TRANSPORT NOTES

TRANSPORT ECONOMICS, POLICY AND POVERTY THEMATIC GROUP

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Notes on the Economic Evaluation of Transport Projects

In response to many requests for help in the application of both conventional cost benefit analysis in transport and addressing of the newer topics of interest, we have prepared a series of Economic Evaluation Notes that provide guidance on some of issues that have proven more difficult to deal with.

The **Economic Evaluation Notes** *are arranged in three groups. The first group (TRN-6 to TRN—10) provides* **criteria** *for selection a particular evaluation technique or approach; the second (TRN-11 to TRN-17) addresses the selection of values of various* **inputs** *to the evaluation, and the third (TRN-18 to TRN-26) deals with specific* **problematic issues** *in economic evaluation. The Notes are preceded by a* **Framework** *(TRN-5), that provides the context within which we use economic evaluation in the transport sector.*

The main text of most of the Notes was prepared for the Transport and Urban Development Department (TUDTR) of the World Bank by Peter Mackie, John Nellthorp and James Laird, at the Institute for Transport Studies (ITS) , University of Leeds, UK (The draft text of Note 21 was prepared for ITS by I.T. Transport Ltd). TUDTR staff have made a few changes to the draft Notes as prepared by ITS. Funding was provided from the Transport and Rural Infrastructure Services Partnership (TRISP) between the Department of International Development (DFID) of the Government of the United Kingdom and the World Bank.

The Notes will be revised periodically and we welcome comments on what changes become necessary. Suggestions for additional Notes or for changes or additions to existing Notes should be sent to rcarruthers@worldbank.org

VALUATION OF ACCIDENT REDUCTION

The World Health Organization has estimated that nearly 25% of fatal injuries worldwide are a result of road traffic crashes, with 90% of the fatalities occurring in low and middle income countries." (The World Report on Road Traffic Injury Prevention, World Health organization, 2004). Road accidents cause significant social and economic costs (typically between 1 and 3 percent of GNP) [i]. They also result in the use of a high proportion of medical facilities and the scarce depletion of foreign exchange. Attention is therefore focussed on designing transport infrastructure that is safe. Unfortunately, the safest form of transport infrastructure is often not the least (capital) cost option. For example, on a road the provision of separate pedestrian and animal footpaths, or the provision of lay-bys or widened shoulders that allow villagers to sell local produce are safer, but more expensive, than the non-provision of such facilities.

The failure to associate explicit costs to road accidents will therefore lead to wide differences in the assessment of projects that will affect road safety and at a national level is likely to lead to an under investment in road safety.

The objective of this note is to advise on a desired and workable method that can be used to place values on accident reduction. Methods of achieving accident reduction are not discussed and the reader is referred to texts such as TRL Overseas Road Note 5 [ii] and Infrastructure Notes RD-6 and RD-9 [i] [iii]. The note has drawn heavily on several publications Jacobs (1995) [iv]., Cropper (undated) [v] and Nellthorp et al (1998) [vi].

The first section of this note identifies the need to categorise accidents if accidents are to be valued and suggests a method of categorisation. Section 0 identifies the components of cost that make up total accident costs, whilst Sections 0 and 0 suggest methods that can be used to value casualty related costs and incident related costs. Sections 0 discusses how accident valuation may vary between modes and suggests that accident valuations are consistent with those utilised in other World Bank projects (e.g. health projects). Sections 0 and 0 discuss the manner that accident costs vary with time and the relationship between the valuation and the accident prediction m model. Section 0 summarises the principal recommendations of the note.

ACCIDENT CATEGORISATION

In order to provide a valuation of an accident it is necessary to have a consistent set of definitions for casualty severities; accident severities; and the various components of costs associated with them within the country concerned.

A well accepted set of categories for the classification of accidents is that developed by Nellthorp et al [vi] and is detailed in Box 1.

