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ESTIMATING BENEFITS FOR MODAL SHIFTERS: A METHODOLOGICAL REMARK

MAFFII, SILVIA, TRT TRASPORTI E TERRITORIO, MILAN, ITALY. MAFFII@TRT.IT
PAROLIN, RICCARDO, TRT TRASPORTI E TERRITORIO, MILAN, ITALY. PAROLIN@TRT.IT

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MAFFII, Silvia, TRT Trasporti e Territorio, Milan, Italy. maffii@trt.it

PAROLIN, Riccardo, TRT Trasporti e Territorio, Milan, Italy. parolin@trt.it

ABSTRACT

In some European countries (e.g. Italy, France) it is common practice in the evaluation of public transport projects to estimate the benefits for users shifting from one mode to another as being the difference between the generalized cost of the original and the new mode. This paper argues that this methodology is in fact incorrect and aims to open a debate on the matter. Given the widespread use of the methodology criticized, the methodological point raised in the paper has significant consequences in policy terms, above all because investments in public transport projects may be associated with substantially lower user benefits and therefore their justification in terms of welfare may be questioned.

Keywords: Cost-Benefit Analysis, Consumer Surplus, Project appraisal.

INTRODUCTION

The cost-benefit methodology is used to appraise public investments of infrastructures in a large number of countries, although the methods for project evaluation can be different. There have been a number of studies over the last decade that have reviewed transport appraisal methods in use in different countries (e.g., Bristow and Nellthorp, 1998; Bickel et al., 2005; Odgaard, Kelly and Laird, 2005; Olsson, Økland and Halvorsen, 2012). Nevertheless, to the authors, the issue related to the assessment of the benefits for modal shift users has still not found a satisfactory formulation. The common practice in some European countries (e.g. Italy, France, but also Japan) in the evaluation of transport projects is to estimate the benefits for the users shifting from one mode to another as the difference between the generalized costs of the two modes. This approach is also recommended by the

Railpag handbook[1], prepared by the European Investment Bank and the European Commission with reference to the evaluation of rail projects. While such a methodology seems suitable for the assessment of the benefits of the existing traffic component, it is not appropriate to measure the benefits of the diverted and generated traffic. For generated traffic the widely accepted approach is to estimate the benefits as half of those affecting the existing users of that specific mode of transport. For the diverted traffic the theory does not leave room for doubts especially in the light of the most recent contributions like in particular, Kidokoro (2006), who clarified the relationship between the assumptions made in the transport-demand modelling and the methodology to calculate the benefits of diverted traffic.
Building on a concise review of the basic principles of cost-benefit analysis of transport infrastructure projects, we discuss the relationship between the demand curves for two modes, when the unrealistic assumption of perfect substitution does not hold and how this impacts on the calculation of the consumer surplus. A simplified illustrative example for a rail project is provided.

The purpose of the paper is to clarify the issue and to pave the way for a debate on the matter.

1. BENEFITS FOR USERS OF TRANSPORT[2]

1.1 Basic principles

The starting point for measuring costs and benefits is willingness to pay: i.e. the amount of money each individual would be willing to pay to obtain some form of benefit (such as a faster journey). The demand curve for a good (such as journeys from a certain point of origin to a certain destination) lays out the willingness to pay for an additional unit of the good. Thus, willingness to pay for a price reduction is measured by the variation in the area below the demand curve and above the curve indicating the price (this represents the so-called “consumer surplus”). The price in transport projects and the “generalized price” of a journey, including, travel time (valued by the willingness of individuals to pay for savings in travel-time) in addition to the monetary costs incurred. It can be imagined that a demand curve that is a function of the generalized price for journeys of a certain origin to a certain destination be similar to that shown in Figure 1.

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[1] EC-EIB Railpag (2006), p.34: “The effects on new rail users diverted from other modes (automobile, bus, air transport) to rail as a consequence of the investment are valued comparing their resource costs before and after the project”.

[2] This chapter draws heavily on Kidokoro (2004) and Kidokoro (2006).

