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Congestion, pollution, and benefit-to-cost ratios of US public transit systems

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Abstract

This paper presents a broad set of benefit–cost analyses of the public transit systems of 81 urbanized areas. The calculated sources of benefits are to riders and the reduction of congestion costs. Other sources of benefits are shown to be quite small. Costs are calculated based upon operating costs and adjustment factors to account for capital costs and the excess burden of taxes used to support public transit. For the medium estimates the aggregate benefit–cost ratio is 1.34. Only 23 of the urbanized areas have a benefit–cost ratio of one or greater for the medium estimates, but these were mainly the largest in population and transit use. Even for the high estimates, the benefit–cost ratio was less than one for almost half the areas considered.

Keywords: Public transit; Benefit–cost analysis; Congestion; Pollution

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1. Introduction

Authors, such as Obeng and Sakano (2002), Winston (2000), Karlaftis and McCarthy (1999), and Love and Cox (1991), have presented theory or evidence that public transportation is inefficient in various ways. It tends to use inefficient input combinations, overpay workers, and may provide too much service. To the extent that these views are correct, it implies that one could improve the net benefits of public transportation by making adjustments at various margins. Presumably these adjustments would only come about via changes in programs and processes that fund public transportation. However, even if the production of public transportation is done inefficiently, it is of interest to ask how the benefits of public transportation compare with the costs under recent conditions across a range of urban areas.[1]

Here we look at 81 urbanized areas (UZAs) with estimates of the reduction in congestion cost provided by public transportation. These estimates, for 2002, have been created by Schrank and Lomax (2004) of the Texas

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[1] Shapiro and Hassett (2005) offer a set of benefit and cost numbers for public transit for the US as a whole in the context of estimates of benefits and costs for the operation of highways and public transit. Their methods and assumptions for public transit are simpler than offered here and ultimately give a much more favorable picture of the benefit-to-cost ratio of public transit.

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Transportation Institute for only the second time, and are presented in their 2004 Urban Mobility Report (UMR). Additional data comes from the National Transit Database and includes locality-specific information on operating costs, passenger miles and fares, which provide inputs into the estimation of rider benefits and relevant costs. Additional sources are used to justify further assumptions that allow the calculation of a ratio of benefit to costs for each urban area.

2. Data and assumptions regarding benefits from congestion reduction

The 2004 Urban Mobility Report (UMR) estimates the reduction in congestion cost provided by public transportation for 85 urban areas. Here we use the UMR (Table 3) numbers for 81 of the 85 areas because the others were not listed in the relevant National Transit Database, that offers information on transit use and related statistics for the top 150 urbanized areas.[2] According to UMR there were $63.2 billion in actual congestion costs in the 85 urban areas in 2002. It is estimated that public transportation saved an additional $20 billion in congestion costs for this group. UMR based estimates of travel delay on data of actual road usage and formulas that determine how fast traffic will move under various conditions. Only peak-period use is considered in determining congestion. The peak periods during a working day are presumed to last seven hours divided between morning and evening rush hours. Key assumptions in the estimates include that there are 1.25 persons per vehicle and 250 working days per year. Additionally, passenger time is valued at $13.45 per hour, commercial vehicle operating cost is assumed to be $71.05 per hour, and 95% of vehicles are assumed to be passenger vehicles and 5% commercial. The largest part of the saved congestion cost is driver time, but the cost of wasted fuel is also included in the estimate. The UMR estimates show that congestion has been getting significantly worse over the last twenty years as the increase in traffic has exceeded the increase in available roadway.

Using information on passenger miles for 2002 traveled by public transportation from the National Transit Database, the UMR estimates imply an average of approximately $0.47 in congestion saving for every passenger mile of travel on public transit. Parry and Small (2004, Table 1), drawing on Delucchi (1997, 1998) and other sources, offer estimates for the external congestion cost and external accident cost per mile of automobiles averaged over all driving in the US. The sum of these two numbers is $0.065 per mile for the year 2000. To compare this with the congestion-cost numbers from UMR, some adjustments are called for. The group of urbanized areas considered contains over 140 million persons, or nearly half the US population. A rough estimate is that congested driving times account for about half of all driving within these areas. On this basis one can scale up Parry and Small's estimate by a factor of four to obtain an estimate of congestion cost per mile at peak periods in the most urbanized half of the nation; some $0.26 per mile, with perhaps a couple more cents added for inflation and worsening traffic between 2000 and 2002. This scaled-up estimate is still only about 60% of the $0.47 derived from the UMR. However, not all rides on public transit are at peak times, so presumably the UMR congestion saving per peak-period rider would be significantly higher than $0.47. Thus, UMR's congestion cost estimate seems large relative to Parry and Small's numbers.

A more direct consideration is that the UMR congestion savings estimate rests partly on the assumption that all riders on public transportation would otherwise be in cars at the rate of 1.25 persons per vehicle, an approach criticized by Cox and O'Toole (2004). Economic reasoning indicates that previous transit riders would reduce the total number of trips taken and would use modes such as walking or car-pooling for some trips formerly taken by transit.

The UMR estimated congestion savings are further reduced when taxes on extra gasoline usage due to congestion are considered. These are not a social cost, but represent a transfer to governments that would be reduced if less gasoline were consumed. Another important consideration is the assigned value of time of $13.45 per hour. This compares with an average hourly earning of production workers in 2002 of $14.95 and annual total compensation of full-time employees of $48,652.[3] The latter compensation implies around $24 per hour for a 2000-hour work year. Mohring et al. (1987) refer to a significant literature that places the value of time

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[2] The areas considered in the 2004 Urban Mobility Report not used here are Boulder, Laredo, Brownsville, and Beaumont.

[3] These are from the Statistical Abstract of the US (2004–2005). Total compensation includes executive compensation, bonuses, and the employer contribution to social security insurance, among other things.

spent in transit at roughly half the value of the wage earned for relatively high-wage workers and a smaller ratio for lower-wage workers. The recent results by Perez et al. (2003) are roughly in line with this. Based upon this literature and that the average transit rider arguably has a lower opportunity cost of time than the average person, one might argue that $13.45 is high for the value of time lost to congestion. If, for example, $10 per hour were chosen, calculations indicate that the estimate of total congestion costs would drop by around 19%.

Not all the problems raised regarding the UMR congestion numbers necessarily reduce the value one would assign to the cost of congestion. Downs (2004) and the Washington State Department of Transportation (2004) indicate that the unpredictability of delay tends to lead to drivers leaving early enough so that their expected arrival time is before the most desired arrival time. On balance, however, the UMR numbers appear to be on the high side. Therefore, the congestion-cost savings in the low, medium, and high estimates of benefits over costs are taken at 80%, 90%, and 100% of the UMR number.[4]

3. Benefits from reduced greenhouse gases and pollution

Benefits associated with reductions in greenhouse gases or conventional pollutants that can be attributed to the use of public transit are, at most, quite small compared with the benefits estimated for congestion reduction, and even smaller when compared with overall benefits. As a first comparison, consider the greenhouse effect of automobile driving. The National Research Council (2003), in discussing corporate average fuel economy standards, and Parry and Small, in discussing the optimal gasoline tax, respectively used $50 and $25 per ton for carbon external cost. This level of externality presumably reflects the global impact and not simply the US external cost, which is significantly less. At $50 per ton, an external cost per gallon of gasoline of $0.12 is obtained. An automobile getting 20 miles per gallon would accordingly generate $0.006 per vehicle mile of greenhouse externality. The estimated greenhouse externality would be even smaller if one used damage numbers in line with Nordhaus and Boyer (2000). Furthermore, since public transport consumes fossil fuels to a substantial extent, the net reduction in the greenhouse gas emissions is only a fraction of any fall implied by a reduction in the use of the automobile due to public transport.

