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Affordability of Public Transport

A Methodological Clarification

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Abstract

There has been a surge of interest recently on the relation between poverty and transport policies. When analysing the relation between poverty and transport, concern often centres on the affordability of public transport. In this paper we present two alternative definitions of affordability used in the transport literature and discuss their limitations. Any affordability measure covering only transport expenditure is bound to be a very partial view of household welfare. In addition, the required affordability benchmark to determine whether or not transport costs are high is arbitrary. Therefore, the approach that uses the absolute level of these affordability measures is meaningless. We also show in this paper that the change in the affordability measures, as opposed to its absolute level, can be given a more rigorous interpretation in terms of traditional welfare economics. In spite of this last result, we argue that to analyse whether transport subsidies are meeting their social or distributional objectives it may be more fruitful to use traditional income distributional tools such as the relative benefit curve and its associated Gini coefficient.

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1.0 Introduction

It is well known in the transport economics field that under certain circumstances public transport subsidies improve resource allocation in society. This is particularly so when other modes of transport, namely private transport, do not pay their full social costs and second-best considerations call for subsidising competing modes.

However, in many situations subsidies are introduced for social or distributive reasons, particularly in developing countries. The social case for transport subsidies starts by recognising the importance of accessible and affordable transport for the well-being of people. Transport is a complementary input to the obtainment of other social benefits such as education, health services and employment opportunities, among others. This is sometimes couched in the catch-all concept of 'social inclusion', an appealing term that is unfortunately hard to define in an operationally useful way for policy decisions.

Among the multilateral agencies, the relationship between poverty and transport has received considerable attention of late. Incorporating poverty issues and pro-poor project design in transport projects has become an important priority for lending by multi-lateral banks.[1] The social impact of transport projects is also something that governments in developed countries are increasingly concerned about at the project appraisal stage (Geurs *et al.*, 2009).

Unfortunately, much attention in this field has centred on the 'affordability' of public transport and on policies to make public transport 'affordable' to the poor.[2] However, it is not clear what is meant by 'affordable' public transport or how this concept should be applied in designing transport policies.

In this paper, we examine two definitions of affordability and discuss their relative merits. We then show that the *change* in these affordability indices can be given a rigorous economic welfare interpretation. However, in spite of this last result, we argue that the use of an affordability measure may not be the most promising approach to analyse poverty and transport issues. Instead, we argue in favour of a methodological approach more in line with traditional income distribution analysis. This latter approach has been used in a number of recent case studies analysing the impact of public transport subsidies on poor households.

[1] See, for example, Gannon and Liu (1997), Asian Development Bank (2001), chapter 3 of The World Bank (2002) and The World Bank (2005).

[2] See Godard and Diaz Olvera (2000), Howe and Bryceson (2000), Shuiying *et al.* (2003), ECORYS and NEA (2004) and SITRASS (2004a,b) among others.

2.0 How to Define Affordability in the Transport Sector[3]

The most common approach to measure affordability is to estimate the proportion of household income or expenditure spent on public transport. To be more precise, this affordability measure can be defined as:

$$\mathrm{Aff}_1 = \frac{\sum_{m=1}^{M} x_m(p_m, y) \cdot p_m}{y}, \tag{1}$$

where $x_m(p_m, y)$ are the number of trips — usually public transport trips or work-related trips — taken during the month by household member m, and y is household income or expenditure. The number of trips is presented as an explicit function of the price of trips, which can differ among household members, depending on the type or mode used, and household income.

In Singapore, such an affordability measure was explicitly considered by The Committee on the Fare Review Mechanism (2005) and tracking this measure figures prominently in the review process for public transport fares (Looi and Tan, 2007). However, on its own this affordability measure is not very useful. Some acceptable cut-off level of expenditure must be defined in order to determine whether public transport is affordable or not. For example, Armstrong-Wright and Thiriez (1987) consider that there is an affordability problem when more than 10 per cent of households spend more than 15 per cent of their income on work-related trips. Venter and Behrens (2005) report that the South African government's 1996 White Paper on Transport Policy (Department of Transport, 1996) established an affordability benchmark equal to 10 per cent of income. In a similar vein, Gomide *et al.* (2004) define a 6 per cent limit in their evaluation of the affordability of public transport in Bello Horizonte, Brazil.

Due to its simplicity, such a measure of affordability has also been used in other sectors of the economy, in particular in the public utility industries. For example, Foster (2004) considers 15 per cent as the affordability limit on expenditure on water, electricity and gas. A 5 per cent expenditure limit on water and sewerage bills is used operationally by the Chilean government to estimate the number of water subsidies given each year and their value.[4] As another example, the Environmental Protection Agency in the

[3]Parts of this section are based on Estupinan *et al.* (2009).
[4]See Gómez-Lobo (2001) for more details.

United States has set a threshold of 2.5 per cent of Median Household Income as its affordability limit for small drinking-water systems.[5]

Despite its intuitive appeal, there are several problems with the above affordability measure and the way it is used in practice. For example, there is no guarantee of a monotonic relationship between the percentage of household income or expenditure spent on public transport and household welfare, a point raised by Venter and Behrens (2005). Due to trip suppression or mode choice (walking or cycling) poor households may spend a smaller proportion of their income on public transport compared to middle or higher income households.[6] Thus, a naive interpretation of the above measure may imply, paradoxically, that there is no public transport affordability problem amongst poor households but that middle income households do face affordability problems with respect to this service. In essence it is not clear that a household that spends 5 per cent of its expenditure on public transport is worse off than one that spends 3 per cent.

