EUROPEAN CONFERENCE OF MINISTERS OF TRANSPORT

ECONOMIC RESEARCH CENTRE

ECONOMIC EVALUATION OF ROAD TRAFFIC SAFETY MEASURES

ROUND TABLE

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ECONOMIC RESEARCH CENTRE

REPORT OF THE
HUNDRED AND SEVENTEENTH ROUND TABLE
ON TRANSPORT ECONOMICS

held in Paris on 26th-27th October 2000
on the following topic:

ECONOMIC EVALUATION OF ROAD TRAFFIC SAFETY MEASURES

EUROPEAN CONFERENCE OF MINISTERS OF TRANSPORT

EUROPEAN CONFERENCE OF MINISTERS OF TRANSPORT (ECMT)

The European Conference of Ministers of Transport (ECMT) is an inter-governmental organisation established by a Protocol signed in Brussels on 17 October 1953. It is a forum in which Ministers responsible for transport, and more specifically the inland transport sector, can co-operate on policy. Within this forum, Ministers can openly discuss current problems and agree upon joint approaches aimed at improving the utilisation and at ensuring the rational development of European transport systems of international importance.

At present, the ECMT's role primarily consists of:

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– helping also to build a bridge between the European Union and the rest of the continent at a political level.

The Council of the Conference comprises the Ministers of Transport of 41 full Member countries: Albania, Austria, Azerbaijan, Belarus, Belgium, Bosnia-Herzegovina, Bulgaria, Croatia, the Czech Republic, Denmark, Estonia, Federal Republic of Yugoslavia, Finland, France, FYR Macedonia, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Moldova, Netherlands, Norway, Poland, Portugal, Romania, the Russian Federation, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine and the United Kingdom. There are six Associate member countries (Australia, Canada, Japan, New Zealand, Republic of Korea and the United States) and two Observer countries (Armenia and Morocco).

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The ECMT's Documentation Service has extensive information available concerning the transport sector. This information is accessible on the ECMT Internet site.

For administrative purposes the ECMT's Secretariat is attached to the Organisation for Economic Co-operation and Development (OECD).

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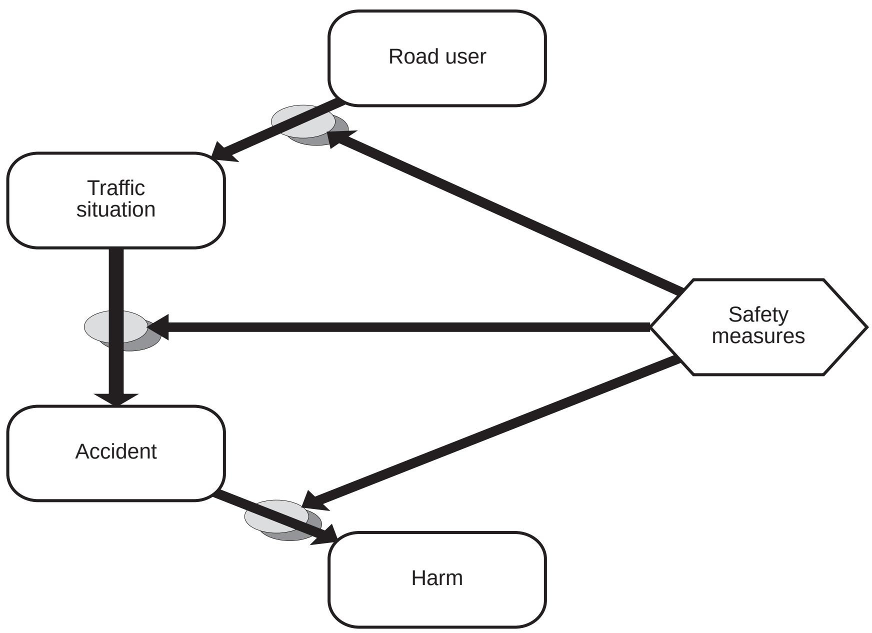
1. INTRODUCTION

The number of road traffic casualties is still very high, even though the number of fatalities in Germany and many other European countries is falling. In road traffic accidents involving personal injury, economic resources are destroyed and the productivity of the economy is correspondingly impaired. Costs resulting from traffic accidents represent the largest single part of the overall cost of traffic to the economy. Knowledge about the harm this does to the economy is essential if measures to reduce road traffic accidents are to be identified and introduced. Once an economic assessment of road safety measures has been made, work on improving safety in accordance with economic criteria can be organised as efficiently as possible. To this end, it is necessary to select measures that are likely to be successful, to quantify their effects, and lastly to evaluate them. The object is to employ available resources in such a way as to achieve the greatest possible benefit for society. Even with a favourable trend in the incidence of road accidents there is still a need for measures to increase road safety. Such measures can be introduced at different stages of an accident scenario (Figure 1).

Figure 1. **Points at which road safety measures may be introduced**



Source: H. Baum and K.-J. Höhnscheid, 2000.

Planning road safety measures is a complex exercise, since a great many such measures – technical and non-technical – are available:

- The potential of technical measures to improve road safety has yet to be exhausted. In recent years, technical innovations have led to a steady increase in road safety (e.g. airbag, strengthened passenger compartment, plastic fuel tank). But active and passive safety can be improved still further in the future through technical means (e.g. telematics applications).

- Active security can be increased by improvements in human behaviour. Education and training programmes for those using the roads can help reduce individual traffic problems.

Even in the context of the economic framework conditions there are possibilities for increasing road safety. By way of example, changes in insurance tariffs can provide incentives for prudent behaviour on the roads.

2. EVALUATION METHODS - A CRITICAL REVIEW

Controversy exists over the choice of the correct way of evaluating road safety measures. The following distinguishes between cost-benefit analysis and alternative approaches.

2.1. State of the art

Cost-benefit analysis is regarded as a fairly sophisticated, objective way of making assessments. Economic cost-benefit analysis goes back to the welfare theory. The increase in macroeconomic output potential resulting from the measures adopted serves as an evaluation criterion. Against this must be set the costs of the measures contemplated. The benefits are defined as the saving of productive resources ("cost savings approach"). The result of the evaluation is obtained by comparing costs with benefits (difference or quotient rule). A measure is macro-economically profitable, if the difference between benefits and costs is ≥ 0 or the ratio of benefits to costs is ≥ 1.

Economic evaluation of road safety measures using cost-benefit analysis is based on the costs incurred as a result of road accidents. Avoiding such costs represents the economic benefit of road safety measures. If the scale of these benefits is to be ascertained, the costs of road accidents must be worked out. The costs of safety measures cover implementation and its follow-up (maintenance). The ratio of benefits to costs represents the economic advantage of the safety measures:

$$\text{Cost-benefit ratio} = \frac{\text{benefit}}{\text{costs}} = \frac{\text{reduction of accident costs}}{\text{costs of measures}}$$

According to a more widely held interpretation, the benefits of the measure encompass other reductions in costs, such as those resulting from emissions, noise, or loss of time. It should be borne in mind that road safety measures can also produce higher costs, which are offset by the overall benefits (e.g. loss of time due to speed limits).

In addition to cost-benefit analysis, other methods are used to evaluate road safety:

- In **cost-effectiveness analysis** the cost of a measure is weighed against its effects. The effects of the measure are not expressed in monetary terms.

- **Multi-criteria processes** are “open” methods of evaluation. They make the lowest demands in terms of data. The evaluation is based on (policy-orientated) objective functions, which have to be established before the evaluation. It measures the extent to which objectives are met, and this is evaluated using a points system.

With processes such as these, which do not all involve monetary values, collating results presents a serious problem. However, because they can be used more generally and their scope of application is broader, they are often preferred to cost-benefit analysis.

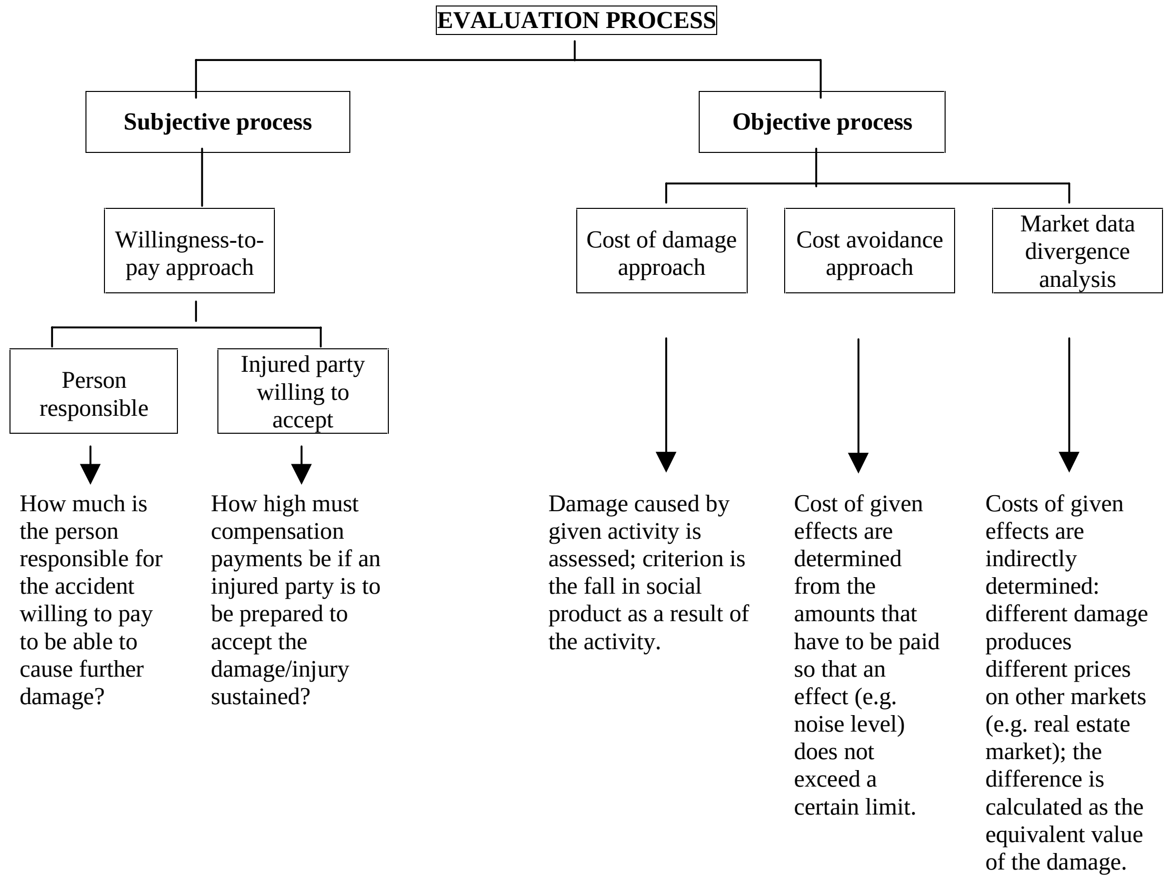
2.2. A true evaluation - mission impossible?

In the evaluation of road traffic accidents a dilemma exists, in that different evaluation procedures produce different opinions and estimates. Moreover, with past research concentrating on accident costs a generally accepted view has not emerged. Estimates of the costs of accidents display considerable diversity. Different results are obtained depending on the method chosen for quantifying them. The question arises, which method of evaluation should be used. To determine the economic cost of road traffic accidents it is of prime importance to establish an appropriate value framework. To this end a variety of concepts can be used (Figure 2).

The “cost of damage” method determines costs through direct assessment of the damage caused by accidents. By determining the actual damage caused, this approach attempts to make a thoroughly objective evaluation of the costs, based on economic factors. The “cost of damage” method has been used hitherto to calculate the cost of accidents, in Germany and the USA amongst other countries. Several objections have been made to this approach (INFRAS, IWW, 1995):

- It is argued that the “cost of damage” method, which is based on lost output, would send out the wrong signal with respect to welfare. Although a greater number of accidents leads to an increase in restoration costs (e.g. repair of damage to property, net product from hospital treatment, etc.), the social product will turn out to be higher, the greater the number of accidents. Against this argument it can be objected that accidents cause a reduction in the productive factors of labour and real capital, which, according to the production function used, leads to a fall in social product. Losses of resources through road traffic accidents are accordingly reflected in a reduction and not an increase in social product. The argument that it causes an increase in social product could therefore apply at most to the restoration services, which are included in the statistical records of the national economy’s net product. However, it must also be noted that the factors of production used in restoration services would have been used in other applications if no accident had occurred. The increase in the social product does not stem specifically from restoration work following accidents but from the productive potential of available resources.

Figure 2. **Methods for calculating the cost of accidents**



Source: H. Baum et K.-J. Höhnscheid, 2000.

- The "cost of damage" method does not cover all damage, but only such as represents a reduction in economic net product. This point seems reasonable, but then that is the whole purpose of the evaluation procedure. It is supposed to determine costs incurred through accidents, and these costs are derived from an economic assessment of what is lost as a result of accidents. Any damage that is not relevant to the market can also be taken into account in the assessment.

- The "cost of damage" method can lead to ethical problems in that injury may be assessed differently, depending on the individual injured and his/her contribution to production. For example, the value of a human life would be assessed differently depending on whether the victim of the accident was a full-time or part-time worker. It is possible to avoid the kind of value distinction that depends on working arrangements by establishing the individual's potential productive value, i.e. what could be achieved with normal use of the factors of production.

Sometimes accidents costs need to be reassessed on the basis of "willingness to pay", so that a more accurate indication of the losses to the national economy resulting from road accidents may be obtained. The "willingness to pay" method is also used internationally for evaluating accidents costs, in Great Britain for example.

- The “willingness to pay” approach determines the extra financial burden a person is prepared to accept to refrain from harmful practice or the amount a person suffering the effects of such practice is prepared to pay to prevent it.

- The “willingness to accept” approach establishes the payments that must be made to induce a person responsible for harmful practice to stop or an injured party to tolerate such practice.

The following objections have been made to the “willingness to pay” approach (Baum, Esser, Höhnscheid, 1997):

- Willingness to pay analyses are conducted using surveys ("stated preference approach"). The results depend on the way the survey is designed and conducted. The extent to which the methods of evaluation are comparable in different cases is therefore questionable.

- In establishing their “willingness to pay”, false estimates may be made by the respondents. Expressing a willingness to pay is one thing, actually having to pay is another. Even on the question of human health it is necessary to be aware of the danger that hypothetical and actual willingness to pay are at variance.

- The “willingness to pay” concept sets out to determine the cost of accidents in terms of the market price the road user would be prepared to pay to prevent accidents. In the “willingness to pay” analyses, however, only the evaluation of the demander is considered and there is no assessment of the price at which the supplier would provide certain services. If, however, the “willingness to pay” expressed in the survey is used as a basis for calculating costs, the costs in structural terms are overestimated. The “willingness to pay” approach goes further than the market price level approach as it includes an assessment of consumers’ incomes.

In this respect, even the “willingness to pay” approach to evaluating the cost of accidents is fraught with problems and disadvantages. The cost of accidents should be calculated by means of a completely objective process, geared to actual economic loss. The “cost of damage” approach best fulfils the claim to providing the most objective representation of costs. Investigations involving more subjective surveying methods provide additional information, which increases what we already know of the complexity of calculating the costs of accidents. However, their disadvantages make them less suitable for planning purposes.

2.3. Are accident costs external or internal?

The economic costs of traffic can subdivided into internal and external costs. This also applies to costs resulting from accidents, though in some calculations of traffic costs, all costs due to accidents are classified as external costs. The classification of the different costs due to accidents as internal and external is not uniform, however. Very often the cost of loss of resources is classified as an external cost and the cost of restoration as an internal cost. In order to arrive at clear definitions, it is necessary to establish whether particular heads are to be included under external or internal costs. To discuss the externality of costs arising from accidents, those involved in the accident should be divided into those who cause and those who are victims of accidents. According to the definition of externality, costs arising from accidents are external when one person causes harm to another person involved in an accident, or to a third party, without providing appropriate compensation. Compensation for the harm suffered may be provided by the person who caused the accident or by an insurance company. The payment compensates the victim of the accident and requires the person responsible to pay the corresponding costs. They replace the price mechanism that is lacking in the case of externalities and are therefore an effective means of reallocation.

- The costs of restoration where the victim was not the cause of the accident are borne through a "knock-for-knock" process by the person who caused the accident himself or by his vehicle- or third-party insurance. They are therefore internalised by the third-party insurance system and the law on liability. An exception is made in the case of accidents incurring costs in excess of the limit of liability laid down in the insurance policy.

- The cost of loss of resources to victims of accidents who were not responsible for them, are also borne by the third-party insurance of the person responsible or by that person himself. It is worked out on the basis of the average income of the victim in the months preceding the accident.

- The costs of restoration and loss of resources to the person responsible for the accident, which the latter bears himself, e.g. through loss of income, are internal costs.

- The costs of restoration to the person responsible for the accident, which are met by various types of insurance (e.g. health insurance), are borne by a group of insured parties, which does not fully correspond to the group of road users or the group covered by third party insurance. The costs of restoration are external in that extra costs in the form of higher insurance premiums are incurred by those who do not use road transport.

- The human costs to victims who are not responsible for accidents and to their families are internalised by the payment of damages.

- Costs incurred outside the market (losses in the black economy and housework) to victims who are not responsible for accidents are not internalised through insurance and are therefore external.