Estimation of any reduction in the damages from the conventional automobile pollutants due to the use of public transportation must recognize that damages come from the three main types of emissions—nitrogen oxides, volatile organic compounds, and carbon monoxide—plus the indirect product of ozone that is related to the first two pollutants. Parry and Small (2004), referring to studies by Delucchi (1997, 1998) and others, offer the estimate of $0.02 per vehicle-mile as the distance-related pollution damage for the US. This would translate to $0.016 per passenger mile using the 1.25 passenger per vehicle assumed in UMR. It is possible that the marginal damage of pollution is higher in the urban areas considered here. However, using public transportation reduces automobile pollution only by causing an increase in pollutants from fuels used to power the buses and rails carrying the extra passengers. Since buses generally use diesel fuels and rail relies on electricity generated by a variety of means, the mix of pollutants from public transportation is somewhat distinct from pollutants from autos. More particles and sulfur dioxide and fewer volatile organic chemicals would derive from public transit.

Given the different mix of pollutants, it is not clear that bus transportation would reduce air pollution damages compared to travel by automobile. One can calculate from Delucchi (1998) that particle-related health effects account for roughly half of all non-monetary external costs outside of external accident costs and traffic congestion.[5] Furthermore, reduced visibility is largely caused by particles. Monahan and Friedman (2004) indicate that gasoline consumption in the US is three times the level of diesel fuel consumption, but that diesel

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[4] Anyone in a personal car who has had to wait behind a bus stopped for passengers might also wonder to what degree buses, in comparison with their absence, also cause traffic delay. Downs (2004) recognizes this when he states, "Hence buses themselves are important contributors to general traffic congestion ..." In response to an e-mail, Dr. Schrank indicated that the calculations in Schrank and Lomax (2004) did not account for any offsetting effects of reduced congestion from buses in considering how much higher congestion would have been if transit riders had been in cars, as it was considered on the order of rounding error.

[5] Delucchi includes many other categories of non-monetary external cost associated with motor vehicles. These include air pollution damage to crops, forests and materials, plus noise and water pollution damages. They are relatively small in magnitude and, with many of these, the substitution of travel by public transportation would not entirely eliminate the external cost.

trucks and buses emit more than twice the particles of all cars and light trucks. An inference from this is that burning a gallon of diesel has, under recent conditions, led to roughly six times as many particles as burning a gallon of gasoline. Data from the National Transit Database indicates that in 2002 there were 19.7 billion passenger miles by motor bus and buses burned 0.47 billion gallons of diesel implying 41.9 passenger miles per gallon of diesel[6]. Although this is about twice the average passenger miles per gallon of conventional cars (carrying the 1.25 persons assumed by UMR), it still means that buses, on average, emit several times the particles per passenger mile than do cars.[7] Given the relative size of the damage from particles, the net reduction in pollution-related external cost created by switching travelers from cars to buses might not even be positive.[8]

4. Discussion and assumptions regarding estimation of rider benefits

The other main source of benefits of public transportation is for the riders. A standard economic measure of the benefits of consuming an amount of good is the area under the compensated demand curve. To simplify, it is assumed that the compensated demand curve is linear and quantity is measured by the number of passenger miles. A linear demand curve can be located by two points. One point is provided by the fare per passenger mile (an average of actual fares for any one system) and the number of passenger miles for each urbanized area. The second point is provided by the intercept. The assumed intercept value takes on three values depending upon whether we are estimating a high, medium, or low estimate of the benefit–cost ratio. The medium value taken for this intercept is \$1 per passenger mile. This compares with an actual fare per passenger mile that averages to about \$0.17 per mile for the group considered.

With the assumed linearity, an intercept of \$1 yields an estimate of the elasticity of the compensated demand curve of approximately $(0.17/0.83) \approx 0.2$ at the average fare of \$0.17, based upon the well-known relationship between the point elasticity of demand and location of the point on a linear demand curve. If anything, this would be on the low side of empirical estimates of elasticity as indicated by Savage (2004) and Goodwin (1992) with reference to buses. Specifically, Goodwin summarizes the results of a collection of studies by stating, "The unweighted mean value of 50 quoted bus fare elasticities is -0.41, compared with the -0.3 earlier taken as orthodox." It is not noted if these elasticities are for compensated or uncompensated demand. However, since public transit fares are generally a small part of most persons' budgets, the income effect of a price change is unlikely to be large.[9] There is less evidence with regard to the elasticity of demand for intra-urban rail travel. Goodwin (1992) cites a study of the London underground that offers elasticities that range from -0.2 to -0.4 depending upon whether one considers the short run or the long run and whether or not one assumes that all modes of public transit change their prices proportionately.[10] With linear demand, a higher elasticity at current fares implies a lower estimate of total benefits via the implied reduction in the relevant demand intercept. An alternative interpretation of the approach is to think of the value of the intercept as an average over various individuals with varying intercepts. Such an average of differing linear demand

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[6] The numbers necessary for the computation were taken from Excel files for 2002 labeled "energy consumption" and "service" downloadable in a group of files from the NTD website.

[7] It is assumed that buses and trucks are roughly the same in the emissions of particles per gallon of diesel. The author does not know of any direct evidence on this. However, acceleration does increase the emissions of a diesel engine compared to smooth movement and buses in urban public transportation accelerate as they move away from a stop. This suggests that the exposure of people per pound of particle emissions from buses may exceed that from cars, which tend to stay further from the curb on average.

[8] Monahan and Friedman (2004) also point out that burning a gallon of diesel leads to the release of 17% more greenhouse gases than does burning a gallon of gasoline. Thus, the average of 40 bus passenger miles per gallon of diesel indicated in the text would mean that a car carrying 1.25 persons and getting 28 or more vehicle miles per gallon of gasoline would be emitting fewer greenhouse gases per passenger mile than the average bus running on diesel.

[9] In passing, it should be noted that for normal (inferior) goods, the compensated elasticity of demand is higher (lower) than the uncompensated demand elasticity. Based on the evidence it seems more likely that public transportation is an inferior good and thus would have a compensated elasticity higher than the uncompensated elasticity.

