Cost–Benefit Analysis of Rural and Small Urban Transit in the United States

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The true value of transit systems in rural and small urban areas in the United States has been largely unmeasured, and there are often effects that go unidentified. Many studies have documented the benefits of urban transit systems with benefit–cost analysis. However, not many have looked into the benefits of transit in rural and small urban areas, where there is a great need for public transit, especially for transportation-disadvantaged individuals. This study focused on evaluating the qualitative and quantitative benefits of rural and small urban public transit systems and analyzed the benefit–cost ratio for rural and small urban transit areas for fixed-route and demand-response services in the United States. Data for rural and small urban transit systems from the national transit database (NTD) and rural NTD were used for calibrating the transit benefits and costs. Results were presented at a national level to show the effects of transit investments in rural and small urban areas nationally. Transit benefits in the United States for 2011 were found to be $1.6 billion for rural transit and $3.7 billion for small urban transit, not including the economic effects. Results showed a benefit–cost ratio of 2.16 for small urban transit and 1.20 for rural transit in the United States. Sensitivity analysis showed that increasing the percentage of forgone trips to 50%, increasing the cost of forgone medical and work trips by 25%, and increasing the percentage of medical trips to 30% substantially increased the total transit benefits by 88%, 20%, and 158%, respectively.

Transit systems in rural and small urban areas are often viewed as valuable community assets because of the increased mobility they provide to those without other means of travel. The value of those services, however, has been largely unmeasured, and there are often effects that go unidentified. As transit systems compete for funding at local, state, and federal levels, it is important to identify and quantify, where possible, the effects that the services have in local communities, as well as throughout the state or country. The benefits accruing to transit services, especially those in rural areas, have rarely been quantified, often because of a lack of data or the cost of collecting those data.

Benefits to the public transit user include lower-cost trips, new trips that are made, and relocation avoidance. The alternative means of travel for transit users, which may involve purchasing an automobile or paying for a taxi ride, are often more expensive. As transit provides access to work, health care, education, shopping, and so forth, additional trips will be made for those purposes, resulting in increased earnings, improved health, involvement in social activities, and additional spending in the local community. Furthermore, the service reduces the likelihood of transportation-disadvantaged individuals experiencing isolation and depression. The existence of transit operations also creates economic activity in the community. This activity includes jobs created directly by the transit system, income generated by industries that supply inputs to the transit system, and induced economic activity.

Decision makers need objective and credible information on the costs and the benefits of transit operations to support their decisions on investment in public transportation. Some of these benefits lend themselves easily to quantification, while others do not. A full representation of the benefits, including quantitative and qualitative benefits, is necessary for local and state governments to make informed choices. The objectives of this study are to develop a method and estimate the economic costs and benefits of rural and small urban transit at the national level.

LITERATURE REVIEW

The major findings of previously conducted studies show that publicly operated transit provides significant benefits to the community compared with the costs contributed by the community. Burkhardt conducted national and local analyses of rural systems and concluded that returns on investment of greater than 3 to 1 can be achieved by allowing residents to live independently, increasing the level of business activity in the community, allowing residents to live more healthy lives, and making more productive use of scarce local resources (*1*). Analysis by Southworth et al. in Tennessee yielded benefit–cost ratios greater than 1.0, with most of the benefits coming from increased accessibility (*2*). In its research in Wisconsin, HLB Decision Economics, Inc., concluded that every dollar invested in public transportation provided $6 in economic returns (*3*). HDR Decision Economics estimated that every dollar spent on public transit in South Dakota generates $1.90 in economic activity, on average, and the social benefits equal $9.11 per trip in urban areas and $2.42 per trip in rural areas (*4*). Skolnik and Schreiner calculated a benefit–cost ratio of 9.7 to 1 for a small urban system in Connecticut (*5*). Peng and Nelson analyzed the economic benefits of elderly riders, work trip riders, and school trip riders in rural Georgia and also found benefits to exceed costs (*6*).

Burkhardt (*1*) and Southworth et al. (*2*) both showed that the benefits of rural transit systems vary significantly, depending on the characteristics of the service provided and the percentage of transit-dependent riders that they serve. Burkhardt found that two types of rural transit services generated the greatest economic benefits: employment transportation for riders and services that enabled people to live independently (*1*). Southworth et al. showed that transit

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services that provide rides to those who otherwise would not make the trip, and therefore place additional burden on state resources or suffer a significant loss of mobility, are very cost-effective (*2*). Cronin et al. found the highest return on investment for nutrition and medical trips (1,252% and 1,108%, respectively) although return on investment for education, employment, and life-sustaining and other trips for transportation-disadvantaged individuals was also very high (585%, 571%, and 462%, respectively) (*7*).

