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Monetary Valuation of the External Effects of Transport: the State-of-the-Art in Switzerland

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Abstract

Our paper aims to set the stage for a debate, to be conducted in this Journal, on the pros and cons of the monetary valuation of the environmental impact of transport. It demonstrates in succinct form that a welfare-maximising policy requires an intervention to correct for external effects. This in turn makes a monetary valuation of external effects necessary. A few methodological problems are outlined and exemplified by a study of the health impact of air pollution. Switzerland has carried out a number of studies on the external effects of transport. Although existing estimates vary widely, current values are high enough to justify political steps in various areas, and they are useful not only for taxation-related issues, but also for assessing the cost-benefit ratio of infrastructure projects and policy instruments.

1 Introduction

The purpose of this paper is to provide an overview of the current state of the monetary valuation of transport externalities in Switzerland. As this debate is meant to address a politically interested public above all, we shall not deal in detail with all the relevant economic and methodological issues. Instead we aim to outline the economic aspects we deem the most important for political debate.

We shall first present an overview of the economic rationale for internalising external costs. Section 3 addresses some methodological problems, and section 4 goes on to outline the relevant scientific and political activities in Switzerland in this area. Section 5 discusses monetary valuation as exemplified by the assessment of health costs related to air pollution. The last section presents a number of considerations on the possible applications of current estimates and some conclusions.

We may note at the outset that although external costs and monetary valuation are often directly linked to cost internalisation (i.e. charging the polluters). This is definitely not the

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only use of monetary valuation of environmental goods and "bads" (i.e. damages): Monetary values are used in various types of cost-benefit analyses when deciding on and rating investment projects, assessing priorities for a set of policy instruments, establishing adequate levels of environmental protection and even when fixing compensation levels following environmental damages.

2 Overview: Why do external costs matter?

Economists usually assume that market-based systems provide an efficient way of dealing with shortages of almost all resources, goods and services: Price mechanisms and the interplay of supply and demand in a free market (with perfect information and perfect competition) will give rise to an efficient, welfare-maximising situation. There are a number of prerequisites for this, however. One of them is that the price of a good should reflect the totality of costs generated by its production, use or consumption. In other words, as long as there are costs that transport users impose on others outside of market mechanisms, or "external costs", the market system will fail to reach its optimal state. It should be noted that "internal costs", sometimes referred to as "private costs", are the costs paid by users or polluters. The term "social costs" refers to the totality of internal and external costs (Baumol and Oates 1975; OECD 1989).
At least since Pigou (1920), economists are aware that such external costs do exist, and that adverse environmental effects of transport, and of other economic activities, noise or air pollution for example, can damage human health, buildings and nature. The reason why the market mechanism fails here is that individuals and firms make decisions concerning their travel arrangements or shipping orders on the grounds of market prices and market qualities, without accounting for the costs to others. Many trips would be avoided or carried out by more environmentally friendly means of transport if drivers were forced to consider the full social costs of their actions and had to pay a price including external costs.[2]

In order to correct for this market failure, economists often demand that external costs be internalised, i.e. that polluters pay the full marginal social costs of their activities. They should pay not only private costs, such as car maintenance and fuel, but also the external costs: air pollution, noise etc. The way to "get the prices right" (Kageson 1993) that is usually proposed is to set taxes at a level where they reflect external costs. This is the classical Pigou tax (Pigou 1920). For greater precision, the optimal price would have to include social marginal costs, i.e. the social costs of an additional unit of traffic, which would result in an "optimal" equilibrium situation, after the adjustment of demand to the new prices (Baumol and Oates 1975; ECMT 1994).
Such a view of the "polluter pays" principle is much broader than the one in current legislation. This principle in political and legal practice is usually limited; polluters pay the expenses required to cope with the standards and emission restrictions set by

2 For the transport sector, Walters (1961) was particularly important with respect to congestion costs. See also OECD (1989), ECMT (1994) and Mishan (1971) for a survey of the issue of transport externalities.

environmental legislation. Implicitly, polluters are not responsible for any further payments for damages that would persist after compliance with all environmental laws.