[10] Given the premise of the benefit–cost analysis done here, the most appropriate elasticity of demand would be a long-run price elasticity where all modes of public transit change their prices proportionately. The long-run elasticity would tend to be greater than the short-run elasticity, but the elasticity of demand for a mode of public transportation is likely to be higher if other modes are not changing their prices proportionately.

curves would produce a convex aggregate demand curve with a higher intercept, but the same estimate of total benefits for the same initial fare and passenger miles.

It is likely that the appropriate demand intercept would be higher for larger cities with higher local price levels and greater traffic congestion. (Since public transportation is an inferior good, the high incomes associated with some of the largest cities would actually work in the opposite direction.) Thus, assuming the same intercept for the demand curve for all urban areas will tend to bias the benefit–cost ratios, in a relative sense, downward for more populous areas compared to less populous ones. However, since the results tend to show benefit–cost ratios that are positively related to the size of the population of the urban area, the relative ranking of benefit–cost ratios should not be significantly affected. As will be seen, the largest areas tend to have benefit–cost ratios above one and the smaller ones have benefit–cost ratios less than one. Thus, if the correct value of the intercept for the median urban area is close to what is assumed, then a classification of urban areas according to whether they have a public-transit system with a benefit–cost ratio larger or smaller than one should not be subject to substantial errors.[11] In any case, the methodology is moderately sensitive to variations in rider demand. If higher general prices or congestion shift the demand for public transportation to the right for a given fare, the estimated (inverse) demand curve is swung to the right accordingly by pivoting on the assumed intercept. The measure of total benefit would go up by $(\Delta M)[f + (1/2)(a - f)]$, where (ΔM) is the change in passenger miles, f is the fare per passenger mile, and a is the price intercept in dollars per passenger mile. The portion of this that is added consumer surplus is $(\Delta M)(1/2)(a - f)$.

A relevant reference value for the choice of intercept for the public transportation demand curve is the cost of using an automobile. The Automobile Association of America (2005) estimated the cost of driving a typical automobile in 2002 at $0.502 per vehicle mile. With 1.25 passengers per vehicle, this puts the cost at $0.402 per passenger mile. This estimate includes gasoline, maintenance, insurance, depreciation, and interest in the form of finance charges. It does not include parking or the value of time spent driving. With regard to time, public transportation, particularly buses, is slower than autos over the same route.[12] Also, the transit rider takes time to get to the transit stop and will generally have to wait to be picked up. Thus, the amount of time to cover a given distance is usually significantly greater for the transit rider. Furthermore, the amenities of being in a private automobile are considered by most people to be preferable to those involved in public transportation. On the other hand, the transit rider does not have to drive, so one component of effort is smaller. The cost of parking varies greatly by time and location and is not directly related to distance traveled. However, it seems unlikely that this would add more than $0.10 to $0.20 per passenger mile. Given this, an intercept of $1 for the compensated demand is at a level roughly twice the estimated cost per passenger-mile of using a typical automobile.

5. Discussion of data and assumptions regarding costs

The National Transit Database provides numbers for passenger miles, operating costs, and other pertinent data for an estimation of the cost of providing public transportation in each of the urban areas considered here. To get an estimate of the full cost of public transportation, some additional assumptions and adjustments are made. First, consider the cost of capital. The ideal measure would be the depreciation and interest cost associated with providing service for the year 2002. Unfortunately, there are no generally reported estimates of the capital stock for the various transit agencies upon which to base calculations. However, using data in the National Transit Summaries and Trends Report for 2002, one can calculate that the ratio of operating cost plus capital spending to operating cost for all reporting agencies was 1.53 for the 2002 and 1.33 for the year 1991, with the average of the ratios for years 1991 through 2002 being 1.43. If the capital stock of transit agencies were growing in a given year at a rate no faster than the interest rate one would apply to capital, then using the ratio of total spending to operating cost would not overestimate the full cost. The numbers

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[11] As the reader is likely to already know, high prices and congestion are associated with the New York City, San Francisco Bay, Los Angeles, and Washington, DC areas. These areas are among those that are estimated to have the highest benefit–cost ratios of public transit.

[12] Downs (2004) reports, "… in 2000, the average commuting trip by transit in the US required 47.7 min versus 24.1 min for such trips by private vehicles driven by single occupants and 28.5 min for trips in car pools."

used in this study to scale up cost are closer to the ratio of total spending to operating cost for the year 1991 since there appears to have been an unusually high rate of capital spending in recent years. However, a further set of adjustments is made to account in a rough way for the differing capital costs of bus and rail transportation.

The publication State Transportation Statistics (2004) provides data on the fraction of passenger trips that are on buses for the top 50 urban areas. All rides not taken on buses are assumed to be by rail, although this is not so. However, the fraction of "other" modes is generally small and in some cases these other modes also have relatively high capital costs. These numbers indicate that close to 56% of all trips are by bus for the top 50 urban areas, with the proportion of trips taken by bus increasing as the size of the urban area declines. It is assumed that buses account for 100% of trips for those urban areas in our study not in the top 50 listed. It is well known that capital cost is lower for bus transportation than for light rail, and lower for light rail than for heavy rail. Accordingly, based upon the spending data cited, the estimated ratio of total (capital plus operating) cost to operating cost is put at 1.2 for buses. This is slightly below the value used by Cox (2000). The total cost of rail transit is assumed to be 1.4 times the portion of operating cost attributed to rail. The portion of operating cost attributed to buses is taken to be equal to the share of buses in total trips times the total operating cost. Since the operating cost per trip of a given length tends to be larger for buses than for rail, this procedure might be seen as underestimating the fraction of operating costs belonging to buses. However, bus trips tend to be somewhat shorter on average than trips by rail, so there is an offsetting effect.[13] The estimation of costs with regard to those areas with large amounts of rail service is likely to be one of the larger sources of area-specific error in that anecdotal evidence suggests that the costs of rail projects can vary greatly. Given the distribution of trips in the top 50 urban areas, the estimated average ratio of total costs to operating costs for this group is less than 1.3, which in turn is less than the 1992 ratio of total spending on public transport to operating cost.[14]

A further adjustment in the estimate of costs is required to account for the excess burdens associated with taxes used to subsidize transit. Nearly all of the operating expenses not covered by fares are provided by taxation through directly dedicated revenues or through tax-derived monies provided by local, state, and federal governments. Furthermore, nearly all capital is provided to local transit authorities from state and federal sources. Thus, with minor exceptions, such as revenues from advertising on vehicles and structures belonging to public transit, non-fare monies are generally derived from taxation. The exact set of taxes that could be said to fund public transit is a question of what might be considered the "marginal" sources of tax revenue. Many factors will affect the size of excess burdens associated with any taxes used to fund public transportation, including their jurisdictional reach and the presence of other taxes.