An alternative way to define affordability that overcomes the above problem is the one proposed by Carruthers *et al.* (2005). They use a fixed number of trips to estimate the required expenditure on public transport instead of using the observed expenditure of a household.[7] They define affordability as 'the ability to make necessary journeys to work, school, health and other social services, and make visits to other family members or urgent other journeys without having to curtail other essential activities'.

Formally, their affordability index is defined as:

$$\mathrm{Aff}_2 = \frac{\sum_{m=1}^{M} \bar{x}_m p_m}{y}, \tag{2}$$

where $\bar{x}_m$ is a fixed parameter that in the case of Carruthers *et al.* (2005) is set at sixty 10-kilometre trips per month per household member.[8]

The methodology proposed by Carruthers *et al.* (2005) makes it possible to compare the affordability of public transport across cities and countries. The results of their study are reproduced in Table 1. The figures in the

[5]See Environmental Protection Agency (2006).

[6]There is substantial evidence showing that the poor choose to walk much more often than the non-poor. See Howe and Bryceson (2000), Badami *et al.* (2004), SITRASS (2004a,b) and Cropper (2007) for evidence from developing country cities. There is also evidence that in many cities transport expenditure is non-monotonic with respect to income. See Estupinan *et al.* (2009) for examples.

[7]This approach has also been used by ECLAC (1992).

[8]In a similar vein, Haider and Badami (2004) calculate the fare level that each income group could pay in order to afford forty work trips per month for two earner households in Islamabad, Pakistan.

Table 1
Affordability Index for Different Cities Assuming Sixty 10-kilometre Trips per Household Member per Month

	City	Affordability index: Average	Affordability index: Bottom quintile
1	Sao Paulo	11%	107%
2	Rio de Janeiro	6%	63%
3	Brasilia	6%	59%
4	Cape Town	4%	38%
5	Buenos Aires	4%	26%
6	Mumbai	9%	23%
7	Kuala Lumpur	5%	22%
8	Mexico City	3%	19%
9	Chennai	8%	19%
10	Manila	5%	17%
11	Krakow	6%	17%
12	Amsterdam	6%	16%
13	Moscow	4%	15%
14	Guangzhou	4%	14%
15	Warsaw	4%	11%
16	New York	3%	10%
17	Los Angeles	3%	10%
18	Chicago	3%	10%
19	Singapore	2%	10%
20	Beijing	3%	9%
21	Seoul	4%	9%
22	Shanghai	2%	6%
23	Cairo	3%	6%
24	Budapest	3%	6%
25	London	2%	5%
26	Prague	2%	4%
27	Bangkok	1%	4%

Source: Carruthers *et al.* (2005).

table show the percentage of per capita income required to make sixty 10-kilometre trips per month both for households in the first quintile of the income distribution and for the average household.

The affordability index proposed by Carruthers *et al.* (2005) is also subject to criticism as it ignores possible changes in fares due to supply responses needed to accommodate the fixed number of trips used to construct this measure. For example, if it were the case that each household member made sixty 10-kilometre trips per month, in most cities aggregate public transport demand would be different (probably much larger) than current demand. Therefore, equilibrium fares would also be different unless there are constant returns to scale in public transport supply, including any indirect effect that added congestion may have on fleet requirements.

Both affordability indices defined above suffer from other more fundamental problems. First, they both ignore the cost of travel times. Although this cost is not an 'out of pocket' expenditure, it is still relevant to evaluate household welfare. Households may be better off paying higher fares for a public transport system that delivers faster trips or higher quality services. Second, neither is it clear how the results are to be used for policy decisions. Any threshold level used to gauge whether or not expenditure on public transport in a given city is affordable — such as the approach of Armstrong-Wright and Thiriez (1987) or Gomide *et al.* (2004) — is arbitrary. Should it be 10 per cent, 15 per cent, or 5 per cent of total expenditure or income? Economic theory has nothing to say on this matter. Furthermore, conclusions drawn by comparing household expenditure on public transport (using either observed or a fixed exogenous number of trips) to this threshold level can be quite misleading and policy decisions based on these comparisons can be misguided. The following example taken from Estupinan *et al.* (2009) shows why.

Assume that one calculates a transport affordability index in two cities. In the first city the calculations show that poor households spend, on average, 15 per cent of their total expenditure on public transport, while in the second city they only spend 10 per cent. One may conclude that public transport is unaffordable in the first city and efforts should be made to lower the cost of this service to poor households, perhaps subsidising fares. However, it could well be the case that an analogous affordability index calculated for food (or any other product or service one considers important for household welfare) reveals that poor households spend 45 per cent of their total expenditure on this group of goods in the first city and 50 per cent in the second city. Overall, households spend the same percentage on transport and food in both cities and thus it is no longer clear that a subsidy is warranted for public transport in the first city.[9]

This last problem points to the pitfalls of analysing welfare issues from a sectoral perspective instead of a global perspective. In order to make consistent welfare comparisons, a fixed basket of all the goods and services consumed by an average (or poor) household should be used to gauge their welfare, not just of public transport trips. This is precisely what a consumer price index does, allowing welfare comparisons across time. It is also the idea behind the Purchasing Power Parity exchange rate index used to compare welfare (real income) across countries. In both cases, a fixed basket of many goods and services is used.