Box 1. Accident Classification

Casualty severities:

- 'fatality' - death within 30 days for causes arising out of the accident;
- 'serious injury' - casualties who require hospital treatment and have lasting injuries, but who do not die within the recording period for a fatality;
- 'slight injury' - casualties whose injuries do not require hospital treatment or, if they do, the effects of the injuries quickly subside.

Accident severities:

A 'damage-only' accident is one in which there are no casualties. A 'fatal' accident is one in which there is at least one fatality. A 'serious' accident is one in which there is at least one serious casualty but no fatalities. A 'slight' accident is one in which there is at least one slight casualty but no serious injuries and no fatalities.

Source: Nellthorp et al (1998) [vi]

COMPONENTS OF TOTAL ACCIDENT COSTS

Accident costs are often thought about as a combination of items, some of which are resource costs incurred by society as a consequence of the accident (emergency services, medical aid, material damage, etc), some of which represent a part of the individual's expected contribution to production which is no longer possible due to their injuries (i.e. lost output) and some of which represents the individual's personal loss of welfare (or 'human costs'). These human costs are sometimes characterised as 'pain, grief and suffering'.

A list of potential accident cost items would be:

- material damage - damage to property (vehicles, their contents, pedestrians and cyclists' property, buildings and street furniture, etc - also engineers/ assessors' fees);
- emergency services - police, fire and ambulances;
- legal and court costs;
- insurance administration;
- medical costs (including hospital treatment);
- lost economic output;
- delays to other transport users (passengers or freight);
- welfare loss (consumption);
- reductions in leisure time;
- willingness to pay to reduce risk; and
- human costs including pain, grief and suffering.

If this list were used as the basis for an appraisal value, there would be extensive double-counting. Box 2 sets out an accepted approach that avoids double counting for casualty related costs and for accident or incident related costs.

Box 2. Components of Accident Cost

Casualty-related costs:

- medical and healthcare costs including administration
- lost output
- human costs - pain, grief and suffering.

Accident-related costs:

- material damage
- police and fire services
- insurance administration
- legal and court costs
- delays to other road users (but care should be taken to avoid double counting with road traffic delays attributable to other causes)

Total costs:

The total appraisal value of an accident is the sum of the casualty-related and accident-related costs.

Adapted from: Nellthorp et al (1998) [vi]

METHODS TO COST ACCIDENT CASUALTIES

Methods used to value the economic cost of an accident fatality can be categorised into six approaches, a described in Jacobs (1995) [iv] and summarised in Box 3. The methods focus on different aspects of the impact of a casualty with respect to specific aspects of the economy or society in general. As these methods can also give rise to substantially different estimates of costs and values, the choice of which method to use is dependent upon the objectives of the study. In addition to the costs of a fatality, those attributable to injuries are another source of significant social and personal costs. These are the medical and support service costs involved in an injury accident, as well as the loss of output and personal costs.

Box 3. Methods of Assessing the Cost of a Fatal Casualty

A) The "gross output" or human capital approach: In this method the cost of a fatal casualty is the loss of future output, which equivalent to foregone earnings.

B) The "net output" approach: the cost of an accident is equivalent to the "gross output" figure minus the discounted value of the victim's consumption

C) The life-insurance approach: the cost of an accident is directly related to sums typical individuals are willing to insure their own lives.

D) The court award approach: With this approach, the sums awarded by the courts to the surviving dependants of those killed or injured are regarded as an indication of the cost that society associates with the road accident.

E) The "implicit public sector valuation" approach: With this method an attempt is made to determine the costs and values that are implicitly placed on accident prevention in safety legislation or in public sector decisions taken either for or against investment programmes that affect safety.

F) The "value of risk change" or "willingness to pay" approach: with this method the value of a given improvement in safety (i.e. a reduction in risk) is defined in terms of the aggregate amount that people are prepared to pay for it. That is the value of a particular safety improvement is defined as the sum of all the amounts that people (affected by the improvement) would be willing to pay for the (usually very small) reductions in risk provided by that improvement.

