>Los Angeles-Long Beach-Santa Ana, CA</td>
<td>-0.968066</td>
<td>-4.54883</td>
<td>14.02947</td>
<td>3.09036</td>
</tr>
<tr>
<td>Dallas-Fort Worth-Arlington, TX</td>
<td>-1.111555</td>
<td>-2.29054</td>
<td>10.6816</td>
<td>1.744934</td>
</tr>
<tr>
<td>San Diego-Carlsbad-San Marcos, CA</td>
<td>-1.269283</td>
<td>-6.19471</td>
<td>22.68289</td>
<td>4.970685</td>
</tr>
<tr>
<td>Houston-Sugar Land-Baytown, TX</td>
<td>-1.609715</td>
<td>-3.60382</td>
<td>13.323079</td>
<td>2.825059</td>
</tr>
<tr>
<td>Indianapolis-Carmel, IN</td>
<td>-2.163311</td>
<td>-5.46704</td>
<td>15.749759</td>
<td>4.69786</td>
</tr>
<tr>
<td>Denver-Aurora-Broomfield, CO</td>
<td>-3.254208</td>
<td>-10.7151</td>
<td>23.8356</td>
<td>6.344199</td>
</tr>
<tr>
<td>Seattle-Tacoma-Bellevue, WA</td>
<td>-4.411936</td>
<td>-8.2286</td>
<td>24.4032</td>
<td>5.250507</td>
</tr>
<tr>
<td>Austin-Round Rock-San Marcos, TX</td>
<td>-5.800731</td>
<td>-10.0383</td>
<td>11.817301</td>
<td>5.950078</td>
</tr>
</tbody>
</table>

Transit equity can be evaluated at multiple geographic scales, and doing so reveals different results. The presence of rail transit in concert with fixed route bus service is associated with the regions with the least variance in transit accessibility by income class. This is likely due to the higher average speed associated with rail transit as compared to most bus transit, in addition to the larger overall transit investments of all modes found in Atlanta, Los Angeles, and Dallas.

Analysis at the regional level reveals variances in accessibility of transit by income class, but these results must be reviewed with caution. Though the regions with the least apparent variance are well-served by at least fixed route bus and rail transit, the location of low income groups is not necessarily static, and transit agencies are challenged to coordinate their services in an efficient manner while serving the riders with the most need. However, global statistics can hide the relationships and clustering of transit access within and between neighborhoods, which is addressed by analysis of local spatial clustering.

Cluster and outlier analysis of local Moran’s I unpacks the relationships between low-income and all transit-accessible workers at the block group level. Each of the maps in Figure 2
displays this relationship classified into either clusters indicating similarity between block
groups, or outliers indicating dissimilarity. Each grouping is significant at the 0.05 level, or it is
designated as Not Significant. Clusters of high percentages of transit accessibility for both low
and all transit-accessible workers (High-High Cluster); clusters of low accessibility for both
groups (Low-Low Cluster); outliers that show the greatest discrepancy by income (High-Low
Outlier); and outliers with the least discrepancy in transit access by income (Low-High Outlier).

FIGURE 2 Cluster and outlier analysis of difference between the percentage of transit-
accessible workers and low-income transit-accessible workers.

Regional analysis of spatial autocorrelation reveals neighborhood effects between transit
access by income group. Each region reviewed is characterized by a different relationship
between low income and all transit-accessible worker communities, but no region has a cluster of both low transit accessibility and low-income workers near its urban core. The radial patterns of the cluster and outlier analysis in Houston, Dallas, Atlanta, and to a lesser degree Indianapolis, are partly due to the spatial pattern of the transit network, but may generally indicate that the transit services do not have major spatial omissions across the region. Conversely, Austin, Denver, and Seattle have large areas including their downtowns with a significant difference between transit access among low and all income groups. In addition to the potential for transit service equity variance, this could be associated with constraints in the cost of service extensions, clustering of low-income neighborhoods, or other factors. Generally, Los Angeles and San Diego do not share the previous cities’ spatial clustering of low and high transit access discrepancies by income at the neighborhood level.