So much as a brief introduction to the discussion of externalities. In the last decades the debate has focused on a number of different issues, such as:

- How should one estimate the monetary value of external effects?
- Are there external benefits which outweigh external costs?
- How should one make use of external cost estimates in cost-benefit assessments, transport accounts and especially when taxing and pricing transport?
- What are the best instruments in a real world to make polluters pay, taking into account differences relative to the time of day, the region in question, the type of vehicle etc., as well as practical implementation problems and transaction costs?

We shall discuss some of these problems below.

3 Methods and Methodological Problems

A presentation of the state of the art in terms of economics would go beyond the scope of this paper. We shall limit ourselves to some basic facts.[3]

Any monetary valuation must be based on knowledge of a causal relationship, i.e. the impact pathway that links *traffic flows*, *emissions* (or any other action which might affect the environment), *effects* on the state of the environment (e.g. concentration of pollutants, results of transmission phenomena), and finally the *impact* on human beings or the natural environment. This is what we call the "technical data set" (or "Mengengerüst", in German).
Scientific knowledge of many environmental effects is relatively limited, especially for some of the most critical ones (i.e. the influence of various factors on climate change, the transmission phenomena of ground-level ozone, the exact sources of particulate matter etc.). It is therefore often much more difficult to establish a reliable *technical* data set than a *monetary* data set ("Wertgerüst").
This means that economic valuation is a problem of the second stage, when effects that have been technically identified have to be valued. A number of methods have been established and different classifications used in recent years.[4]

- *Willingness to pay*
  The most widely used *direct method* for measuring the individual value (the demand) of non-market goods is contingent valuation, in which sophisticated questionnaires are used to conduct an survey of people's individual willingness to pay for a certain environmental good or for partial risk reduction. This methodology is also referred to as "stated preferences"; see the survey in Brookshire et al. (1982). In some cases,

3 See Baumol and Oates (1975) for a general introduction and OECD (1989) on the methodologies.

4 For a very good presentation of the methods see OECD (1989), for a recent Swiss contribution see Roschewitz 1999. For a graphical illustration of the three main approaches, see Walter et al. 1992: 110.

such as establishing the financial contribution an individual would be willing to make in terms of environmental protection**,** this method could directly define monetary values without having a clear idea of the cause-effect-pathway. However, to do so data on the degree to which transport - among other emission sources - is responsible for the final effect are still a minimal requirement.
Indirect methods make use of data on observed behaviour (revealed preferences), in complementary markets (travel cost assessment in cases where a natural good is to be visited), whereas hedonic regression techniques attempt to partially explain price differences in the housing market (or other markets) as a result of differences in environmental quality.

- *Damage and repair cost methods:*

  In cases where damages have a market value, such as damages to buildings caused by air pollution, the loss of value (or alternatively the cost of repair) can be assessed directly.

- *Avoidance costs*

  This method does not estimate external costs but shows the other side of the coin, i.e. the cost of avoiding a certain type of damage at the outset, by using other technologies, or of reducing the damage where it occurs, such as double glazing to reduce noise. Avoidance costs depend on the extent to which a damage or an emission should be avoided, without saying anything about the value of environmental goods per se. For these two reasons, avoidance costs can only be used as a rough substitute for the willingness to pay values in cases where the environmental targets are clearly stated - the Kyoto protocol for carbon dioxide, for example. This means that society puts a value on the environmental good corresponding at least to the cost of reaching this target.

Without going into detail we can say that many methodological problems associated with the willingness-to-pay studies have been solved. The results - the value of a statistical life, for example - are convergent. This means that we are increasingly able to ascribe reliable economic values to certain environmental goods and damages. However, the reliability of the *technical* data set determines whether the costs can be associated with *a specific pollution or emission*. This data set has become an increasingly important part of the chain.