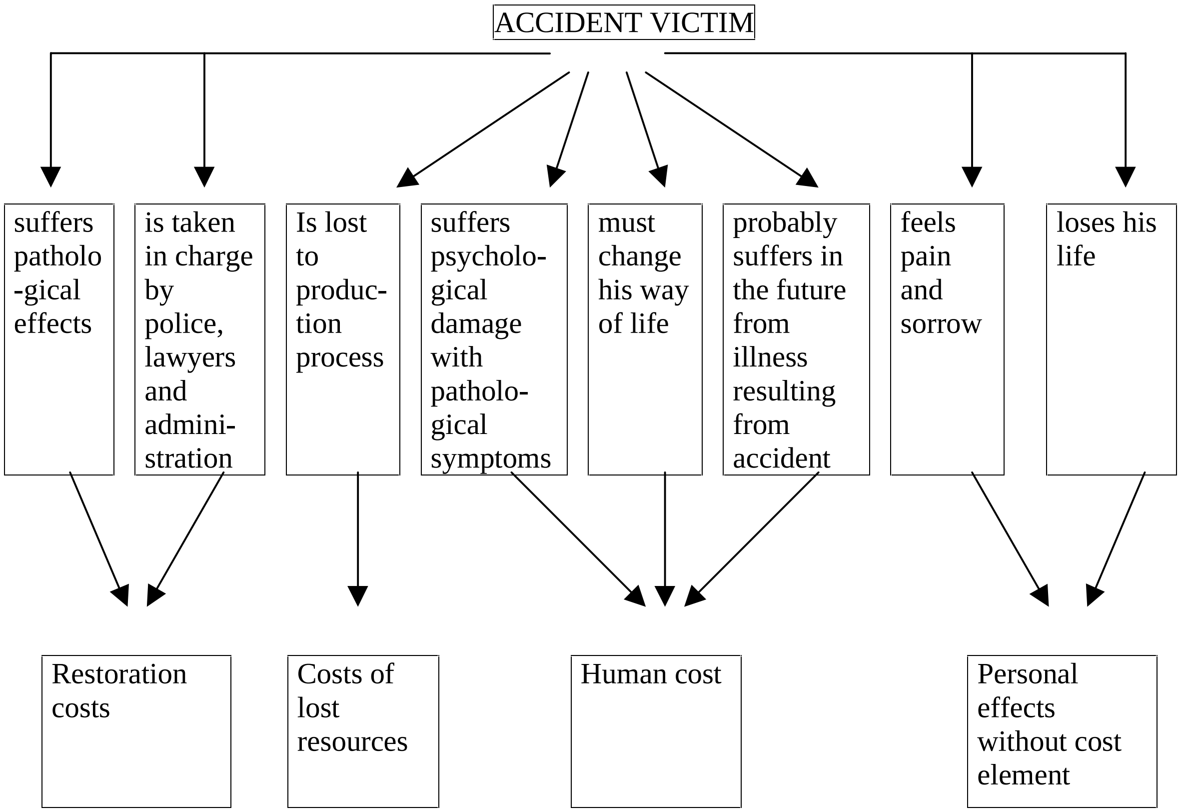
These examples show that accident costs cannot generally be classified as internal or external, but that they need to be viewed with discernment. The splitting up of such costs into internal and external components from one country to another depends on the way their national insurance systems and laws on liability operate. However, in an evaluation of road safety measures, the total economic cost of road accidents involving casualties would normally be ascertained. The division into internal and external costs is therefore not usually relevant.

2.4 Additional heads: human and extra-market costs

Some consequences of accidents are not accounted for, or only partly, by the costs of restoration and lost resources. These include, for example, the pain and suffering of the victim, psychological considerations, a diminished capacity to endure stress, and a fall in the quality of life. These consequences are described as human. These human costs are gaining increasing importance in the evaluation of accident costs. They mainly cover damages paid for physical and psychological harm to the victim and his family, lower educational and professional opportunities, and loss of independence, amongst other things. An assessment is required of whether the human consequences can actually be quantified in monetary terms or whether they represent a payment that should not be taken into account for accounting purposes. The calculation of accident costs in some countries (e.g. Great Britain) involves an assessment of the human costs, which are added to the overall costs arising from an accident.

The human consequences of accidents may amount to the loss of productive human resources or a decline in their performance. It is therefore justified to regard human costs as a component part of the overall costs arising from accidents. Human consequences that do not lead to a loss of resources and entail no costs, are not to be taken into account in the calculation of costs arising from accidents. Figure 3 shows the distinction.

Figure 3. **Distinguishing consequences of accidents and assigning costs**

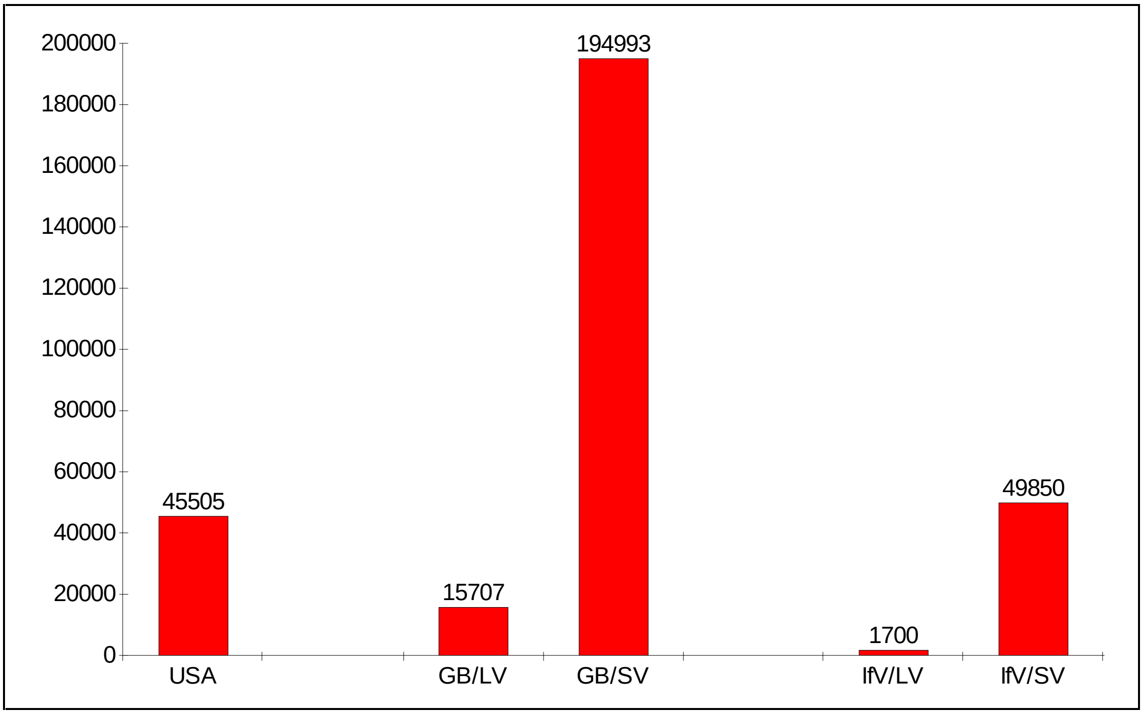


Source: H. Baum et K.-J. Höhnscheid, 2000.

An attempt is sometimes made in the literature to replace the “resources” approach with the "value of life” (*pretium vivendi*) approach (INFRAS, IWW, 1995). A comprehensive evaluation of human life (the “human” as well as the economic aspects) is thereby made. Such an attempt goes beyond establishing the contribution to economic output of the accident victim. It may be an appropriate way of highlighting the personal consequences of accidents, but it does not reveal the economic loss, which is the basis of the cost concept here. The “value of human life” concept should not therefore be pursued as a means of establishing the human cost.

An international comparison (Fig. 4) reveals very diverse findings with respect to human costs. The main causes of this diversity are the different assessment methods (“willingness to pay” approach, “cost of damage” approach) used in different investigations. The results obtained from the “costs” approach used in Germany, based on the cost of damage approach, are the lowest (Baum, Höhnscheid, 1999). The American and British calculations use the “willingness to pay” method. The value for the USA was calculated as the average of the costs for individual injuries of different severity, weighted by the frequency of accidents

Figure 4. **International comparison of human costs (DM)**



Notes: LV = Minor injury, SV = serious injury, IfV = costs for Germany.
Sources: NHTSA, 1994; UK Department of Transport, 1996; H. Baum et K.-J. Höhnscheid’s own calculations.

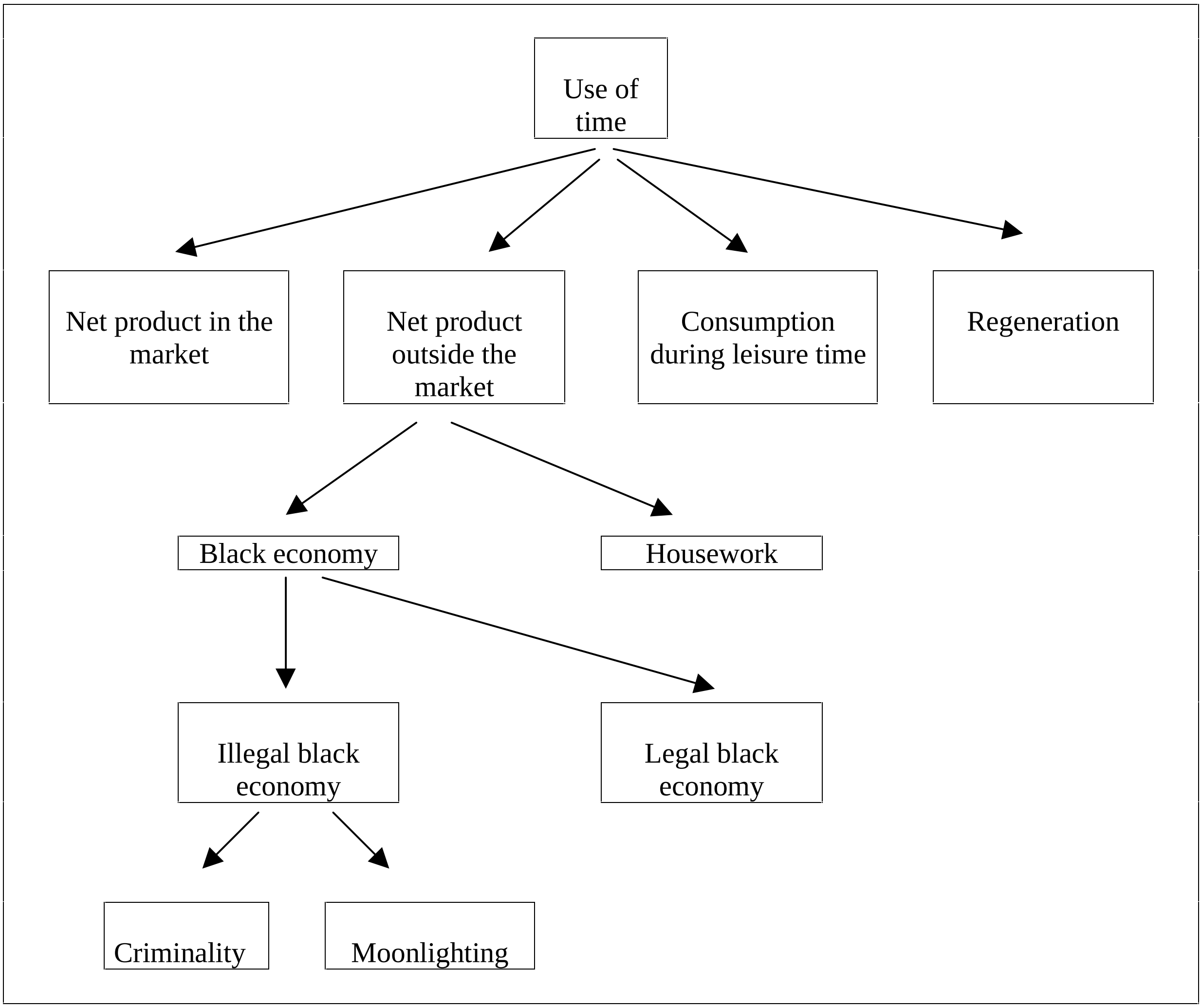
Most calculations of accident costs include only the loss of net product in the markets resulting from accidents. In a national economy, over and above the net product from the market, which appears in the social product, other goods and services are produced outside the market, which do not contribute to the social product. Such extra-market costs must also be factored into the costs of road accidents. Extra-market economic activity is of increasing importance; the black economy alone accounts for the equivalent of 10 to 27% of the social product. In determining costs arising from accidents, the corresponding reduction in this part of the net product should also be taken into account. The extra-market activities of private economic players extend to the following areas:

– Housework is carried out in the individual’s own household and involves such activities as bringing up children or cleaning.

– The black economy covers all services (except housework) that ought to be, but are not included in the calculation of the official social product. The black economy may be legal or illegal.

Time is also spent in leisure activities, i.e. use of time that yields no net product (e.g. sporting activity). In determining costs arising from accidents, the legal black economy and leisure activities should not be taken into consideration. This is because of lack of information and practical considerations.

Figure 5. **Possible net product from private individuals based on breakdown of their available time**



Source: H. Baum et K.-J. Höhnscheid, 2000.

On behalf of the *Bundesanstalt für Straßenwesen*, the Institute for Transport Economics at the University of Cologne is supplementing the evaluation of accident costs in Germany by factoring in human costs and extra-market net product losses (Baum, Höhnscheid, 1999). The results of the calculation are presented in Chapter 3.

2.5. Macroeconomic basis for the evaluation of accident costs

The economic costs of lost resources are based on the loss of net product by the accident victim. The overall national calculation provides different parameters from which the net product can be determined. As regards the evaluation of road traffic victims this gives rise to three questions:

1. What is the appropriate measurement of the overall contribution to output? Above all it must be decided whether gross or net output is to provide a basis for the evaluation of accident victims.

2. Should the assessment be made on the basis of actual or potential output? Hitherto road accidents costs have been calculated on the basis of actual output values. Since the end of the sixties productive potential has been used in macroeconomic analysis as an indicator of macroeconomic capacity. It is necessary to determine whether a corresponding use of productive potential should also be used in evaluating road accidents.

3. To what extent should macroeconomic output performance be attributed to the factor labour or the factor capital? Until now overall productive performance has been ascribed to the factor labour and road accidents have been evaluated accordingly. If a production function is used, it is possible to take account of the different contributions to output of labour and capital.

2.5.1 Overall economic account indicators

The overall economic account determines several characteristic variables, which can be used as indicators of overall economic output:

– Gross net product corresponds to the sum of the output values of all economic sectors (= turnovers) minus their outlay;

– Gross domestic product at the market price is obtained from the gross net product, in that non-deductible turnover tax and import duties are added;

– Net domestic product at the market price is obtained by subtracting depreciation costs from gross domestic product;

– Net domestic product at factor cost (= national income) is obtained by taking net domestic product at market prices, subtracting indirect taxes and adding subsidies.

The productive potential itself is not an element in the overall economic account, but is determined by special calculations. The productive potential shows the production rate that can be achieved in a national economy with normal utilisation of the factors labour and capital. The fact that it only indicates potential distinguishes it from actual output performance variables. In the evaluation of lost output due to road accidents it is necessary to decide which net product indicator should be used as a basis, since it will have a significant effect on the level of costs arising from loss of resources.

2.5.2 Actual output or output potential?

Since the end of the sixties, potential output (= productive potential) rather than actual output has been used in some countries to measure the economic efficiency of an economy in quantitative terms. Thus, the European Commission and the OECD, for example, use productive potential to indicate economic capacity.

The argument for productive potential is based on the view that actual output depends on a great many specific circumstances, e.g. the influence of monetary or financial policy. In order to identify the actual productive potential of an economy, it is necessary to consider its supply side. This depends on the availability of the factors labour and capital. The amount and the productivity of the factors determine what an economy can produce in terms of goods and services in a given period with normal utilisation of resources, unaffected by economic policy measures. If actual output were a basic factor in the evaluation of road accidents, economic losses would vary depending on whether the economic climate was good or bad.

2.5.3 Evaluation of loss of labour and capital

The factor labour (i.e. the performance of the workforce) is often held fully responsible for down times in terms of production. In fact, the social product is determined both by labour and by capital. It is therefore necessary to split the economic net product to reflect the different contributions of the factor labour and the factor capital. The consequence of this corrective measure would be a reduction of costs arising from loss of resources. Leaving the factor capital out of consideration would to some extent prove that the accumulation of capital depends on the factor labour. Recent developments in growth theory, however, have emphasised the autonomy of the factor capital, so that a division of the output yield corresponding to both factors seems reasonable.

3. NEW EVIDENCE IN ACCIDENT COSTS

There is new research work, which is concerned with updating and developing the calculation of accident costs and which also produces quantitative results. The paragraphs below show the elements that make up an accident cost analysis and give the results of the current analysis for Germany.