Burkhardt's research was based on 22 case studies of rural transit systems, including eight in-depth case studies showing cost–benefit ratios ranging from a low of 1.67 to 1 to a high of 4.22 to 1 (*1*). Burkhardt noted, however, that the study focused on the primary types of benefits and did not attempt to exhaustively quantify all benefits, so the estimates might slightly underestimate the actual benefits. HDR Decision Economics also noted that its results are conservative and do not account for some benefits that are too difficult to quantify (*4*).

CATEGORIZATION OF TRANSIT BENEFITS

The transit benefits in rural and small urban communities are categorized primarily as transportation cost-saving benefits, low-cost mobility benefits, and economic impact benefits. If transit is not provided in a community, then transit riders would have to either use a different mode or forgo the trip. Transportation cost savings are the savings that result when individuals are able to use transit in place of another mode, and affordable mobility benefits are the benefits that result when trips are made that would otherwise be forgone (trip that would not have been made) in the absence of transit. Transportation cost-saving benefits included vehicle ownership and operating expenses, chauffeuring cost savings, taxi trip cost savings, travel time cost savings, crash cost savings, and emission cost savings. Low-cost mobility benefits include cost savings by avoiding forgone medical, work, and other trips. Economic benefits result from the economic activity generated by transit operations. Economic benefits were not analyzed in this study because of the lack of data for calculating those benefits nationwide.

There are additional benefits that can be included among transportation cost savings or other benefits, such as parking cost savings and land use impacts. These benefits were not monetized for this analysis because they are not significant in small urban and rural communities.

METHOD FOR ESTIMATING BENEFITS

This study focuses on transit systems operating in rural and small urban areas across the United States. Rural transit systems are defined as those receiving Section 5311 Non-Urbanized Area Formula Funding and who report to the rural national transit database (rural NTD). Small urban transit agencies are defined as those receiving Section 5307 Urbanized Area Formula Funding and serve areas with a population of 200,000 or less.

Unlike previous research that included cost–benefit analyses of specific transit systems or specific states or regions, this study makes a broad analysis of rural and small urban transit across the country. Data for small urban transit systems for 2011 were obtained from the NTD, and 2011 data for rural transit systems were obtained from the rural NTD. A total of 1,392 rural transit agencies and 351 small urban transit agencies were identified and included in the analysis. Cost data and operational data for each of these agencies were obtained through the NTD and rural NTD. Small urban and rural transit benefits, transit costs, and benefit–cost ratios were calculated at the national level. The analysis was restricted to modes defined as fixed-route bus or demand-response service although that included most of the transit service in those areas.

Travel Behavior in the Absence of Transit: Use of Alternative Modes and Forgone Trips

Estimating the benefits of public transit first requires an estimate of how transit riders would respond if transit service were not available. This study uses results from previously conducted surveys of the Transit Performance Monitoring System (TPMS) study prepared for the American Public Transportation Association to predict the behavior of transit users in the absence of transit (*8*). According to the TPMS study survey results, 21.5% of transit riders would not make a trip in the absence of transit, which can be called a forgone trip. The TPMS results also show that in the absence of transit, 12.8% of transit riders drive a car, 22.8% ride with someone, 11.7% take a taxi, 26.7% walk, and 4.5% ride a bicycle to make the trip.

It was determined by the authors that the TPMS results may be appropriate for fixed-route riders, but demand-response riders may face different alternatives. Mattson et al. conducted a series of surveys of demand-response riders at different sites across the country in urban and rural areas, collecting information on how riders would make the trip if the service were not available (*9*). Preliminary results from that study showed that 31% of demand-response riders would not make the trip in the absence of transit, 51% would ride with someone else, 7% would use a taxi, 5% would walk, and just 5% would drive themselves. The results were used to estimate travel behavior in the absence of transit for demand-response riders in rural and small urban areas for this study.

Information on trip purpose is also necessary for estimating the cost of forgone trips. Trip purpose data from the TPMS for small transit systems were used for small urban areas in this study. For rural areas, trip purpose data were obtained from the *2012 Rural Transit Fact Book* (*10*), which was derived from the 2009 National Household Travel Survey.

Transportation Cost Savings

A potential benefit of transit services is a reduction in transportation costs to those who use transit in place of another mode of travel. If the rider already owns and can operate an automobile, the cost of traveling by another mode includes fuel and other operating costs. Some who do not own a car may have to purchase one, incurring the costs of automobile ownership. If the rider were to get a ride from someone else, the cost would again include the operating costs plus the time and inconvenience required for someone to provide the ride. A trip by taxi, if available, would cost the taxi fare. The costs of walking and bicycling would also be considered. Most of these alternatives will cost more to the user than the cost of transit.

In addition to out-of-pocket costs, there are other costs associated with travel, including the cost of time, safety costs resulting from crashes, and environmental costs resulting from emissions. Switching from transit to other modes would also affect each of these costs, so they need to be included in the analysis. In many cases, transit can reduce these costs, but sometimes the costs can be higher.