[9]This point is also noted in World Bank (2002).

Therefore, the use of an absolute measure of public transport affordability is bound to be problematic and possibly misleading. However, the next section shows that changes in the first affordability index defined above — as opposed to its absolute level — can be given a rigorous and standard economic welfare interpretation. Thus, changes in this index could potentially be used to evaluate the impact of different policy interventions in the public transport sector.

3.0 Measuring Changes in Economic Welfare

Throughout, the unit of analysis will be the household.[10] The question is to ascertain how each household is affected by different policies in the public transport sector. Assume an expenditure function $C(\mathbf{p}, U)$. This function measures how much money a household requires to reach a certain level of utility or welfare, and will depend on a household's preferences, the vector of prices of the goods and services consumed, $\mathbf{p}$, and the reference utility or welfare level (U).

As is well known, the welfare impact on a household of a change in prices, say from $\mathbf{p}^0$ to $\mathbf{p}^1$, can be measured by the Compensating Variation (CV), that is, (minus) the amount of monetary resources that a household needs to be given or taken away so that after the change it can still reach its original utility level or $\mathrm{CV} = C(\mathbf{p}^0, U^0) - C(\mathbf{p}^1, U^0)$ where U^0 is the original welfare of the household. Since the money needed to reach the original utility level at the original prices is just the income of the household, the CV measure can also be defined as $\mathrm{CV} = y - C(\mathbf{p}^1, U^0)$ where y is the monetary income of the household. This last expression indicates that if prices rise, CV would be negative, since the money resources needed to reach the original welfare level at these higher prices is greater than the original income level of the household. Minus CV is the amount of money that should be given to the household in order to 'compensate' for the price change and allow the household to reach its original welfare level.

An alternative measure of the exact welfare change on a household brought about by a change in prices is the Equivalent Variation (EV). This measures the change in the household's income that is equivalent to

[10]What follows applies also if the individual is taken as the unit of analysis. It is more common to consider welfare impacts on households rather than individuals. This practice, however, ignores all the issues related to intra-household resource allocation. This paper does not address these issues as regards transport.

the change in price. In this case the reference utility is the final ex-post utility of the household, U^1 or

$$\mathrm{EV} = C(\mathbf{p}^0, U^1) - C(\mathbf{p}^1, U^1) = C(\mathbf{p}^0, U^1) - y.$$

Since a price rise decreases a household's welfare, reaching that ex-post level of welfare at the original price level ($C(\mathbf{p}^0, U^1)$) requires fewer financial resources than the household's monetary income and thus the EV measure is negative, as desired.

Often, the change in consumer surplus is used to gauge the welfare impact of a price change. This is defined as the change in the area below the demand curve and above the price line for the good whose price rises or falls. It is well known that the change in consumer surplus is not an exact welfare measure but it will always be bounded by the other two exact measures (CV and EV). For small changes in prices, all three give very similar results, especially if the good represents a small percentage of household expenditure (Willig, 1976).

3.1 First-order approximation to the true welfare change

In order to measure the CV (or EV) empirically, the analyst needs to know the expenditure function of the household, $C(\mathbf{p}, U)$. This can be recovered from the estimation of a demand system such as the Almost Ideal Demand System (Deaton and Muellbauer, 1980), or its more flexible extension, the Quadratic Almost Ideal Demand System (QUAIDS) (Banks *et al.*, 1997). However, this requires much data and effort, and is prone to specification and estimation errors.[11]

For most practical purposes, a more useful approach is to use a first-order approximation to the true welfare change. For example, the first-order Taylor approximation to the expenditure function is:

$$\begin{aligned} C(\mathbf{p}^1, U^0) &\cong C(\mathbf{p}^0, U^0) + \nabla C(\mathbf{p}^0, U^0)'(\mathbf{p}^1 - \mathbf{p}^0) \\ &= y + \sum_{i=1}^{n} \frac{\partial C(\mathbf{p}^0, U^0)}{\partial p_i} \cdot (p_i^1 - p_i^0) \\ &= y + \sum_{i=1}^{n} x_i^0 \cdot (p_i^1 - p_i^0), \end{aligned} \tag{3}$$

where x_i^0 is the original level of consumption of the good or service i and the last equality is obtained using Sheppard's Lemma. Using this last

[11] When only a single price changes, only the demand for this good needs to be estimated, a somewhat simpler and less data intensive problem. However, this may still be not possible in many applications.

expression, a first-order approximation to the CV would be:

$$y - C(\mathbf{p}^1, U^0) \cong -\sum_{i=1}^{n} x_i^0 \cdot (p_i^1 - p_i^0), \tag{4}$$

that is, minus the sum of the pre-change consumption of each good times its price change. This quantity does not require estimating a demand system and it will be feasible in most applications.[12]

How good is this first-order approximation? This will depend on the household's preference structure and the size of the price change. However, empirical evidence such as Banks *et al.* (1996) using UK household data shows that even for large price changes, it may be a very good approximation. In that study they compared the first-order approximation with the welfare change estimated using the expenditure function recovered from a QUAIDS demand system estimation. They found that for a 20 per cent price rise for a significant expenditure group (clothing) the first-order approximation was, at most, 10 per cent from the true CV value.[13]

Given its simplicity and advantages as regards data requirements, together with evidence that shows that it may in fact be a very good approximation, the first-order approach seems like the ideal choice to use to study the impact of different policies. This is particularly so when comparing several policy interventions and comparing case studies across several countries, where data availability may be very diverse.

