SUSTAINABLE URBAN TRANSPORTATION
- SUTRA –

D08/B: ECONOMIC ASSESSMENT

First Interim Report
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Content of this first interim report

This report *D08/b- Economic assessment* is part of the final deliverable of Workpackage 8 of SUTRA – Sustainable Urban Transportation (EVK4-1999-00006P). The final version of the report will describe the methodology to be applied for the *economic assessment* of the scenarios of sustainable urban development.

This *first interim report* outlines the structure of the final report. Each section starts with a description of its future content in the final report. It also provides *an overview of the proposed methodology* for the economic assessment of scenarios in SUTRA, including a first selection of the categories of costs that are likely to be included in the final economic assessment.

The structure of the report is based on the assumption that this report needs only to describe the methodology. The description of the results of economic assessment will be in D.12 (Scenario analysis –city and summary report) and D.13 (Scenario comparison and multi-criteria assessment).

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1. Introduction

This report is part of the project SUTRA – Sustainable Urban Transportation (EVK4-1999-00006P). It describes the methodology to be applied for the *economic assessment* of the scenarios of sustainable urban development (Workpackage 8).

The primary objective of SUTRA is to develop a consistent and comprehensive approach and planning methodology for the analysis of urban transportation problems, that helps to design strategies for sustainable cities.

The project is based on the model-based elaboration of scenarios of urban development using transport, emission, air quality and energy system analysis models. Scenarios are defined for each of the cities participating in the project, considering the current base line, and a set of probable development strategies in terms of demographic, socio-economic, spatial, structural, and technological developments over the next decade and beyond (30 year horizon).

A set of indicators compatible with the indicators for urban sustainability used in the Dobris Report, are used for a baseline analysis, ranking and benchmarking (within the participating cities and across all of Europe) that ultimately support a discrete multi-criteria selection mechanism to identify preferred strategies and policies.

The economic assessment is part of the overall strategy of the project and intends to complement the multi-criteria selection mechanisms with an overall assessment of costs associated with each scenario of urban sustainable development.

This report describes the methodology to be applied for the economic assessment to be undertaken for each scenario. Results are reported and discussed in D.12 (Scenario analysis –city and summary report) and D.13 (Scenario comparison and multi-criteria assessment).

In particular, this report:

- discusses the main features of the evaluation of scenarios;
- identifies the categories of costs that need to be included in the economic assessment of SUTRA scenarios;
- introduces the approach undertaken in this study for each category of costs;
- reviews for each category the estimations available in the literature, summarising the findings in a way that will be applicable in the modelling exercises.

2. Economic assessment of urban transportation scenarios

The economic assessment of a given urban development scenario aims at evaluating the main costs implied in a transition from the baseline to that scenario. The purpose of this evaluation is to complement the multi-criteria selection mechanisms, providing policy makers with a main information, which cannot be set aside in public decision making.

In SUTRA, each scenario can be interpreted as a *programme* of projects that include a variety of things, such as changes in the composition of the fleet, in land-use patterns or in mobility management devices and practices. Each of these programmes is likely to have important consequences for individuals and households, for businesses of all sizes, and for local, regional, and national governments and it is therefore likely to change the *total social transport cost.* Total social transport cost is the sum of private and external costs. Private costs are costs supported by the same individuals who benefit from transportation. Therefore, in economic terms they are referred to as internal costs. They include individual’s time, investment and operating costs (i.e., fuel etc). External costs, on the contrary, are costs derived from the behaviour of some individuals, but supported also by other people. They include congestion costs (the increase in time costs of other drivers), air pollution costs (i.e.: damages to building, human health), noise costs.

The implementation of a set of measures in a scenario modifies the stream of private and external costs that define the total social transport cost. The economic assessment of a scenario implies the evaluation of the change in total social transport cost relatively to a do-nothing alternative. The change in total social transport cost is not intended to represent a precise quantitative measure of the gains or the losses that can emerge when adopting a certain scenario: the uncertainties involved in the measurement of impacts and in the assignment of an economic value to these impacts prevent from relying on such an index. The purpose is just to provide policy makers with a rough information about whether and to what extent a program is likely to reduce or increase total social costs of transportation with respect to the baseline scenarios.

3. Evaluation of the total social transport cost

As stated above, total social transport cost can be viewed as the sum of private and external costs. In a social-economic perspective, costs can be seen as burdens which affect individuals' welfare. It is very easy to understand how private costs influence the welfare of people, through modifying their wealth. Hence, the economic valuation of this category of costs is an unavoidable task. Since in an urban development scenario private costs concern "market goods", such as durable goods (e.g. cars), non-durable goods (e.g. fuel), services (e.g. periodic car maintenance) and time (which has an economic value in the labour market), the economic assessment concerning these cost is straightforward.