Transportation cost savings benefits include primarily vehicle ownership and operation cost savings, chauffeuring cost savings, taxi fare cost savings, travel time cost savings, crash cost savings, and environmental cost savings.

Transit riders using personal automobiles for their trips would incur vehicle ownership and operating expenses, which can be considered savings if the rider instead used transit. The savings were calculated on the basis of the savings per vehicle mile of the personal vehicle traveled. The vehicle ownership and operation cost for an average U.S. driver is estimated as $0.65 per mile, which is the average of values for all vehicle types from the American Automobile Association data for 2013 (*11*).

While some will drive themselves in the absence of transit, many cannot drive or do not have access to an automobile and will get a ride from someone else, such as a family member or friend. Chauffeuring trips are additional automobile trips made specifically for a passenger (*12*). Litman's estimate of $1.05 per chauffeured vehicle mile was considered appropriate for this study to determine the cost of the chauffeured trips (*12*). This estimate will be multiplied with the average trip length derived from the NTD database to determine the cost of a chauffeured trip.

Taxi trips can be very expensive. According to Litman's study, average taxi fare of $2.25 per mile was used to calculate the cost savings from taxi trips for rural and small urban areas (*12*). This study also takes into consideration differences in travel times between modes and the associated costs. Travel costs suggested by Litman (*13*) were used in this study, with adjustments made according to median wages for 2011 (Bureau of Labor Statistics) (*14*). With Litman's estimate for urban off-peak and rural transit travel, the travel time of transit passengers is assumed to be 25% of wages ($4.14), and the travel time of automobile driver and passenger is valued as 25% of the average wages times ⅔ ($2.76) (*13*). Time devoted to walking and bicycling is charged at $3.75 per hour. The difference between travel time costs of alternative travel modes and travel time costs of transit gives the travel time cost savings values.

Crash costs were calculated for all alternative modes by multiplying total miles of travel by cost per mile. A crash cost of 10¢ per vehicle mile was used for automobiles (*13*). For small urban transit, Litman's estimate of 28.9¢ per bus mile, considering an average of 5.2 passengers, was considered appropriate (*13*). Crash costs for rural transit were calculated by multiplying the types of crashes (fatality or injury) by the respective cost values. On the basis of the crash cost values in the National Highway Traffic Safety Administration's *National Pedestrian Crash Report* for 2008, pedestrian and bicycle crash costs were estimated in this study as 10¢ per walking mile and 10¢ per bicycle mile, respectively (*15*). The crash cost difference between the alternative modes and the transit modes determines whether any crash cost savings are attributable to using transit.

Finally, emission costs of $0.15 and $0.06 per vehicle mile were used for transit and alternative travel modes (driving a personal car or riding with someone), respectively, following Litman (*13*).

Low-Cost Mobility Benefits

Low-cost mobility benefits result when trips are made that would otherwise be forgone in the absence of public transit. For many, there may be no feasible alternative modes, or the costs are prohibitively expensive, so they will forgo trips. The costs of those forgone trips can be substantial. A missed work trip, for example, means lost income. A missed health care trip means a person's health might not be properly managed and could result in a need for in-home care or a future emergency care trip via an ambulance. Lost educational trips could reduce a person's future earnings potential, and lost shopping trips mean less money is spent in the community. Providing trips that would otherwise not be made results in other intangible benefits, such as providing enjoyment and fulfillment and preventing social and physical isolation. To estimate low-cost mobility benefits, the costs of trips that would be forgone in the absence of transit, such as missed health care trips or missed work trips, were estimated. Forgone trips were categorized as medical trips, work trips, and other trips, and different methods were used for each.

Medical Trips

The benefit from providing a trip for medical purposes is the difference between well-managed and poorly managed care, which can include a reduction in more costly care and improved quality of life. Calculations from a spreadsheet tool developed by Hughes-Cromwick et al. were used to estimate this benefit (*16*). This study made assumptions about the percentage of adult users of nonemergency medical transportation services who have different chronic conditions or require preventive care as well as the number of office visits required for each (*16*). These estimates are national norms identified by Hughes-Cromwick et al. (*16*). The benefits of nonemergency medical transportation trips are calculated as the cost difference between well-managed and poorly managed care, plus improvements in quality of life, minus costs of additional medical treatment incurred, divided by the number of trips required. The tool developed by Hughes-Cromwick et al. shows a net benefit of $713 per round-trip, or $357 per one-way trip (*16*). Therefore, that is assumed to be the cost of forgone medical trips. The total number of forgone medical trips was multiplied by $357 to determine the total cost of forgone medical trips.

Work Trips

Building on previous research (HLB Decision Economics 2003 and HDR Decision Economics 2011), this study estimates the benefit of providing work trips by the effect it has on reducing public assistance spending (*3, 4*). If a person cannot go to work because of a lack of transportation, he or she may be eligible for assistance from the government through the Temporary Assistance for Needy Families (TANF) program or the Supplemental Nutrition Assistance Program (SNAP).