3.1. Elements of accident cost analysis

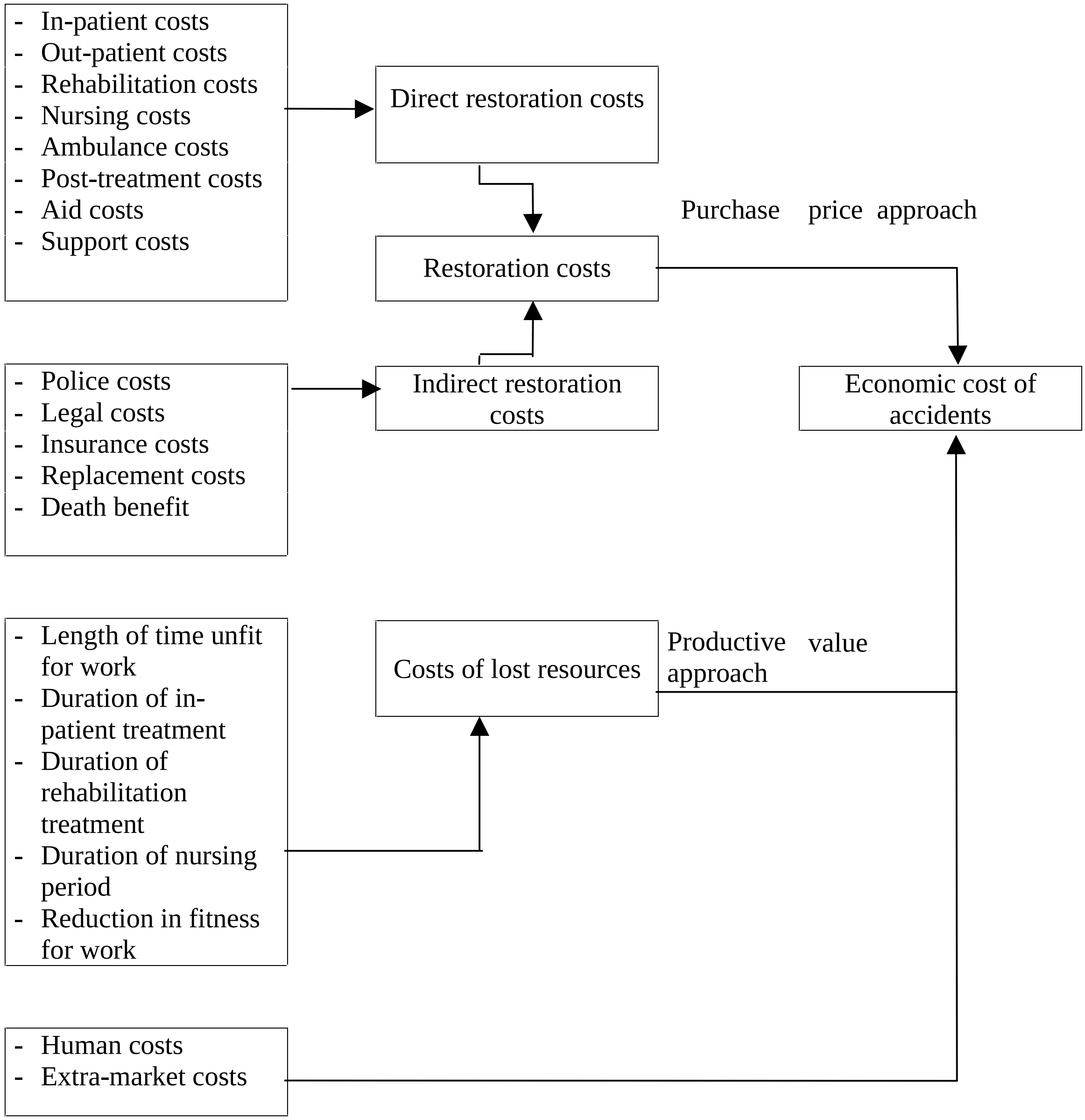
In economic analyses of road safety measures, it is important to assess costs arising from accidents – like investment costs. The calculation of the economic costs of road accidents take account of all the consequences of an accident that lead to a loss of net product. The elements of accident cost analysis are presented in Figure 6. A comparable breakdown can be made for damage to property.

1. **Restoration costs** are incurred where a situation equivalent to the one before the accident is brought about through recourse to medical, handicraft, legal, administrative and other measures.

    - Direct restoration costs arise from the medical and professional rehabilitation of the accident victim. Medical rehabilitation comprises in-patient or out-patient treatment of the victim, provision of transport and after-care treatment. Professional rehabilitation consists of measures that enable the accident victim to resume his professional activity.

    - Indirect restoration costs arise from the attempt to settle legal matters (police costs, legal costs, insurance claims).

Figure 6. **Elements of accident cost analysis**



Source: H. Baum et K.-J. Höhnscheid, 2000.

2. The **costs arising from loss of resources** cover the reduction in economic net product resulting from the fact that persons injured or killed in an accident are no longer able to take part in the production process. The consequence of the death or injury of a person is thus to reduce social product in the future. Moreover, vehicles are damaged or destroyed in road accidents. These vehicles represent real capital. As a result of the damage caused by road accidents this real capital is available to the production process for a reduced period or is permanently disabled.

   Furthermore, road accidents lead to losses other than the loss of net product in the markets. Loss of net product from housework and work in the black economy are not reflected in the official social product. Any calculation of the economic cost of accidents must ensure that these losses of net product are also included.

3. Lastly, **accidents have human consequences** that lead to a loss of resources:

   - An accident is an experience that can have harmful psychological effects on those involved and their families, for which no pathological symptoms can be identified. This may so limit their capacity to endure stress as to make them unfit for work, and this entails a loss in net product.

   - Many accident victims have to change their way of life as a result of their experience. This leads to a reduction in productivity.

   - Moreover, when assessing human costs it is necessary to consider the possibility of further unpredictable consequences. These include costs associated with the higher probability of future illness.

Where there is no loss of resources, the human consequences of accidents should not be taken into account in calculating the costs arising from accidents. These mental problems will only be factored in when costs are incurred. The emotional state caused by the experience of an accident (e.g. bereavement) cannot be evaluated in monetary terms.

The human costs are the basis for actual decisions to award damages. The most suitable approach to determining human costs is therefore based on the payment of damages to the accident victim.

3.2. Results of accident cost analysis – The case of Germany

By way of example, the Tables below show the actual results of accident cost analysis for Germany, established annually by the *Bundesanstalt für Straßenwesen*. By linking costs arising from accidents, grouped according to degree of severity, with the frequency with which they occur in the survey year, the cost to the economy of personal injuries sustained in road accidents can be worked out. The Bundesanstalt für Straßenwesen’s computation model is used to determine accident costs, which are broken down according to the severity of the injury (fatal, severe, slight). Persons killed in road accidents in 1998 accounted for the highest cost: more than 2.3 million DM, of which the costs arising from loss of resources – more than 1.5 million DM – represented the highest proportion. A basic factor in calculating the costs arising from damage to property in road accidents is the police estimate of the repair costs. The following table shows the costs arising from personal injury in 1998, according to degree of severity, and from damage to property according to the type of accident.

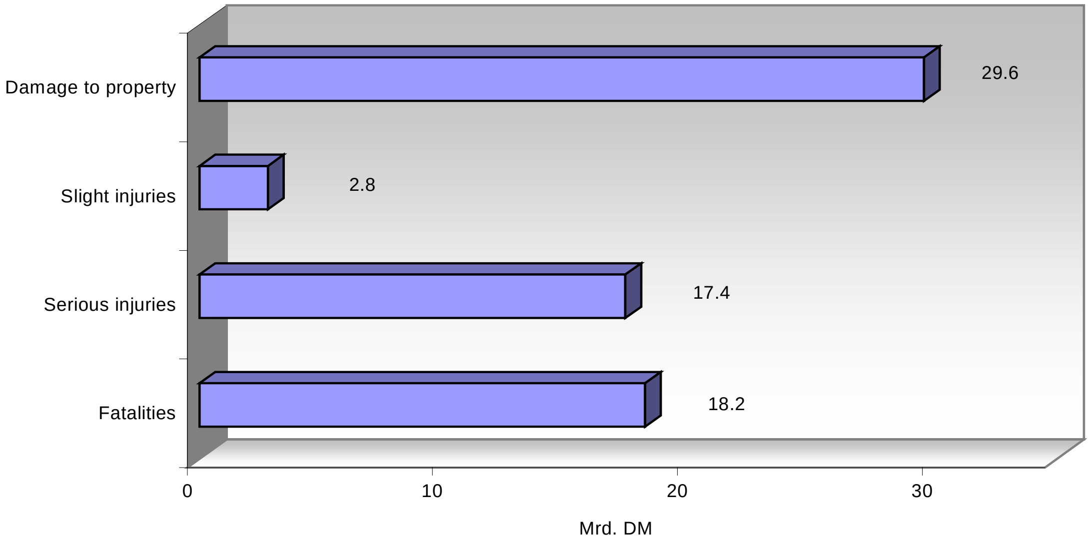
Table 1. **Costs arising from personal injury and damage to property sustained in road accidents in 1998**

	Cost (DM)
Personal injury:	
Fatal	2 333 989
Severe	159 856
Slight	7 139
Damage to property:	
Accidents involving fatalities	49 575
Accidents involving severe injuries	24 343
Accidents involving slight injuries	17 970
Serious accidents involving damage to property only	24 481
Other accidents involving damage to property	10 981
Various accidents involving drunk drivers	8 546

Source: Baum, Höhnscheid, 1999; Baum, Höhnscheid, Höhnscheid, Schott, 1999.

The total cost of road accidents to the German economy in 1998 amounted to 68 billion DM.

Figure 7. **Cost of road accidents to the German economy in 1998 (in billions of DM)**



Source: Baum, Höhnscheid, 1999; Baum, Höhnscheid, Höhnscheid, Schott, 1999.

Personal injuries accounted for 56 per cent of the total costs in 1998 and damage to property for 44 %. Total costs arising from personal injuries were more than 38 billion DM, the highest proportion of which were the costs arising from loss of resources, amounting to 26.84 billion DM (Table 2).

Table 2. **Costs arising from personal injury in 1998**

	Cost (DM)
Restoration costs	4.67
Costs arising from lack of resources	26.84
of which:	
Costs due to loss of resources in narrow sense	17.89
Black economy	2.09
Housework	6.86
Human costs	6.85
Total costs arising from personal injury	***38.37***

Source: Baum, Höhnscheid, 1999; Baum, Höhnscheid, Höhnscheid, Schott, 1999.

As to the different categories, fatal injuries cost the economy over 18 billion DM and account for the largest proportion of the costs arising from personal injuries. The overall costs arising from damage to property are determined by adding the restoration costs to the costs resulting from lost resources, as well as the loss of net product from extra-market activity. In 1998 they amounted to over 29.5 billion DM. Other accidents causing damage to property accounted for 19.3 billion DM, the highest amount for any individual category. The results of the analysis of costs arising from road accidents in Germany in 1998 are set forth in Table 3.

Table 3. **Costs arising from road accidents in 1998 (in Billion DM)**

Costs arising from personal injuries	
Fatal	18.19
Severe	17.41
Slight	2.77
Costs arising from damage to property	
Accidents involving fatalities	0.342
Accidents involving severe injuries	2.158
Accidents involving slight injuries	4.920
Serious accidents involving damage to property only	2.609
Other accidents involving damage to property	19.297
Various accidents involving drunk drivers	0.227

Source: Baum, Höhnscheid, 1999; Baum, Höhnscheid, Höhnscheid, Schott, 1999.

4. EMPIRICAL EVALUATIONS OF ROAD SAFETY MEASURES

The results of selected investigations into the effect on accidents of traffic measures are presented below. They cover a number of individual measures.

4.1. Identifying the causes of accidents

Road safety is affected by three factors: man, vehicle and infrastructure. The following table shows the most common causes of accidents involving personal injury. It emerges that human error is a far more frequent cause than technical failure or the condition of the infrastructure.

Table 4. **Causes of accidents involving personal injury in Germany (1997)**

	Percentage
Driver error	85.4
of which:	
Driving too fast	*16.0*
Not giving way, not observing highway code	*11.8*
Turning, driving on/off, turning around	*11.8*
Driving too close	*9.3*
Driving under the influence of alcohol	*5.4*
Using the wrong lane	*6.1*
Overtaking, passing	*5.1*
Disregarding pedestrians	*3.7*
Other causes	*16.3*
Vehicle fault	0.9
Pedestrian's fault	5.1
Road conditions	6.4
Other	2.1
Total	**100.0**

Source: Bundesministerium für Verkehr (Ed.), *Verkehr in Zahlen 1998*, Bonn, 1998, p. 173 ff.

4.2. Case studies

4.2.1 Active and passive safety measures

The TÜV Rheinland has produced estimates of the potential of safety measures to reduce traffic accidents (Rompe, 1998). They are based on study of the international literature, expert opinions and test results. The estimates of the potential for reducing accidents relate to the European Union. This potential is not expressed in monetary terms.

Other possible ways of reducing accidents, which have yet to be quantified, include:

- Improving facilities in vehicles (e.g. driver-support systems, optimised headrests).
- Fitting under-run protective devices at the sides and rear of lorries.
- Developing vehicle surveillance.
- Improving safety of buses and tanker lorries.
- Improving procedures in the event of an accident (e.g. automatic distress call).

Table 5. **Potential for reduction of traffic accidents**

	Measures	**Potential for reducing accidents**
Active	Reduction of average speed on all roads (by 5 km/h)	25 %
	Checking alcohol level in blood	8 – 16 %
	Day-time running lights for private car	2 – 7 %
	ABS systems for all private cars	3 – 5 %
	Day-time running lights for motorcycles	1 %
	Reflective edges on lorries	1 %
Passive	Crash evaluation programme	15 – 25 %
	Greater use of seat belts	15 %
	Driver and passenger airbag	5 – 10 %
	Side airbag	3 - 5 %
	Front underrun protective device for lorries	3 %
	100% use of protective helmets	3 %
	Better protection for pedestrians	2 – 7 %
	Greater use of restraint systems for children	1 %

Source : Rompe, 1998.

4.2.2 Regulatory measures for transferring and reducing traffic

Pischinger, Sammer, Schneider *et al.* have checked the effects on the environment of various measures. Their effect on the incidence of accidents was also evaluated. The potential for reduction applies to those injured and those killed. The investigation conducted in 1997 concerned Austria (Pischinger, *et al.*, 1997).

Table 6. **Potential for reducing accidents by 2005**

Measures	Cost-benefit difference* (in million Sch)	Injured	Killed
Speed surveillance	663	- 5.2 %	- 5.0 %
Speed limit	28 211	- 21.3 %	- 20.8 %
Parking space management	- 906	- 0.1 %	- 0.1 %
Increasing fuel prices	149 183	- 16 %	- 16 %
Eco-bonus	144 887	- 16 %	- 15 %
Tax on road use	118 789	- 20 %	- 19 %
Vehicle access restriction, Pedestrian zones	- 4 363	+ 0.1 %	+ 0.1 %
Use of cycles ("cycle-friendly city")	42 111	+ 11.3 %	0 %
Development of multi-modal transport	- 22 071	- 0.1 %	- 0.1 %
Development of rail passenger transport	- 31 900	- 1.8 %	- 1.6 %
Development of public transport	- 17 122	- 2.7 %	- 1.7 %
Logistics	44 953	- 0.3 %	- 0.5 %
Road guidance systems	- 15 307	- 1.3 %	- 1.2 %
Campaigns to increase awareness	11 208	- 5.0 %	- 5.0 %

* without CO_2 assessment
Source : Pischinger *et al.*, 1997.

4.2.3 Accident prevention measures

For Switzerland, the Beratungsstelle für Unfallverhütung (bfu) has made national assessments of 22 different safety measures (Eckhardt, Seitz, 1998). Of the 22 measures investigated, 12 have relevance for traffic:

- Two-phase model: three-year probationary period with further training for new drivers, additional instruction for those who fail probationary period;
- Random breath tests for alcohol level: police may carry out breath tests where driver shows no sign of drunkenness;
- Accident data recorder: fitted to all newly registered private cars and motor cycles;
- Speed warning device: fitted to all newly registered private cars.
- Distance warning device: fitted to all newly registered private cars;
- Development of thoroughfares: reducing speed and increasing attentiveness through arrangements to ease traffic on main city centre (roundabouts, traffic islands with shrubbery, centre islands, etc.);
- Compulsory child restraint systems: tested restraint systems ensuring the safety of children up to 7 years old;
- Higher level of control: level of police control increased by 50 %;
- ADMAS point system: penalty points for certain traffic offences and temporary confiscation of licence when a minimum number of points has been exceeded;
- Cycle and moped courses: compulsory courses for young persons;

- Increase in the proportion of public transport: requirement that 10% of individual motorised transport is transferred to public transport;
- Compulsory wearing of cycling helmets: children obliged to wear cycling helmets.

Table 7 shows cost-benefit ratios and cost-benefit differences for the various traffic safety measures.

Table. 7. **Cost-benefit results of traffic safety measures**

No.	Measure	Benefits (in mill. CHF/year)	Costs (in mill. CHF/year)	Cost-benefit ratio	Cost-benefit difference (in mill. CHF/year)
1.	Two-phase model	109	66	1.6	43
2a.	Random breathalyser tests for alcohol level without blood-alcohol test	227	12	19.0	215
2b.	Random breathalyser tests for alcohol level with blood-alcohol test	227	14	17.0	213
3.	Accident data recorder	49	83	0.6	- 34
4.	Speed warning devices	187	162	1.2	25
5.	Distance warning devices	113	157	0.7	- 44
6.	Development of thoroughfares	27	25	1.1	2
7.	Compulsory child restraint systems	5	5	1.1	0.5
8.	Higher level of control	26	5	5.5	22
9.	ADMAS point system	524	26	20.0	498
10.	Cycle and moped training courses	5	4	1.1	0.5
11.	Higher proportion of public transport	1 122	61	18.0	1 061
12.	Compulsory wearing of cycling helmets	40	9	4.7	32

Source : Eckardt, Seitz, 1998.

4.2.4 Comprehensive traffic safety programmes

For the USA, the current results of cost-effectiveness analyses of more than 550 different safety measures are available from Tengs, Adams, Pliskin and others (Tengs, *et al.*, 1995). Table 8 shows the range of costs for different categories of measures required to save one year of a person's life.