A large portion of taxation is based upon labor income and Browning (1987) has demonstrated that the marginal excess burden of a labor tax can have a wide range based upon a relatively narrow range of assumptions regarding relevant parameter values. The range of possibilities he indicated is from an excess burden of under 10% to over 100% for the marginal dollar raised. Of course, sales and property taxes may also be the source of revenue. With regard to taxes on commodities, the analysis of Goulder and Williams (1999) indicates that in the presence of pre-existing taxes on labor, commodity taxes tend to have a marginal excess burden that is greater than the marginal excess burden due to increasing labor taxation alone. This is due to the fact that a commodity tax not only creates substitution effects among commodities, but it also creates a further

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[13] According to the National Transit Database the average operating expense per unlinked passenger trip for the top 50 transit agencies in 2002 for buses was $2.30. In comparison the operating expense per unlinked passenger trip for heavy rail, commuter rail, and light rail was $1.60, $7.10, and $2.40, respectively. Thus, the various forms of rail have operating costs per trip that fall on both sides of the number for buses.

[14] There are two other issues of relevance here that are not numerically accounted for. One is that some capital projects apparently include investments not directly related to providing public transit services. The Euclid Corridor project in Cleveland, OH is described by the Federal Transit Administration (2002) as involving various re-arrangements of signs, light poles, sidewalk space, and the provision of landscaping. One might wish to exclude these types of costs to some degree. A second issue relates to road construction and maintenance costs in general. The Federal Highway Administration (2000) indicates that automobiles pay in federal user fees roughly an amount equal to what is spent on federal highway costs on their behalf. However, buses (it is not known what portion would be public transit) pay user fees that are roughly only 20% of the expenditures on highways attributed to them. Thus, public transit buses appear to create another fiscal externality by their use of the roadways.

substitution effect away from work and toward leisure. Only if the particular commodities taxed (at differentially higher rates) tend to be complementary to leisure is commodity taxation likely to create less additional excess burden than raising money from labor taxation. Browning offers a "preferred" range of estimates for the marginal welfare (excess burden) cost of additional labor taxation, which "would lie between 31.8% and 46.9%". All things considered, this paper uses a factor of 1.3 in its medium estimate of the benefit–cost ratios to multiply the portion of costs not covered by fares to reflect the total burden of a dollar raised by taxation. For the high and low estimates of the benefit–cost ratio, respectively, tax-cost multipliers of 1.15 and 1.45 are used. This range runs below Browning's preferred range for labor taxation, but this allows for some non-fare revenues coming from sources other than taxes.[15]

6. Specific notation and formulas and basic data

The assumptions regarding the methods of calculating benefits and costs can be summarized with the aid of some notation: G is the saving in congestion cost due to public transportation in a given urban area, as estimated in the 2004 Urban Mobility Report; h is the fraction of G used in this paper to estimate actual congestion saving in a given urban area; R is the operating cost for public transit; β is the fraction of trips in an urban area taken on buses; $1+k_\beta$ is the multiplier on operating cost attributed to buses to estimate operating plus capital cost of bus operations; $1+k_\rho$ is the multiplier on operating cost attributed to rail to estimate operating plus capital cost of rail operations; $1+e$ is the multiplier on tax-financed (non-fare covered) cost to estimate the total social cost of a dollar of subsidy for public transit. The symbol e stands for the relevant excess burden per dollar of tax revenue; M is passenger miles, f is the average fare per passenger mile collected by a given area's public transportation; a is the price intercept for compensated demand curve for passenger miles in a given urban area; B is the benefits of public transportation for a given urban area; and C is the social cost of public transportation in a given urban area.

Using this notation,

$$B = (1/2)(a-f)M + fM + hG = (1/2)(a+f)M + hG \tag{1}$$

$$\begin{aligned} C &= (R-fM)(1+e)[\beta(1+k_\beta)+(1-\beta)(1+k_\rho)] + fM[\beta(1+k_\beta)+(1-\beta)(1+k_\rho)] \\ &= R[\beta(1+k_\beta)+(1-\beta)(1+k_\rho)] + e(R-fM)[\beta(1+k_\beta)+(1-\beta)(1+k_\rho)] \end{aligned} \tag{2}$$

With regard to B, the expression $(1/2)(a-f)M$ is an estimate of the amount of net benefit obtained by riders who ride M passenger miles and pay fare f. The total benefit adds this to the total fare paid. To this rider benefit is added the congestion cost savings estimated by the 2004 Urban Mobility Report adjusted by the factor h to get an estimate of the total benefits of public transportation for a given urban area. To get total cost, operating costs are scaled up by the factor $[\beta(1+k_\beta)+(1-\beta)(1+k_\rho)]$ to roughly reflect both the operating and capital cost of public transport and account for the mix of rides on buses and by rail. The portion of the cost not covered by fares is funded by taxes and has the added excess burden cost of e per dollar spent out of taxes. This part of the cost is reflected in the second term in the last version of the expression for total social cost. No benefit from reduced air pollution or greenhouse gases is considered.

7. Data tables and results

The New York area has by far the largest number of passenger miles, highest total operating costs, and highest fares collected (Table 1). On the other hand, it has one of the lowest operating costs per passenger mile and is only slightly above average in the fare per passenger mile at $0.19. While the average operating cost per passenger mile is approximately $0.47, a number of areas have an operating cost over $1 per passenger mile,

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[15] It might be argued that public transportation provides individuals with a means to get to work and, therefore, it may generate some positive fiscal externalities via the taxes paid by those who might not otherwise hold a job because of transportation difficulties. This argument may have some merit. One would take it into account by lowering the estimate of excess burden per dollar of tax revenue used to subsidize transit. However, absent any direct information on the size of this effect, it is taken to be too small to call for any adjustment in the assumptions presented in the text.

Table 1
Passenger miles, expenses and fares[a]