Of course, economists are confronted by a number of outstanding problems.

- One is the problem of *aggregation*: how is one to aggregate monetary values from different socio-economic groups, from different regions, situations with different environmental characteristics, etc.
- Another major problem is linked to the fact that most monetary values *are average costs* and refer to the current environmental situation. Calculating efficient prices requires marginal costs, however. In more precise terms, it requires knowledge of the *marginal costs* that would occur *in a new equilibrium*, after adjustment of traffic volumes and technologies.

- A third problem is the *differentiation*: Even if we knew more about cost curves and hence marginal costs, it is highly unlikely that in reality taxes levied would take into account all the theoretical variations required, namely time of day, traffic flows, technologies used, people and regions affected etc.
- Another important problem is that of the *life cycle*, that is: all external costs from the cradle to the grave should be considered, from production through consumption to the recycling stage. This is often very difficult and raises the problem of the system's delimitation.

In recent years, estimation tools have made a certain amount of methodological progress.[5] In particular, geographical differentiation has improved thanks to the use of complex models, which attempt to pinpoint relationships between traffic flows, the location of people affected and impacts thereof. Especially for air pollution and noise, it is essential to distinguish between the various levels of emission to which the population is exposed. Some of these models are connected to geographical information systems (GIS). Unfortunately, they require a very detailed database which is not always available.

4 Monetary valuation in Swiss transport policy

Switzerland has been dealing with the external effects of transport for a long time. As far back as 1977, the „Integral Concept for Transport" (Gesamtverkehrskonzeption, see EVED 1978 and Walter 1998) demanded that external effects be identified, monetarised and internalised. It took some years until a system of indicators for social costs and benefits was published in a study commissioned by the Bureau for Transport Studies of the Federal Department of Transport (GVF 1988). The decision to launch the monetary evaluation of external effects was taken at this time, limiting it to the areas in which physical effects were easy to identify, and monetary values not too difficult to assign.
The study on the external cost of traffic *accidents* (ECOPLAN 1991) was the first to be published. Other studies followed: on *damages to buildings* (Infras 1992) and on *noise* (Infraconsult 1992). Studies by the National Research Programme "Cities and Transport" (NRP 25) dealing with external transport costs in urban areas (ECOPLAN 1992b, Infras 1992, Jeanrenaud et al. 1993) were published at the same time.
A joint study by the ministry and NRP 25 (ECOPLAN 1992a) dealt extensively with the issue of external *benefits*. It concluded that they are almost irrelevant for optimal pricing, since nearly all the considerable benefits of transport are transmitted via market mechanisms. Called pecuniary externalities, these benefits are of no importance in optimal pricing, but have to be considered in investment decisions based on cost-benefit assessments.
This first series of official studies concluded with a summary report (GVF 1993; Schwab et al. 1993) which showed how these costs might be integrated within transport accounts.

5 The most recent overview based on various EU studies might be: High Level Group On Infrastructure Charging (1999).

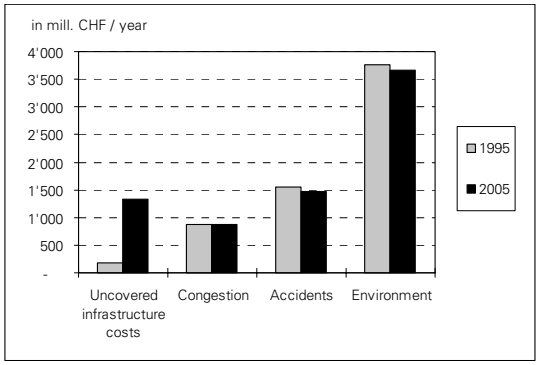
In the following years, a number of these studies were updated. Only one type of external effect, the *health impact of air pollution* (ECOPLAN 1996) was added. Studies of the costs of *climate change* (Infras et al. 1996) and of *congestion* (Infras 1998) have not been fully integrated within the "official" external costs framework that is regularly published by the Ministry.