TANF, commonly referred to as welfare, provides cash assistance to needy families with dependent children. In FY 2011, $30.6 billion was spent on the program, including federal and state expenditures, for 1.8 million families receiving assistance (*17*). The amount of SNAP benefits a household can receive is dependent on net income and household size. The maximum monthly allotment for a four-person household in 2013 was $668 (*18*).

A four-person household receiving TANF and SNAP assistance, therefore, could result in $24,400 in state and federal expenditures. These are costs that could potentially be avoided by providing transit services to transportation-disadvantaged individuals. Providing transit to work for one individual for a year would require approximately 500 trips, or two trips per day (one trip to work and a return trip home) for 250 working days per year. If providing these 500 trips allows the person to keep a job and not require government assistance, government payments could be reduced by an average of $49 per trip. On the basis of these calculations, the cost of a forgone work trip is estimated to be $49 although it is recognized that there is significant variation in this number.

Other Forgone Trips

The cost of forgone trips for other trip purposes is calculated by using the concept of consumer surplus. HDR Decision Economics (*4*) and HLB Decision Economics (*3*) also used that approach. Consumer surplus is the difference between the maximum price a consumer is willing to pay and the price the consumer actually does pay. Providing transit service increases consumer surplus by decreasing the amount users must pay for a trip.

RESULTS

Transit Cost Data

The 1,393 rural transit agencies reporting to the 2011 rural NTD had total operating expenses of $1.3 billion. Operating expenses averaged $10.78 per trip and $2.49 per mile for those rural systems. For agencies operating only demand-response service, average cost per trip was $17.31, while average cost per trip for fixed-route agencies was $6.96.

Total operating expenses for the 351 small urban transit agencies was about $1.6 billion. The average cost per trip was $4.49, and the average cost per vehicle mile of service was $5.25. Cost per trip was $21.39 for demand response and $3.63 for fixed route.

Estimated Transportation Cost Savings and Low-Cost Mobility Benefits

Transportation cost savings and low-cost mobility benefits were calculated for all agencies. The rural and small urban area transit benefits were further categorized according to the two primary types of service in these areas: demand-response service and fixed-route bus service.

Rural Transit Results

The transit benefits for transit agencies operating in rural areas are summarized in Table 1. It is observed that there are no travel time cost savings and emission cost savings for either the fixed-route mode or the demand-response mode, and no crash cost savings for demand-response service. The negative travel time savings may be attributed to the lack of congestion for regular traffic when compared with transit, which can be a completely different scenario in urban areas. No emission cost savings are observed in rural areas because of lower vehicle occupancy rates. Results also show that demand-response service has larger negative values when compared with fixed-route bus, most likely because of lower vehicle occupancy rates. However, the essence of demand-response service is to provide mobility for people who are in need.

Overall, transportation cost saving benefits in rural areas totaled $196 million for fixed-route bus and $34 million for demand-response service. Forgone trip benefits were observed to be $738 million for fixed-route transit and $639 million for demand-response service. Overall, transportation benefits of $934 million were observed in fixed-route transit and $673 million were observed in demand-response service. Among the total transit benefits, the share of low-cost mobility benefits were observed to be substantially high for fixed-route bus service (79%) and demand-response service (95%), proving that low-cost mobility benefits are very important transit benefits in rural areas.

Small Urban Transit Results

Transportation cost benefits and low-cost mobility benefits for small urban transit agencies operating in the United States are summarized in Table 2. Travel time cost savings were negative for fixed-route bus and demand-response, proving that there are no travel time benefits to transit in small urban areas. Because fewer people ride demand-response transit in small urban areas, the crash cost savings and emission cost savings associated with transit cannot be seen unless the transit vehicle ridership nears its capacity. Apart from travel time benefits, the remaining categories for fixed-route bus were positive, indicating the existence of transit benefits. However, for demand-response service, the travel time cost savings, crash cost savings, and emission cost savings were negative.