UZA name	Passenger miles (millions)	Operating cost (millions)	Operating cost per passenger mile	Total fares (millions)	Fares per passenger mile
1 New York–Newark, NY–NJ–CT	17472.20	$6,893.80	$0.39	$3,343.49	$0.19
2 LA–Long Beach–Santa Ana, CA	2799.00	$1,391.70	$0.50	$334.01	$0.12
3 Chicago, IL–IN	3630.10	$1,530.50	$0.42	$619.85	$0.17
4 Philadelphia, PA–NJ–DE–MD	1687.80	$932.50	$0.55	$364.61	$0.22
5 Miami, FL	672.30	$413.70	$0.62	$93.08	$0.14
6 Dallas, Ft. Worth–Arlington, TX	443.20	$331.90	$0.75	$30.20	$0.07
7 Boston, MA–NH–RI	1796.50	$792.60	$0.44	$226.68	$0.13
8 Washington, DC–VA–MD	2327.90	$1,013.80	$0.44	$438.98	$0.19
9 Detroit, MI	293.30	$263.40	$0.90	$32.13	$0.11
10 Houston, TX	580.50	$252.00	$0.43	$47.88	$0.08
11 Atlanta, GA	856.30	$312.10	$0.36	$85.20	$0.10
12 San Francisco–Oakland, CA	1869.50	$1,154.50	$0.62	$330.19	$0.18
13 Phoenix-Mesa, AZ	181.90	$127.10	$0.70	$24.02	$0.13
14 Seattle, WA	883.00	$633.50	$0.72	$112.13	$0.13
15 San Diego, CA	511.30	$214.00	$0.42	$81.96	$0.16
16 Minneapolis-St. Paul, MN	329.00	$248.90	$0.76	$68.95	$0.21
17 St. Louis, MO–IL	281.20	$164.70	$0.59	$33.60	$0.12
18 Baltimore, MD	463.20	$280.00	$0.60	$80.08	$0.17
19 Tampa-St. Petersburg, FL	94.30	$69.20	$0.73	$14.81	$0.16
20 Denver-Aurora, CO	355.80	$231.20	$0.65	$42.08	$0.12
21 Cleveland, OH	258.10	$221.10	$0.86	$38.03	$0.15
22 Pittsburgh, PA	354.70	$280.70	$0.79	$65.96	$0.19
23 Portland, OR–WA	447.00	$269.60	$0.60	$54.19	$0.12
24 San Jose, CA	297.20	$339.30	$1.14	$32.23	$0.11
25 Riverside-San Bernardino, CA	109.50	$75.50	$0.69	$16.31	$0.15
26 Cincinnati, OH–KY–IN	160.10	$90.20	$0.56	$23.45	$0.15
27 Virginia Beach, VA	81.90	$49.60	$0.61	$13.00	$0.16
28 Sacramento, CA	136.50	$98.90	$0.72	$23.83	$0.17
29 Kansas City, MO–KS	58.70	$58.60	$1.00	$8.56	$0.15
30 San Antonio, TX	190.50	$95.40	$0.50	$15.07	$0.08
31 Las Vegas, NV	172.50	$95.00	$0.55	$30.50	$0.18
32 Milwaukee, WI	188.30	$143.70	$0.76	$40.24	$0.21
33 Indianapolis, IN	53.30	$34.90	$0.65	$6.14	$0.12
34 Providence, RI–MA	114.60	$79.30	$0.69	$13.88	$0.12
35 Orlando, FL	145.10	$77.30	$0.53	$12.68	$0.09
36 Columbus, OH	67.90	$67.30	$0.99	$13.06	$0.19
37 New Orleans, LA	142.30	$120.70	$0.85	$38.99	$0.27
38 Buffalo, NY	73.90	$76.70	$1.04	$19.48	$0.26
39 Memphis, TN–MS–AR	67.80	$43.00	$0.63	$9.12	$0.13
40 Austin, TX	118.00	$92.20	$0.78	$3.04	$0.03
41 Bridgeport-Stamford, CT–NY	214.80	$74.10	$0.34	$21.41	$0.10
42 Salt Lake City, UT	116.50	$89.30	$0.77	$13.04	$0.11
43 Jacksonville, FL	59.10	$58.10	$0.98	$17.20	$0.29
44 Louisville, KY–IN	51.20	$48.50	$0.95	$6.01	$0.12
45 Hartford, CT	67.20	$44.00	$0.65	$11.79	$0.18
46 Richmond, VA	53.70	$30.30	$0.56	$8.70	$0.16
47 Charlotte, NC–SC	67.00	$37.80	$0.56	$6.27	$0.09
48 Nashville-Davidson, TN	32.00	$23.90	$0.75	$6.38	$0.20
49 Oklahoma City, OK	23.90	$16.40	$0.69	$3.33	$0.14
50 Tucson, AZ	57.80	$38.60	$0.67	$7.06	$0.12
51 Honolulu, HI	323.00	$125.90	$0.39	$31.98	$0.10
52 Dayton, OH	42.40	$53.00	$1.25	$6.25	$0.15
53 Rochester, NY	46.40	$41.50	$0.89	$13.57	$0.29
54 El Paso, TX–NM	67.60	$34.20	$0.51	$6.26	$0.09
55 Birmingham, AL	14.80	$12.70	$0.86	$2.25	$0.15
56 Omaha, NE–IA	14.00	$16.80	$1.20	$3.65	$0.26
57 Albuquerque, NM	21.60	$24.60	$1.14	$2.85	$0.13

Table 1 (*continued*)

UZA name	Passenger miles (millions)	Operating cost (millions)	Operating cost per passenger mile	Total fares (millions)	Fares per passenger mile
58 Allentown-Bethlehem, PA–NJ	22.10	$17.30	$0.78	$2.89	$0.13
59 Springfield, MA–CT	37.20	$28.40	$0.76	$4.37	$0.12
60 Akron, OH	28.50	$28.90	$1.01	$3.27	$0.11
61 Sarasota-Bradenton, FL	17.70	$13.90	$0.79	$1.20	$0.07
62 Albany, NY	46.70	$38.60	$0.83	$9.19	$0.20
63 Tulsa, OK	16.00	$16.00	$1.00	$2.66	$0.17
64 Fresno, CA	38.00	$26.10	$0.69	$7.75	$0.20
66 Raleigh, NC	20.70	$12.70	$0.61	$2.53	$0.12
67 Grand Rapids, MI	24.00	$21.20	$0.88	$3.18	$0.13
69 New Haven, CT	226.50	$75.30	$0.33	$19.73	$0.09
71 Toledo, OH–MI	20.40	$22.40	$1.10	$4.73	$0.23
73 Colorado Springs, CO	14.20	$8.90	$0.63	$2.06	$0.15
75 Charleston-N. Charleston, SC	15.30	$10.80	$0.71	$2.30	$0.15
77 Columbia, SC	6.40	$5.60	$0.88	$0.00	$0.00
82 Bakersfield, CA	31.60	$14.20	$0.45	$3.79	$0.12
88 Little Rock, AR	13.20	$9.10	$0.69	$1.43	$0.11
91 Oxnard, CA	23.20	$13.70	$0.59	$2.66	$0.11
93 Spokane, WA–ID	38.10	$35.40	$0.93	$5.27	$0.14
94 Cape Coral, FL	9.40	$8.00	$0.85	$1.38	$0.15
96 Pensacola, FL–AL	7.70	$6.30	$0.82	$0.92	$0.12
107 Corpus Christi, TX	21.60	$16.00	$0.74	$0.83	$0.04
135 Anchorage, AK	20.10	$17.90	$0.89	$3.79	$0.19
136 Eugene, OR	29.00	$22.50	$0.78	$4.07	$0.14
145 Salem, OR	14.70	$14.60	$0.99	$1.47	$0.10
Sum or average	42781.50	$20913.60	$0.49	$7141.16	$0.17

[a] The numbers next to the names of the urban areas represent the rank of the urban area in terms of population size among all urban areas.

with notable cases being San Jose and Buffalo. The lowest operating costs per passenger mile is in New Haven, with New York and Honolulu transit systems tied for second lowest. Jacksonville and Rochester tie for the highest fare per passenger mile at approximately $0.29. Austin has the second lowest fare at $0.03 per passenger mile, with Columbia recording zero fares.