Source: Jacobs(1995) [iv]. See also Hills and Jones-Lee (1981, 1983) [[vii], [viii]])

The primary goals of World Bank interventions are reductions in poverty and improvements in social inclusion. As such the correct question to put from a policy viewpoint is *"How much should society be willing to pay for a measure which would prevent the loss of one (statistical) life?"*. Of the methods in Box 3, C and D are unsuitable for answering this question. B provides the answer to the subtly different question *"How much would the rest of society lose as a result of the loss of one (statistical) life?"* whilst Method E is interesting but unlikely to give clear and consistent answers. The two methods likely to be most useful are therefore the "Gross Output" and "Willingness to Pay" methods.

The **Willingness To Pay** approach is based on the fundamental premise that decisions made in the public sector concerning the allocation of scarce resources should reflect the preferences and wishes of those citizens who will be affected by the decisions and is therefore especially useful for social welfare maximisation and for use in cost-benefit analysis.

Obtaining Willingness To Pay (WTP) estimates for accident casualty costs can, however, be quite complex and this is particularly true in developing countries. In such situations it may therefore be necessary to use the simpler "Gross Output" or "Human Capital" approach. The Gross Output approach is however best suited as an indicator for the objective of maximising the wealth of a country.

The Gross Output approach can be shown to provide a lower bound to the WTP value (Cropper, undated) [v]. How much of a lower bound depends upon how risk averse people are. If a person is risk averse they will pay a multiple of the Human Capital value to reduce their risk of dying. If they are risk neutral they will pay an amount equivalent to the Gross Output value.

Gross Output or Human Capital Approach to Valuing a Casualty

The Gross Output approach utilises measured data in the country in which the transport investment will take place to obtain estimates of lost output. [—The Human Capital approach usually refers to indirect costs (lost productivity) only. The Cost of Illness approach refers to both direct (i.e., medical) and indirect (lost productivity) costs.

Information is therefore required on:

- Average wage rates, adjustments may have to be made for self employed agricultural workers and "unpaid" workers such as housewives;
- Length of absence from work as a result of the accident (by casualty severity);

[The next 2 bullets belong in a discussion of measuring medical costs.]

- In-patient hospital costs including average length of stay in hospital and average cost of treatment (by casualty type)
- Out-patient costs including the number of out-patient visits and average costs of such a visit, average costs of general practitioners and the ambulance service.

TRL Overseas Road Note 10 (Jacobs, 1995 [iv]) includes worked case study examples of projects in Cyprus and Jordan where the Gross Output method has been utilised.

The human costs of pain, grief and suffering cannot be estimated from an analysis of observed data using the Gross Output method. Table 1 presents the values for pain, grief and suffering detailed in TRL Overseas Road Note 10. These percentages should be used in the absence of more localised data. It should be noted that the values represented by these percentages are essentially arbitrary.

Table 1. Human Costs as a Percentage of Quantifiable Costs

Casualty Type	Value of Human Costs as a Percentage of Quantifiable Costs
Fatal casualty	38%
Serious casualty	100%
Slight casualty	8%

Source: Jacobs (1995) [iv]

Willingness to Pay Approach to Valuing a Casualty

The Willingness to Pay approach should capture the value of the pain and suffering avoided, as well as the value of time lost due to illness (both leisure and work time) and the costs of medical treatment. If some of these costs are not borne by the individual, and are therefore not reflected in their WTP the value of the avoided costs must be added to the WTP to measure the social cost to society. In practice, therefore it is often necessary to add the medical cost of illness and the loss of productivity (estimated as in the Gross Output approach) to the WTP estimates [v].

The weaknesses of the WTP approach, particularly with respect to estimating robust values within a developing country, are that the complexity of the WTP survey means that only adults are surveyed, even though children form a very high percentage of those killed or injured in developing countries. Additionally, it may be difficult to value changes in risk in developing countries because of the difficulty experienced by respondents when placing a monetary value on risk when daily transactions do not necessarily involve money exchange [iv]. Lastly respondents appear to face difficulties in consistently valuing small probabilities and therefore changes between small levels of risk [v].