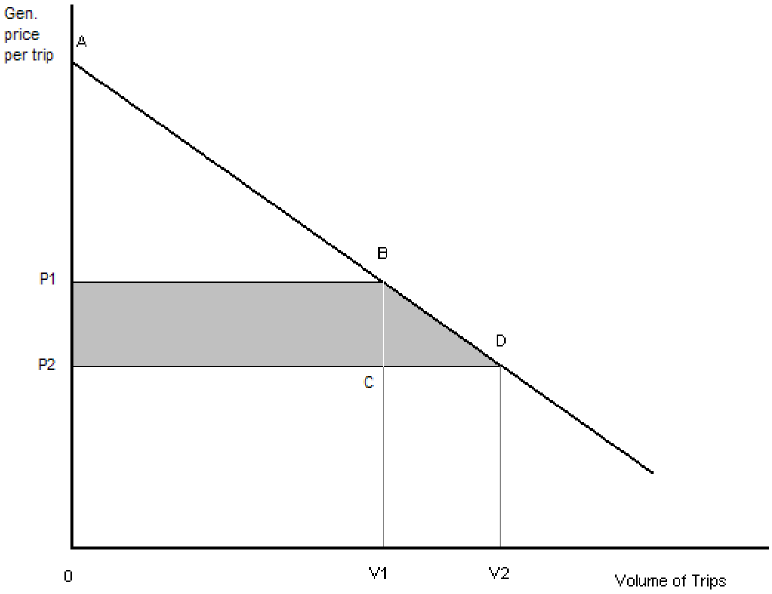

Figure 1 – Benefits for existing and new users

Let us suppose that the investment reduces the generalized price of the journey from P_1 to P_2.

The reduction in generalized price brought about by the investment leads to an increase in the quantity of traffic. Again, referring to Figure 1, two components of traffic can be distinguished:

- Pre-existing traffic (V_1), i.e. that which also accepted generalized price P1;
- New traffic (V_2-V_1), attracted by the reduction in generalized price from P_1 to P_2.

For existing users V_1 the consumer surplus without the project was ABP_1 and with the project ABP_2. Their aggregate benefit is therefore measured by the rectangle P_1BCP_2. Then there are the new users, V_2-V_1 some of whom are willing to pay almost the entire reduction in price (P_1-P_2), and others who are willing to pay something just above P_2, i.e. they are almost indifferent to making the journey or not making it at price P_2. If the demand curve is approximately linear between B and D, as shown in Figure 1, the area BDC is approximately triangular and equal to one half of the number of new users multiplied by the reduction in generalized price. This approximation in the estimate of benefits for users is known as the "rule of one-half".

1.2 Towards greater realism

The conceptual framework is simple when a single link is imagined between a single point of origin and one of destination: in this case, there are no effects on other parts of the network or other modes and additional users are all the traffic generated, and so the "rule of one-half" for the estimate of benefits is accepted by all.

But it becomes more complex when greater realism is introduced.

1.3 The general equilibrium demand curve

An important feature complicating the economic analysis of transport projects is that the investment is usually placed within a transport network. This results in the benefits and the costs associated with a reduction in the generalized price in respect of a link, not being confined to the link itself. Indeed, changes in route, mode and other behavioural responses typically occur following the investment until such time as a new network equilibrium is achieved. Kidokoro (2004) usefully underlines that for this reason the demand curve through which the consumer surplus is measured is a demand curve for general equilibrium, and not a normal Marshallian demand curve which assumes constant income and prices in other markets. When the demand for transport is estimated the demand curve also depends on prices in other markets: the investment in a certain mode of transport does not influence the generalized price and the demand for that mode alone, but also the generalized price and demand for other modes that can be substituted or complemented by the mode considered. This series of complex effects produces a shift downwards in the (Marshallian) demand curve which assumes constant income and prices in other markets. When the) demand curve for the route concerned: observing Figure 2, it can be seen that an equilibrium point without the project, point B, and a point of equilibrium with the project, point D, lie on different (Marshallian) demand curves (D_1 and D_2). The general equilibrium demand curve for the route considered is where the equilibriums obtained lie: it passes through points B and D and implicitly includes all the effects of variations in generalized price on other modes. The variation in the consumer surplus can be measured along this general equilibrium curve, with the significant advantage of its being based on a demand function that can be observed directly: the equilibrium points B and D of Figure 2 can be derived directly from the modelling simulation "without and with" the project.

