# What to do with the changes in the revenues of transport operators in cost-benefit analysis?

**Georg Abay, Rapp Trans AG**

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# What to do with the changes in the revenues of transport operators in cost-benefit analysis?

Georg Abay
Rapp Trans AG
Zurich

Phone: +41432686031
Fax: +41432686040
email: georg.abay@rapp.ch

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# Abstract

Price changes and demand shifts in the transport sector induced by some policy measures or by investments in transport infrastructure have in general an impact on the net revenues of the affected transport operators. A new road e.g. might attract some people who formerly used public transport; in consequence the revenues of public transport operators might decline. On the other hand the new road might increase or decrease the fuel tax revenues of central government.

According to the prevailing opinion and practice in the german speaking countries, above all in Germany, these changes in the net revenues are regarded as „pecuniary spillover effects“ (transfers) and therefore they are explicitly not included in cost-benefit analysis (CBA).

The same view was adopted also in Great Britain by well known economists and also by the ministry of transport in the early 1970-ies.

However soon after that it has been realised (first by Robert Sugden) that there is a fallacy in this reasoning; in the british CBA-practice of today these effects are fully included. This view is summarized for instance in the Scottisch Transport Appraisal Guidance (2004) by the following statement: “The accepted best measure of welfare gain is the change in consumer surplus enjoyed by individuals and the change in producer surplus/deficit accruing to transport suppliers.“

Not so in the actual german standardized assessment scheme. Due to this fact, the results of some of the CBA’s carried out in the last 25 years might be at least questionable.

The article shows why these and similar effects (e.g. tax benefits) must be included in a cba to achieve a better allocation of ressources and as why the german assessment method must be changed.

# Keywords

Cost.benefit analysis–producer surplus–consumer surplus– tax benefit

# 1. Introduction

From 1983 to 1984 I was working on my Ph.D. thesis "Cost-Benefit Analysis for transport projects" (Kosten-Nutzen-Analyse für Verkehrsinvestitionen) at the University of Zurich. My work started and ended with the study of the relevant textbooks. The majority of these textbooks were written in English, because CBA was originally a discipline whose theoretical foundations have been developed in the US. And the years following the most important contributions came from US and British economists. Of course at that time also german textbooks and papers were available because CBA proved to be a powerful assessment method.

Reading the textbooks I found several questions or topics which were not clearly explained and other topics which were answered or explained contradictory. One of these was the following question:

Should changes in the revenues of transport operators be included in the calculation or not?

In some textbooks the view was adopted that these changes have to be included without any reasoning why they should be, as if this would be self-evident anyway. In most other textbooks the view was adopted that these changes may not be included in a CBA because they were regarded as pecuniary spillover effects or transfers of payment. I could not find any discussion of these controversial opinions. In any case the latter view was prevailing in the CBA practise everywhere. The argument that these effects are transfer payments convinced me too. If I decide one day not to use the railway for my commuting travel anymore, than the railway company loses some money but I can save the same amount; so nothing else happens in the economy.

Gwilliam (1972) summarized this view in his paper (with the subtitle "The State of the Art") in the following way:

*"If a road improvement reduces the demand for public transport it will have the immediate affect of reducing the gross revenues to the undertaking at existing prices. If the undertaking makes no reaction to this, its financial balance will decline by an amount equal to this loss of gross revenue. But this does not involve any reduction in the level of public transport service involved. If public transport congestion is reduced it may even cause some improvement in the quality of service. In the absence of this the only effect is a reduction of surplus, or increase in deficit of the undertaking, which has redistributive, but no allocative significance. …..but in term of efficient use of resources the relevant elements for the appraisal would appear to be the following:*

*i. Any variation of resource inputs resulting from service variations*

ii. *Any variation of the value of service provided to remaining users (such as effects of deterioration in frequency or waiting time or improvements in comfort due to reduced congestion).*

*There is no reason to assume that the change in the financial position of the public transport operator will offer a reasonable proxy for this."*

This was the official view of the German and also British Transport Departments and of the majority of economists who were concerned with cost-benefit analysis in the early 70-ies.

## 2. What is the problem with this view?

Before finishing my thesis, I found a paper, whose content roused my suspicion that things are not as simple as they look. The author of this paper was a young British economist, Robert Sugden. The title of his article was: "Cost-Benefit Analysis and the withdrawal of railway services.