An alternative approach to undertaking a WTP survey is to translate the results of one country to the country being studied. Box 4 discusses the principal issues associated with such a transfer and presents the methodology that would be used to undertake such a transfer.

ACCIDENT OR INCIDENT RELATED COSTS

As presented in Box 3 the principal accident or incident related costs, as opposed to casualty related costs, are: material damage, police and fire services, insurance administration and legal and court costs. Delays to other vehicles and to freight, where significant, should also be incorporated into the appraisal, though to avoid double counting these should form part of the travel time analysis.

Measured data from the country under study should be obtained to provide local values for accident related costs. TRL Overseas Road Note 10 (Jacobs, 1995 [iv]) presents detailed advice and worked case study examples on the types of information that are required to develop such estimates (with respect to a road accidents). Typical data would include:

- Information from insurance companies, regarding accident types and costs particularly if a significant percentage of vehicles have insurance;
- Information regarding the costs of replacement parts for vehicles and labour rates;
- Information from insurance companies and local authorities regarding damage to fixed property including walls, lamp standards, signs, etc.; and
- Information from the police regarding the administrative time associated with accidents

Box 4. Transfer of Casualty Costs between Countries and Adjustments for Income Growth

In estimating the value of the cost of [a casualty] in a developing country it is often the case that original estimates of WTP to avoid illness and death are unavailable in the country in question. Estimates of forgone earnings and medical costs can usually be obtained, but these provide only a lower bound to the value of health benefits. An alternative is to transfer estimates of WTP to avoid premature death illness from countries where such studies have been conducted to the country in question. Such transfers implicitly assume that preferences are the same in the study country and the transfer country, only incomes differ.

This implies that the WTP estimate from the study country (WTP_S) must be adjusted for income differences between the study and transfer countries. In transferring estimates from country S to country T the formula used is

(1) $WTP_T = WTP_S * [Income_T/Income_S]^{\varepsilon}$

where ε represents the income elasticity of WTP—the percentage change in WTP corresponding to a one percent change in income.

Even when the income ratio in equation (1) is based on Purchasing Power Parity incomes, the equation is likely to assign much lower values to lives saved in developing countries than in industrialised countries. Is this wrong? Recall that the goal of valuation is to estimate what people would pay to reduce their risk of dying, given other, competing uses of their income. It is certainly reasonable that this amount is smaller in low-income than in high-income countries. To ascribe a WTP to health and safety reductions that is higher than people would themselves pay will result in a misallocation of resources.

What value of ε should be used in benefits transfer? It should be acknowledged that there is considerable uncertainty regarding estimates of the income elasticity of WTP, especially for mortality, even within a country. Within-country estimates of the income elasticity of WTP to avoid acute illness generally fall between 0.3 and 0.6. It is, however, unclear that within-country estimates can be applied across countries. It should also be noted that assuming an income elasticity of WTP that is well below 1 often leads to implausibly high estimates of WTP. For example, the ratio of PPP-adjusted per capita income in Mexico in 1999 to the per capita income in the U.S. is 0.28. Using an income elasticity of 0.4 to transfer WTP estimates from the U.S. to Mexico implies that WTP in Mexico is 60% of WTP in the United States. A conservative approach to benefits transfer is to use an income elasticity of 1.0, including smaller and larger values for sensitivity analysis.

The choice of an income elasticity of WTP also has implications for adjustments to WTP to reflect income growth. If an income elasticity of one is assumed, then estimates of WTP should be multiplied by (1+g) where g is the rate of income growth to reflect increases in income. If an income elasticity of ε is assumed, the relevant multiplier is $(1+g)^{\varepsilon}$.

Source: Cropper (Undated) [v]

VARIATION BETWEEN MODES AND WORLD BANK SECTORS

Casualty Related Costs

Casualty related costs are mode independent. That is the cost of a fatality is the same irrespective of whether the person was travelling by bicycle, car or train or working in a port.