Various applications of the results of these studies were proposed. In 1998, ECOPLAN suggested a method for the application of monetary valuation *in cost-benefit assessments of transport projects*, at both national and local level. As part of the National Research Programme "Transport and Environment" (NRP 41), Infraconsult (1999) demonstrated the use of monetary values for a cost-benefit assessment of various nature and landscape *protection measures* in the context of road and rail infrastructure projects. Maibach et al. (1999a and 1999b) established a *prospective analysis* of external costs for 2010 and proposed various scenarios for *internalising* external costs. Ott et al. (1999) showed how various *regions* are affected to different degrees by the external costs of transport: urban areas have higher health and noise costs per capita, whereas mountain regions have very high per capita costs as a result of climate changes and damages to forests.
Studies conducted on behalf of the Transport Ministry on the costs of damages *to nature and landscape* are currently underway, as well as a study on noise pollution costs, which uses a considerably improved methodology.

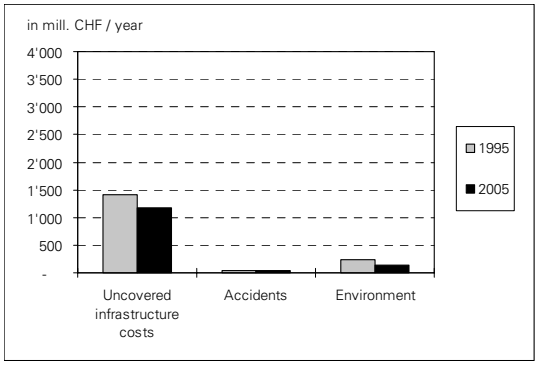
It is interesting to see that apart from the benefit study (ECOPLAN 1992a), none of these studies have ever been seriously and publicly challenged by other institutes. Although the scientific community reached a relatively broad consensus as to the fact that these values, in some way, could be seen as a minimum level of external costs, the same cannot be said for the political arena (see Werder and Herczog in this journal). The areas in which valuation is more difficult. i.e. nature and landscape, were not tackled until very recently. The few existing studies, moreover, do not have an "official" character (climate change, see Infras 1994; Infras et al. 1996).

The scope of this paper does not allow for a detailed presentation of data on external costs for Switzerland.
Just to give readers a rough idea (see figures), let us say that the external costs of accidents, environmental impact and impact on human health are currently estimated at about 7000 million CHF for road transport and 400 million CHF for rail transport. The rail transport system, however, is unable to meet its infrastructure costs, which amount to about 2000 million CHF; a further 800 million CHF are paid by taxpayers for the operation of non-profitable services as a "public service obligation" ("gemeinwirtschaftliche Leistungen"). It is still open to discussion, whether and in what framework congestion costs and uncovered infrastructure costs should be considered as external costs.
External costs make up about 2.8% of the Gross Domestic Product (GDP), less than the average estimates given in a number of international studies (Suter 2000).

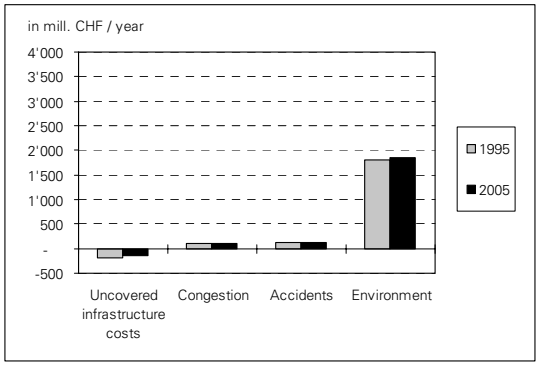
External costs of road passenger transport