TABLE 1 Rural Transit Benefits Categorization

	Fixed-Route		Demand-Response		Total	
Transit Benefit Category	Benefit [$(%)]	Benefit per Trip ($)	Benefit [$(%)]	Benefit per Trip ($)	Benefit [$(%)]	Benefit per Trip ($)
Transportation Cost Savings						
Vehicle ownership and operation costs	34,548,296	0.50	7,866,150	0.19	42,414,445	0.38
Chauffeuring costs	49,704,699	0.72	84,279,527	2.05	133,984,227	1.21
Taxi cost savings	109,312,967	1.58	38,342,849	0.93	147,655,816	1.34
Travel time cost savings	−19,560,594	−0.28	−36,213,133	−0.88	−55,773,727	−0.51
Crash cost savings	29,212,649	0.42	−13,170,826	−0.32	16,041,823	0.15
Emission cost savings	−7,079,055	−0.10	−47,129,195	−1.14	−54,208,250	−0.49
Total transportation cost savings	196,138,962 (21)	2.83	33,975,372 (5)	0.83	230,114,334 (14)	2.08
Low-Cost Mobility Benefits						
Forgone medical trip benefits	393,088,598	5.68	340,365,706	8.27	733,454,304	6.65
Forgone work trip benefits	296,014,254	4.28	256,311,430	6.23	552,325,684	5.00
Other forgone trip benefits	49,078,193	0.71	42,495,595	1.03	91,573,788	0.83
Total low-cost mobility benefits	738,181,045 (79)	10.67	639,172,731 (95)	15.53	1,377,353,776 (86)	12.48
Total transit benefits	934,320,007 (100)	13.50	673,148,102 (100)	16.35	1,607,468,110 (100)	14.56

TABLE 2 Small Urban Transit Benefits Categorization

	Fixed-Route Bus		Demand-Response		Total	
Transit Benefit Category	Benefit [$(%)]	Benefit per Trip ($)	Benefit [$(%)]	Benefit per Trip ($)	Benefit [$(%)]	Benefit per Trip ($)
Transportation Cost Savings						
Vehicle ownership and operation costs	109,504,604	0.33	3,736,711	0.22	113,241,314	0.32
Chauffeuring costs	157,544,484	0.47	40,035,876	2.35	197,580,360	0.56
Taxi cost savings	346,479,411	1.03	18,214,264	1.07	364,693,675	1.04
Travel time cost savings	–148,062,294	–0.44	–17,202,571	–1.01	–165,264,865	–0.47
Crash cost savings	41,930,026	0.13	–17,631,822	–1.03	24,298,205	0.07
Emission cost savings	5,504,437	0.02	–8,914,173	–0.52	–3,409,736	–0.01
Total transportation cost savings	512,900,668 (15)	1.53	18,238,285 (7.5)	1.07	531,138,953 (14.5)	1.51
Low-Cost Mobility Benefits						
Forgone medical trip benefits	1,362,173,952	4.07	100,952,297	5.92	1,463,126,250	4.16
Forgone work trip benefits	1,389,891,143	4.15	103,006,451	6.04	1,492,897,594	4.24
Other forgone trip benefits	160,459,212	0.48	21,690,446	1.27	182,149,657	0.52
Total low-cost mobility benefits	2,912,524,307 (85)	8.70	225,649,194 (92.5)	13.24	3,138,173,501 (85.5)	8.92
Total transit benefits	3,425,424,975 (100)	10.23	243,887,479 (100)	14.31	3,669,312,454 (100)	10.43

In summary, transportation cost saving benefits existed in small urban areas, with benefits being $513 million for fixed-route bus and $18 million for demand-response service. Forgone trip benefits were $2.9 billion for fixed-route transit and $225 million for demand-response service. Overall, transportation benefits of $3.5 billion were observed in fixed-route transit and $244 million were observed in demand-response service. Of the total transit benefits, the share of low-cost mobility benefits was high for fixed-route bus service (85%) and demand-response service (92.5%), proving that low-cost mobility benefits are very important transit benefits in small urban transit.

The average transit benefits per trip for fixed-route service are observed to be $10.23. Similarly, the average transit benefits per trip for demand-response service are observed to be $14.31. On average, the transit benefits per trip for transit in small urban areas are found to be $10.43. The transit benefits per trip are comparatively higher for demand-response service because of the increased proportion of forgone trips.

Benefit–Cost Analysis

Transit in small urban areas yielded a benefit–cost ratio of 2.16, which means every dollar invested in transit in small urban areas resulted in $2.16 in benefits (Table 3 and Table 4). Transit in rural areas resulted in a benefit–cost ratio of 1.20, which means every dollar invested in transit in rural areas results in $1.20 in benefits. In small urban areas, because of data availability, results were differentiated between fixed-route and demand-response service, with the analysis showing a benefit–cost ratio of 2.60 for fixed-route and 0.64 for demand-response. Though demand-response service is not found to have a high benefit–cost ratio, these services are considered to be critical to the community to meet the mobility needs of the transportation disadvantaged. The benefit–cost ratios were calculated in this study assuming transportation cost savings and low-cost mobility benefits as total transit benefits and not including the economic effects of transit. Therefore the benefit–cost ratios are likely conservative estimates that do not include all potential benefits.