At that time in Great Britain several railway lines have been closed and replaced by a bus service. To decide whether a rail service should be closed or retained, two approaches of cost-benefit techniques were used. The first one ignored the effect of the closure on the revenues of public transport operators the second one included them. The ministry of transport accepted the argument of those used the first approach, that the loss of revenue by public transport operators is a "pecuniary spillover effect", which should not be included in cost-benefit appraisal, if the objective of policy is to achieve a better allocation of resources.

Sugden showed in his article that there was a fallacy in reasoning of the Ministry of transport. His argumentation follows a case study about the replacement of a railway line by a bus service:

There is an unprofitable railway line, which should be replaced by a bus service, because the operation costs of the bus are cheaper. The further assumptions are:

- The journey time by bus is a bit longer than the journey time by rail
- Bus fares and rail fares are equal
- There are no transfers from rail to private car

What are the consequences?

(1) After the replacement of the railway by bus some former rail passengers do not make the journey at all. They bear a welfare loss which can be approximated by the known 1/2 –formula
(2) Those who transfer from rail to bus have lost a sum equal to the value of the additional journey time
(3) Saving in rail operating costs $(C_R)$
(4) Loss of railway revenue as a consequence
(5) Costs of additional bus services to carry the diverted traffic from rail $(C_B)$
(6) Additional revenue received by bus operators from former rail passengers

Let

$N$ be the flow of passengers making the journey by rail,

$T$ be the fraction (between 0 and 1) of these journeys which is made by bus after the closure,

$\Delta J$ be the money value of the additional journey time in bus,

Then the social net benefit of retention of the railway line is equal:

Approach 1: $B_1 = NT\Delta J + 0.5N(1-T)\Delta J + C_B - C_R$ (1)

Approach 2: $B_2 = NT\Delta J + 0.5N(1-T)\Delta J + C_B - C_R + NF - NTF$ (2)

The difference between the two approaches is: $NF(1-T))$

A former rail passenger who after the closure does not make the journey at all bears a welfare loss which is equal to: $0.5\Delta J$ . But this does not reflect the full effect on the economy of his decision not to use public transport.

Before the closure of the railway line he spent ***F*** on making a journey by rail; after the closure he saves ***F*** to use this amount of money to buy something other . He substitutes the rail journey with e.g. additional beer consumption in the same amount. This means that he imposes a real cost (additional resources) on the economy equal to the marginal social cost of manufacturing the beer which sells for ***F***.

It is normal in cost-benefit studies to assume that prices equal marginal social costs, unless there are good reasons for thinking otherwise. As we do not know what goods the former passenger will buy with the money he saves from not having to pay rail fares, we can assume, that that a real cost of ***F***. is incurred in producing goods to substitute the former rail journey. On the other hand there is a saving, since the economy is no longer required to produce the rail journey. But this saving is part of $C_R$ and has already been counted in the appraisal. Thus approach 2 is the correct measure of the gain or loss in real resources which is due to the closure.

A difference between rail and bus fares can easily be incorporated into the formula (2).

Let $\Delta F$ be the difference between rail-fare $(F_R)$ and bus-fare $(F_B)$. If the rail-fare is greater than the bus fare then $\Delta F$ is greater zero. The net loss of the revenue by public operators is $\Delta F$ for each journey transferred to bus and $F_R$ for each journey not transferred. The net loss of the revenue by public operators on all journeys is thus: $NT\Delta F + N(1-T)F_R$

It has been shown that this represents a real resource loss. So the social net benefit of retention of the railway line can be written as (approach 2):

$$\hat{B}_2 = NT(\Delta J - \Delta F) + 0.5N(1-T)(\Delta J - \Delta F) + C_B - C_R + NT\Delta F + N(1-T)F_R \quad (3)$$

If we relax the assumption that there was no transfer from rail to private car, approach (2) can still be used. Consumption of "journey by car" as a substitute for "journeys by rail" is not different in principle from the consumption of beer or any other substitute. The economy as a whole loses a sum equal to the cost of producing the goods that a former rail user buys with the money previously spent on fares. In this case, these goods will include inputs for car journeys, such as fuel.

We assume, as before, that price equals marginal costs for all 'goods'. But in the case of car journeys we know that the private cost of a car journey is not equal to its marginal social costs. There are two main reasons for this: one is the existence of external costs such as road congestion or air pollution. This kind of costs are usually included in cost benefit accounts. The other reason ist the existence of fuel tax. Therefore the increase in government revenue due to additional fuel consumption should be taken into account. Equation (3) can be revised thus to:

$$\hat{\hat{B}}_2 = NT(\Delta J - \Delta F) + 0.5N(1-T)(\Delta J - \Delta F) + C_B - C_R + NT\Delta F + N(1-T)F_R + E - R \quad (4)$$

where T is still the transfer fraction to bus, E is the additional external cost of car traffic and R is the net increase in government revenue due to additional fuel tax revenues (R is also known in the literature as tax-benefit).