3.2 A welfare interpretation of the affordability indices

The first-order approximation to the economic welfare change can be used to give a welfare interpretation to the affordability measures discussed earlier. Let us take the first-order approximation to the CV developed above and assume that only the price of one transport mode changes and that travel times remain constant. From equation (4):

$$-\text{CV} \cong v^0 \cdot (p_v^1 - p_v^0), \tag{5}$$

where v^0 is the observed number of rides in the affected mode prior to the price change and p_v is the fare level. Notice that this is equal to the

[12]Note the similarity of this result with how a consumer price index is calculated. For the EV, the formula would be identical except that the post-change level of demand replaces the pre-change level of demand in the formula. In practice, the standard approach in transport project appraisal is to use the rule of a half; that is, to use mean between the before and after levels of demand multiplied by the price change. Notice that this is equivalent to using the average of the first-order approximation to the CV and EV, and is also equal to the change in consumer surplus, assuming that the demand function is linear.

[13]The estimated value from the demand system is, in reality, a second-order approximation to the true expenditure function, since the QUAIDS is a second-order flexible functional form.

difference in expenditure on public transport before and after the price change for a fixed number of rides equal to the original number of rides:

$$-\mathrm{CV} \cong v^0 \cdot p_v^1 - v^0 \cdot p_v^0. \tag{6}$$

If this is then normalised by the income (or expenditure of the household) then we have:

$$-\frac{\mathrm{CV}}{y} \cong \frac{v^0 \cdot p_v^1}{y} - \frac{v^0 \cdot p_v^0}{y} = \Delta \mathrm{Aff}_1. \tag{7}$$

This last expression is the change in the affordability index using the number of rides observed prior to the price change (or Aff_1 in equation (1) above). Thus, the change in this affordability measure is proportional to the first-order approximation of the CV.

In most studies it is common to estimate the average affordability by income groups, say quintiles or deciles, of the income distribution. The average change in the affordability index in a sub-group of the population is:

$$\overline{\Delta \mathrm{Aff}_1} = \sum_{h=1}^{H} \frac{\Delta \mathrm{Aff}_{1h}}{H} \cong - \sum_{h=1}^{H} \frac{\mathrm{CV}_{1h}}{y_h} \cdot \frac{1}{H}, \tag{8}$$

were h indexes the household unit. This last expression is equivalent to measuring the welfare impact of a price change using a welfare function approach. Define the social welfare function

$$W = W[u_1, u_2, \ldots, u_H] = W[v_1(\mathbf{p}, y_1), v_2(\mathbf{p}, y_2), \ldots, v_H(\mathbf{p}, y_H)], \tag{9}$$

where, u_h is the welfare level attained by household h, measured by the indirect utility function $v_h(\mathbf{p}, y_h)$. Following Banks *et al.* (1996) and based on Stern (1987), we derive the first-order approximation to the change in social welfare of a price change using Roy's Identity:

$$\Delta W = -\sum_{h=1}^{H} \theta_h \cdot q_h^0 \cdot \Delta p. = \sum_{h=1}^{H} \theta_h \cdot \mathrm{CV}_h, \tag{10}$$

where θ_h is the marginal social weight of each household and is defined by

$$\theta_h = \frac{\partial W[v_1, v_2, \ldots, v_H]}{\partial v_h} \cdot \frac{\partial v_h(\mathbf{p}, y_h)}{\partial y_h}. \tag{11}$$

Therefore, if the marginal social weight of each household takes the particular form

$$\theta_h = \frac{1}{y_h}, \tag{12}$$

then the average change of the affordability index over a group of households is proportional (by a constant $1/H$) to the (negative) change in social welfare:

$$\overline{\Delta \mathrm{Aff}_1} \cong -\frac{1}{H} \cdot \sum_{h=1}^{H} \theta_h \cdot \mathrm{CV}_h \propto -\Delta W. \tag{13}$$

The use of marginal social weight inversely proportional to income is very popular among practitioners and is often used to measure the welfare impact of policies empirically. These social weights are reasonable since they give higher weight to lower income households. However, they are not free from criticism, as will be discussed below.

In summary, the average change in the affordability measure that uses the initial observed number of trips made by households can be rationalised as a reasonable approximation to the social welfare change generated by transport policies. The affordability measure proposed by Carruthers *et al.* (2005) also has a welfare interpretation. However, it is a bit more involved and requires additional information. Appendix 1 presents the details of that result.

4.0 Should We Use an Affordability Measure to Analyse Social Policies?

Although we can give a welfare interpretation to the change in the affordability index, using this approach when analysing social policies in the transport sector is not without problems and requires strong assumptions.