Table 8. **Cost-effectiveness analyses for different groups of measures**

	Cost/life-year
Automobile design improvements	≤ 0 – 450 000 USD
Automobile occupant restraint systems	≤ 0 – 360 000 USD
Helmet promotion	≤ 0 – 44 000 USD
Highway improvement	29 000 – 420 000 USD
Light truck design improvements	13 000 – 10 000 000 USD
Light truck occupant restraint systems	14 000 – 67 000 USD
School bus safety	150 000 – 4 900 000 USD
Speed limit	6 600 – 510 000 USD
Traffic safety education	≤ 0 – 720 000 USD
Vehicle inspections	1 500 – 1 300 000 USD

Source : Tengs *et al.*, 1995.

The following measures are particularly cost-effective, each of them amounting to less than $100 for each year of life saved:

- Fitting windscreens using adhesive substance rather than rubber seal.
- Automatic rather than manual driver safety belt.
- Compulsory wearing of seat belts.
- Compulsory use of child restraint systems.
- Compulsory wearing of motor cycle helmets.
- Further training for incompetent drivers (rather than withdrawal of their licences).
- Ban on the sale of three-wheel cross-country vehicles.

4.2.5 Telematics

The Institut für Verkehrswissenschaft at Cologne University has analysed the effect on safety of the use of telematics (Baum *et al.*, 1994). The results apply to Germany. The evaluation was made using a traffic simulation model.

Table 9. **Effect of telematics on improving road traffic safety**

	Cost-benefit ratio	Accident cost (in mill. DM)
Road guidance technologies		
«Companion»	1.1	- 12.07
Integrated telematics system	1.6	- 361.95
HGVs electronically coupled to driver information systems	4.37	- 13.42

Source : Baum *et al.*, 1994.

4.2.6 *Measures regarding infrastructrure and organisation*

The Institut für Verkehrswissenschaft at Cologne University has investigated the impact on road traffic safety of measures to improve infrastructure and organisation in the context of various research projects (Baum *et al.*, 1994). These assessments were also made using a traffic simulation model.

Table 10. **Effects of measures to improve safety on the roads**

	Cost-benefit ratio	**Cost of accidents (million DM)**
Integration measures		
Integrated transport (BVWP 92)	1.1	- 46.73
Freight transport centres	1.9	- 9.88
Park and Ride	2.5	- 167.21
Organisational measures		
Replacement of own-account transport	8.6	- 98.91
Increasing payload	6.4	- 103.70
Cooperation (Alternative 1)	3.3	- 23.30
Planning trips	1.9	- 23.49
Satellite radio	2.6	- 4.41
Transport exchange	3.7	- 0.55
JIT avoidance	0.3 – 3.2	- 50.03
High occupancy (Alternative 2)	1.7	- 22.83
Road infrastructure		
Closing gaps	2.2	- 88.80
Bypass (dual carriageway)	3.9 – 5.1	- 209.49
Long-term building sites	3.4	- 0.80
Daytime building sites	0.3	- 9.47
Third lane on motorway	5.2	0
Hard-shoulders	0.5	- 3.37

Source : Baum *et al.*, 1994.

4.2.7 *Insurance incentives*

The possibility of improving road safety by providing financial incentives through insurance systems has not so far been sufficiently exploited. If we consider the insurance systems that are currently found world-wide, two basic types can be identified (Table 11).

Table 11. **Characteristics of third-party and no-fault insurance systems**

	Third-party insurance	**No-fault insurance**
Liability	Person responsible for accident	No liability
Benefits	Parties injured by policy holder	Victim of accident (= policyholder

Source : Baum, Kling, 1997.

The existing motor insurance systems in Europe are based on several charging criteria, such as type of vehicle, licensing authority, and individual claims record (no-claims or bonus-malus system). It is generally agreed that road safety is promoted by the bonus-malus system, which punishes those responsible for accidents with higher premiums and rewards those who are not with lower ones.

A fundamentally different system applies in certain states in the USA and Canada. There, accident victims are compensated by private or public motor insurance institutions, whether or not they were responsible for the accident ("no fault"). At present, no-fault systems exist in 23 states in the USA. Under the system, the injured party loses his legal third party claims upon the person responsible for the accident. It appears that this limitation of liability on the part of the person who caused the accident tends to lead to a rise in the frequency of accidents. Studies that have attempted to identify the effect of the no-fault rule on the incidence of accidents, have concluded that the number of accidents and accident victims has risen (Sloan *et al.*, 1995, p. 72 ff.); furthermore, the number of fatal accidents has increased (Cummins, Weiss, 1991, p. 22).

Table 12. **Individual measures ranked in order of effectiveness**

Ranking	**Measure**
1	Taking points record into consideration
2	Closer identification of the driver of the vehicle
3	Setting up a franchise
4	Reimbursement of payment
5	No claims bonuses in cash and kind
6	Savings scheme model
7	Refusal to pay in cases of gross negligence
8	Promotion of technologies that increase safety
9	Greater spread of bonus-malus system
10	Extension of possibility of compensation
11	Greater differentiation of premiums
12	Contracts based on annual mileage
13	Variable insurance premiums
14	General rise in premium levels

Source : Baum, Kling, 1997.

To be able to estimate the effects of insurance schemes, a standardised expert survey was conducted as part of a study carried out by the Institut für Verkehrswissenschaft at Cologne University. The respondents had to name the five instruments that in their opinion had the greatest effect on traffic safety. The answers to this question were very much in line with the assessments of the individual measures. The respondents as a whole ranked the instruments as follows (see Table 12).

All those surveyed felt that taking account of the points record when assessing tariffs had the most significant effect. After that came two instruments intended to achieve a more distinct, more individual liability, namely the closer identification of the driver of the vehicle and the setting up of a franchise for third-party insurance. At the lower levels were the different arrangements geared to kilometre performance and the general rise in premium levels.

4.2.8 Local incentive schemes

In 1981, **France** set out to reduce the fatality rate by a third, from 45 to 30 deaths per billion vehicle-km, within five years. To this end, responsibility for road safety was to be largely transferred to those able to exert influence on the incidence of accidents at local level (Brühning, 1985, p. 30 ff.). Accordingly, two programmes were initiated in 1982-83:

– "REAGIR" (Réagir par des Enquètes sur les Accidents Graves et par des Initiatives pour y Remédier) provides for the investigation of every serious accident by a multidisciplinary commission. The concluding report, drawn up jointly, is supposed to reconstruct the accident as far as possible and offer suggestions in the light of presumed causes of the accident.

– With the programme "MINUS 10%", the number of accidents involving personal injury was expected to fall by 10% per year. The state entered into agreements with larger municipalities (populations more than 50 000) and Departments, under which the latter undertook to improve road safety. The state provided the following grants for this purpose:

    - a one-off payment corresponding to 1 FF per inhabitant, regardless of success, amounting to at least 100 000 FF, and at most 500 000 FF;

    - in the event of the -10% target being reached within a year, an award for each accident avoided of 20 000 FF in rural areas and small villages (competence of the gendarmerie) or 10 000 FF in other municipalities (competence of the police).

In the period 1983 to 1988, around 372 million FF were set aside, of which 12% was to pay participants and 88% to reward success. Table 13 shows that MINUS 10% proved to be a success.

Of the departments and local authorities taking part, one of them (Soissons) actually managed to achieve the 10% reduction level five times. The figures nevertheless show that longer-term programmes – lasting several years – and substantial financial resources are required for significant improvements in road safety. It also emerges that the potential for improvement diminishes after the scheme has been in progress several years and “natural” limits to accident prevention seem to become apparent (Schlabbach, 1991, p. 146 ff.). In mid-1989 the MINUS 10% was abandoned and replaced with an information and training scheme.

Table 13. **Success rates of "MINUS 10%" programme in France**

Year		Administrative areas			
		Departments	**Towns**	**Other**	**Total**
1	Participating	90	79	23	192
	Target reached	71	74	21	166
	Success rate	79%	94%	91%	86%
2	Participating	70	74	21	165
	Target reached	20	45	10	75
	Success rate	29%	61%	48%	45%
3	Participating	19	41	9	69
	Target reached	2	19	4	25
	Success rate	11%	46%	44%	36%
4	Participating	1	15	3	19
	Target reached	0	3	1	4
	Success rate	-	20%	33%	27%

Source : Schlabbach, 1991.

Austria followed the French example and implemented a similar programme (*Aktion Minus-10-Prozent weniger Verkehrsunfälle*), in which the district authorities were to participate. The Austrians, however, took the view that the commitment of those involved should not be bought with financial benefits and instead success was repaid with honours and distinctions, and with benefits in kind. The object was to reduce the number of accidents (from the average number for 1984 and 1985) by 10% per year. All 121 district authorities took part (Schlabbach, 1991). The results of the scheme are by no means clear. Although the number of accidents fell by 4.1% in the first six months of the scheme (second half of 1986), the influence of "Minus 10%" could not be demonstrated. In the second year of the scheme, however, the number of accidents increased by 3.6%, and fatalities by 13.1%.

4.2.9 Assessing the problems of dealing with organs

Since 1997, a new law on transplants, regulating the removal and transplanting of organs, has been in force in Germany. Amongst other things this law forbids trade in organs. It is not certain how organ transplants and the law on transplants affect costs arising from accidents or whether the incidence of accidents has any effect on the cost of transplants (Baum, Höhnscheid, 1999). In road accidents causing serious personal injury the effects are twofold:

- Injuries may be sustained that can only be treated by means of a transplant. In that case, accidents victims are demanders of organs; the corresponding costs must be considered as restoration costs when the costs arising from the accident are calculated.

– In road accidents with fatal consequences, accident victims may end up as organ donors. Organ donations can save lives and the survival of the recipient can lead to a reduction in the costs due to loss of resources. Researchers need to determine whether this reduction of costs is to be regarded as a possible economic benefit of road accidents.

With the development of medical science, the transplantation of certain organs has now become a normal part of medical care. Organ transplants have different effects on costs resulting from acidents:

– There is considerable excess demand for organ transplants, i.e. the demand for replacement organs cannot be fully satisfied, or only after a long delay. This often results in higher treatment costs; regular dialysis is required, for example, until a replacement kidney becomes available (Table 14).

Table 14. **Costs of dialysis and kidney transplants**

	Cost
Dialysis, annual	45 000 – 90 000 DM
Kidney transplant, one operation	50 000 DM
After-care costs, annual	15 000 – 20 000 DM

Source : Arbeitskreis Organspende, 1995.

– The effect of organ transplantation on the economic cost of accidents is relatively low. The injuries most often sustained in road accidents cannot be treated by means of a transplant. Table 15 shows the injuries from accidents that entail the highest economic costs.

Table. 15. **The most cost-intensive injuries (in millions of DM)**

	Economic cost (mill. DM)
Closed fracture of the femur	214
Contusio cerebri	158
Closed fracture of the tibia	145
Fracture of the vertebrae	120
Closed fracture of the foot	89
Closed fracture of the shoulder joint/head of humerus	84
Open fracture of the tibia	84
Closed fracture of the elbow, forearm bones	64
Commotio cerebri	58
Torn knee	35

Source : Mattern et al., 1988.

Transplants are not shown as a separate item on the list of restoration costs owing to their minor significance in accident costs. They are accounted for under medical treatment costs.

- Anybody killed in an accident is a potential organ donor. The organs from fatal accident victims represent an increase in supply, which could have the effect of lowering costs.

    - With the greater supply of donated organs, there is an increase in the number of persons having organ transplants, who are thus able to survive. As a result, there is a fall in costs due to loss of human resources, i.e. of persons who would not have survived without the donated organs.

    - An organ transplant may well entail lower restoration costs than a protracted alternative treatment (e.g. dialysis).

    - Today many organ transplants still present challenges to medical science. With the increase in the number of operations, made possible by accidents, staff carrying out operations and those conducting research are able to learn more.

The beneficial effects of accidents are, however, subject to various limitations:

- Not all those killed in accidents are potential organ donors. Only a certain number of accident victims may legally be used as organ donors. Of this number a further proportion of the fatally injured have to be ruled out, since their body parts have been so badly damaged in the accident that there can be no question of using them for transplantation purposes. It must nevertheless be recognised that even a small number of fatally injured persons with organs suitable for transplantation represent a significant increase in the organ supply, given the number of transplant operations carried out in Germany every year. Moreover, an accident victim might serve as a donor of different organs.

- Hitherto certain types of organ transplantation have only guaranteed the short-term survival of the recipient. There is no certainty that he will become fit to work again. If the organ recipient remains unfit for work, the donation of organs does not lead to a fall in the costs arising from lack of resources.

- As regards the cost of treatment, it is not clear whether organ transplants lead to cost savings. The costs of after-care treatment of organ recipients have to be seen in relation to the cost of the very short courses of treatment that patients who have not received a new organ are often given throughout their lives.

Furthermore, there are serious ethical objections to interpreting the loss of a human life as a “benefit”. The protection of human life is recognised as the highest ethical goal by society. Calculation of costs arising from accidents is not done for its own sake. Rather, these costs provide a source of information on which to base traffic policy, whose most important concern in the field of road safety is the protection of human life. To interpret death as beneficial therefore offends not only the common values of society, but also discredits the trend in research into accidents costs as the economic basis of road safety measures.

4.3. Comparability of road safety measures

The results of these case studies on the effectiveness of road safety measures cannot always be easily compared:

- Studies of the costs arising from road accidents reveal considerable differences in scope and composition. For example, damage to property is often not taken into account in the calculation of accident costs, although they account for a considerable proportion – over 40% – of overall costs.

- Differences in accident cost levels also result from the fact that the cost components and evaluation procedures used in the calculations are not always the same. Assessments based on willingness-to-pay surveys normally lead to substantially higher valuations of casualties than other methods.

- The origin of data is not always clear from studies, which makes comparison and judgement difficult. The information available for assessing the measures is sometimes incomplete. The functional connections between traffic parameters (e.g. kilometre performance, speed) and the frequency and seriousness of accidents are not always apparent. These are, however, important factors in assessing the validity of the results.

- The studies and the results concern different countries. The extent to which the results obtained can be applied to other countries is open to question. In this connection, the comparability of situations should be checked and, where appropriate, weighting should be introduced to offset any differences. Examples of differences between countries are to be found *inter alia* in legal regulations (requirement to wear seat belt, helmet) or financial incentives in insurance arrangements.

The reductions shown in the studies should be understood as potential reductions, while the actual results of the reduction in accident numbers should be empirically investigated. Furthermore, the overall assessment of road safety measures must include effects that cannot be measured in terms of allocations (costs or benefits). These include in particular the distributive and social effects of road safety measures.

4.4. Conclusion

The many and varied international assessments show that the implementation of certain road safety measures could develop the potential for safety even further. This potential is associated with technological and legal measures, as well as those that address behaviour:

- The introduction of a points register has produced one of the best cost-benefit results. This regulation is already being successfully applied in Germany. Moreover, further improvements can be expected from a link between the points record and insurance premium levels.

- As regards legal measures, the requirement to wear seat belts and helmets is proving to have a significant effect on road safety while also being more cost-effective.

- A further tightening of blood-alcohol tests is also regarded by many experts as an effective way of improving road safety.

- Various measures that increase the share in the modal split of less hazardous means of transport also show promise. These are mainly public transport systems. The problem lies in ensuring that that the increase in safety is not offset by a fall in quality.

- If the accident reduction target alone is considered, we might expect speed restrictions to have a significant effect on road safety. Unfortunately, the available data on the cost-effectiveness of speed restrictions are still insufficient. Investigations carried out in the USA – the broader relevance of which is by no means certain – suggest that such a measure would lead to higher costs, resulting mainly from loss of time.

- Technological innovations also promise further improvements in road safety. This involves measures taken both inside and outside the vehicle. The critical point is that technological improvements are often associated with significant costs, which mean unsatisfactory cost-benefit ratios.

- Studies of the cost-effectiveness of measures that affect behaviour are comparatively rare. Nevertheless some studies of campaigns to increase awareness reveal positive results, showing a fall in the number of casualties as well as good cost-effectiveness. Particular stress is placed on the effectiveness of the special training given to incompetent drivers.

5. PROSPECTS FOR FURTHER EVALUATION PROCEDURE

A modernised evaluation procedure has to meet different demands and address outstanding questions:

1. In all calculations of accident costs and economic assessments of road safety measures it is essential that data should be highly transparent. Every stage in the calculation and assessment process must be comprehensible, so that, for example results from different countries can be compared.

2. Establishing a quantitative framework for reviewing accidents can still present serious problems. It is not always possible to quantify the connection between the effect of safety measures and the incidence of accidents. This is true *inter alia* of measures designed to influence behaviour, whose effects on the incidence of accidents can seldom be isolated. But these very measures are of increasing importance in the field of traffic policy. In particular, it is difficult to establish a clear relationship between the causes of accidents, the effects of accidents and the effects of road safety measures, because the incidence of accidents is due to a wide range of factors.

3. A further problem arises from the fact that the numbers of cases, whether those involving casualties or damage to property, are often simply estimated. As a result, the costs themselves are underestimated. False estimations may result from problems of definition or recording. In calculating the cost of accidents, an attempt should be made to keep the number of estimated figures as small as possible.

4. A great many different cost accounting and assessment procedures are used across the world to provide answers to questions that arise in the context of work on road safety. A greater convergence and harmonisation of the different procedures is called for. This presupposes an international economic consensus on the most effective approaches.

5. The question of the extent to which human suffering should be taken into account in the economic evaluation meets with a different response in different countries. Whereas Germany consistently gears its evaluations to the question of resources, other countries also take account of the human consequences of accidents that are unrelated to any loss of resources.