Equation (4) is quite different from the usual approach shown in equation (1). Because T < 1, the usual approach will understate the net benefit of the rail retention and other things beeing equal, the lower the value of T the greater the understatement.

According to equation (4) we have the following net benefit elements:

- The expression $NT(\Delta J - \Delta F) + 0.5N(1-T)(\Delta J - \Delta F)$ is the well known change in consumers surplus of the travellers
- The expression $C_B - C_R + NT\Delta F + N(1-T)F_R - R$ is the sum of all changes in the net revenues of the transport operators (including government) which is also called the change in producers surplus of the transport suppliers. This is also equal to the change of resources used in the relevant transport industries.
- $E$ is the change in external costs

Then we can rewrite (4):

| The net benefit = $\Delta$ consumers' surplus + $\Delta$ producers' surplus + $\Delta$ external costs (5) |
|---|

This is a short summary of Sugden's article.

Sugden did not explicitly mentioned equation (5) in his article but he mentioned all the relevant elements of the net benefit calculation including tax benefit of the government and the importance of external costs.

In the Scottish Transport Appraisal Guidance (2003) we can find the following statement:

***„The accepted best measure of welfare gain is the change in consumer surplus enjoyed by individuals and the change in producer surplus/deficit accruing to transport suppliers.“***

The change in the consumers' surplus enjoyed by individuals is identical to the change of surplus under the transport demand curves. The change in *producer surplus/deficit* is identical with the net changes in the revenues of the *transport suppliers* (including the government) and this is also identical to the change of the resource inputs to the economy

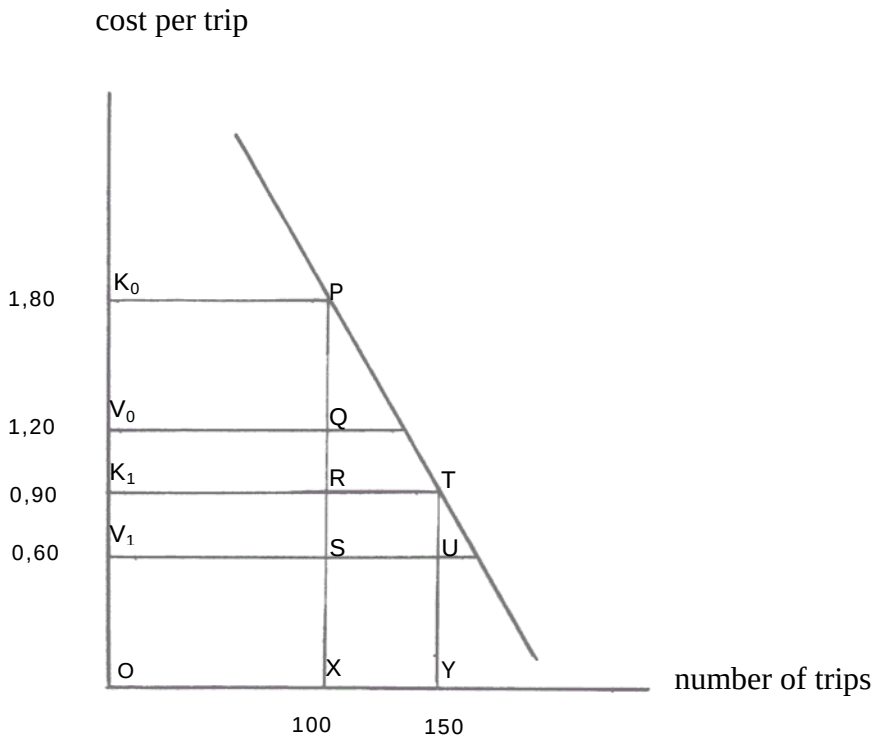
The significance of the "tax benefit" can be best demonstrated with a specific road investment example:

The underlying assumptions are:

- A new, shorter road will be built between A and B
- The market price of fuel is Fr. 1.80 per litre
- The fuel tax is Fr. 0,60 per litre; the social cost of fuel is therefore Fr. 1,20.
- The generalised costs of a trip between A and B consist only of fuel costs
- To get from A to B on the old road exactly 1 litre of fuel is needed
- The price of a trip on the old road was Fr. 1.80 ($=K_0$), the corresponding social costs were Fr. 1.20 ($=V_0$)
- On the old road 100 individuals made 100 trips per day
- On the new and shorter only 0.5 litre of fuel is needed; the price of a trip falls to Fr. 0.90 (=K1) and corresponding social costs are Fr. 0,60 (=V1)
- After the opening of the new road everybody switches to the new road
- Because the cost of a trip decreased on the new road, 50 additional individuals make 50 additional trips. The number of daily trips on the new road increases to 150

The following figure shows the effects of the investment:.