This is consistent with approaches elsewhere, such as Nellthorp et al [vi]. The rationale behind the approach is that for a given individual the WTP to avoid risk should be the same regardless of the mode they are travelling or the location in which they are working. It is a consequence of the individual'spreferences rather than an outcome of their current activity. Obviously individuals with similar attitudes to risk may favour one mode or activity over another, thus meaning that the average attitude to risk (and therefore WTP) of users of one mode of transport may differ from users of another mode. For example in a congested urban environment risk averse people may prefer walking to cycling as there is a degree of segregation between pedestrians and the traffic flow whilst cyclists mix with the traffic flow. However, the use of different values for different individuals within the appraisal is generally politically unacceptable as it would suggest that one individual is valued by society more than another individual.

Accident Related Costs

Accident related costs (such as damage to vehicles and administrative costs) will vary between modes. One would for example expect the cost of the damage to a train to exceed the damage to a car. Additionally, in environments where animals (such as donkeys or bullocks) are involved in an accident the costs of the animals should also be included in the accident costs.

World Bank Sectors

The cost of a transport accident casualty should be consistent with costs used for other World Bank projects within the same country. Thus the economic cost of a fatality used within a World Bank sponsored transport project appraisal should be the same as that used within the appraisal of a World Bank sponsored health project.

GROWTH IN RESOURCE VALUE OF ACCIDENT COSTS

Accident costs are forward looking and their resource value will alter with time. It is recommended that accident cost estimates should allow for increases over time are using the same growth assumptions as are applied to the value of time. Typically this will reflect the expected income growth for the country.

ACCIDENT PREDICTION

Accident Prediction Model

The focus of this note has been on the valuation of accidents. In determining total project related accident costs and benefits a model predicting the number of accidents that will occur in the future is also needed.

Accident prediction models require extensive data to support them. There are three key relationships within an accident model that are required:

- An understanding of the basic accident rates and their relationship to current traffic volumes and design standards;
- An understanding of the future accident rates and their relationship to current traffic volumes, particularly if accident remedial measures have been implemented; and
- An understanding of the relationship between accident rates and the growth in traffic and how changes in behaviour over time may influence for design standards.

At the minimum it is expected that a locally calibrated accident prediction model should be developed that relates total annual traffic volumes with the numbers of accidents. Accident rates are often quoted in terms of the number of accidents per million vehicle kilometres travelled within a year. A stand-alone accident prediction model used in World Bank studies is described in Infrastructure Note RD-5 [ix], alternatively the Highway Demand Management System software (HDM 4) is being developed to incorporate accident modelling [x].

The accident rates suggested by the predictive model should be utilised in both the Do Minimum and the Do Something situation unless there is strong evidence to suggest that the improved transport facility will have a different accident rate (accidents per vehicle kilometre travelled) from that currently exhibited.

It should be noted that country specific behaviour including the manner that slow traffic (e.g. pedestrians, cyclists, donkeys and bullocks) interact with motorised traffic means that the transfer of accident rates from one country to another often has a very tenuous basis in reality. Such a transfer of accident rates should be fully explained and defended in the Staff Appraisal Report (SAR).

Conversion of Casualty and Accident Related Costs to the Units of the Accident Model

An accident prediction model will generally predict the number of accidents that will occur. Usually an injury accident will involve more than one casualty. In the Cyprus case study presented in TRL Overseas Road Note 10 [iv] the average number of casualties per accident is 1.83. This when calculating the total economic costs of accidents forecast by the accident prediction model the economic cost per accident should reflect the average number of casualties by severity per accident type (fatal, serious, slight or damage only). An example is contained in Table 2.