TABLE 3 Estimated Transit Benefits

	Small Urban Areas		Rural Areas	
Benefit Category	Transit Benefit ($)	Benefit per Trip ($)	Transit Benefit ($)	Benefit per Trip ($)
Vehicle ownership and operation cost savings	113,241,314	0.32	42,414,445	0.38
Chauffeuring cost savings	197,580,360	0.56	133,984,226	1.21
Taxi cost savings	364,693,674	1.04	147,655,815	1.34
Travel time cost savings	–165,264,864	–0.47	–64,230,510	–0.58
Crash cost savings	24,298,205	0.07	16,041,822	0.15
Emission cost savings	–3,409,736	–0.01	–54,208,250	–0.49
Cost of forgone medical trips	1,463,126,250	4.16	733,454,303	6.65
Cost of forgone work trips	1,492,897,594	4.24	552,325,683	5.00
Cost of other forgone trips	182,149,657	0.52	91,573,788	0.83
Total transit benefits	3,669,312,454	10.43	1,599,011,322	14.49

TABLE 4 Estimated Transit Costs

	Small Urban Areas		Rural Areas	
Cost Category	Transit Cost ($)	Cost per Trip ($)	Transit Cost ($)	Cost per Trip ($)
Operational expenses	1,581,017,438	4.49	1,322,556,555	10.78
Capital expenses	117,565,000	0.33	113,346,800	1.03
Total transit costs	1,698,582,438	4.83	1,435,903,355	11.81

Sensitivity Analysis

The travel behavior and unit costs used in this study for monetizing the transit benefits were based on many assumptions made from previous studies. To account for the uncertainty and variation of the values used that might occur, a series of sensitivity analyses were conducted to understand how results change when some of the key variables change. Sensitivity analysis was conducted for the study by considering eight different scenarios. In each scenario listed below, changes were made to one of the travel behavior or unit cost variables, while the other variables maintained the values from the base case:

Scenario 1. Fifty percent of passenger trips were assumed to be forgone in the absence of transit, as opposed to 22% for fixed route and 31% for demand response in the base case, and the rest of the trips were distributed according to their proportion from the base case. This scenario examines how results would change for transit systems that serve a higher percentage of transit-dependent riders and how results are sensitive to the percentage of forgone trips.

Scenario 2. The percentage of trips made by walking or bicycling in the absence of fixed-route transit was reduced by half (from 27% to 13% for walking and from 5% to 3% for bicycling). This scenario was run because the survey results used for the base case provided walk and bicycle shares that may be too high. The rest of the trips were distributed according to the proportions observed in the base case.

Scenario 3. The average automobile cost was increased from $0.65 per mile to $0.84 per mile (which is the American Automobile Association estimate when the average mileage is 10,000 mi).

Scenario 4. The costs of forgone medical and work trips were increased by 25% from the base case.

Scenario 5. The costs of forgone medical and work trips were decreased by 25% from the base case.

Scenario 6. The value of travel time for automobile was adjusted to be the same value as that for transit. A value of travel time of $4.14 per hour was used for transit and automobile travel.

Scenario 7. Travel time, crash cost, and emission cost savings were excluded from the analysis. These are among the most difficult to quantify of the costs considered in this study, and therefore there is a higher degree of uncertainty concerning their results. For demand-response service, negative values were found for each of these, resulting in lower benefit–cost ratios. Negative values were also found for travel time savings for fixed-route service in urban and rural areas and emissions savings for fixed-route service in rural areas. However, users of transit services may have a lower value of travel time than that used in the analysis, and the costs associated with crashes and emissions are more difficult to quantify. Therefore, the purpose of this scenario is to show how results would differ if these three costs were excluded.

Scenario 8. The proportion of medical trips was increased to 30%, as opposed to 5.3% for small urban transit and 7.4% for rural transit in the base case, and the remaining trips were distributed according to the proportion of trip purposes from the base case. This scenario examines how results would change for transit systems that serve a higher percentage of medical trips and how results are sensitive to the trip type.

Table 5 presents the individual transit benefits, total transit benefits, and benefit–cost ratio for the base case and for each scenario. The percentage increase and decrease of all transit benefits when compared with the base case in each scenario are also provided in parentheses.

In Scenario 1, modifying the percentage of forgone trips to 50% for fixed-route and demand-response service resulted in an overall 88% increase in total transit benefits, with the benefit–cost ratio being 3.17. Under this scenario, the benefit–cost ratios increase from 2.16 to 4.22 in small urban areas and from 1.20 to 1.93 in rural areas. Further, for small urban transit, the benefit–cost ratio for demand-response service increased from 0.64 to 0.93 and the benefit–cost ratio for fixed-route service increased from 2.60 to 5.17.

Figure 1 shows how the benefit–cost ratio of public transit varies with the percentage of forgone trips in the absence of public transit. The benefit–cost ratio varies from 0.98 to 5.92 when the percentage of forgone trips ranges from 10% to 100%. This finding shows that results are highly sensitive to the percentage of trips that would be forgone in the absence of transit and that transit systems serving a greater percentage of transit-dependent riders produce more benefits. Further, Figure 1 shows the benefit–cost ratio of rural and small urban transit for various forgone trip percentages when 30% of the trips are dedicated for medical trip purposes (as explained in Scenario 8). This situation substantially increases the benefit–cost ratio of rural and small urban transit ranging from 2.17 to 17.83 when the percentage of forgone trips ranges from 10% to 100%.