6. In the case of loss of resources as a result of road accidents, a problem arises from the fact that casualties fall into different employment categories (full-time or part-time workers, unemployed persons, housewives). In face of the constant change in employment arrangements (e.g. part-time employment) or chronic unemployment, an assessment should be made of the extent to which the costs of accidents affect the situation in the labour market. A distinction should be made here between short-term, economic developments (e.g. short-time work, short-term part-time work, cyclical unemployment) and structural changes to the labour market (e.g. a rise in natural or structural unemployment, or a permanent increase in part-time work at the expense of full-time work).

7. An assessment needs to be made of the cost of lost resources when children and young people are the casualties. In some calculations they are merely included in the costs of upbringing and education. This means that the cost has been underestimated. The evaluation must take account of the influence of children and young people in terms of the overall contribution they could have made to net product if they had not been involved in accidents. The socio-demographic structure of casualties must also be reflected in the evaluation. An evaluation that ignores the age distribution of the accident victims leads to distortions.

8. Individual cost items require constant updating and extrapolation. Costs should take account of the current state of relevant factors. If, for example a long-term care insurance policy creates a new market for nursing services, which would presumably be accompanied by a greater demand for services, this would have to be taken into account in the restoration costs. Other changes in restoration costs result, for example, from measures to reduce costs in the health sector.

9. Environmental and congestion costs resulting from road accidents have not been taken into consideration so far. Congestion costs correspond to the loss of time experienced by road users as a result of accidents. Environmental costs arise, for example, where an accident involving a vehicle carrying dangerous goods pollutes surface and ground water or damages flora and soil. Environmental costs also arise as a result of the extra emission of pollutants when traffic is congested as a result of an accident. Loss of time and damage to the environment as a result of accidents should also be considered in assessing road safety measures.

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SUMMARY

A great deal of effort is still needed to improve road safety in Europe. As well as assigning responsibilities and a systematic approach, optimum use of available resources is also required. For this last item, knowledge, methods and techniques developed by the economic sciences can be used.

Firstly, criteria have been formulated which can be used to determine whether there is sufficient need for government intervention in traffic and road safety. Analysis shows that there are different reasons: safety is a 'merit good', the external costs of accidents have not been completely internalised, the consequences of accidents are sometimes unfairly divided, a road system is a 'public good', has external benefits and has large indivisible production units, and safety is a qualitative aspect in terms of construction, maintenance, and management of such a road system by the government.

Secondly, evaluation tools have been developed to (1) determine the optimum size of the total government budget for road safety policy and (2) to find out how a given budget can be optimally employed in drawing up a package of measures. The method of social cost-benefit analysis is suitable for both objectives, cost-effectiveness analysis is only appropriate for the second objective. To determine who will be affected by the advantages and disadvantages, a supplementary redistribution analysis can be carried out. To test the robustness of the figures (particularly with regard to the effects of policy alternatives investigated) a sensitivity analysis can be done.

To apply a social cost-benefit analysis, information is needed to quantify all the effects and put a monetary value to each. A portion of this information is also needed for a cost-effectiveness analysis. In practice, not all the necessary information will usually be available, so the optimum size of the road safety budget and/or the optimum composition of a package of measures cannot be determined using these methods. Nonetheless, decision-makers can still be supported by information about the costs and effects of measures that is available. With the help of non-monetary methods, like the 'goals achievement matrix' and the scorecard, this information can be classified and processed for decision-makers. This puts them in a better position to rank policy alternatives; an assessment of efficiency is not possible however.

1. INTRODUCTION

The lack of road safety is a major problem in Europe. In 1995 there were 45 000 fatalities as the result of traffic accidents, and 500 000 serious injuries. The socio-economic impact of all accidents, including those with only material damage, is estimated to be in the order of 162 billion Euros (see Table 1).

Table 1. **Socioeconomic costs of traffic accidents, in 1995, in the European Union in billion Euros (ETSC, 1997)**

Accident outcome	Economic costs	Value of human life	Total socio-economic costs
Fatalities	21	29	50
Serious injuries	23	33	56
Reported	*16*	*23*	*39*
Non-reported	*7*	*10*	*17*
Slight injuries	7		7
Reported	*3*		*3*
Non-reported	*4*		*4*
Damage-only accidents	49		49
Reported	*12*		*12*
Non-reported	*37*		*37*
Total reported	52	52	104
Total unreported	48	10	58
Total	**100**	**62**	**162**

In recent decades, much has been done already in an attempt to improve road safety, and not without success. In most countries the fatality risk (expressed as the number of fatalities per million kilometres travelled by motor vehicle) has fallen dramatically, despite the major increase in car use. The actual number of fatalities has therefore fallen as well. However, this favourable development has not been constant, either in time or place. In a number of the ‘safest’ countries, the fall in accident statistics seemed to bottom out in the mid-nineties. At present there are indications that the declining tendency has returned.

Despite the increase in road safety, people have not been inclined to rest on their laurels. On the contrary: the achievements so far seem to inspire even greater efforts in reducing the number of traffic victims. In the first instance, such efforts will involve formulating quantitative objectives: within a given period, the number of victims (usually fatalities) must be reduced by a certain percentage against a specific reference year. Table 2 shows an overview of countries in which such targets have now been set. To enable easy comparison, the desired annual reductions are shown as percentages. The level of ambition in this regard varies enormously between different countries. We should remember though that being able to meet these objectives will rely in part on the level of safety in the starting situation. In principle, a country with a good level of safety will find it more difficult to improve road safety than a country that is relatively 'unsafe'. Nevertheless, even among the 'safest' countries, some have set themselves very ambitious targets. Sweden, for example, has developed a policy that targets on the (very) long-term goal of zero fatalities ("Vision Zero").

Table 2. **Overview of road safety targets for several countries (OECD, 2000)**

Country	**Target percentage (number of fatalities)**	**Annual percentage***	**Target year**	**Base year and approx. number of fatalities**	**Fatalities per billion vehicle kilometres (1997)****
EU	- 15 % (38 000) - 40 % (27 000) «1 million Euro test»	3.2 3.4	2000 2010	1995 (45 000)	13.9 (1996)
Canada	"safest in the world"	-	2001	-	-
Denmark	- 40 %	4.2	2000	1988 (250)	11.3
Finland	- 50 % (367) - 65 % (less than 250)	6.1 6.4	2000 2005	1989 (734)	10.1
France	- 50 %	12.9	2002	1997 (8 000)	16.4
Iceland	- 20 %	5.4	2000	1991-1996 (250)	7.8
Netherlands	- 25 % - 50 %	0.9 2.9	2000 2010	1985 (1 438) 1986 (1 527)	10.2
Sweden	- 25 % (max. 400) - 50 %	6.9 6.1	2000 2007	1996 (537)	8.1
United Kingdom	- 33 % - 33 % (yet to be decided upon)	2.6 3.3	2000 2010	1981-1985 (5800) 1994-1998	8.1
USA	- 20 %	1.8	2008	1996	10.2

* as percentage of preceding year.

** *Source:* IRTAD (except EU, Denmark and Sweden: estimation by ETSC).

Secondly, the efforts to increase road safety involve the systematic and goal-oriented development of effective packages of measures. The systematic approach involves such elements as:

- A thorough analysis of the nature, extent and development of the most significant road safety problems.

- An explanation of such problems, with scientific evidence wherever possible.

- Identification of the most promising bases for measures.

- The development of a co-ordinated package of measures, making use of existing knowledge regarding effective solutions. For new problems and solutions, with which no relevant experience has yet been gained, experimental projects are implemented and evaluated.

- The monitoring and evaluation of these measures after implementation, followed by feedback on the results to make it possible to modify the policy if necessary.

A third factor is the requirement of efficiency. In some countries, the usefulness of the measures must be proven by means of a cost-benefit analysis, or the most cost-effective measures are selected within a pre-defined budget. Another example of such decision criteria is the ‘one million Euro test’. This requirement exists because road safety is not served by just formulating objectives and developing an effective approach. The funds available to governments are always limited, and must therefore be spent in the most efficient way possible. In other words, the objective is to arrive at the optimal allocation of the available production resources (labour and capital). The discipline of economic science, mainly based on the Paretian theory of economic welfare, has developed knowledge, methodologies and techniques which can be applied in this.

Three main questions must first be asked:

- Is it possible to leave the allocation of production resources to the free market mechanism, or is government intervention called for?

- If the government takes responsibility, how can the best possible division of government resources between the various sectors of policy be determined?

- Having established the budgets for these sectors, how can the best possible package of road safety measures be composed within the budget available?

This paper examines how these questions are answered by the Paretian theory of economic welfare (named after the French-Italian economist Vilfredo Pareto). The following aspects will be considered:

- The free market mechanism.
- The role of government.
- Government interventions in the market for mobility and road safety.
- Evaluation methods.
- Determination of the road safety budget.
- The composition of packages of measures.

2. THE FREE MARKET MECHANISM

Pareto's theory of economic welfare examines the preconditions for society's optimal use of the scarce resources available to it: labour, materials, clean air, etc. (see e.g. Braff, 1969). The central precept is that, through their consumption of countless material and immaterial 'goods', from cream cakes to concerts and from holidays abroad to church services, people strive to achieve as high a level of personal satisfaction as possible (given their income and the production factors available at any given time).

The theory assumes that people, in their capacity as either producer or consumer, acquire production or consumption goods by means of exchange (usually involving the payment of money). This exchange takes place on a market in the metaphorical meaning of the word. The market is the coherent complex of supply and demand for a commodity or service (e.g. coffee, grain, the services of a broker or banker, etc.). In principle, it concerns (sub-)markets on which an article is traded that is in every respect the same regardless of supplier or customer: it is only the price which determines customer preference for a particular supplier. It is also assumed that all customers and suppliers are aware of all other supply and demand prices, and that an individual producer or consumer is not able to influence the price of the goods traded. A market which meets these requirements is characterised by 'full and free competition'. On such a market only one price can prevail influenced by supply and demand, i.e. the lowest price for which the supplier is willing to sell his article. The quantity of the article that can be sold on the market will depend on the number of potential customers who are willing to pay that price.

The theory of consumer behaviour, i.e. the expenditure decisions of households, has attempted to explain this number of willing customers. It first provides an explanation for the behaviour of the individual consumer, from which it derives an explanation for collective consumer behaviour. The consumer is able to spend his or her income on various goods or services, and the quantity of each article purchased can also vary. However, more of one will always mean less of another, and so the consumer is able to select from among a limited number of 'packages' of goods and services. According to the theory, the individual will select that package which - within his income and given the prevailing market prices - will provide maximum benefit. The exact form of that package is a matter of personal preference and can thus vary significantly between individuals, even where those individuals have comparable incomes. One consumer may prefer comfortable housing above a car, another may be willing to economise on both in order to finance a trip around the world. The so-called 'preference schemes' of all consumers together thus determine the quantities of goods and services that can be sold on the market, given the existing distribution of income and the market prices. Working backwards from this conclusion, we can state that people's purchasing patterns can be used to determine the value that society (all potential consumers) attaches to a particular article. A cost-benefit analysis also uses this assessment method. It is essential that the price of goods is determined by their consumers and producers and not by some external agency such as the government.

Consumer behaviour theory also tries to explain the behaviour of all potential producers wishing to meet the demand for a certain commodity by offering it for sale on the market. This theory is of lesser importance in this regard and the briefest of summaries will be sufficient here. In short: on markets with full and free competition, the desire for the maximisation of profits leads to allocation of production resources to the production of those goods (and in those quantities) for which there is consumer demand at the existing market price. According to the theory this production will make the most efficient use of the resources available.

This means that the production resources available within society under the conditions stated above will be allocated in such a way as to result in the greatest degree of consumer satisfaction possible, within the limitations of income. This allocation of production resources is known as ‘Pareto-optimal’ and will automatically come into being when markets function as described above. Within the theory, ‘optimal’ is defined only by the individual preferences of consumers: the so-called ‘consumer sovereignty’.

3. THE ROLE OF GOVERNMENT

According to the traditional theory of economic welfare, one of the conditions which must be met before the optimal allocation of production resources is achieved is that there must be complete transparency of markets. In other words, everyone must be fully informed on the properties, the actual costs and the usefulness of the products involved. Only then will the prices represent a true reflection of the products' scarcity and desirability on the market. In practice, this condition is not always met: a commodity may have certain effects that are not expressed in its price. We then speak of the 'external effects' of the production or consumption of a commodity (Hennipman, 1968; Mishan, 1981). This can lead to the commodity being offered at too low or too high a price. If the price is too low, the quantity of the commodity sold on the market will generally be greater than socially desirable, and if too high the quantity will be lower than the optimal level.

A price that is too low will develop if, for example, the production of a commodity results in external costs such as air pollution in the area of a factory. As long as local residents receive no appropriate compensation from the factory owner, those external costs will not be reflected in the price of the product. Because a greater quantity of the product is likely to be sold at this (artificially low) price, more production resources are likely to be allocated to it than are 'optimal' from the social perspective.

The reverse may also hold true, i.e. if there are external benefits. This is the case when, for example, passers-by can enjoy someone else's beautiful garden. No doubt there would be many more beautiful gardens if passers-by were required to make a financial contribution to their upkeep. Because they are not, fewer production resources are allocated in this area than may be seen to be socially optimal. External effects of production and consumption therefore result in a non-optimal allocation of production resources. We then speak of a ‘market imperfection’.

In the theory of Public Finances, and in particular of government expenditure, this is seen as one of the reasons for government intervention in free market relationships (Musgrave & Musgrave, 1976). The aim of such intervention is to arrive at production quantities which are indeed socially optimal: the quantity which would normally result if all effects were to be reflected, ‘internalised’, in the price. In the case of the factory causing air pollution, this aim could be achieved by imposing some sort of environmental levy, equivalent to the costs incurred by local residents. Other methods of internalising these external costs include establishing a legal right to clean air (so that those who are denied it can claim damages), or prohibiting the use of certain types of equipment.

Besides the internalisation of external effects, the theory of Public Finances (see Musgrave & Musgrave, 1976) identifies further market imperfections which can call for government intervention in production and/or consumption. Here, a distinction can be drawn between the production of private goods (which we have considered exclusively thus far) and of public goods.

'Public goods' are those goods and services which cannot be divided into units that can be sold on a market individually. Unlike private goods, their use cannot be directly linked to the payment of a price. Economists therefore also refer to them as 'indivisible goods'. Only a government is able to provide such goods and services. Examples include a water defence dike, an army, an anti-malaria programme, the police and the legal system. Everyone on the territory on which such goods and services are provided derives their benefit. Samuelson (1954) terms this 'joint consumption'.

Other reasons for government intervention in the production of private goods, besides the external effects described above, are:

- Indivisible production units: there is a downwards production cost curve until the capacity limit is reached. The rules used in determining the economic welfare optimum (marginal price equals marginal costs) would lead to a permanent loss-making situation. In this case a monopolist (a public sector company, or a private company with a government concession) must see to the production. Examples include a telephony company operating a cable network.

- 'Merit and demerit goods' (Drees & Gubbi, 1968). These are goods of which consumers consume either too little (art) or too much (alcohol), because people do not know what is good for them. They are not able to assess the utility of the commodity, perhaps because they are not well informed. The government can nevertheless achieve optimal allocation by means of intervention.

- Absence of free competition. Certain markets may operate in such a way that the optimal allocation of production resources is obstructed. This is especially the case with monopolies and oligopolies.

Government intervention may be justified for reasons other than the promotion of optimal allocation of production resources. For example:

- to promote a more just distribution of income. The theory of welfare economics described assumes a distribution of income based solely on a free (employment) market. However, many governments wish to control this to some extent.

- to achieve economic stability and reduce cyclical fluctuations. Government expenditure can serve to counterbalance the ups and downs of national-economic development.

4. GOVERNMENT INTERVENTION IN THE MARKET FOR MOBILITY AND ROAD SAFETY

For a clear analysis of the role of government in relation to the incidence of traffic accidents, we must first imagine the situation in which there is a traffic system (comprising people, vehicle and road) without any form of government intervention. This mental exercise becomes easier if we concentrate on a traffic system in the Middle Ages.

A traffic system without government influence then proves imaginable for the components people and vehicle, but not for the component of the road. The construction and maintenance of the roads network is, next to the maintenance of an army, one of the main *raisons d'être* of a government organisation. This is largely due to a combination of market imperfections: a road network is traditionally a public good, it has external benefits and its construction involves large indivisible production units. In the Middle Ages, toll collection by public authorities did exist but was restricted to a few, specific conditions.

For a long time, government intervention in the traffic system was indeed confined to the road component. Everyone had a free choice in his mode of transport, solely limited by his income. Vehicles were produced and sold freely. There were few rules governing the use of the road, and there was little attempt to enforce them. In the event of an accident whereby a third party sustained any damage or injury, the guilty party would be tried on the spot according to local rules of general criminal or civil law. He would be sentenced to some appropriate punishment and/or required to pay compensation to the victim.

This situation changed when road safety became a more important consideration, largely as the result of the introduction of motorised vehicles. People started to think about ways in which accidents could be prevented, or at least to limit their harmful effects, and to settle the damage in a more acceptable manner for the victims (faster, simpler, more complete). To an extent, this led to changes which were market-led: car manufacturers developed safer vehicles, driving schools were established, insurers offered policies which would cover both damage to one’s own vehicle and harm of third parties. The costs were met by the customers purchasing such goods and services.

However, the market did not succeed in solving the road safety problem accurately. In order to save money, at least in the short term, consumers continued to buy unsafe vehicles, and to drive without proper instruction or insurance. During the twentieth century, this situation prompted many governments to take action - it should be remembered that governments had by this time developed into large bureaucratic organisations with considerable knowledge, financial resources and power. One objective was to educate and inform road users, to promote safer behaviour on the road, and to encourage more consideration for the risk of damage or injury when purchasing any of the (private) goods and services mentioned above. Occasionally, a subsidy or tax concession would be created to make the purchase of certain facilities financially even more attractive.