Besides private costs, however, even external costs concur to influence quality of life at a very high degree. Some examples are the effects on health of air pollution and accidents, the time lost due to congestion, the implications of high levels of noise in urban areas. Because of the main impact of these costs on individuals' welfare, they cannot be ignored in a comprehensive cost assessment of urban development scenarios, whose objective is to provide policy makers with a global view of the cost implications of each considered alternative.

In order to achieve this ambitious goal, there is a need to evaluate external costs. Contrary to the case of private costs, at this point a major problem arises, because goods which external costs refer to are generally "non-market goods". Clean air, health, free time are not traded in markets, so that market dynamics cannot give us a "price", which is normally used as a starting point to derive the real value of the considered good. Nevertheless, the recent environmental-economic literature has developed powerful tools to give an economic value to some goods, which cannot be estimated through market considerations. Applying these methodologies, it is possible to evaluate the most important external costs, which are likely to be generated by the implementation of a considered program.

A comprehensive assessment would include all the primary and secondary effects that complex social and natural systems would involve. An economic assessment cannot consider every single category of costs which is generated in each step. Even if it could, the outcome of the analysis would not be reliable, since the estimates provided by existing economic tools are subject to a very high level of uncertainty. Particularly as regards external costs, the economic theory is very recent and still incomplete: many proposed evaluation methods have not been sufficiently tested and for what concerns some impacts, no acceptable evaluation methods have been found yet.

Because of these reasons, a limited set of private and external costs will be considered in this analysis. The criteria used to choose which costs to include are the following:

- the relative burden of a category of costs compared to the others: according to the existing literature, we will not consider costs which are likely to be of minor importance;
- the reliability of the assessment of particular impacts: if the estimation of a certain impact is source of major discussion between experts, the corresponding category of costs will not be taken into consideration;
- the existence in the literature of reliable estimates of the considered costs: if there is a lack of information, the interested class of costs will not be assessed.

In the following subsections, literature on the evaluation of the main private and external costs will be reviewed and the methodologies which are likely to be applied in each case will be briefly mentioned. The exclusion of a category of costs will be justified on the basis of the criteria mentioned above.

3.1 External costs

In an urban transportation scenario, an external cost arises when a direct effect of the transportation system is the source of an indirect effect, or impact, on either humans, materials or natural systems When this impact is strong enough to cause a change in individuals' welfare and the responsibles of this impact (i.e. the users of transportation) don't cover the full cost of the social utility loss, then an external cost is born.

Main direct effects of transportation capable to produce external costs are:

- air pollution;
- accidents;
- noise;
- congestion;
- GHGs emissions.

In what follows, each of these phenomena is investigated with respect to the main external costs it is likely to generate.

Air pollution

Transportation is a main source of emissions in the atmosphere. In particular, pollutants which cause major negative impacts are: NO_X, VOCs, CO and PM_{10}.

NO_X is a responsible of acid rain that, as it is known, have adverse effects on vegetation. Some have observed that exposure to NO_X can cause an aggravation of asthmatics crisis in susceptible subjects. Some of the VOCs have carcinogenic effects on human and animals, while others are precursor of molecules (oxygenated molecules) that is known can damage vegetations and materials. CO is responsible of damage on people health and life quality as it has a very strong affinity for emoglobin and, therefore, it binds itself to this molecule, causing a less oxygen distribution to tissues. PM_{10} is a pollutant very important in damaging health as, for its very small dimension, it could be inhaled and thus enter in respiratory organs; the danger lies in the fact that often it contain other dangerous substances, as carcinogenic Pb and Cr.

These pollutants are implicated in the following impacts:

	NO_X	VOCs	CO	PM_{10}
HEALTH (mortality and morbidity)	X	X	X	X
BUILDINGS AND MATERIALS	X	X		
CROPS	X	X		
FORESTS	X	X		

According to the existing literature, effects on health, crops and materials have the highest relative importance, while impacts on ecosystems, forests and visibility are suggested to a very high level of uncertainty. [See, for example, the Economic Assessment of PEEP, in which an exhaustive review of the literature up to 1998 can be found].

As regards impacts on crops, an important specification has to be made: NO_2 and SO_2 are responsible of fertilisation effects, i.e. the impact of these pollutants on agricultural production is positive. On the contrary, O_3 has a negative effect on crops. Different evaluation studies have tried to assess the overall effect of NO_2, SO_2 and O_3 on crops. The net impact results to be in some cases positive, in other negative [see Holland et al., 1999]. Hence, in this study we assume that fertilisation effects offsets crop yield damages due to O_3.

For what concerns buildings and materials, all the considered pollutants have a noxious impact on them. Nevertheless, the damage results to be of minor importance if compared to the effects on health. Hence, the analysis will focus exclusively on health effects, with regard to both mortality and morbidity.