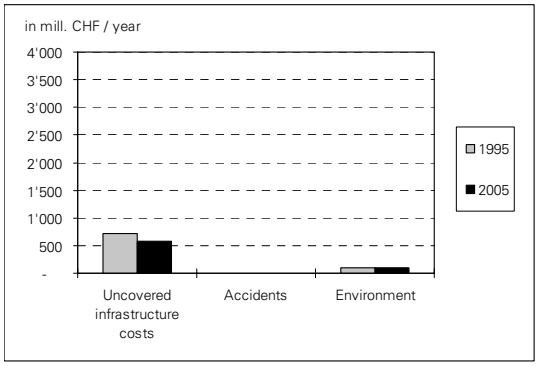
External costs of rail passenger transport



External costs of road freight transport



External costs of rail freight transport



Figures: External costs of transport in Switzerland 1995 and 2005; data based on Maibach et al. (1999a).

This brief and fragmented history nevertheless shows that Switzerland actively attempted to establish the monetary value of transport externalities. Swiss institutes at the same time have contributed to international projects (see Kageson 1993, Infras and IWW 1994, COST-Action 313 on accidents).

On the other hand, efforts to use these values to internalise costs were less frequent. No clear concept on how to use external costs exists as yet, and no official transport accounts integrating external costs are published on a regular basis. Although studies like ECOPLAN (1992b), Neuenschwander et al. (1998) or Maibach et al. (1999a and 1999b) contain numerous proposals on internalisation, the only official concept that was developed focused on taxation of heavy goods vehicles:

Article 85 of the Swiss Constitution, which establishes a distance-related Heavy Vehicle Fee (HVF, voted in 1994) explicitly mentions external costs. It states that the Confederation may levy taxes on heavy goods vehicles if they generate costs that are not otherwise covered. This constitutes a landmark on the path towards "getting the prices right" and a breakthrough for the principle of internalisation. After the gradual introduction of the new HVF as of 2001, road freight transport will more or less pay the costs as

calculated in the above-mentioned studies. However, voting on the subject was dominated by other issues, such as the financing of rail infrastructure and contribution to the bilateral agreements with the EU. Even advocates of the tax avoided using the term "external costs".

Another attempt is being launched by the parliamentary initiative on "cost-fairness in transport", which aims to amend the Constitution. The proposed amendment is very watered-down, and includes an extensive range of exceptions, however (KVF 1999).

5 The example of health costs

A short overview of a recent study carried out on behalf of the World Health Organisation WHO and its Ministerial Conference in London in June 1999 (Sommer et al. 1999; Seethaler 1999) will illustrate the progress made in this domain. The study assessed health costs due to road traffic-related air pollution.
Three mixed teams from Switzerland, Austria and France, which included specialists in air pollution, epidemiology and economics, established a jointly approved methodology for all three fields. Results showed that health costs due to air pollution from all sources amount to about 1.1% to 5.5% of GDP in the three countries. Costs for Switzerland are about 6.7 billion CHF per year; a share of about 3.5 billion CHF may be attributed to road traffic.
The study also concluded that the costs of mortality (premature deaths) are the largest part of these costs. The method used to calculate the "value of life" is therefore particularly important. Economists never assess the value of life at an individual level, of course. They assess the benefit of risk reduction and calculate the value of preventing a statistical fatality (VPF). A similar approach estimates the value of a life *year* (VOLY), which makes it possible to distinguish between the victims' age groups. Sommer (1999: 26) did not use the concept of VOLY, since empirical evidence shows that VPF does not decrease *linearly* with higher age. However, an adjustment was made for the fact that most premature deaths seem to occur among the elderly, whose willingness to pay to avoid the risk of a fatality is demonstrably lower.
A further approach focuses on loss of production (or consumption). Amongst others, this was used in the Swiss accident study (ECOPLAN 1991), being considered more transparent and acceptable than a willingness-to-pay approach at the time. The advantages of the VPF-concept, clearly based on welfare economics, are nowadays more widely accepted.
As mentioned before in the methodology section, the willingness-to-pay approach for calculating the value of a reduction in risk is now widely used. Empirical studies often conclude that the value of preventing one statistical death is about 1 to 3 million EUR. After conducting an intense meta-analysis of existing studies, the WHO project (Sommer 1999) used a value of 1.4 million EUR, considered a conservative valuation. An extensive sensitivity analysis was carried out, of course.