At the same time, more legislative measures were introduced to control such aspects as the construction and maintenance of vehicles (these measures being aimed at manufacturers and owners), and legal requirements for conduct on the road, driving a vehicle (both in terms of aptitude and physical ability), and insurance. Further to these measures, certain organisations, such as the police and the judicial system, were given responsibility for ensuring their observance.

It is difficult to assess the reasons for government interventions in the market for road safety in other countries. The following is therefore based on the situation in the Netherlands, although that in most other European countries is unlikely to be very different.

The principal reason for the stated government measures being imposed is that road safety is a ‘merit good’: consumers are not able to assess its utility adequately, or may not possess sufficient information. This is in essence due to the fact that an accident is a rare event in the individual's driving career and, by the very definition of the word, an accident occurs through an unexpected combination of circumstances. In general, people are not able to assess the statistical probability of having an accident, small as it is, and they are not able to take such risks into account when making their decisions. Accordingly, people are not inclined to take particular account of safety considerations. This problem can be approached on the demand side of the equation by influencing consumer decision-making behaviour. On the supply side a halt can be called to the production and distribution of dangerous goods and services.

A second reason for government intervention is demonstrated by the requirement for compulsory insurance to cover third party liability. This is intended to protect victims against guilty parties who are unable to pay appropriate damages or compensation. In most cases, Dutch law has placed liability for all costs firmly at the door of just one of the parties involved in an accident; in the formal sense there were therefore no ‘external costs’. However, when the costs to be paid were particularly high (as is usually the case when personal injury occurs) the party responsible was often unable to pay. Compulsory third-party liability insurance for the drivers of motor vehicles (who were usually the responsible party in such serious accidents) served to internalise the external costs, not only in theory but also in practice.

However, one should realise that ‘*ex ante*’ payment of a (compulsory) insurance premium does (or could) influence other decisions then ‘*ex post*’ payment of compensation. A premium is part of the overhead expenses taken into account when deciding on the purchase or use of a vehicle. The probability of an accident and its financial consequences (such as payment of compensation to victims) is supposed to be taken into account when driving in traffic. From safety’s viewpoint, the first form of pricing (*ex ante* payment of premiums) is preferable to the second one (*ex post* payment of compensation). That is because routinely and semi-automatically taken decisions (such as most decisions when driving in traffic) are much less sensitive to financial arguments then decisions of a strategic nature (such as purchase of a vehicle) (SER, 1999).

The more insurance premiums are reflecting the risk of accident costs (by differentiation based on safety characteristics of the vehicle, the driver and the roads that are being used), the more the costs are internalised (Verhoef & Van der Vlist, 1998). Having compared various pricing instruments to enhance safety considerations in consumer decisions of a strategic nature, the EU-Green Paper “Towards fair and efficient pricing in transport” (1996) even concludes that insurance premiums offer better opportunities for such risk-differentiation then other forms of pricing (such as fuel, car and road taxes).

In some countries, government intervention in this particular section of the insurance market has gone a step further, whereby insurance is provided by a state-owned company. Without more detailed knowledge of national insurance markets, it is not possible to state the proportion of such 'public' insurance within the total insurance market.

A third reason for government intervention is presented by the external costs of accidents. In the Netherlands, a certain proportion of costs of an accident is not part of the direct liability of the responsible party. Until recently this was the case, for example, with long-term incapacity due to injuries sustained in an accident; compensation was paid to the victim on the basis of social security insurance but the insurer was unable to reclaim the costs from the party responsible for the accident. This situation has now been rectified, whereby this section of the third-party liability insurance has been internalised. Another example is the ‘emotional cost’ resulting from death or serious injury - the so-called ‘pain and suffering’ component. Victims or their relatives have only been entitled to a symbolic payment. Proposals have now been made for legislation providing norms for a more substantial, realistic amount.

We have so far considered only government intervention in the market for private goods and services, with improvement of allocation as a target. In some cases, considerations of a more just division of advantages and disadvantages of accidents played a role. This was the case, for example, when devising legislation to strengthen the position of the vulnerable road users (children, slow traffic) in motorised traffic. It seems that in some cases the principle of 'the perpetrator pays' has more to do with considerations of 'fair play' than with any concern for internalising external costs. An example is a recent proposal whereby certain exclusions would be added to third-party liability insurance in the case of 'high-risk' conduct on the part of the insured, such as driving at excessive speed. Were such exclusions to be applied, the driver would be personally responsible for the costs of any damage incurred. The external costs argument applied in this proposal is far from realistic, since it is known that drivers do not allow their driving behaviour to be influenced by any consideration of a possible accident.

Finally attempts to improve road safety have come to play a more important role in the traditional government task of constructing, maintaining and operating roads. Road safety demands in terms of road design have become more stringent over the years. Road authorities have developed standards to be applied by the departments or private companies responsible for constructing, improving or maintaining roads. Occasionally the requirements have been imposed on the road authorities by some other branch of government specialising in matters of (road) safety. Gradually, the government's responsibility for the safety of the hard infrastructure has expanded to include concern for the safe movement of traffic on the roads. Instruments used in this regard include legislation to control the behaviour of road users, information and, more recently, automated traffic guidance systems. In their design and operation, such measures are not readily distinguishable from the government interventions described above, meant to influence road users on the basis of the ‘merit good’ argument.

5. EVALUATION METHODS

5.1. Introduction

As we have seen, there are various reasons for government intervention in the market, intended to improve road safety. There are also many instruments available. In preparing and establishing road safety policy, a choice between these possibilities must be made.

The introduction to this paper stated that it is now usual to adopt a systematic approach, taking into account the demands of effectiveness and efficiency. Efficiency is of particular concern when determining the overall budget for road safety policy, and when actually spending this budget on road safety measures.

In the broadest sense, the question becomes whether social welfare is best served by allocation of the resources available to government to this particular purpose rather than any other (the ‘integral question’). In other words, which of the alternative choices for expenditure will result in the highest social returns (aiming for optimal allocation of resources, or optimisation). The question can also be framed more concisely, (the ‘partial question’), that is based on either a fixed budget or a fixed objective. We must then ask how a certain objective can be attained at the lowest possible cost (cost minimisation), or how a fixed budget can be allocated so as to result in the greatest possible benefit (effect maximisation).

Here, we shall examine two evaluation methods which can be used to address these efficiency questions: the cost-benefit analysis (CBA) and the cost-effectiveness analysis (CEA). Both are known as ‘monetary methods’. The CBA is intended to answer the integral efficiency question, and thus investigates the social returns presented by the measures. Therefore by CBA is understood below a social CBA. The CEA is appropriate in answering the partial efficiency question.

We shall also briefly examine some non-monetary methods used to support the decision-making process in this regard, being in a number of ways comparable with the monetary methods. These will be divided into two categories: the multi-criteria methods and the overview table methods. Because strictly speaking only the monetary methods involve an economic evaluation, we shall concentrate on these. The other methods are covered because the data available are often insufficient to perform a full CBA or CEA, but are able to support the use of a non-monetary method. We begin by looking at those characteristics common to all methods.

This section is largely based on two publications which present a particularly useful summary for our purposes: the report on Policy Research published by the Netherlands Ministry of Finance (Department of Policy Analysis) in 1992, and the same department's report on Evaluation Methods of 1984. Both documents were based on the ‘state of the art’ of the time, as derived from professional and scientific publications. Much has been published on the individual methods, especially on the monetary methods. Where relevant, direct reference will be made to these sources.

5.2. General characteristics of the methods

The common point of departure for all the methods is the so-called ‘project effects matrix’ or effects overview.

Along one axis of the matrix is a list of all alternative expenditure possibilities (projects or combinations of projects within programmes or packages). Along the other are shown the various criteria by which these projects are to be assessed. The body of the matrix shows the scores for each project on each criterion.

The effects of a project are always determined in comparison to a reference situation. This might be a measure which is part of all projects, and which has already been selected for use. Frequently the ‘zero situation’ (also known as the one with ‘unaltered policy’ or ‘business as usual’) serves as the reference point. This is based on the existing situation and its natural development if no new policy measures are implemented. It is essential to define accurately the new measures on a case-by-case basis: even without an explicit decision having been taken, government departments continue to develop new activities further to previously established policy, and can achieve ‘autonomous’ gains in efficiency or more effective performance as a result. Such aspects must be taken into account when describing the zero situation.

‘Effects’ include all changes (against the reference situation) as the result of a project. In the first instance, these are the intended effects, i.e. changes which the project was consciously intended to bring about. In general, these are the contributions to the solution of the policy problem which the project was developed to address. In the current case, this is greater road safety.

However, in addition to its intended effects, a project can also have other effects, the so-called ‘side effects’. These may be positive, sometimes even intended in that they will contribute to the solution of another policy problem. For example, a road safety measure such as the introduction of a lower speed limit can also have the effect of increasing the quality of the human environment in terms of reduced air pollution and noise nuisance. A side effect may also be negative, as in the case of longer journey times as the result of lower driving speeds. Negative effects are sometimes expressed as ‘costs’. This is not recommended since it can lead to confusion with the actual implementation or programme costs included in the effects overview, usually under the heading of ‘costs’ (see below).

The effects that are a direct result of the implementation of a project are known as the ‘direct effects’. There are also ‘indirect effects’ which, in principle, must also be included in the evaluation of the project. The distinction between direct and indirect effects does not relate to intended and unintended effects. Indirect effects can sometimes themselves be intended, sometimes not. Furthermore, they can be either positive or negative. The reduction in the number of accidents resulting from a (reduced) speed limit may increase people's subjective feeling of safety - a positive indirect effect. An increase in air pollution as the result of increased traffic due to the absence of traffic jams can be seen as a negative indirect effect.

Caution must be exercised to avoid double-counting of an effect. For example, if reduced noise nuisance has been listed as a beneficial effect, the increase in property values as an indirect result of that reduction cannot also be included. Transfer payments are another source of errors. These are payments which are not done in exchange for some performance (supply of goods or services) but are a mere transfer of money between (public or private) parties. Examples are taxes, unemployment benefits and fines. Because the costs for the paying party equal the benefits for the recipient, they have to be left out of a balance sheet which covers the positive and negative effects of a project for all involved parties (which is e.g. the case in a social cost-benefit analysis [Mishan, 1981]).

To be included in the overview, indirect effects must derive from the project itself. As the distance in time and space between the project and its direct results on the one hand and the indirect results on the other increases, it becomes more difficult to establish a causal link. The importance of the effects also depends on the length of time it is likely to take before they are felt. In practice therefore, the number of indirect effects included in the evaluations will be limited.

The costs of a project must be considered in a totally different light to that of the effects. Effects are seen as the result of the implementation of an alternative, while costs are incurred in bringing about that alternative. We therefore speak of ‘implementation costs’ or ‘programme costs’. These costs are included in the effects overview.

The formulation of an alternative will always be linked to the deployment of production resources. As a rule, the value of the resources is used as an indication of the costs of the project. In theory, the ‘opportunity costs’ (i.e. the benefits that could have been derived from the production resources had they been allocated to some other project) should be calculated. However, in practice it is impossible to identify another project to be used in calculating the opportunity costs.

Both costs and effects appear spread over a period of time. In principle, the costs should be calculated throughout the entire life cycle of the alternative. In addition to investment costs, which can be spread over a number of years, the running and maintenance costs must also be taken into account. It is not possible to make any accurate predictions regarding the price development of the production factors (influenced, *inter alia,* by inflation) throughout the life cycle of the alternative. It is therefore advisable to base all prices on a constant, such as the price level in the year in which the evaluation study is conducted. Wherever possible, relative price fluctuations should be taken into account.

It is not generally acceptable to aggregate the future cost flow or to calculate average costs per year. To do so takes no account of the moment at which the costs are incurred and the relevant value assessment in time, the so-called 'time preference'. One possible solution is to apply a system of discounting (in the sense applied in accountancy), which entails relating the value of the investment stream in various years to the base value in one particular reference year. Because mostly the present year is chosen as reference, the system is also known as 'determining the present (discounted) value'. It is based on the principle that an amount of money spent now is to be assessed at a higher value than the same amount spent some time in the future (because of inflation and future returns on alternative investments, e.g. in government bonds). This difference in value is expressed by means of a 'discount factor' by which all amounts are multiplied. The Dutch government has set the discount rate for all government projects at 4%. This rate is not meant to cover against uncertainties about future costs and benefits; such risks should be dealt with separately in the estimations of the effects (e.g. by a sensitivity-analysis).

Effects are also spread over time, usually over a longer period than the costs. In infrastructural projects, the life cycle is generally taken to be twenty to thirty years. When the effects are assessed in financial terms, it becomes clear that discounting can take place in exactly the same manner as costs. Indeed, the same method can be applied even when the effects are not assessed in financial terms but in other units, provided these are measured on a ratio scale. The application of the discounting method negates the factor of time, whereby direct comparison with other effects and costs of the project is facilitated.

5.3. Cost-benefit analysis

The cost-benefit analysis (CBA) is an evaluation method which provides a quantified overview of the advantages and disadvantages of alternative projects or measures. These advantages and disadvantages are expressed in terms of cost and benefit entries on a cost-benefit balance sheet. Wherever possible, all such entries are expressed in monetary terms.

Originally, the cost-benefit analysis derived directly from the traditional theory of economic welfare. A number of significant textbooks therefore place this method of analysis in the context of this theory (Mishan, 1981; Dasgupta & Pearce, 1975). In practice however, some problems arise to which this theory offers no immediate solution. The most significant example is how one can take into account effects on the distribution of income. Under Paretian theory, the existing distribution of income is taken as a non-variable, whereby any shift as the result of a project cannot be included in the analysis. The assessment of the social effects of government measures is determined by individual preferences alone, and not according to the government's own objectives. This is closely related to the concept of 'optimality' in Paretian theory, based as it is on the principle of 'consumer sovereignty'. However, most governments wish to take into account the side effects of a project in terms of distribution of income; after all, they have implemented an income policy which aims to achieve a fair and just distribution of income.

In order to provide study results which were nevertheless useful to the policy-makers, certain modifications were made to the basic Paretian theory of economic welfare (Klaassen & Verster, 1974). Accordingly, Van den Doel (1978) distinguishes between the Paretian and the Bergsonian cost-benefit analysis.

It is not appropriate to discuss the advantages of the various types of cost-benefit analyses here (see, e.g. Kraan, 1982). It is sufficient to state that this paper considers the Paretian version, as used in the overview report for the Ministry of Finance (1992).

The other evaluation methods we discuss offer greater opportunities for taking the government's own objectives into account. Under certain circumstances, the combination of a CBA with these other methods provides a solution to the limitations of the CBA alone. To this end the Ministry of Finance recommends to perform, in addition to the CBA, a separate 'analysis of redistribution'; this should demonstrate to whom in society accrue the costs and benefits. We shall return to this once all the other methods have been discussed.

An example of a cost-benefit balance sheet (using headings rather than actual figures) is given in Table 3. This is taken from a study for the construction of a second national airport in the Netherlands, to supplement the existing national airport at Schiphol.

Table 3. **Social cost-benefit balance sheet of a second Netherlands national airport**

Costs	**Benefits**
Construction costs	Operating revenue
Modification of airspace structure	Net revenue from passengers and freight
Other costs (including road traffic infrastructure)	Indirect economic effects
	Noise nuisance at new airport
	Noise nuisance at Schiphol
	Planning assimilation
	Employment opportunity
	Other effects
Balance: Benefits against costs.	

This balance sheet includes entries which affect those directly involved (as producer or consumer), such as the construction costs, operating revenue and the net revenue from passengers and freight. It also shows the effects for those not directly involved, such as noise nuisance. In a commercial (business economics) CBA, the first category is of interest; in a socio-economic or purely social CBA, all effects must be taken into account, including the effects for those not directly involved. Any analysis of road safety measures taken by the government must include a socio-economic CBA. Such projects are, after all, undertaken due to the existence of market imperfections whereby the intended effects occur outside the market.

The objective of such an analysis is to assess one or more projects in terms of socio-economic yield. Firstly it is necessary to establish the present (discounted) values of all costs and benefits. These values are then used to establish a certain investment criterion whereby the social profitability can be calculated. One of these criteria is the Benefit-Cost Ratio (BCR), i.e. the relationship between the aggregated present value of the benefits and the aggregated present value of the costs. Another frequently used criterion is the Internal Rate of Return (IRR), which represents net returns expressed as an interest rate on the invested amount. A third measure of profitability is the net present value (NPV, the difference between the aggregated present value of the benefits and of the costs, as it is mentioned in Table 3). For the purposes of this paper, we shall focus on the BCR.

When more than one project is being evaluated, they can be ranked in order of profitability using the BCR. The project with the greatest BCR will be considered for implementation firstly. When only one project is being analysed, as in the above example, it will become eligible for implementation if the socio-economic yield is greater than a set pre-established minimum value. In general, a project is seen to be of sufficient profitability if the BCR is greater than 1. Where the Internal Rate of Return method is applied, the IRR must be greater than the market interest rate. This requirement is also applied to a project, selected on the basis of comparison with a number of other alternatives.

The foregoing assumes that it is possible to quantify all benefits and to value them in terms of money. In practise this poses mostly many problems. For several reasons quantification of effects is surrounded with much uncertainty. It is recommendable to test the solidity of the figures with a sensitivity-analysis. In this way the risks of a project become evident.