First, the definition of any welfare function is arbitrary and subject to the preferences of the analyst. Different studies may arrive at different results simply because they chose different social welfare functions. There in no way to obtain a consensus or unanimous social welfare function specification.[14]

Second, the use of the change in the affordability index as an exact welfare change measure requires a very particular social welfare function

[14]In spite of this, in the transport literature several authors have used the welfare function approach to evaluate policies. For example, Proost (2001), assigns a weight to lower income households which is two or three times the weight assigned to higher income households. Dodgson and Topham (1987) also use a welfare function approach, with a specific functional form due to Feldstein (1972). In both of these cases the weights or the welfare function are used to aggregate distributional results allowing quantitative trade-offs to be made between efficiency and equity in the determination of optimal policies.

to be assumed and some very strong assumptions regarding preferences. Theorem 1 of Banks *et al.* (1996) shows that in order to obtain marginal social welfare weights that are independent of prices, the social welfare function must be:

$$W = W[v_1(p, y_1), v_2(p, y_2), \ldots, v_H(p, y_H)] = \sum_{h=1}^{H} (k_h \cdot \ln y_h - a_h(p)), \quad (14)$$

where k_h is a constant and a_h is a function of prices. Thus, for the proportionality result (13) to hold, the social welfare function must be log-linear in the indirect utility function of each household:

$$W = W[v_1(p, y_1), v_2(p, y_2), \ldots, v_H(p, y_H)] = \sum_{h=1}^{H} k_h \cdot \ln |v_h(p, y_h)|. \quad (15)$$

Furthermore, each indirect utility function must take a particular form given by:

$$v_h(p, y_h) = \frac{y_h}{\alpha_h(p)}, \quad (16)$$

where

$$\ln |\alpha_h(p)| = \frac{a_h(p)}{k_h}. \quad (17)$$

Only in this case will the marginal social weight be independent of prices and inversely proportional to income:[15]

$$\theta_h = \frac{\partial W[v_1, v_2, \ldots, v_H]}{\partial v_h} \cdot \frac{\partial v_h(p, y_h)}{\partial y_h} = 1 \cdot \left(\frac{k_h}{y_h}\right). \quad (18)$$

These assumptions imply that preferences are homothetic and the income elasticities of the demand for every good are equal to one, which is clearly unrealistic.[16]

Therefore, in order for the change in affordability to represent a social welfare change, very special assumptions regarding preferences and the social welfare function must be made. Otherwise, social welfare weights for each household will depend on prices and possibly the incomes of other households and using the inverse of each household's income to

[15] The constant k_h could be set to $1/H$ for each household to make the relation between the average change in affordability and the change in social welfare exact. Given the ordinal nature of the aggregate social welfare measure, this is not really required. However, this constant must be the same for each household.

[16] Using Roy's Identity it is trivial to show that for given prices, the expenditure on each good will be proportional to income if preferences are represented by equation (16).

aggregate the change in affordability will no longer result in an exact social welfare change.

5.0 An Alternative Approach

Rather than aggregate individual household impacts using a welfare function, an alternative approach is to analyse the social or distributive implications of a subsidy by graphing the Lorenz curve or relative benefit curve.

The relative benefit curve (or Lorenz curve) graphs the cumulative empirical distribution of benefits of a certain policy with respect to the distribution of income, expenditure or wealth of households. Assume that H households are ranked according to one of these three variables, which, for the purpose of the current discussion, we denominate as y_h. Thus, $y_h < y_{h+1}$ for $h = 1, \ldots, H$. Denote s_h as the benefit (CV, for example) accruing to household ranked h. Then, starting at the origin, the Lorenz curve is the interpolation of the points:

$$\left(\frac{h}{H}, \sum_{j=1}^{h} \frac{s_j}{S}\right),$$

where

$$S = \sum_{j=1}^{H} \frac{s_j}{S},$$

are the total benefits distributed.

Each point on the Lorenz or relative distribution curve represents the fraction of cumulative benefits accruing to a given fraction of households ranked from the lowest to highest in the income, expenditure, or wealth distribution. Figure 1 gives an example. The 45° line would indicate a neutral distribution of benefits, since the lowest ranked x percentage of households receive exactly x per cent of total benefits. A relative benefit curve above the 45° line would indicate a progressive distribution of benefits, since lower income households receive more than their proportionate share of benefits. The opposite would be the case for a curve below the diagonal.

Closely associated with the relative distribution curve is the Gini coefficient (see Figure 2). This coefficient is calculated as the area between the diagonal and the distribution curve (with a negative value when the curve is above the diagonal) divided by the area below the diagonal. The

Figure 1

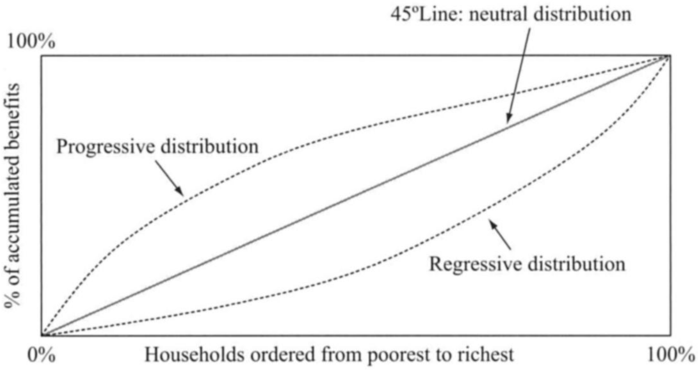
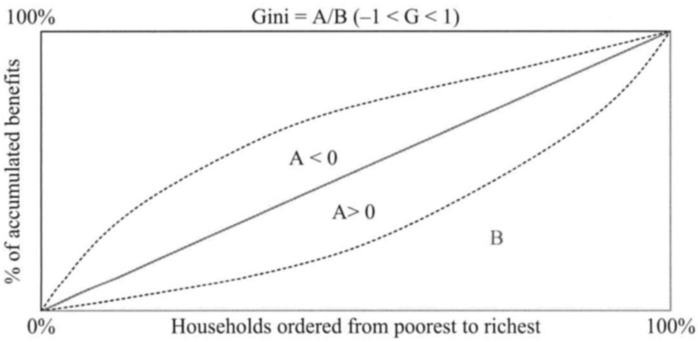


Figure 2



Gini coefficient then takes a value between -1 and 1, with a lower value indicating a more progressive distribution of benefits.