This example shows that it is possible to agree on a common methodology and publish figures concerning the complex issue of air pollution and health effects, involving

uncertainties in various disciplines, and this at international level and in a politically highly sensitive context.

6 Conclusions: How useful and how reliable are monetary valuations?

The considerable methodological progress that has been made notwithstanding, estimates of the external costs of transport still vary widely at international level (see ECMT 1994). It is in fact quite astonishing that Swiss values are more or less generally accepted. This may be due partly to the government policy of estimating costs only in areas in which data are relatively reliable. Many studies opt for the "at least" approach - i.e. a conservative estimation methodology - so as to arrive at a minimal level for external costs. These minimal levels often suffice to justify policy interventions such as tax hikes, etc. Other studies attempt to integrate the parts of the costs that are more difficult to estimate - and are probably very important, especially those having to do with climate change.
Although an indisputable or undisputed valuation of external costs will probably never exist, we observe a growing consensus concerning the fact that even a conservative estimate of external costs calls for considerable changes in current policies. "How accurate is accurate enough?" was a much-asked question in the debate on applied scientific results. Most scientists involved in Swiss research would probably answer that the current degree of accuracy is sufficient to focus more closely on other issues, i.e. the search for an adequate combination of tools, for a careful, step-by-step implementation process, and for the best ways to use the revenues generated to gain acceptance.

These monetary values can be used in many ways: *Internalisation* and more specifically *taxation* are politically the most sensitive (it comes as no surprise that other arguments than external costs - financing, modal shift, environmental effects - were advanced much more often in the political debate on the Swiss Heavy Vehicle Fee). We are nonetheless convinced that the discussion on the external effects and true costs of transport has considerably boosted the introduction of environmentally more compatible transport policies.
Monetary valuation may assume even greater importance in other areas, for decisions on infrastructure investments, for example (see Walter 1997 for an application in energy investments), on the mix of instruments required to reach certain objectives, based partly on cost-benefit analyses that include environmental benefits, see ECOPLAN 1998) and for establishing priorities in environmental protection (e.g. Infraconsult 1999).

If the monetary values that are already available are not put to use at all, implicitly all non-market effects will be assigned a zero value, clearly leading to decisions, be it in investment or taxing, which do not maximise welfare.
Even if we do not consider taxation, external costs are very important, since they represent information on the achievable benefits of environmental improvements (benefits in the sense of a reduction in external costs). Information on the costs and harmful effects of environmental policies is often sufficiently available, while little is

known about the other side of the balance sheet. Only monetary valuation will endow these environmental benefits with an economic voice of their own.

Our overview has shown that although estimates vary considerably, a sound "minimal consensus", both methodological and quantitative, on the monetary valuation of the external effects of transport already exists. Remaining uncertainty is largely due to insufficient technical knowledge about the technical data set, rather than to the lack of a consensus on the economic part of the valuation.
As a pioneer in this field Switzerland has reached this relatively sound consensus on most of the values and studies published. However, further steps aiming for a real-world application of the economic concepts - internalisation, cost-benefit assessments - were taken only recently.

Although policies may never be based exclusively on external cost calculations, it will never be possible to make decisions without to some degree accounting for the costs and benefits of policies, whether explicit or implicit. We are convinced that monetary valuation do make environmental values more explicit, and thus more important for decision making processes. Exact figures are not important, but rather the consideration of external costs at all.
Major efforts will nevertheless be required: in environmental economics, so as to keep up with international advances in this area, and beyond, to convince people that monetary valuation has its uses.

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