Appraisal becomes a problem especially if the effects are felt outside the market. It may be possible to measure some benefits in terms of scope or intensity, while others can only be expressed in qualitative terms. For example, it may be possible to state how many lives will be saved by a particular road safety measure, although it remains impossible to express this in financial terms. Similarly, it may be possible to state that the effect will be favourable (i.e. a general decline in the number of fatalities) although impossible to state exact numbers. Effects such as this, stated in qualitative terms, are known as *imponderabilia* and are shown as an open entry of the cost-benefit balance sheet. The overall effect is that the BCR value will provide an incomplete indication of the yield of a project. A definite ranking of alternatives by potential yield is therefore often impossible, as is any comparison based on the minimum BCR value of 1.

Much has been published on solving the problem of *imponderabilia*, especially in connection with the assessment of external effects. As in the case of (de)merit goods, we see an ‘unpriced scarcity’, i.e. it is not possible to rely on market prices to establish the value placed on these commodities goods by the consumer. Nevertheless, methods have been developed to make this possible. By way of illustration, one well-known example is cited here, that of the factory which causes pollution and hence damage to local residents.

The goal is to quantify the loss of welfare to the people involved. Because there is at present no market for clean air, there is as yet no pricing system by which its value can be assessed. However, it does not necessarily follow that it is impossible to quantify empirically the need people feel for this sort of scarce commodity. Their need can be measured by other means. Hueting (1974) presents a number of methods that can be used. On the one hand, the value assessment can be derived from the costs that people are prepared to incur in taking measures to compensate for the pollution, e.g. the purchase of a tumble drier to avoid having to hang clothes outside, or air filters for the windows. On the other, it is possible to examine the financial losses incurred, for example as the result of falling property prices. Finally, it is possible to quantify local residents' value assessment on the basis of their behaviour pattern with regard to clean air, such as the costs incurred in travelling to areas in which it is more readily available. Using these methods, the external costs become at least partially quantifiable.

5.4. Cost-effectiveness analysis

The cost-effective analysis (CEA) is closely related to the CBA and is indeed seen as a variant thereof. A common feature of the two methods is that they each provide as quantified an overview as possible of the advantages and disadvantages of the various alternatives. A difference is that in the CEA not all effects are expressed in financial terms. As in the case of the (Paretian) CBA, the CEA is unable to take into account any aspects of distribution, such as the distribution of effects between various income groups.

As with the CBA, a distinction can be drawn between a commercial analysis and a socio-economic or purely social analysis. In a social analysis, all effects including those felt by third parties, are included. The evaluation of road safety measures will always involve the performance of a social CEA.

The CEA can be described as an analysis by which the alternative is identified that can be most efficiently implemented to reach a fixed amount of intended social effects (cost minimisation). Alternatively, it may examine how fixed resources can best be used to achieve a certain social objective (effect maximisation).

In a cost minimisation exercise, the effects of the alternatives are not explicitly considered because it is assumed that these will not demonstrate any great divergence. This will be the situation when alternative implementations of the same type of project are being examined (e.g. the runway of our airport example may be constructed in various different ways).

In effect maximisation, it is the alternatives of similar cost which are examined, or those that bear no major influence on the decision-making process. This will be the situation where there is a fixed budget within which alternative (combinations of) measures (which may vary according to subject and/or extent) are to be financed.

Unlike the CBA, the result of the CEA does not provide any information concerning the socio-economic profitability of the various alternatives. It merely provides a ranking order.

In cost minimisation, not only the extent of the overall costs must be considered, but also the time at which these costs arise. If the distribution of the costs in time differs between the alternatives, the discounting method can be used to correct the differences. In effect maximisation, the same applies to the effects' distribution over time. A complicating factor is that the effects may not be (entirely) expressed in financial terms, whereupon the discounting method is not able to offer a complete solution. Here, one can attempt to express a sufficient proportion of the effects in financial terms, so that the remaining effects become roughly comparable in terms of extent and distribution over time. Ranking can take place according to the monetary value of the differences.

The results of a CEA may vary. In the case of effect maximisation, the results will depend on whether all alternatives studied have been scored on a single intended effect, or on a combined set of various effects. If there is but one specific intended effect, and other effects do not play any significant role in the decision-making process (because, for example, they do not differ from each other greatly in terms of scope) then the costs-per-unit-effect can be calculated for each alternative. This is usually referred to as the cost-effectiveness ratio.

Where the alternatives have been scored according to various effects (intended and unintended, positive and/or negative, direct and/or indirect), the result will be a table or balance sheet in which the effects of all alternatives are systematically arranged (positive against negative).

5.5. Other methods

5.5.1 Overview table methods

The use of an overview table method involves a limited modification of the effects overview as described in the project-effects matrix. The intention is not to arrive at any ranking or 'league table' of alternatives, and it is certainly not to arrive at any firm statement regarding the socio-economic profitability of the alternatives. Rather, overview table methods are used to arrange the information about the alternatives thus far collected in such a way as to make it more accessible to those who must make a decision. They will be the ones to judge ('weight') the various aspects. Examples of this type of evaluation method include the planning balance sheet method and the scorecard method.

The scorecard method is used to facilitate the comparison of various alternatives without making any judgement regarding their order of priority. It is a presentation tool which enables a clear impression of the advantages and disadvantages of the alternative under review to be given. An example of a scorecard is given in Table 4.

Table 4. **Example of scorecard for three alternative road schemes (ranking numbers on each aspect are given between brackets)**

Criteria	**Alternatives**		
	A1	**A2**	**A3**
C1 : costs	40 (1)	60 (2)	80 (3)
C2 : journey time gain	25 (2)	30 (1)	20 (3)
C3 : loss of nature area	2 (3)	1.5 (1)	1.75 (2)
C4 : fewer accidents	40 (3)	50 (2)	100 (1)

An effects overview is prepared for each aspect, or for all aspects together (including the costs aspect). A score for each criterion of the alternatives is recorded. Those costs and effects having a market price are expressed in monetary terms. Those without a market price are expressed in other appropriate units (e.g. journey time in minutes, loss of nature area in square kilometres, numbers of accidents). Where quantification is not possible, the anticipated effect is stated (e.g. the likelihood of an appeals procedure) or the consequences are expressed in qualitative terms (similar to the plus points and minus points which consumer organisations award in comparative studies of various types of household goods).

Once the effects overview has been drawn up, the ranking per criterion of each alternative can be indicated by means of a number (as in the example) or a colour. The entire overview then takes on the appearance of a scorecard. The assessment of the relative importance of the scores (the 'weight') is a matter for those who have to make the final selection.

Both the costs and effects of each alternative can be spread over time in different ways. It therefore becomes necessary to apply a correction for each criterion, wherever possible. The discounting method can be used for all scores expressed in monetary terms. Where this method is not appropriate, the effects can be aggregated over the entire lifetime, or expressed as an annual average. The scorecard should be accompanied by an explanation of the manner in which the scores and their ranking have been arrived at.

5.5.2 Multi-criteria methods

This class of evaluation methods is characterised by the fact that they rely on various explicit assessment criteria. These can differ significantly. The relevant scores per criterion can each be expressed in an appropriate unit and cannot therefore be aggregated over the criteria. A second important characteristic of multi-criteria methods is that greater importance is attached to some criteria than to others in making the overall assessment. This is achieved by assigning each a 'weight' that should reflect the preferences of the decision-maker(s). Where there is a significant divergence of opinion between the decision-makers, several sets of weighting factors may be used. Like the effects themselves, the weights may be expressed quantitatively or qualitatively. The exact form they take will depend on the method used.

There are many multi-criteria methods, including the weighted aggregation method, the goals achievement matrix, the concordance analyse, the permutation method, the regime method, the multi-dimensional scale analysis and the Evamix approach. Here, it will be sufficient for us to confine our attention to just one example, the goals achievement matrix (GAM) method.

The GAM method relies on the principle of bringing the effects of the various alternatives into relationship with a number of stated social objectives. For each objective, a so-called 'cost-benefit account' is created, showing the degree to which that particular objective is achieved. Here, the costs and returns are defined somewhat differently than in the CBA: the effects are expressed as negative changes (costs) and positive changes (benefits) with regard to desired situation. In Table 5, an example of a relatively simple GAM is presented, showing just one alternative, two objectives and five groups of interested parties.

Table 5. **Example of a goals achievement matrix (GAM)**

Groups of interested parties	**Objective I**			**Objective II**		
	Relative weight objective: 2			**Relative weight objective: 3**		
	Relative weight	**Costs**	**Benefits**	**Relative weight**	**Costs**	**Benefits**
a	1	A	D	5	E	-
b	2	H	-	4	-	R
c	1	L	J	3	-	S
d	2	-	-	2	T	-
e	1	-	K	1	-	U

A matrix is drawn up for each alternative in which the score per objective (I and II) is shown. Where an objective is presented in quantitative terms, the effects must be expressed in the same unit. In the case of qualitative objectives, the effect will only be stated as being further to or negating the objective. In Table 5, the letters A to U represent these scores. A dash indicates no change in relation to the relevant objective.

A weight is assigned to both the objectives and the various groups of interested parties. The weight assigned to the objectives (the figures 2 and 3 on the second line of the table) shows the value assessment given by the community (represented by the appropriate governmental body, such as the local authority) to the objectives in relationship to each other. If the opinions of the decision-makers vary on this matter, two or more weight sets may be used. The assignment of a weight to each of the groups of interested parties (those who experience the effects of the alternatives) is necessary because the effects of a certain alternative will not necessarily be felt equally by all groups. Here, these weights are shown by the figures 1 to 5 in the ‘relative weight’ columns of Table 5.

In principle, it is possible to complete the analysis once the matrices have been drawn up. It then falls to the decision-makers to assign a ranking order to the various alternatives. Because this is no simple matter (especially when there are several alternatives and objectives involved), a further phase is sometimes incorporated, whereby the scores are corrected to allow aggregation of objectives and groups. However, from the methodological point of view, this is a somewhat controversial course of action. For this reason, and in view of the complexity of the procedures applied, we shall not consider this method here.

5.6. Conclusion

Of all the evaluation methods described above, only the CBA is suitable for determining the socio-economic profitability of various alternatives, taking time preference into account.

If the objective is cost minimisation based on a given set of alternatives, or if it is effect maximisation based on a fixed budget, then only the CEA is appropriate for ranking the various expenditure possibilities according to efficiency. However, where the alternatives have been scored on several aspects, it is not always possible to arrive at a clear-cut ranking order.

In applying either method, it is not possible to take into account the effects on the distribution of income. Furthermore, the available information must fulfil certain stringent requirements: quantitative information regarding the costs and all effects. In the case of a CBA, it must be possible to assess all effects in monetary terms.

Therefore, it is recommended to perform two additional analyses, in addition to a CBA and CEA: a) an analysis of redistribution to demonstrate to whom the costs and benefits accrue, and b) a sensitivity analysis to test the solidity of the figures.

The other methods discussed (the scorecard and the GAM) do not enable any statement to be made regarding the efficiency of the alternatives. Neither do they arrive at any ranking order of alternatives. They do enable various different types of information concerning effects - both qualitative and quantitative - to be processed, including the effect on the distribution of income. Using the GAM method, a weighting of the effects also enables various priorities on the part of the decision-makers as well as the various interests of groups affected by the alternatives to be taken into account. Here, a stringent requirement is that the effects can be quantified and that both decision-makers and the interested parties must agree on the specific weights. It is recommended to perform a sensitivity analysis also in addition to these methods.

The various evaluation methods are not mutually exclusive. It is not unimaginable for a CBA to be carried out, followed by a multi-criteria analysis of the effects assessed in monetary terms against the *imponderabilia*. The outcomes of the analysis of redistribution can also be incorporated.

In conclusion, it should be realised that the final choice always falls to those who bear the political or administrative responsibility for the decision being taken. The use of evaluation methods will provide information which supports the making and justification of decisions. Considerations which are in themselves perfectly legitimate but which are separate from the information provided by the evaluation study may lead to decisions other than those suggested by the results of the study.

6. DETERMINING THE TRAFFIC SAFETY BUDGET

6.1. Options and method of evaluation

In developing a global traffic safety budget, the question of efficiency should first be discussed when a total budget for this policy sector has to be established. At this point it still has to be decided what measures need to be taken and whether there are any pre-set limits to the resources to be spent on it. Therefore an integral assessment of the social profitability of alternative expenditure options is necessary.

Other budget restrictions also apply if a traffic safety budget has not yet been established. First of all, the current overall government budget and then those of all the ministries concerned (unless the evaluation is part of a broad review of the effectiveness of government expenditure). Finally, decision-makers at the ministries involved will have their own views regarding the maximum portion of their budget that can reasonably be spent on traffic safety. A great deal of government expenditure cannot be altered in the short-term and considerations other than efficiency can play a part in this decision.

In assessing the social profitability of alternative spending options for traffic safety, things need to be weighed up with all kinds of other policy sectors. A social-economic CBA is the appropriate evaluation method for this. To this end the costs and benefits of alternative traffic safety programs need to be investigated. The results (a BCR value for each program) are compared with the BCR values of programs in other sectors so that a ranking order can be established. This is only possible if a similar evaluation has already taken place in these sectors, for instance in determining the budgets for those sectors. If the BCR values are unknown, then selecting safety programs with a BCR value greater than 1 (or an IRR larger than the market rate of interest) will have to suffice.

Depending on the budgeting procedure, weighing up can be limited to those sectors governed by the ministry where traffic safety policy is being established; in the Netherlands, like in so many other countries, this is the Ministry of Transport. This means that the usefulness of traffic safety measures can be compared with for instance that of a new rail line, improvements in waterways, reconstruction of dikes or a second national airport.

It also conceivable, however, that this weighing extends to the policy sectors of other ministries; finally, budget shifts between ministries also need to be taken into account, particularly where changes in responsibilities are concerned. Traffic safety policy can prove to be much more profitable than other programs also aimed at preventing death and injury, for example in public health, crime prevention and industrial safety. Taking a cross-ministries view is certainly advisable if some traffic safety measures are to be implemented by a ministry other than that for Transport; this happens in many countries including the Netherlands. The Ministry of Justice is primarily responsible for enforcing traffic regulations by the police and the courts. Traffic instruction at school is the task of the Ministry of Education. Looking at the profitability of alternative projects at these ministries and their budget restrictions is therefore unavoidable; otherwise the Ministry of Transport runs the risk that measures included in its traffic safety plan, despite their efficiency will not be implemented by other ministries primarily responsible for them.

The result of a CBA is that alternative expenditures for traffic safety are selected using their BCR value (all those with a value less than 1 are dropped) and then ranked. Those with the highest values, within the limits of the available budget, can be considered for implementation. The budget restriction applies to each ministry where the measures are part of the responsibilities. In theory this can lead to a situation where a high-scoring measure falling under ministry A is not implemented because of a lack of available resources, whilst ministry B does have these provisions. The foregoing research results in an optimum package of traffic safety measures with a certain cost and benefit. Thus the total budget for traffic safety policy is established.

In this respect, reference should be made to the quantitative target setting that is often used in current development of traffic safety policy. This indicates the reduction in the number of victims to be achieved in the target year, expressed as a percentage of the number of victims in a reference year (usually just before the year in which the policy plan was established). This target setting is determined on political grounds, even before decisions are made regarding the policy's content and budget. It even has to give some direction to these decisions. Politicians impose on themselves the obligation to compose a package of measures that reaches these targets. It is assumed that the most efficient measures are selected using a CEA (see below). In this way the level of resources needed is determined as well. In other words, target-setting implicitly determines the traffic safety budget. The problem with this approach is that it can lead to a non-optimal allocation of government resources.

The consequence of this method is that the CBR value of an alternative is of no further importance. Measures with a CBR value greater than 1 or even larger than the CBR value of alternatives in other policy sectors can be excluded from the package when pre-selected (and presumably more efficient) measures are considered sufficient to achieve the targets. The target setting then functions as an unintentional budget restriction. Conversely, measures with a CBR value less than 1 can also be added to the package; this is the case when measures with a CBR value greater than 1 do not prove sufficient to achieve targets and policy makers resort to inefficient solutions.

Another problem with this sort of target-setting arises when budget restrictions are enforced as well. The chosen package with which targets will be achieved can prove to be too expensive, meaning that more resources are required than those available. In this scenario targets have to be amended downwards.

All these problems can be overcome if targets are only set after an optimal package of measures (with a CBR value greater than 1) has been drawn up. This is a 'bottom-up' approach rather than 'top-down'. The estimated overall effect of this package in a particular year becomes the target, of which both the feasibility and the affordability are already assured.

Finally, a special complication needs to be mentioned. Sometimes measures that have important side effects on traffic safety are taken in other sectors. An example of a measure with a strong positive effect on traffic safety has been the construction of the motorway network. A sharp increase in public transport fares is another example, this time with a negative effect. These measures cannot be taken into account when developing traffic safety policy since they are meant to solve an entirely different problem. However, awareness of side effects on traffic safety could be promoted in other relevant sectors during decision making processes.

6.2. Set-up of the cost-benefit analysis

A CBA for the entire traffic safety policy sector cannot easily be compared with previously mentioned examples of CBAs (i.e. the one of the second national airport). An important difference is that here a complete policy sector is being evaluated in the form of alternative packages of measures or programs. The assumption is that these programs have been developed, using existing knowledge, with a definite vision on the improvement of road safety. Each alternative program will therefore have a certain internal cohesion and be deemed effective through the combination of measures. The alternatives differ in the composition and/or the extent of the packages.

An evaluation that investigates the costs and benefits of each separate measure has little point. No single measure is meant to be implemented separately, it is always in combination with other related measures. Furthermore, it concerns an assessment of the sector as a whole; a highly detailed evaluation of all the separate elements will exceed its goal.