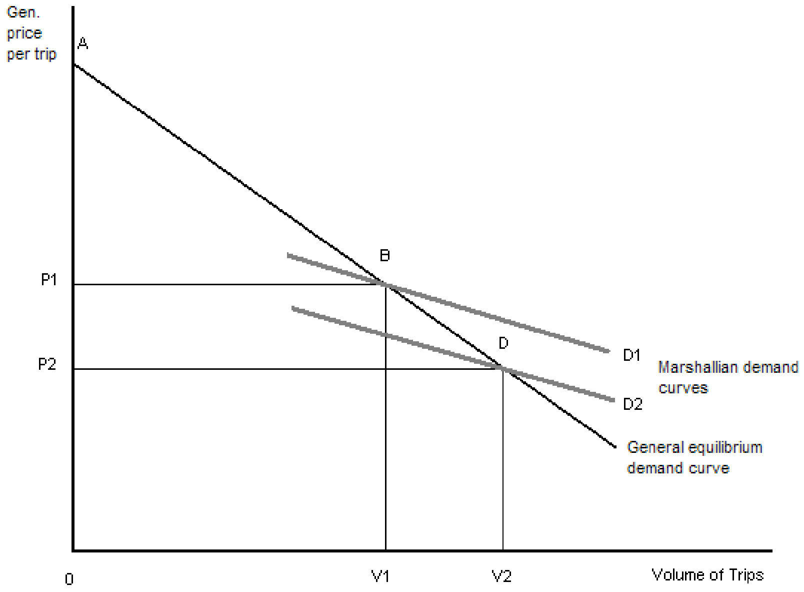

Figure 2 – The demand curve for general equilibrium

1.4 The various modes of transport ought to be dealt with as different goods

A second important element to be considered is that the various modes of transport ought to be dealt with as different goods. Certainly, each is a *substitute* for the other, but normally they are not *perfect* substitutes and consumers have a different willingness to pay for each, even when the generalized price is the same (time + monetary cost). These preferences for mode 1 or mode 2 on the part of consumers are "revealed" by their behaviour and, by calibrating the simulation model, they are "recorded", for example, by the modal constant. It is thus possible to trace an equilibrium demand curve for each mode of transport that takes into account the effects on other modes of transport.

When there are a number of modes of transport, if the project under consideration reduces the average journey time of a mode for example, this will attract new users. The "new" traffic (V_2-V_1) which can be seen in Figure 1 may be traffic either "diverted" from other modes or "generated", or the sum of both these categories, but the method for estimating the variation in surplus for both the components is the same: the variation in surplus always amounts to ½ (P_1 - P_2) * (V_2 - V_1), where P_1 and P_2 are the generalized price without and with the project applied to the destination mode. The "rule of one-half" greatly simplifies the estimation of benefits to new users because one need estimate only the number of new users and the cost savings to existing users (Small, 1999).

1.5 A numerical example

In order to clarify further in this regard a numerical example will be useful.
Let us imagine a simple model with two zones, connected by two modes, mode 1 and mode 2. For example, mode 1 could be an airline and mode 2 a railway. Table I illustrates the details of a hypothetical rail investment project. The project reduces train journey time by two hours and this produces an increase in demand by 100 train journeys and a matching reduction for air travel.

Table I Example of quantities and costs with non-perfect substitution modes

Modes	Quantity	Time (h)	Tariff	Value of time/h	Gen. Price
Plane					
Without the project	500	2	130	15	160
With the project	400	2	130	15	160
Train					
Without the project	400	6	60	15	150
With the project	500	4	70	15	130

First of all it is useful to note that in our example, although already in the solutions of reference the generalized price of the flight is higher than that of the train, there are 500 consumers who prefer the flight. This means that for these consumers the willingness to pay for the air journey is greater than that of the train journey. Therefore, the two modes are not perfect substitutes.

At the margin, where willingness to pay is equal to the generalized price, this amounts to 160 euros for the plane journey and 150 for the train journey. When the generalized price falls to 130 euro, 100 consumers abandon the plane and chose to travel by train. This means that the willingness to pay for the train journey by these users diverted from the plane is at a minimum greater than 130 euros (otherwise they would not have switched modes, given that the cost of the train is 130 euros) and as a maximum just below 150 euros (otherwise they would have switched mode even in the reference solution without the reduction in price allowed by the projects). Distributing the willingness to pay for a train journey in a linear manner between maximum to minimum value, the demand curve is obtained for the segment BC, and the triangle BCD represents the variation in surplus for diverted users.

The willingness to pay to travel by train is not detectable ex-ante but, as has been seen, is deduced from the (simulated) behaviour of consumers.