The New York City area has the highest absolute size of congestion cost saving from public transit at just under 30% of all congestion cost saving (Table 2). However, the highest rate of congestion cost saving is in the California areas of San Francisco–Oakland and Los Angeles–Long Beach–Santa-Ana at $0.83 and $0.81 per passenger mile, while the number for New York City is approximately $0.39 per passenger mile. Since congestion savings are the main source of external benefits and operating costs not covered by fares are a low estimate of the costs to non-riders of public transit, G/S can be taken to be a very rough version of a benefit–cost ratio for the group of non-riders of public transit. Since the full costs to the taxpayer are generally significantly greater than S (even allowing for the fact that riders do pay some taxes), while external benefits are not significantly greater than G, this ratio would have to be greater than one to plausibly assert that the non-riding public as a whole gains from public transit. In fact, only 20 urbanized areas have a G/S of greater than one; values range from 2.3 for Atlanta to 0.07 for Anchorage.

The assumptions regarding the value of the parameters that lead to the low, medium, and high estimates of the ratios of benefits to costs are summarized in Table 3.

The benefit–cost ratios are displayed in Table 4. The first column indicates the rank of each UZA's benefit–cost ratio. The other numerical columns indicate the low, medium, and high estimates of the benefit–cost ratio. Some sense of how high the B/C ratio is compared to what one might expect can be gotten by comparing the urbanized area's rank with respect to the B/C ratio and comparing that with others with similar population. Concentrating on the medium estimates, the top B/C ratios are achieved by Atlanta, the Los Angeles area, and Houston. The lowest B/C ratios are associated with Akron, Salem, and Dayton. Only 23 areas have a B/C

Table 2
Congestion and subsidies

UZA name	Congestion saving (millions)	Congestion saving per passenger mile	Operating subsidy (millions)	Congestion saving per $ subsidy
1 New York–Newark, NY–NJ–CT	$6,837	$0.39	$3,550.31	1.93
2 LA–Long Beach–Santa Ana, CA	$2,337	$0.83	$1,057.69	2.21
3 Chicago, IL–IN	$1,621	$0.45	$910.65	1.78
4 Philadelphia, PA–NJ–DE–MD	$644	$0.38	$567.89	1.13
5 Miami, FL	$359	$0.53	$320.62	1.12
6 Dallas, Fort Worth–Arlington, TX	$195	$0.44	$301.70	0.65
7 Boston, MA–NH–RI	$1,110	$0.62	$565.92	1.96
8 Washington, DC–VA–MD	$1,242	$0.53	$574.82	2.16
9 Detroit, MI	$109	$0.37	$231.27	0.47
10 Houston, TX	$381	$0.66	$204.12	1.87
11 Atlanta, GA	$521	$0.61	$226.90	2.30
12 San Francisco–Oakland, CA	$1,518	$0.81	$824.31	1.84
13 Phoenix-Mesa, AZ	$98	$0.54	$103.08	0.95
14 Seattle, WA	$585	$0.66	$521.37	1.12
15 San Diego, CA	$236	$0.46	$132.04	1.79
16 Minneapolis-St. Paul, MN	$180	$0.55	$179.95	1.00
17 St. Louis, MO–IL	$65	$0.23	$131.10	0.50
18 Baltimore, MD	$329	$0.71	$199.92	1.65
19 Tampa-St. Petersburg, FL	$23	$0.24	$54.39	0.42
20 Denver-Aurora, CO	$143	$0.40	$189.12	0.76
21 Cleveland, OH	$45	$0.17	$183.07	0.25
22 Pittsburgh, PA	$62	$0.17	$214.74	0.29
23 Portland, OR–WA	$256	$0.57	$215.41	1.19
24 San Jose, CA	$112	$0.38	$307.07	0.36
25 Riverside-San Bernardino, CA	$62	$0.57	$59.19	1.05
26 Cincinnati, OH–KY–IN	$53	$0.33	$66.75	0.79
27 Virginia Beach, VA	$27	$0.33	$36.60	0.74
28 Sacramento, CA	$56	$0.41	$75.07	0.75
29 Kansas City, MO–KS	$8	$0.14	$50.04	0.16
30 San Antonio, TX	$67	$0.35	$80.33	0.83
31 Las Vegas, NV	$78	$0.45	$64.51	1.21
32 Milwaukee, WI	$75	$0.40	$103.46	0.72
33 Indianapolis, IN	$12	$0.23	$28.76	0.42
34 Providence, RI–MA	$20	$0.17	$65.42	0.31
35 Orlando, FL	$43	$0.30	$64.62	0.67
36 Columbus, OH	$19	$0.28	$54.24	0.35
37 New Orleans, LA	$31	$0.22	$81.71	0.38
38 Buffalo, NY	$11	$0.15	$57.22	0.19
39 Memphis, TN–MS–AR	$24	$0.35	$33.88	0.71
40 Austin, TX	$46	$0.39	$89.16	0.52
41 Bridgeport-Stamford, CT–NY	$6	$0.03	$52.69	0.11
42 Salt Lake City, UT	$63	$0.54	$76.26	0.83
43 Jacksonville, FL	$11	$0.19	$40.90	0.27
44 Louisville, KY–IN	$18	$0.35	$42.49	0.42
45 Hartford, CT	$24	$0.36	$32.21	0.75
46 Richmond, VA	$6	$0.11	$21.60	0.28
47 Charlotte, NC–SC	$32	$0.48	$31.53	1.02
48 Nashville-Davidson, TN	$10	$0.31	$17.52	0.57
49 Oklahoma City, OK	$3	$0.13	$13.07	0.23
50 Tucson, AZ	$17	$0.29	$31.54	0.54
51 Honolulu, HI	$97	$0.30	$93.92	1.03
52 Dayton, OH	$5	$0.12	$46.75	0.11
53 Rochester, NY	$5	$0.11	$27.93	0.18
54 El Paso, TX–NM	$18	$0.27	$27.94	0.64
55 Birmingham, AL	$2	$0.14	$10.45	0.19
56 Omaha, NE–IA	$4	$0.29	$13.15	0.30

Table 2 (*continued*)

UZA name	Congestion saving (millions)	Congestion saving per passenger mile	Operating subsidy (millions)	Congestion saving per $ subsidy
57 Albuquerque, NM	$5	$0.23	$21.75	0.23
58 Allentown-Bethlehem, PA–NJ	$3	$0.14	$14.41	0.21
59 Springfield, MA–CT	$2	$0.05	$24.03	0.08
60 Akron, OH	$4	$0.14	$25.63	0.16
61 Sarasota-Bradenton, FL	$3	$0.17	$12.70	0.24
62 Albany, NY	$3	$0.06	$29.41	0.10
63 Tulsa, OK	$2	$0.13	$13.34	0.15
64 Fresno, CA	$7	$0.18	$18.35	0.38
66 Raleigh, NC	$11	$0.53	$10.17	1.08
67 Grand Rapids, MI	$4	$0.17	$18.02	0.22
69 New Haven, CT	$11	$0.05	$55.57	0.20
71 Toledo, OH–MI	$4	$0.20	$17.67	0.23
73 Colorado Springs, CO	$4	$0.28	$6.84	0.59
75 Charleston-North Charleston, SC	$2	$0.13	$8.50	0.24
77 Columbia, SC	$1	$0.16	$5.60	0.18
82 Bakersfield, CA	$3	$0.09	$10.41	0.29
88 Little Rock, AR	$1	$0.08	$7.67	0.13
91 Oxnard, CA	$5	$0.22	$11.04	0.45
93 Spokane, WA–ID	$4	$0.10	$30.13	0.13
94 Cape Coral, FL	$2	$0.21	$6.62	0.30
96 Pensacola, FL–AL	$1	$0.13	$5.38	0.19
107 Corpus Christi, TX	$2	$0.09	$15.17	0.13
135 Anchorage, AK	$1	$0.05	$14.11	0.07
136 Eugene, OR	$4	$0.14	$18.43	0.22
145 Salem, OR	$1	$0.07	$13.13	0.08
Sum or average	$20051	$0.47	$13772.45	1.46