The methodology used to compute external costs related to health impacts is, nowadays, rather accepted in the health-economic literature. It is based on the concept of "willingness to pay" (WTP) for reducing the risk of dying or of contracting a specified illness. WTP is estimated through individual surveys, where the questionnaires are constructed following different criteria, depending on the chosen method (contingent valuation, stated preferences etc.).

Once WTP has been estimated, it is possible to derive the so called "value of a statistical life" (VOSL). This estimate can be applied in the evaluation of air pollution related mortality. Alternatively, an approach that takes into account the length of life lost through "premature" mortality can be used, where the "value of a life year" (VOLY) is computable on the basis of estimates of the VOSL. As regards VOLY, different values exist, depending on whether we consider chronic or acute effects and on what type of chronic illnesses.

For what concerns morbidity, the WTP for an illness is composed of the following parts: the value of the time lost because of the illness, the value of the lost utility because of the pain and suffering, and the costs of any expenditures on averting and/or mitigating the effects of the illness.

In the European Project ExternE, the reference value for a VOSL equal to MECU 3.1 (1995), corresponding to an average VOLY between 84,000 ECU (0% discount rate and age 35) and 322,392 ECU (10% discount rate and age of 45). Besides, WTP for many air pollution related diseases is provided. Because these estimates have been chosen after a serious review of the literature and hence are commonly used as a benchmark in other studies, we will rely on them, once adjusted for the average GDP real growth rate.

Accidents

Strictly speaking, accident costs are just partially external costs: the users of transportation, who are responsible of accidents, do generally pay a big share of the cost of unsafety, in terms of deaths, injuries and other losses. Hence, these costs should probably be better considered as private costs.

Methods used for evaluating the cost of accidents generally involve multiplying the numbers of dead and injured people and other damages by the per unit cost of these deaths, injuries and losses. As stated above, cost estimates are increasingly based upon individuals' willingness to pay. Hence, this methodology will be adopted.

Noise

Noise impacts are very difficult to evaluate, since they depend on a number of features, like the frequency and regularity of noise, the source of noise (e.g. railway noise and road noise producing the same nuisance differ of 5 dbA) and individuals' perception of noise.

The most common methods of evaluation are:

- Assessing the effects on the market value of buildings, since a negative correlation exists between noise levels and the market value of dwellings.
- Evaluating the cost of actions, which would have to be taken to eliminate or attenuate noise.
- Evaluating the damage caused by noise and the cost of corrective action, where the damage is essentially related to health.

All of these methods present major limits and a high level of uncertainty. This is the reason why there exists a wide dispersion within current evaluations. Greene et al. (1997) provide a set of evaluations in terms of ECU per 100 passenger-km, coming from several studies on different European countries. The range is between 0.03 and 1.00, with a mean value of 0.37. Avoiding extreme values, as well as evaluations referred to non-urban areas, a value of 0.4 ECU per 100 passenger-km, seems reasonable and will be used in the assessment.

Congestion

The green paper of the European Union refers to congestion costs as the difference between real transport times and transport times, which would be possible without any congestion, at a very low traffic. The main difficulty involved in the valuation of these costs is that there exists a large spectrum of values of time, according to the personal characteristic of the user and the purpose of the travel.

VISUM model will be used to assess the time lost due to congestion per passenger-km. In order to give a value to this time, the average wage rate will be used.

GHGs emissions

The increase in concentrations of CO_2 and other gases (mainly CH_4 and N_2O) in the atmosphere causes the so called greenhouse effect, i.e. an increase in the global temperature. Likely consequences of this warming include such things as biodiversity losses, effects on agriculture, a rise in sea level, etc. The exact extent of temperature increase due to urban emissions of such gases and its impact on regional and local meteorological conditions, as well as the resulting economic and social impacts are uncertain.

Studies of the monetised value of damage done from global warming are now quite extensive. Two forms of estimate have been produced in the literature:

- estimates of actual damage arising at the point in time when $2xCO_2$ occurs (i.e. a doubling of pre industrial atmospheric concentrations of CO_2) and arising from a small increase in emissions now;
- a "shadow price" defined as the level of tax required to keep emissions on an optimal trajectory as estimated by the modeller.

Because the estimates relate to damage or benefit at the time when $2xCO_2$ occurs, they are then discounted back to the present so that the choice of discount rate matters. Frankauser (1995) provides estimates of marginal damage values for the main greenhouse gases, using the discount rate as a random variable (p=0%, 0.5%, 3%), with a "best guess" value of 0.5% for p. The resulting estimates for the 3 considered gases are expressed in terms of 1997$/tonne. Alternatively, Greene et al. provide, as for noise, a set of estimates from different studies, expressed in terms of ECU per 100 passenger-km. Both of these bunches of values are worthwhile for SUTRA, since VISUM model is going to provide both estimates of n. passenger-Km and of tons CO_2 emitted for each scenario (consumed fuel times CO_2 coefficient). Hence, either Frankauser's or Greene's values will be used.

4. References

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