Scenarios 4 and 5 also show that the results are sensitive to the values assigned to forgone trips. Increasing the cost of forgone medical trips and work trips by 25% in Scenario 4 increased the total transit benefits by 20%. Similarly, decreasing the cost of forgone medical trips and work trips by 25% in Scenario 5 decreased the total transit benefits by 20%.

Results from Scenarios 2, 3, and 6 produced minimal difference from the base case, showing that the results were not as sensitive to walk and bicycle percentages, automobile costs, and value of travel time. Scenario 7 shows that excluding travel time, crash, and emissions costs from the analysis increases the benefit–cost ratio from 1.68 to 1.76. Scenario 8 shows that results are highly sensitive to trip type and the percentage of trips that are for medical purposes. Increasing the proportion of medical trips to 30% increases the total transit benefits by 160% and the benefit–cost ratio from 1.68 to 4.38. Under this scenario, the benefit–cost ratios increase from 2.16 to 5.92 in small urban areas and from 1.20 to 2.57 in rural areas.

TABLE 5 Sensitivity Analysis Results for Eight Scenarios

	Transit Benefits								
		Benefits, by Scenario							
Benefit Categorization	Base Case	1	2	3	4	5	6	7	8
Vehicle ownership and operation cost savings [$ millions (%)]	156	100 (–36)	203 (30)	201 (29)	156 (0)	156 (0)	156 (0)	156 (0)	156 (0)
Chauffeuring cost savings [$ millions (%)]	332	227 (–32)	397 (20)	332 (0)	332 (0)	332 (0)	332 (0)	332 (0)	332 (0)
Taxi cost savings [$ millions (%)]	512	314 (–39)	680 (33)	512 (0)	512 (0)	512 (0)	512 (0)	512 (0)	512 (0)
Travel time cost savings [$ millions (%)]	–221	–482 (–118)	–507 (–129)	–221 (0)	–221 (0)	–221 (0)	–171 (23)	0 (100)	–221 (0)
Crash cost savings [$ millions (%)]	40	–15 (–138)	39 (–2)	40 (0)	40 (0)	40 (0)	40 (0)	0 (–100)	40 (0)
Emission cost savings [$ millions (%)]	–58	–79 (–38)	–41 (28)	–58 (0)	–58 (0)	–58 (0)	–58 (0)	0 (100)	–58 (0)
Cost of forgone medical trips [$ millions (%)]	2,197	4,787 (118)	2,197 (0)	2,197 (0)	2,746 (25)	1,647 (–25)	2,197 (0)	2,197 (0)	11,255 (412)
Cost of forgone work trips [$ millions (%)]	2,045	4,495 (120)	2,045 (0)	2,045 (0)	2,557 (25)	1,534 (–25)	2,045 (0)	2,045 (0)	1,521 (–26)
Cost of other forgone trips [$ millions (%)]	274	590 (115)	274 (0)	274 (0)	274 (0)	274 (0)	274 (0)	274 (0)	204 (–25)
Total transit benefits [$ millions (%)]	5,277	9,935 (88)	5,287 (0)	5,322 (1)	6,337 (20)	4,216 (–20)	5,327 (1)	5,515 (4.5)	13,742 (160)
Benefit–cost ratio	1.68	3.17	1.69	1.70	2.02	1.35	1.70	1.76	4.38