Figure 1 tax benefit




The users of the old road have a net benefit which equals the area $K_0PRK_1$ (= Fr. 90).

The fuel tax income of the government due to the existing traffic falls by Fr. 30.- ($K_1RSV_1$ minus $K_0PQV_0$).

The new users of the road also have a benefit which equals the area PTR (Fr. 22.50). Their expenses for fuel equals the area RTYX (=Fr. 45.-). But the real social costs of the additional fuel is only SUYX (=Fr. 30.-).

In other words, the government receives from the new users fuel taxes in amount of Fr. 15.- The net benefit (B) generated by the new road is:

**B** = $K_0PTK_1$ + RTUS + $K_1RSV_1$ - $K_0PQV_0$ = $K_0PTK1$ + $K_1TUV_1$ - $K_0PQV_0$

Or in Franks:

**B** = 112.50 +45.00- 60.00 = **97.50**

The net benefit can also be written in the following way:

**B = Increase of consumers' surplus – reduction of the net revenues of the government**

The net decrease in tax revenues of the government equals Fr.15. This also equals to the additional resources imposed on the economy[1].

So the net benefit can also be written as:

**B = Increase of consumers' surplus – additional resource imposed on the economy**

In this special case the net benefit of the investment is smaller than the benefits of the trip makers (consumers'surplus).

But the way from Sugden to today's practice in Great Britain was not straightforward. Above all the concept of the "tax-benefit" was not generally accepted. Some British economists (e.g. Beesley, 1970) vehemently refused to accept it as a relevant element of cost-benefit calculations. But in mid 70-ies it has been accepted by most leading transport economists as a real element of benefit (e.g. van der Tak (1971), Harrison (1974), Thomson (1974), Sassone and Schaffer (1978)).

The british CBA practice[2] to day is consistent with equation (5):

| The net benefit = $\Delta$ consumers' surplus + $\Delta$ producers' surplus + $\Delta$ external costs (5) |
|---|

This has been the recommendation in my Ph.D. thesis as well. Several CBA's in Switzerland have been accomplished according this formula.

However in the german CBA practice the old view is still prevailing.

[1] The road users expenses for fuel decreases by 45 Franks. They spend this amount for other goods imposing additional resources on the economy which equals 45 Franks. At the same time resources in the amount of 30 Franks have been freed because the real costs of fuel decreased by 30 Franks. So the net effect of the resource change equals 15 Franks

[2] And also the US CBA practice.

References

Abay G. (1984): Kosten-Nutzen-Analyse für Verkehrsinvestitionen. Dissertation Universität Zürich.

Abay G. (2004): Müssen in Kosten-Nutze-Analysen die Einnahmenänderungen bei den betroffenen Verkehrsunternehmen berücksischtigt werden?, Zeitschrift für Verkehrswissenschaft, Heft 3, pp 159-178

Beesley M. E. und Walters A. A (1970) Some Problems in the Evaluation of Urban Road Investments, Applied Economics, vol 1, pp 241-259, 1970

Button, K. (1993) Transport Economics, 2nd Edition, England

Gwilliam K. M. (1972) Economic Evaluation of Transport Projects, Transportation Planning and Technology, vol. 1, pp 123-142

Harrison A. J. (1974) The Economics of Transport Appraisal, London

Mishan E. J.(1976) Cost-Benefit Analysis, New York

Sassone P. G. und Schaffer W.A. (1978) Cost-Benefit-Analysis, a Handbook, New York

Scottish Transport Appraisal Guidance, Vers. 1, Sept. 2003, Edinburgh

Sugden R. (1972) Cost Benefit Analysis and the withdrawal of Railway Services, Bulletin of Economic Research, vol. 24, pp 23-32

Sugden R. (1999) Developping a consistent Cost-Benefit Framework for Multimodal Transport Appraisal, University of East Anglia

Thomson J. M. (1978) Grundlagen der Verkehrspolitik, Bern

Van der Tak H. und Ray A. (1971) The Economic Benefits of Road Transport Projects, World Bank Staff Occasional Papers, Nr. 13, Baltimore