The relative benefit curve or its associated Gini coefficient can be used to compare the distributive impact of policies. If the distribution curves for each policy do not cross, then it is possible to unambiguously rank the progressiveness of each one according to the Gini coefficient of each curve.[17] Otherwise, some value judgement must be made as to which part of the income distribution one cares about in order to rank the distributive outcomes of each policy: looking at the impact of each policy on the 20 per cent or 40 per cent poorest households, for example.

[17]When each policy involves a different magnitude of transfers to households, particularly to poorer households, then each Lorenz curve can be multiplied by the average transfer involved before comparing them. The result of multiplying the Lorenz curve by the average transfer is known as the Generalised Lorenz curve (Shorrocks, 1983).

The distribution curve analysis is much more flexible than a welfare function approach, since the data required can always be used subsequently to estimate the social welfare change if desired. However, unlike the welfare function approach, the distributional analysis conveys much useful information without having to assume a particular, and somewhat arbitrary, welfare function.

In addition, the relative distributional curve approach is consistent with prior research on the distributional consequences of transport subsidies. For example, Frankena (1973) and Guriai and Gollins (1986) estimate the benefit and tax incidence by income groups of several transport subsidies in Canada and New Zealand, respectively. Calculating incidence by income groups is equivalent to using a step function approximation to the relative benefit curve where, instead of graphing the incidence of benefits for each individual household, the average over income groups is used.

This approach has been used in a number of recent case studies analysing the distributive impact of transport subsidies in several cities around the developing world.[18] The results show that most transport subsidies are badly targeted and in many cases are regressive.

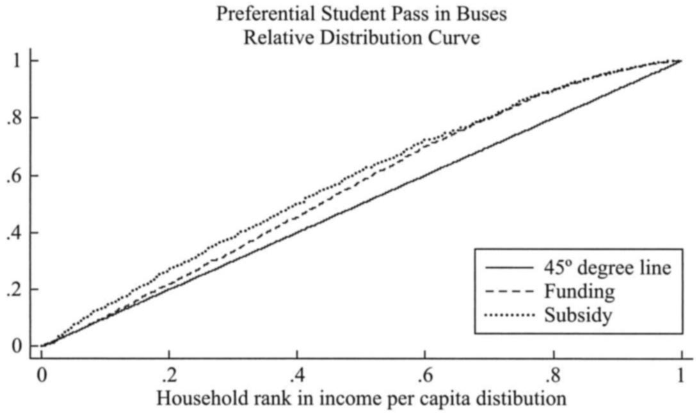
As an example of the use of relative distribution curves, we present a result of the distributive impact of the student preferential fares in Santiago, Chile, taken from Gómez-Lobo (2009). The use of preferential fares for certain groups of users (including students, the elderly, war veterans, and so on) is very common in many countries. However, in Santiago, as in most other cases, these benefits are funded by the other users who pay higher regular fares.

The distributive impacts of these cross subsidies for the case of Santiago are shown in Figure 3. From this figure we can see that the student preferential fare in the bus system is somewhat progressive. The associated Gini coefficient is −0.16, which is a little more progressive than a Gini coefficient of 0 for a neutral distributional impact. However, it can also be seen from the graph that the funding of this subsidy is also regressive in the sense that poorer households pay a higher proportion of this 'tax'. The associated Gini coefficient for the funding of the cross subsidy is −0.11, very close to the coefficient for benefits.

These results imply that the student preferential fare is distributing resources from households without students to households with students.

[18] See Foster (2004) for the case of Buenos Aires, Flynn (2007) for the case of México City, Gómez-Lobo (2009) for the case of Santiago in Chile, and Cropper (2007) for the case of Mumbai in India. A discussion and review of this evidence can be found in Estupinan *et al.* (2009).

Figure 3



Source: Gómez-Lobo (2009)

This distribution of resources occurs across all deciles of the income distribution. Although on average this subsidy is marginally progressive, the majority of poor households are hurt by this policy. The social impact of this subsidy would improve significantly if its funding came from general taxation instead of the current cross subsidy scheme, although, even in this case, with a Gini coefficient of −0.16, the progressiveness of the policy would still not be very impressive.

6.0 Conclusions

Lately, there has been a surge of interest in the relation between poverty and transport policies. This stems from the recognition of the importance of transport as a complementary input for access to basic needs such as health, education, and employment. Many public transport subsidies are justified on social or distributive arguments.

When analysing the relation between poverty and transport, often the 'affordability' of public transport is estimated. This usually entails calculating the percentage of monthly income spent on public transport and comparing it to an arbitrary benchmark considered affordable. If most poor households spend more than this threshold, then it is deemed that public transport is unaffordable for the poor and some type of subsidy is warranted.