Table 2. Example of Calculation of Total Costs for a fatal Accident

	Cost (US$)	Average Number per Accident	Total (US$)
Fatal casualty related costs	150,000	1.1	165,000
Serious casualty related costs	10,000	0.5	5,000
Slight casualty related costs	1,500	1.2	1,800
Fatal accident related costs	5,000	1	5,000
Serious accident related costs	3,000	N/A	0
Slight accident related costs	2,000	N/A	0
Damage only accident related costs	1000	N/A	0
Total Cost for a Fatal Accident			176,800

SUMMARY

The key points that this note promotes are as follows:

- Accidents should be included within the economic appraisal. The exclusion of accident costs would lead to an under investment in safety at a national level and lead to difficulty in assessing the relative merits of projects that improve safety;
- Fatal, serious and slight casualty valuations should theoretically be based on the Willingness To Pay (WTP) approach. However, given the difficulties in deriving WTP values in developing countries the Gross Output approach is recommended as the default approach to casualty valuation. Should WTP values be used, the results of the appraisal should be sensitivity tested to Gross Output values (within the risk analysis);
- Direct accident costs should be based on actual costs incurred or inferred from analysis of markets in the country being studied;
- Casualty valuations are the same for all modes and should also be equivalent to those used in other World Bank sectors (e.g. a World Bank health project). Direct accident costs (e.g. damage to property and vehicles) will vary by mode; and
- The accident prediction model requires good data, the collection of which can be a large undertaking. Error in this predictive model should be incorporated within the risk analysis.
- Default accident rates cannot be imported from a different country without a strong supporting evidence.

The Project Appraisal Document (PAD) should clearly set out the approach adopted to each of the above points.

FURTHER READING

[i] Ross, A. S. Lundebye and R. Barrett (1991) *Road Safety Awareness and Commiment in Developing Countries*. Infrastructure Note RD-6, World Bank, Washington DC, USA. [Available on-line at http://www.worldbank.org/transport/publicat/td-rd6.htm]

[ii] Overseas Road Note 5 (1988) *A guide to Road Project Appraisal, Overseas Development Administration*, Chapter 13 [Available on-line at http://www.transport-links.org/transport_links/]

[iii] Ross, A. (1992) *Road Safety Checks*. Infrastructure Note RD-9, World Bank, Washington DC, USA. [Available on-line at http://www.worldbank.org/transport/publicat/td-rd9.htm]

[iv] Jacobs, G.D. (1995), *Costing Road Accidents in Developing Countries*. TRL Overseas Road Note 10.. Transport Research Laboratory, Crowthorne, UK. [Available on-line at http://www.transport-links.org/transport_links/]

[v] Cropper, M. (Undated). Economic Valuation of the Health Impacts of Air Pollution. (copy supplied digitally and no publication mentioned)

[vi] Nellthorp, J., Mackie, P.J. and Bristow, A.L. (1998) Measurement and Valuation of the Impacts of Transport Initiatives, Deliverable D9, EUNET Project, EI Fourth Framework RTD Programme. ITS, University of Leeds, Leeds, UK.

[vii] Hills, P.J. and M W Jones-Lee, 1981. The Costs of traffic accidents and evaluation of accident prevention in developing countries. PTRC Summer Annual Meeting, University of Warwick, 13-16 July 1981.

[viii] Hills, P J and M W Jones-Lee, 1983. The role of safety in highway investment appraisal for developing countries. Accident Analysis and Prevention, 15, 55-69.

[ix] Lundebye, S. (1991) Road Accident Analysis by Microcomputer. Transport Infrastructure Note RD-5, World Bank, Washington DC, USA {Available on-line at http://www.worldbank.org/transport/publicat/td-rd5.htm]

[x] PIARC (2002) *The Highway Development and Management Model (HDM4), User Manual (Volume 2 - Application Guide)*. [Documentation and Software available on line http://hdm4.piarc.org/]

[x] World Health Organization (2004) The World Report on Road Traffic Injury Prevention. http://www.who.int/world-health-day/2004/infomaterials/world_report/en/

[11] World Bank (2004) Implementing the Recommendations of The World Report on Traffic Injury Prevention, Transport Note No. TRN-1, http://siteresources.worldbank.org/INTTRANSPORT/214578-1099488338138/20281136/tn-1-rd%20safety_b&w_eng.pdf