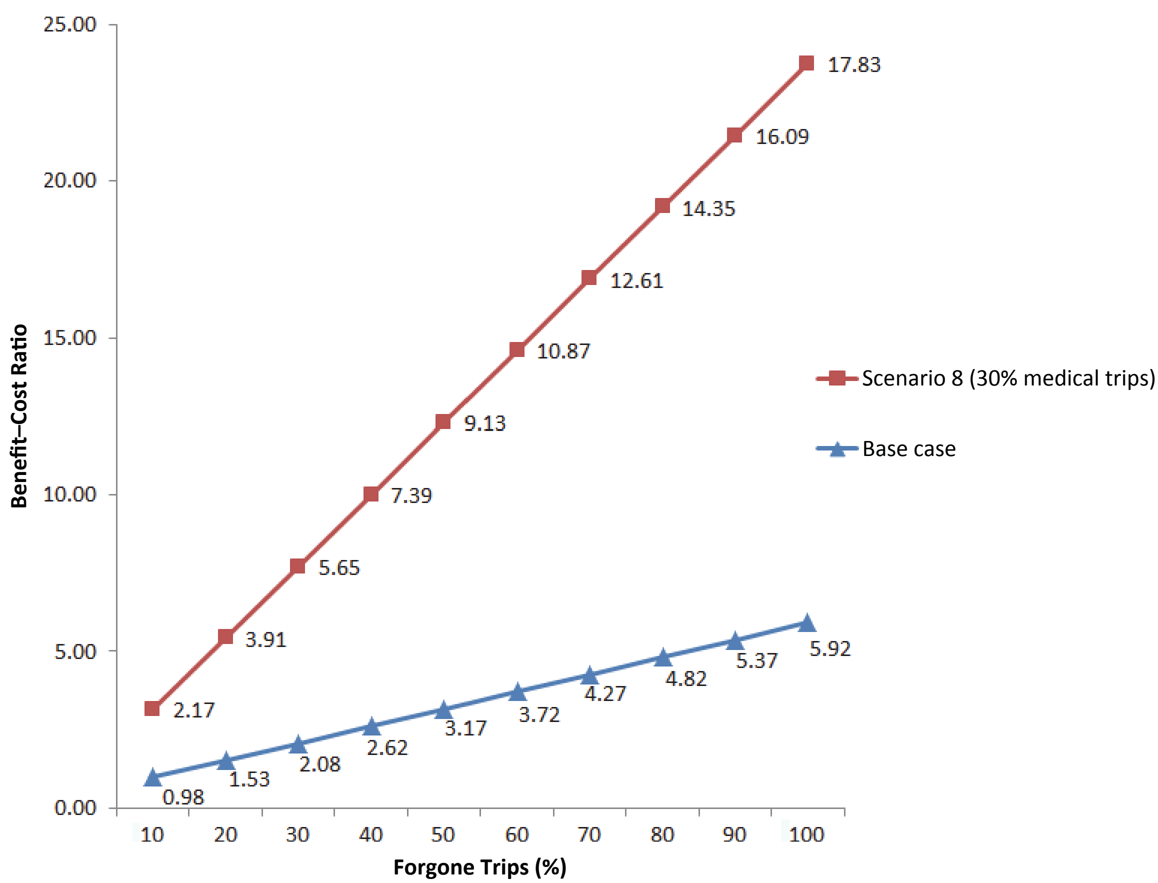

FIGURE 1 Benefit–cost ratio of small urban and rural transit for various percentages of forgone trips.

CONCLUSIONS

Implications

With benefit–cost ratios greater than 1, the results show that the benefits provided by transit services in rural and small urban areas are greater than the costs of providing those services. Results show that benefit–cost ratios are higher in small urban areas than in rural areas, but benefits were found to exceed costs for rural and small urban transit. Results also showed that fixed-route service has higher benefit–cost ratios than demand response. Demand-response service provides significant benefits per trip, but the cost of providing this service is also significantly higher.

While there are a number of different types of benefits from transit service, the study shows that most of the benefits of urban and rural transit services are generated by creating trips for individuals who would not be able to make the trip if the service were not available. In particular, the creation of medical and work trips accounted for the largest share of transit benefits.

The study also showed that the results are highly sensitive to the percentage of trips that would be forgone in the absence of transit, the cost values assigned to those forgone trips, and the percentage of trips that are for medical purposes. Benefit–cost ratios increase to more than 3 to 1 if it is assumed that half of the trips would not be made in the absence of transit and to more than 4 to 1 if 30% of trips are for medical purposes.

The implication from these results is that transit services that serve a higher percentage of transit-dependent riders and those that provide a greater percentage of medical or work trips will provide more benefits per trip. The benefit of providing a medical trip to someone who otherwise would not be able to travel is especially high.

Limitations

This study attempts to estimate overall benefits and benefit–cost ratios at the national level, but it is recognized that these values can vary significantly between individual transit systems according to the types of services they provide and the individuals they serve.

The results can also be considered to be conservative because some benefits are difficult to quantify. While the study showed significant value for providing medical and work trips, the value of providing other types of trips may have been underestimated because of the difficulty in quantifying the benefits of those trips. In many cases, the benefits of providing those trips are more qualitative in nature. Social trips, for example, can have significant quality-of-life benefits that are difficult to quantify. Providing a person with the ability to travel where and when the person wants, regardless of trip purpose, improves quality of life in a way that may have been underestimated in this study.

Further, there are other potential benefits not included in this study because they are generally less relevant to rural and small urban areas or because of the difficulties in quantifying them. For example, parking cost savings, congestion mitigation, and land use impacts are significant effects of transit in urban areas but were not included in this research because they are less relevant for the areas being studied. However, in some small urban areas, these may be significant benefits that need to be considered. There are also a number of less tangible benefits not included in this study that could be considered, such as community cohesion, relocation cost savings, and provision of transportation service during emergencies. Relocation cost savings, in particular, could be significant in rural areas, to the individual and to the community.

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