In this paper, we argue that the above procedure may not be the most fruitful approach to tackle the issue of transport and poverty. We present two alternative definitions of affordability used in the public transport literature and discuss their limitations. Any affordability measure covering only transport expenditure is bound to be a very partial view of household welfare. In addition, the required affordability benchmark to determine whether or not transport costs are high is arbitrary. Therefore, the approach that uses the absolute level of these affordability measures is meaningless.

We also show in this paper that the change in the affordability measures, as opposed to its absolute level, can be given a more rigorous interpretation in terms of traditional welfare economics. In particular, the average change in the affordability of public transport is a reasonable first-order approximation to the change in social welfare. This implies that the change in affordability may be a valid approach to study, among other issues, the social impact of different transport subsidy policies directed to help the poor.

In spite of this last result, we argue that to analyse whether transport subsidies are meeting their social or distributional objectives, it may be much more fruitful to use more traditional income distributional tools such as the relative benefit curve (Lorenz curve) and its associated Gini coefficient. This approach has been used in a number of recent case studies analysing the distributive impact of transport subsidies in several cities around the developing world. The results show that most transport subsidies are badly targeted and in many cases are regressive. This implies that socially motivated transport subsidies are not meeting their stated objectives and more research and effort needs to be in place to improve their design and application.

References

Asian Development Bank (2001): *Handbook for Integrating Poverty and Impact assessment in the Economic Analysis of Projects, Economics and Development Resource Centre* (EDRC), Manila.

Armstrong-Wright, A. and S. Thiriez (1987): 'Bus Services: Reducing Costs, Raising Standards', The World Bank, Washington DC.

Badami, M., G. Tiwari, and D. Mohan (2004): 'Access and Mobility for the Urban Poor in India: Bridging the Gap between Policy and Needs', paper presented at the Forum on Urban Infrastructure and Public Service Delivery, New Delhi, June.

Banks, J., R. Blundel, and A. Lewbel (1996): 'Tax Reform and Welfare Measurement: Do We Need Demand System Estimates?, *Economic Journal*, 106(438), 1227–41.

Banks, J., R. Blundel, and A. Lewbel (1997): 'Quadratic Engel Curves and Consumer Demand', *The Review of Economics and Statistics*, 79(4), 527–39.

Carruthers, R., M. Dick, and A. Saurkar (2005): *Affordability of Public Transport in Developing Countries*, Transport Papers TP-3, The World Bank Group, Washington DC, January.

Cropper, M. (2007): 'Public Transport Subsidies and Affordability in Mumbai, India', paper prepared for the World Bank.

Deaton, A. and J. Muellbauer (1980): 'An Almost Ideal Demand System', *American Economic Review*, 70(3), 312–26.

Department of Transport (1996): 'White Paper on National Transport Policy', South Africa.

Dodgson, J. S. and N. Topham (1987): 'Benefit–Cost Rules for Urban Transit Subsidies', *Journal of Transport Economics and Policy*, 21(1), 51–71.

ECLAC (1992): 'The Impacts of Subsidies, Regulation and Different Forms of Ownership on the Service, Quality and Operational Efficiency of Urban Bus Systems in Latin America', United Nations Economic Commission for Latin America and the Caribbean.

ECORYS Research and Consulting and NEA Transport Research (2004): 'Labor Mobility, Beneficiaries of Public Transport Services in Eastern Europe and Central Asia', Final Report prepared for the World Bank Group, Rotterdam, June.

Environmental Protection Agency (2006): 'Small Drinking Water Systems Variances — Revision of Existing National-level Affordability Methodology and Methodology to Identify Variance Technologies that Are Protective of Public Health', Federal Register, 71(41), March 2, 10,671–85.

Estupinan, N., A. Gómez-Lobo, R. Muñoz-Raskin, and T. Serebrisky (2009): 'Affordability of Public Transport: What Do We Mean, What Can Be Done?', *Transport Reviews*, 29(6), 715–39.

Feldstein, M. (1972): 'Distributional Equity and the Structure of Public Pricing', *American Economic Review*, 62, 32–6.

Flynn, J. (2007): 'Measures to Make Urban Transport Affordable to the Poor: Mexico City Case Study', John F. Kennedy School of Government, Harvard University, Report prepared for The World Bank, February.

Foster, V. (2004): 'Hacia una Política Social para los Sectores de Infraestructura en Argentina: Evaluando el Pasado y Examinando el Futuro', Centro de Estudios Económicos de la Regulación, Universidad Argentina de la Empresa, Buenos Aires.

Frankena, M. (1973): 'Income Distributional Effects of Urban Transit Subsidies', *Journal of Transport Economics and Policy*, September.

Gannon, C. and Z. Liu (1997): 'Poverty and Transport', TWU-30, The World Bank Group, Washington DC, September.

Geurs, K. T., W. Boon, and B. Van Wee (2009): 'Social Impacts of Transport: Literature Review and the State of the Practice of Transport Appraisal in the Netherlands and the United Kingdom', *Transport Reviews*, 29(1), January, 69–90.

Godard, X. and L. Diaz Olvera (2000): 'Poverty and Urban Transport: French Experience in Developing Cities', Final Report, TWUTD, The World Bank Group, Washington DC.

Gómez-Lobo, A. (2001): 'Making Water Affordable: Output-based Consumption Subsidies in Chile', in Brook, P. J. and S. M. Smith (eds), *Contracting for Public Services: Output-based Aid and Its Applications*, The World Bank.