Table 3
Assumptions for benefit-to-cost ratio estimates

	Low	Medium	High
h	0.8	0.9	1.0
e	0.15	0.3	0.45
k_β	0.2	0.2	0.2
k_ρ	0.4	0.4	0.4
a	$0.75	$1.00	$1.25

ratio of unity or more. As a way of summarizing the positive relationship between the B/C ratio and population size of the urban area, a regression was run with the log of B/C regressed against the log of population. The resulting coefficient indicates an elasticity of the B/C ratio with respect to population of 0.29. An examination of the actual versus predicted values of the B/C ratios showed Honolulu and New Haven with the greatest "unexplained" positive gaps, while Kansas City and Detroit possessed the worst benefit-to-cost ratios relative to the "predicted" values.

There is a high correlation between the ranking of areas based upon the medium estimates with those of the low and high estimates. No doubt, one could produce greater variation in the rankings by independently varying the values assigned to the various "parameters" in Table 3. For the low estimates, only 15 areas had a B/C ratio of one or greater. For the high estimates one finds 44 areas with a B/C ratio equal to or greater than one. Even conceding a fair range of uncertainty, one may conclude that there are a number of urbanized areas where public transit has a benefit–cost ratio greater than one and a number of areas where the benefit–cost ratio is less than unity.

Table 4
Benefit-to-cost ratios

Medium				
B/C rank	UZA name	Low	Medium	High
6	1 New York–Newark, NY–NJ–CT	1.22	1.58	1.98
2	2 Los Angeles–Long Beach–Santa Ana, CA	1.35	1.75	2.24
8	3 Chicago, IL–IN	1.19	1.54	1.96
18	4 Philadelphia, PA–NJ–DE–MD	0.86	1.12	1.43
19	5 Miami, FL	0.85	1.12	1.45
42	6 Dallas, Fort Worth–Arlington, TX	0.58	0.78	1.04
7	7 Boston, MA–NH–RI	1.19	1.56	1.99
4	8 Washington, DC–VA–MD	1.25	1.60	2.02
51	9 Detroit, MI	0.48	0.65	0.85
3	10 Houston, TX	1.32	1.74	2.26
1	11 Atlanta, GA	1.45	1.90	2.44
10	12 San Francisco–Oakland, CA	1.04	1.34	1.70
26	13 Phoenix-Mesa, AZ	0.76	1.00	1.30
24	14 Seattle, WA	0.78	1.02	1.32
5	15 San Diego, CA	1.22	1.59	2.03
27	16 Minneapolis-St. Paul, MN	0.76	0.99	1.26
38	17 St. Louis, MO–IL	0.62	0.84	1.11
11	18 Baltimore, MD	1.03	1.34	1.70
45	19 Tampa-St. Petersburg, FL	0.54	0.73	0.96
31	20 Denver-Aurora, CO	0.69	0.93	1.21
62	21 Cleveland, OH	0.41	0.55	0.73
52	22 Pittsburgh, PA	0.46	0.63	0.82
15	23 Portland, OR–WA	0.87	1.15	1.48
70	24 San Jose, CA	0.37	0.49	0.65
22	25 Riverside-San Bernardino, CA	0.79	1.04	1.35
21	26 Cincinnati, OH–KY–IN	0.79	1.05	1.37
29	27 Virginia Beach, VA	0.74	0.98	1.27
36	28 Sacramento, CA	0.64	0.85	1.10
77	29 Kansas City, MO–KS	0.33	0.46	0.61
17	30 San Antonio, TX	0.84	1.13	1.50
12	31 Las Vegas, NV	0.95	1.25	1.60
34	32 Milwaukee, WI	0.66	0.86	1.11
43	33 Indianapolis, IN	0.57	0.77	1.02
47	34 Providence, RI–MA	0.50	0.68	0.91
25	35 Orlando, FL	0.74	1.00	1.33
59	36 Columbus, OH	0.43	0.57	0.75
49	37 New Orleans, LA	0.50	0.66	0.85
73	38 Buffalo, NY	0.36	0.48	0.63
32	39 Memphis, TN–MS–AR	0.68	0.91	1.19
46	40 Austin, TX	0.52	0.71	0.95
20	41 Bridgeport-Stamford, CT–NY	0.77	1.07	1.44
37	42 Salt Lake City, UT	0.64	0.85	1.11
61	43 Jacksonville, FL	0.42	0.56	0.72
53	44 Louisville, KY–IN	0.45	0.61	0.80
30	45 Hartford, CT	0.71	0.94	1.22
39	46 Richmond, VA	0.61	0.83	1.09
14	47 Charlotte, NC–SC	0.86	1.15	1.50
41	48 Nashville-Davidson, TN	0.61	0.80	1.04
48	49 Oklahoma City, OK	0.49	0.67	0.89
40	50 Tucson, AZ	0.61	0.83	1.09
9	51 Honolulu, HI	1.06	1.43	1.87
81	52 Dayton, OH	0.26	0.36	0.48
58	53 Rochester, NY	0.43	0.58	0.74
23	54 El Paso, TX–NM	0.76	1.04	1.38
64	55 Birmingham, AL	0.40	0.54	0.72
69	56 Omaha, NE–IA	0.38	0.50	0.65
78	57 Albuquerque, NM	0.33	0.45	0.60

Table 4 (*continued*)

Medium				
B/*C* rank	UZA name	Low	Medium	High
57	58 Allentown-Bethlehem, PA–NJ	0.43	0.59	0.78
67	59 Springfield, MA–CT	0.38	0.53	0.71
79	60 Akron, OH	0.32	0.44	0.60
60	61 Sarasota-Bradenton, FL	0.41	0.57	0.77
65	62 Albany, NY	0.39	0.54	0.71
76	63 Tulsa, OK	0.34	0.46	0.62
44	64 Fresno, CA	0.58	0.77	1.00
16	66 Raleigh, NC	0.86	1.14	1.48
66	67 Grand Rapids, MI	0.39	0.54	0.72
13	69 New Haven, CT	0.86	1.21	1.62
71	71 Toledo, OH–MI	0.36	0.49	0.64
33	73 Colorado Springs, CO	0.67	0.89	1.17
50	75 Charleston–North Charleston, SC	0.48	0.66	0.88
75	77 Columbia, SC	0.33	0.47	0.65
28	82 Bakersfield, CA	0.71	0.98	1.30
54	88 Little Rock, AR	0.43	0.60	0.81
35	91 Oxnard, CA	0.63	0.85	1.13
74	93 Spokane, WA–ID	0.34	0.47	0.64
55	94 Cape Coral, FL	0.44	0.60	0.79
63	96 Pensacola, FL–AL	0.40	0.55	0.74
68	107 Corpus Christi, TX	0.37	0.53	0.73
72	135 Anchorage, AK	0.35	0.48	0.64
56	136 Eugene, OR	0.44	0.60	0.80
80	145 Salem, OR	0.29	0.40	0.55
	Group ratio	1.03	1.34	1.71