The results of the cluster and outlier analysis in Figure 2 are consistent with the descriptive analysis in Table 2, identifying the greatest variation in transit access by income in the Austin, Denver and Seattle regions, and the least variation in Atlanta, Los Angeles and Dallas. These differences can be due to a combination of factors relating to both transit services and the distribution of populations by income. The literature demonstrates that both of these issues are addressable by transportation and housing policies, planning, and implementation that seek to improve access to the supply of residential choices and mobility options that connect people of a range of incomes to jobs and services needed for a high quality of life.

This study demonstrates a method for analyzing spatial variation in transit access by income. Improvements to transit accessibility such as increases of geographic service and frequency are well-documented, but restricted by available funding. Summary descriptive statistics can be useful for understanding variation between regions using a common dataset, and block group level geostatistics such as Moran’s I is useful for identifying local variation, clusters and outliers in transit access. Previous studies have demonstrated many factors important for equity other than transit accessibility and income levels that should be considered in service planning. Policymakers, planners, and system operators can implement similar analyses incorporating locally-important factors (such as costs of transit services or housing) to evaluate existing or proposed service levels to improve the equity of transit systems.

6. CONCLUSIONS

Transit service changes in large, auto-oriented cities provide uneven access and mobility benefits. Additional methods are needed to leverage advanced data sources for more spatially disaggregate analysis of transit equity. This study adds to the environmental justice methodologies by employing a new, block-group level transit and income data set using spatial statistics.

Despite the recent emphases on equity and performance measurement in federal guidance (3, 25), few spatial methods have been articulated to evaluate transportation equity. Confounding this challenge is the fact that changes in both transit provision and locations of low income demographic groups make equity analysis a moving target. The same challenges that affect travel demand modeling regarding demographics, mode choice, issues of temporal and spatial precision, and accuracy are all present in similar quantitative analyses. The application of recent advancements in spatial modeling, on the other hand, can help control for effects such as spatial autocorrelation, resulting in better understanding of the local nuances of transit service.

This study adds to the literature by employing a new data set integrating transit service, worker locations, and income, allowing standard comparisons of nine large cities as a whole, and
a neighborhood scale as well. Regional summaries of differences in transit service for income classes provide a broad-scale analysis of income-based equity, while analysis of the same data with local Moran’s $I$ geostatistics provide a nuanced view of equity that controls for spatial autocorrelation. The method developed in this study is not aimed to be a substitute for local analysis including specific proposed transportation changes or land use effects, but can be considered a spatial screening tool to identify prospective equity issues at geographic areas larger than the more typical corridor analysis. The provision of transit modes beyond traditional bus service, such as rail, was found to have a positive relationship with transit equity at both the regional and neighborhood levels in this study. Increased numbers of routes and speeds may serve to increase mobility and access for all income levels, promoting job access, and in turn, economic mobility. The methods used in this study point to policy and planning implications of not only the location of service, but speed and frequency having impacts on job access and economic mobility. In order to demonstrate competency in equitable service, planners and policy makers need standardized comparisons of locations that consider income. Transit investments represent a faith that allocation of projects serve existing and future needs, and efficient and accurate equity analyses will support the communicative relationship between the public and transit agencies if shared in open forums of discussion.

In addition to growth in rail and bus transit, the increasing prevalence of bus rapid transit (BRT) may cause significant changes in transit accessibility, but this will be limited to the extent that low-income communities are conveniently served by this mode and its connectivity to destinations for these groups (50). In the cases that BRT can take advantage of managed lanes and other features designed to increase speed, it can reduce the time needed to reach more jobs within a reasonable time frame and can add job accessibility to the communities it serves.

This study examined a limited relationship between transit accessibility and worker income, but does not address the root causes of discrepancies in this relationship. Future studies should add to the literature in this area by integrating spatial analysis of urban form, other demographic variables associated with equity, and transit-based access to social services. Additional research on recent immigrants and their use of transit systems from a geographic perspective is also needed. Finally, future transit services could be modeled with local spatial analysis for equity using similar methods.

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