Since the demand curve of one mode represents the willingness to pay for the characteristics of the mode taking into account the characteristics of the supply of transport on alternative modes (including journey times, comfort, reliability, monetary costs, etc.) once it has been defined, the source mode at this point no longer has any significance for the purposes of cost-benefit analysis, and so what tariffs (or in the case of cars, operating costs) users paid on the source mode, whether the journey time was lower (or greater) than that of the new mode, the losses that consumers may suffer by switching modes such as the reduction in flexibility or reduced comfort are without importance. The choice between the two modes has certainly been effected due to the reduction in generalized price of the mode to which the project allies (and taking into account all the other preferences). Those who switch mode achieve a benefit (otherwise they would not have switched mode): a number gain more, others less and, at the margin, still others gain next to nothing. In the same way, in respect of the traffic generated too, benefits vary from consumer to consumer: they will be just about equal to the entire variation in generalized price for some, close to zero for others. To simplify, it is assumed that these variations in individual surpluses are distributed in a linear manner from maximum (all the variation in generalized price) and minimum (a little more than zero): hence the triangular form of the variation in surplus for additional traffic.

It follows that the area of the triangle enclosed by the demand curve, the variation in generalized price on the destination mode and the additional traffic, measures all the advantage (economic benefits) both in respect of those who switch route or mode and travellers added.

Thus the benefits, in the example are:
In respect of pre-existing demand, 400 * 20 = 8,000
In respect of additional demand, 100 * 20 / 2 = 1,000
Total = 9,000

2. THE IMPLICATIONS OF THE TWO APPROACHES

As has been stated, in a number of countries, in order to estimate the benefits from switching users a different methodology is used: the benefits for these users are measured as the difference between their generalized costs without and with the project. It often occurs dealing with rail projects that aim to foster the modal shift

Measuring the benefits as difference between the generalized costs of the two modes is equivalent to considering them as perfect substitutes. Only if the two modes are perfect substitutes would the total demand between the two zones be relevant in the utility function (i.e. there would be a single demand curve). Only if the two modes are perfect substitutes would the variation in total benefits in transport be equal to the reduction in total social costs of users with projects as compared to the reference solution because, all the other characteristics from the two modes being assumed to be equivalent, the sole element to count would be the generalized price without and with the project. In the example shown above, the elements for calculating would become those shown in the following Table II.

Table II Example with perfect substitutes

	Q	Time (h)	Tariff	Value of time	Gen price
Without the project	900	3.8	98.9	15.0	155.6
With the project	900	3.1	96.7	15.0	143.3

The demand is aggregate (plane + train), and time, tariff and generalized price are the weighted mean of time, tariffs and generalized prices of the two modes.

Benefits would amount to: 900 * (155.6 – 143.3) = 11000. It should be noted that in our example, the overestimate of benefits is around 22%.

But the assumption of perfect substitution between modes is very strong, as it brings about the choice between the two modes being made solely on the basis of the generalized price.
In the example offered, in the reference solution the generalized prices over the plane and the train in reference solution are different (amounting to 160 euros and 150 euros respectively). But if the two modes are perfect substitutes, why does the demand for the plane not all switch to the train? If the generalized prices were inverted, it would be necessary for us to ask ourselves why not all consumers choose the plane. Only with generalized prices that are equal can the demand be distributed between the two modes, because they are seen as being indistinguishable.

Again, following the example proposed, the paradoxical results that can be obtained through disaggregating benefits are noteworthy.

Indeed, if benefits per mode are disaggregated, it can be seen that:

- The plane mode shows benefits amounting to 16,000 euros, whereas
- The rail mode, in which the investment has been made, shows additional costs for 5,000 euros!

It is clear that the assumption of perfect substitution between different modes, and so also of a single demand curve, does not hold up.

3. CONCLUSIONS

This paper is an attempt to show, by using a simplified example that the common practice in the evaluation of transport projects to estimate the benefits for users shifting from one mode to another as the difference between the generalized costs of the two modes is a mistake. And that the underlying assumption of perfect substitution between modes is not consistent with the results of the modelling exercises.

The various modes of transport ought to be dealt with as different goods, each one with a specific demand curve. And the calculation of the changes in consumer surplus for modal shifters must be based on these mode specific functions.

The use of a wrong methodology may determine big consequences on the final results of the evaluation, because it yields a systematic overestimation of user benefits when appraising projects investment which aims at a modal shift, as is often the case of investment in railways and in collective transport. Moreover, as far as these projects are concerned often the diverted traffic component ends up to be a remarkable share of the benefits. In these cases, the initial overestimation can be so huge to determine significant biases in the results and end up by justifying, in terms of welfare a project otherwise unfeasible.

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