8. Conclusions

A benefit–cost ratio greater than one does not necessarily imply that a public transit system is efficient. Apart from cost inefficiencies, a situation where marginal benefit is less than marginal cost is not inconsistent with total benefits exceeding total costs given a declining marginal benefit curve. Thus, an estimate of the inefficiency associated with public transit systems would not only have to account for those systems where the benefits are less than the costs, but for the inefficiencies found even in systems where benefits are greater than costs.

Even if one thinks of public transit as mainly an in-kind transfer program, a benefit–cost ratio less than one increases the likelihood that the "disadvantaged" would be better off for the same amount of tax dollars if they received the "transfers" as cash. For example, one can calculate from Table 2 that the Cleveland area public transit spent about $180 million in tax revenue on operating costs alone to reduce congestion by about $45 million. One can treat the difference of $135 million as a transfer to aid riders and compare this figure with the implied consumer surplus to riders based upon a demand intercept of $1, average fare per passenger mile of $0.15, and total passenger miles of 258 million. The implied consumer surplus of riders is less than $110 million, which is $25 million less than the portion of operating subsidy counted as aid. And this calculation is generous toward public transit as an aid program in that it excludes capital cost and assumes all riders are deemed "needy."

The calculations performed provide one approach for thinking about how well a transit system is doing and the nature of the benefits and costs that it provides. It is perhaps surprising that one can document very little benefit to public transportation associated with the reduction of conventional pollution and greenhouse gases, although these environmental benefits are sometimes used as an argument for promoting public transit. Public transit does have a better payoff in large urban areas and much of that better payoff is related to the greater relief of congestion. The small size of congestion savings for smaller urban areas is a major factor in the relatively low benefit-to-cost ratio estimates of those areas' public transit systems.

References

Automobile Association of America, 2005. AAA says average driving cost is 56.2 cents per mile for 2004. Press release available at <www.csaa.com/global/articledetail/0,100801000%257c4513,00.html> as of March 25, 2005.

Browning, E.K., 1987. On the marginal welfare cost of taxation. American Economic Review 77, 11–23.

Bureau of Transportation Statistics, 2004. State Transportation Statistics 2004, US Department of Transportation, Washington, DC available at <www.ntdprogram.com/NTD>.

Cox, W., 2000. Competition, not monopolies, can improve public transit. Backgrounder No. 1389, Heritage Foundation, Washington, DC.

Cox, W., O'Toole, R., 2004. The contribution of highways and transit to congestion relief: a realistic view. Backgrounder No. 1721, Heritage Foundation, Washington, DC.

Delucchi, M.A., 1997. The annualized social cost of motor-vehicle use in the US, 1990–1991: summary of theory, data, methods, and results. Report #1 in the series: the annualized social cost of motor-vehicle use in the US, based on 1990–1991 data. Report UCD-ITS-RR-96-3(1), Institute of Transportation Studies, University of California, Davis.

Delucchi, M.A., 1998. Summary of the nonmonetary externalities of motor-vehicle use. Report #9 in the series: the annualized social cost of motor-vehicle use in the US, based on 1990–1991 data. Report UCD-ITS-RR-96-3(9), Institute of Transportation Studies, University of California, Davis.

Downs, A., 2004. Still Stuck in Traffic. Brookings Institution Press, Washington, DC.

Federal Highway Administration, 2000. Addendum to the 1997 Federal Highway Cost Allocation Study Final Report, US Department of Transportation, Washington, DC available at <www.fhwa.dot.gov/policy/hcas/addendum.htm> as of April 6, 2005.

Federal Transit Administration, National Transit Database, 2002. National transit summaries and trends for the 2002 report year, US Department of Transportation, Washington, DC available at <www.ntdprogram.com/NTD/NTST.nsf/Web/NTST?OpenDocument> as of March 25, 2005.

Goodwin, P.B., 1992. A review of new demand elasticities with special reference to short and long run effects. Journal of Transport Economics and Policy 26, 155–169.

Goulder, L., Williams III, R.C., 1999. The usual excess-burden approximation usually doesn't come close. NBER Working Paper 7034, Cambridge.

Karlaftis, M., McCarthy, P., 1999. The effect of privatization of public transit costs. Journal of Regulatory Economics 16, 27–43.

Love, J., Cox, W., 1991. False dreams and broken promises: the wasteful federal investment in urban mass transit. Cato Policy Analysis No. 162, Cato Institute, Washington, DC.

Mohring, H., Schroeter, J., Wiboonchutickula, P., 1987. The value of waiting time, travel time and a seat on the bus. The Rand Journal of Economics 18, 40–56.

Monahan, P., Friedman, D., 2004. The Diesel Dilemma. Union of Concerned Scientists.

National Research Council, 2003. Effectiveness and Impact of Corporate Average Fuel Economy Standards (CAFE). National Academy Press, Washington, DC.

Nordhaus, W.D., Boyer, J., 2000. Warming the World: Economics of Global Warming. The MIT Press, Cambridge.

Obeng, K., Sakano, R., 2002. Total factor production decomposition, input price inefficiencies, and public transit systems. Transportation Research Part E 38, 19–36.

Parry, I.W.H., Small, K., 2004. Does Britain or the US have the right gasoline tax? Discussion Paper 02-12 rev., Resources for the Future, Washington, DC.

Perez, P.E., Martinez, F.J., de Dios Ortuzar, J., 2003. Microeconomic formulation and estimation of a residential location choice model: implication for the value of time. Journal of Regional Science 43, 771–789.

Savage, I., 2004. Management objectives and the causes of mass transit deficits. Transportation Research A 38, 181–199.

Schrank, D., Lomax, T., 2004. The 2004 Urban Mobility Report. Texas Transportation Institute, The Texas A&M System available at <http://mobility.tamu.edu> as of March 25, 2005.

Shapiro, R.J., Hassett, K.A., 2005. Healthy returns: the economic impact of public investment in surface transportation. American Public Transportation Associations available at <www.apta.com/research/info/online/documents/healthy_returns.pdf> as of April 6, 2005.

Washington State Department of Transportation, 2004. Measures, markets and mileposts. The Gray Notebook for the Quarter Ending March 31, 2002. Washington State Department of Transportation.

Winston, C., 2000. Government failure in urban transportation. Working Paper 00-8, AEI Brookings Joint Center for Regulatory Studies, Washington, DC available at <http://www.aei.brookings.org> as of March 25 2005.