Gomez-Lobo, A. (2009): 'Public Transport Affordability and Subsidy Policies: A Case Study of Santiago Chile', *Journal of Transport Economics and Policy*, 43(3): 405–25.

Gomide, A., S. Leite, and J. Rebelo (2004): 'Public Transport and Urban Poverty: A Synthetic Index of Adequate Service', The World Bank Urban Transport Program in Brazil, The World Bank, Washington DC.

Guriai, J. C. and A. A. Gollins (1986): 'Net Tax Incidence for Public Transport Subsidies in New Zealand', *Transportation*, 13, 319–28.
Haider, M. and M. B. Badami (2004): 'Public Transit for the Urban Poor in Pakistan: Balancing Efficiency and Equity', paper presented at the Forum on Urban Infrastructure and Public Service Delivery, New Delhi, June.
Howe, J. and D. Bryceson (2000): 'Poverty and Urban Transport in East Africa: Review of Research and Dutch Donor Experience', Report Prepared for the World Bank, International Institute for Infrastructural, Hydraulic and Environmental Engineering, December.
Looi, T.-S. and K.-H. Tan (2007): 'Striking A Fare Deal — Singapore's Experience in Introducing a Fare Review Mechanism', Presentation at the World Conference on Transport Research, 24–8 June 2007, University of California, Berkeley.
Proost, S. (2001): 'Achieving Equity Through Urban Transport Pricing?', mimeo, University of Leuven.
Shorrocks, A. F. (1983): 'Ranking Income Distributions', *Economica*, 50, 3–17.
Shuiying, Z., W. Han, H. Weili, and C. Dening (2003): 'Poverty and Transportation in Wuhan', Economic Research Institute, Wuhan University, Report written for the World Bank, revised draft, 15 December.
SITRASS (2004a): 'Poverty and Urban Mobility in Conakry', Final Report, prepared by the International Solidarity on Transport and Research in Sub-Sahara Africa for the Sub-Sahara Policy Transport Program, The World Bank, November.
SITRASS (2004b): 'Poverty and Urban Mobility in Douala', Final Report, prepared by the International Solidarity on Transport and Research in Sub-Sahara Africa for the Sub-Sahara Policy Transport Program, The World Bank, September.
Stern, N. (1987): 'The Theory of Optimal Commodity and Income Taxation', in Newbury, D. and N. Stern (eds), *The Theory of Taxation for Developing Countries*, Oxford: Oxford University Press.
The Committee on the Fare Review Mechanism (2005): *Report of the Committee of the Fare Review Mechanism*, Singapore, February.
The World Bank (2002): *Cities on the Move: A World Bank Urban Transport Strategy Review*, The World Bank, Washington DC.
The World Bank (2005): 'Distribution of Benefits and Impacts on the Poor', Transport Note No. TRN-26, Transport Economics, Policy and Poverty Thematic Group, The World Bank, January.
Venter, C. and R. Behrens (2005): 'Transport Expenditure: is the 10 per cent Policy Benchmark Appropriate?', Proceedings of the 24th Southern African Transport Conference, SATC 2005, Preotia, South Africa, July.
Willig, R. (1976): 'Consumer's Surplus without Apology', *American Economic Review*, 66(4), 589–97.

Appendix

A welfare interpretation to the Carruthers *et al.* (2005) affordability measure

Carruthers *et al.* (2005) use as an affordability measure an estimate of the percentage of household income that is devoted to public transport, considering a fixed and exogenous number of sixty trips per month.

Taking the first order approximation to the Compensating Variation and normalising this measure by the household's income or total expenditure, we obtain:

$$\frac{y - C(p^1, U^0)}{y} \cong -\frac{v^0 \cdot (p_v^1 - p_v^0)}{y} = -\left(\frac{v^0 \cdot p_v^1}{y} - \frac{v^0 \cdot p_v^0}{y}\right).$$

We can again interpret the income or expenditure normalisation as the social welfare weight associated to each household.

If we interpret the initial situation as the hypothetical case where the price of public transport is sufficiently low — say p_v^0 — so that the household would effectively choose to make these sixty trips per month, then what Carruthers *et al.* (2005) estimate is the first part of the above equation: $v^0 \cdot (p_v^1/y)$. This is the percentage of income that is spent if these trips were made at current prices.

If we could estimate at what price the household would effectively make v^0 trips — that is an estimate of p_v^0 — then the second part of the equation could be estimated and we can then use the measure devised by Carruthers *et al.* (2005) as a first order approximation to a true welfare measure. The difficulty lies in having an estimate of the household's demand for trips.

However, even if the original expenditure, $v^0 \cdot (p_v^0/y)$, cannot be estimated, it is reasonable to assume that it will be more similar across cities and countries than $v^0 \cdot (p_v^1/y)$. This is so because the first measure is bounded below by 0. Therefore, even if the affordability index of Carruthers *et al.* (2005) varies between cities, from 1 per cent to 11 per cent on average according to their study, the expenditure required at the price for which households would effectively make the sixty trips will probably vary by less. If we take the extreme view that this expenditure would be the same for each city or country, $\bar{w}^0$, then subtracting this number from the affordability index of Carruthers *et al.* (2005) would give a reasonable welfare comparison of public transport prices across cities:

$$\frac{\mathrm{CV}}{y} \cong -\left(\frac{v^0 \cdot p_v^1}{y} - \bar{w}^0\right).$$