The following steps can be distinguished in implementing the CBA:

- Estimation of the implementation costs of each program; calculation of the present value based on distribution over time.
- Estimation of the intended effects, i.e. less victims (differentiated by seriousness) and physical damage to vehicles, roads and road facilities; given as a distribution over time.
- Estimate of unintended effects, direct or indirect, each expressed in their own units; similarly given as a distribution over time.
- Assessment of the intended, side and indirect effects in monetary terms; calculation of the present value of the effects based on their distribution over time.
- Calculation of the ratio of the present value of costs and benefits (CBR) (or the IRR).

A number of conditions have to be met to implement these steps: sufficient information about implementation costs and their distribution over time; sufficient knowledge about the extent of the various types of effects and their distribution over time; and an acceptable method for assessment of these effects in monetary terms. One part of these conditions therefore concerns quantifying the effects; another part deals with appraising the effects. Both of these will be looked at in more detail below. Quantifying the program costs in this respect will not be discussed.

6.3. Quantifying effects

Whether there is sufficient information available to quantify effects is mainly determined by the packages being evaluated and the measures that they include. It should be assumed that no research has been done into the effectiveness of the packages put together for this goal, but certainly into a number of the separate measures. The effectiveness of packages therefore has to be assessed on the basis of expert judgement, using knowledge about the effectiveness of individual measures. The distribution of effects over time also has to be estimated in this way.

A complication is that many traffic safety measures are adopted whose direct intended effects do not aim to reduce the risk or seriousness of an accident. This reduction can be a, sometimes highly remote, indirect effect of these measures. This is clear in the following overview of measures that often appear in traffic safety programs:

- People-oriented measures like information, education, training, legislation and enforcement. The direct intended effects consist of certain changes in behaviour (fewer speeding violations, increased seat belt use, changing the speed of approach at junctions, less driving under the influence etc.) or a change in knowledge and attitudes (knowledge of right of way regulations, taking broader risk margins when overtaking etc.).

- Infrastructural measures such as dividing the road network into functional categories and defining construction standards for each category in accordance with its function (e.g. the design of junctions and connections with side roads, the presence of safety constructions). The direct intended effects in this case are usually a reduction in the risk of accident (e.g. measures that inhibit speed) or the seriousness of an accident (like a crash barrier).

- Vehicle-oriented measures like legal requirements for construction and maintenance (e.g. crushable zones, minimum tyre depth, periodic testing) or the presence of safety features (e.g. speed limiters, automatic switch for daytime running lights, seat belts, air bags). The direct intended effects are also a reduction in the risk of accident or the seriousness of this accident when it occurs.

- Post-crash measures like faster alert systems (emergency telephones), faster assistance (helicopter), trauma teams in hospitals. The direct intended effect here is a reduction in the seriousness of the outcome of accidents (timely stabilising of a patient’s condition, faster recovery, fewer long-term consequences).

- Facilitating measures such as the organisation of traffic safety policy (decentralisation of responsibilities to lower management levels), education and information to create the basis for new policy, gathering knowledge (research, monitoring) and distributing existing knowledge amongst professionals. The direct intended effects are more effective and efficient policy management, support for new measures, increase in scientific knowledge and insight, expanding the professional expertise of people preparing policy.

To be able to conduct a CBA, the intended indirect effects of people-oriented and facilitating measures on safety will have to be estimated along with their distribution over time. If it concerns second order effects, this is likely to be successful; the relationship between behaviour and the risk of accident or the seriousness of an accident is well known (driving speed, driving under the influence, seat belt use). With third order effects or higher, this is often no longer possible (organisational changes, changes in the knowledge, opinions and attitudes of motorists and policy makers, increasing scientific knowledge). The effects of this sort of measure will appear as PM items on the cost-benefit balance sheet. If knowledge is available through which it seems that the direct intended effects (and eventual second order effects) will be realised, PM items can be included in the benefits.

The unintended effects, positive or negative, are treated in the same way as intended effects. This can concern increased travelling time (because of the speed limit), less air pollution (idem), reduced mobility (through stricter requirements for a driving licence). These should be expressed in the most appropriate units (seldom or never as the risk or seriousness of an accident). Little research will have been done into most measures, so the chance of PM items is higher. For the same reason (lack of in-depth knowledge) there will be less opportunity to devote attention to unintended indirect effects.

6.4. Appraisal of effects

After quantifying the effects, the project effects matrix can be filled out. Apart from the program costs of each alternative package of measures, three types of effect will appear in the matrix:

- Safety effects; these are changes in the chance of an accident, the seriousness of an accident and of the outcome.

- The intended direct effects that cannot be translated into safety (e.g. increase in knowledge, attitude change, more effective organisation); each is expressed in the most appropriate unit for that effect.

- The unintended effects (e.g. extra travelling time, fewer CO emissions, less movement of cars) are also expressed in appropriate units.

If quantification is not possible, a PM item should be given. It should be indicated as much as possible whether it is a positive or negative item.

In assessing the monetary value of these effects, it is important to establish the changes in people’s welfare the effects would lead to. The problem often encountered will be that one cannot fall back on market prices expressed by consumers as the valuation of that effect. As discussed in section 5.3, there are various ways of solving this problem. What constitutes a suitable method, varies with each effect. Because only the safety effects appear in each CBA of road safety measures, methods of assessing them will be discussed in more detail here. An overview drawn up in connection with the EU-COST 313 project (Alfaro, Chapuis & Fabre, 1994) will be used as the principal source. The treatment of valuation methods in this report has been well summarised by Elvik in connection with SWOV research into the costs and benefits of the Netherlands traffic safety plan; what follows is largely taken from his report of this study (Elvik, 1997).

The intended effects of traffic safety measures consist of reducing the negative consequences of traffic accidents. Reductions in these costs or this damage form the benefits of the measures. The COST report distinguishes 5 main groups of costs as the result of accidents:

- Medical costs.
- Loss of production capacity.
- Loss in ‘quality of life’ (or human value costs).
- Property damage.
- Settlement costs.

Market prices can usually be used in assessing these costs, apart from expressing loss in 'quality of life' as a monetary value.

In the COST report the following methods are given for appraising the different groups of costs:

- The restitution costs method (or recovery costs method).
- The human capital method.
- The willingness-to-pay method.

Table 6 shows which method is recommended for valuation of the respective cost groups.

Table 6. **Recommended valuation methods for accident costs**

Costs group	Deceased victims	Surviving victims
Medical costs	Restitution costs	Restitution costs
Loss of production capacity	Human capital: net loss	Human capital: gross loss
Loss in 'quality of life'	Willingness-to-pay	Willingness-to-pay
Property damage	Restitution costs	Restitution costs
Settlement costs	Restitution costs	Restitution costs

The restitution or recovery costs method determines the extra expenditure caused by accidents (also called direct accident costs). These are determined by current market prices. They include medical costs, costs of physical damage and settlement costs. This method is generally accepted and will not be discussed further here.

The human capital method is generally used to determine the costs of production loss as a result of accidents (also called indirect accident costs).

These costs do not manifest themselves in extra expenditure but in losses in income and production that otherwise would have been realised. In principle, valuations should be made of production losses by victims forming part of the working population, or who carry out unpaid work, but who become unemployed as a result of an accident. It is potential production loss that is actually determined. With the human capital method a distinction is made in the gross and net approach. In the net approach, the value of the lost future consumption by the victim is deducted from the gross production loss; what remains is the value of the lost future production for other members of society. Obviously, this is only applicable to deceased victims since survivors continue consuming. The net method is often heavily criticised, particularly when, in addition to production loss, no account is taken of loss in 'quality of life' for deceased victims.

There is also a general consensus about the method for determining production loss; this will not be discussed further here.

The willingness-to-pay method (WTP) actually includes a number of different methods for assessing loss in 'quality of life'. These are all based on the idea that people are prepared to pay something to reduce the chance that they will die as the result of an accident. People decide to purchase a car that is more or less safe, or to adopt a more or less safe means of transport. Here the costs are weighed against various product qualities, including fatality chances.

One of the approaches for determining the WTP attempts to find out, by interviewing people, how much they are prepared to spare for a certain reduction in fatality risk (value of statistical life). This is called the ‘stated preference’ approach; the so-called ‘contingent valuation method’ is a variation used in many countries (Elvik, 1995). An ETSC study used the results of research in three EU countries (Sweden, Finland and Great Britain) to determine an average value for loss in ‘quality of life’ for the EU (ETSC, 1997).

Another approach attempts to discover the WTP by analysing people's actual spending behaviour, the so-called ‘revealed preference’ approach. For example by wearing safety belts and helmets, or by replacing worn tyres (Elvik, 1995). Payments of premium for life insurance in some professions or branches of sport could be used for this purpose.

The WTP method can be used for both assessing the value of fatality risk and the risk of sustaining a non-fatal injury. The second is less simple than the first and is also done less often. One of the concerns is that unlike fatality risk, assessing a non-fatal injury bears no relation to loss of consumption. Survivors continue to consume. That is why the gross value of production loss for survivors is given in Table 6.

6.5. Conclusion

Quite often not all the conditions for the implementation of a complete CBA will be met. There can easily be effects that cannot be quantified, and quantified effects cannot always be expressed in monetary terms. Lack of knowledge and data are usually the reasons for this. Methodological questions are not generally a problem except in selecting an assessment method for loss in ‘quality of life’ (and some effects that cannot be translated into safety). The principle to include human value costs in CBAs, to be valued with the WTP method, is no longer a point of discussion. The availability of data is an ongoing problem in most countries. This means that one or more PM items in the cost-benefit balance are the rule rather than the exception in CBAs for traffic safety measures.

7. COMPOSITION OF PACKAGES OF MEASURES

In developing a traffic safety policy, the second efficiency question arises when a total budget for this policy sector has been established and concrete measures have to be selected. The question is how an optimal package of measures can be put together within this budget.

Which method should be adopted depends on the way in which the available budget has been established. When this has been done as outlined in Chapter 6, it is no longer necessary to establish the social profitability of alternative expenditure options. In principle this has happened already: the budget is the amount needed to realise a package of measures with a BCR value greater than 1. In doing this, the nature of the measures is established also in general.

They still have to be more concretised. The need for efficiency dictates that the maximum effect is achieved with the budget available, or that the package is realised with a fixed effect and at minimal cost. Since the maximisation of effects is the main issue in implementing traffic safety policy rather than minimising costs, only the first variation will be discussed here.

As a rule, the intended effect of measures on traffic safety will be the only effect on which the majority of measures will be judged. But it is not inconceivable that a particular sub-set of measures will be judged on one or two other effects (mobility or environmental targets for example). In both cases a Cost-Effectiveness Analysis (CEA) is the appropriate evaluation method. With one criterion the CEA results in an E/C value for each of the alternatives investigated. With more criteria the analysis results in a small balance for each alternative with the positive and negative effects. The alternatives can be ranked using the E/C values. Sometimes this can be done with the balances of “several effects” scores but these can have results that allow a number of ranking possibilities.

To conduct a CEA, the implementation costs and the specified effects of the respective measures have to be researched as well as their distribution over time. This is no different from the quantification of costs and effects in a CBA as discussed in paragraph 6.3 (albeit that the evaluation is often focused on several effects). This means that just as with a CBA, the safety effect (changes in accident risk, seriousness and outcome) cannot always be established for every measure but that sometimes PM items have to suffice.

With the above, it was assumed that the total traffic safety budget was established using a CBA. This is not always necessarily the case. It is not unheard of that budgets are divided up according to pre-existing relationships or through political negotiation. It has already been discussed above (in section 6.1) that this happens, albeit implicitly, when target setting is established in a ‘top-down’ fashion.

When a decision about the total budget has been made in this way, nothing is yet known about the potential content of the packages of measures and their social benefits. This is a good enough reason to look at the social benefits of alternative expenditure options when putting together the packages of measures. Otherwise there is the risk of spending the budget on unprofitable measures.

This means that one cannot be satisfied with just a CEA of the alternative measures but that a CBA is the appropriate method for evaluation. In principle, this should be carried out in the same way described in Chapter 6.

In this instance however, a CBAs usefulness is more limited since the total traffic safety budget has already been established. In theory the evaluation can lead to the conclusion that there are not enough profitable measures to use up the entire budget. The question then is whether one will decide not to spend the entire available budget or use the rest on unprofitable measures.

On the other hand, the evaluation could reveal also that profitable measures are more than sufficient, more than the available budget allows. Strictly speaking, there is little point in finding out how large the budget would have to be to implement all profitable measures. The question is whether people are still prepared to discuss the fixed budget and to extend it, during this stage of policy development.

It is worth mentioning the ‘1 Million ECU (now called the Euro) test’ here. This was introduced by the European Commission to help select measures (1997). The test implies that a measure can be considered for implementation when for every million Euros (approximately 2.2 million guilders) invested, at least one death is prevented. This amount takes into account the economic damage (not the loss of human value) of a deceased person, and also a certain proportion of the damage resulting from (serious) injury and from accidents with only material damage (based on the statistical fact that, on average, for every prevented fatality there will also be a number of accidents with injuries and an even greater number of accidents with only material damage). On the one hand the ‘1 million Euro test’ is a BCR criterion that fits with a CBA, but on the other, only the effect on traffic safety is evaluated. In that respect the test fits more with a CEA.

8. CONCLUSIONS AND RECOMMENDATIONS

There are various reasons why the government intervenes in the market for traffic and traffic safety. These are particularly related to attempts to allocate production resources more efficiently. Sometimes the motive here is to promote a more just distribution of the adverse effects of traffic accidents. Furthermore the government can make its allocation policy in this sector partly instrumental in achieving a more just distribution of income. For this reason people are sometimes interested in the distribution of the effects of measures across different income groups.

Two methods are available for assessing the efficiency of measures, the Cost-benefit Analysis (CBA) and the Cost-Effectiveness Analysis (CEA). There is little disagreement about their methodology and they are regularly applied in many areas of government policy. A CBA can be used to establish the social profitability of a package of traffic safety measures (or of an individual measure); whereas a CEA determines, amongst other things, how a fixed budget can be spent on measures in a way that maximises safety effects.

Both monetary evaluation methods have a number of limitations, both fundamentally and in practice. A fundamental limitation of both methods (at least of the 'classic' Paretian variations discussed here) is that considerations of justice by the decision-maker are not taken into account. Another fundamental limitation is that in a CEA where multiple assessment criteria (effects) are involved, no one-dimensional C/E value can be calculated. Practical limitations are that there is often insufficient information to quantify all the effects and (in a CBA) to assess the monetary values of all the effects. Additional analyses can partly meet these limitations: an analysis of redistribution demonstrates to whom the costs and benefits accrue; a sensitivity analysis tests the solidity of the estimated effects.

All these general limitations come to light in the monetary evaluation of traffic safety policy. Also the outcomes of the additional analyses often don’t make it possible to make a clear decision about the most efficient measures (packages). There is no solution to this problem where determining the social profitability of a measure (or package of measures) using a CBA is concerned. One has to come to the best possible conclusion about the profitability based on those effects that are assessed in monetary terms. When the PM items happen to be distributed in a ‘favourable’ way, this can provide a satisfactory result. When the effects of measures (or packages of measures) are very uncertain, various scenarios can be evaluated.

When it concerns the ranking of projects within a given budget however, a solution can partly be offered by combining CEA with techniques that are part of non-monetary evaluation methods. The Score Card method and the Goals Achievement Matrix are examples of these. This combined method produces a ranking order of projects derived from the decision-maker's preferences but it cannot prevent the selection of inefficient measures. Uncertain effects can be dealt with by designing alternative scenarios.

Non-monetary methods can offer a certain solution to the following problems:

- Considerations of justice with respect to distribution effects: a weighting factor can be established for each income group with which the effects for each can be weighed (as happens with the GAM method).
- Quantified but not appraised effects on a cost-benefit balance sheet: can be processed in a similar way as with a CEA or the GAM method.
- Quantified effects on several criteria in a CEA: can be processed in the same way as with the GAM method.
- Non-quantified effects on a cost-benefit balance sheet or in a CEA with several criteria: can be processed in a similar way to the Score Card method.

In the worst case, the outcome of an evaluation that was designed as a CBA or CEA therefore could resemble more a Score Card.

It has to be concluded that at present the efficiency question can only be answered in a limited way using the appropriate evaluation methods.

Still it is recommendable that decisions on the total road safety budget and the composition of packages of countermeasures be taken after an explicit comparison of costs and effects. These can usefully be supported by each of the aforementioned methods (including the Score Card method). The theoretical model of CBA offers the best design to evaluate these decisions: a method to assess systematically the social advantages and disadvantages, and to process this information (e.g. taking into account time preference and avoiding double-counting and transfers). Analyses of redistribution and sensitivity are useful supplements. The feasibility of the CBA will depend on the available data in each case and on the resources (time, manpower, money) provided for the research. The result could resemble a CEA, a GAM or a Score Card.

Further research is needed to expand the possibilities for future CBAs or CEAs on these matters. Therefore, priority should be given to research into the following subjects:

- The direct effects of traffic safety measures; intended effects (on safety) and frequent side effects (particularly on mobility).
- The indirect effects of much-used people-oriented measures (education and enforcement) on traffic safety.
- Assessment methods for ‘quality of life’ and data collection with those amongst population groups.

Obviously increasing knowledge on the direct or indirect effects will improve also the quality of non-monetary evaluations by the GAM and Score Card method.

Finally, it should be realised that the final choice always falls to those who bear the political or administrative responsibility for the decision being taken. The use of evaluation methods will provide information which supports the making and justification of decisions. Considerations which are in themselves perfectly legitimate but which are separate from the information provided by the evaluation study may lead to decisions other than those suggested by the results of the study.

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SUMMARY

This paper reviews the development and use of the monetary valuation of road safety in Great Britain. The most important component of the benefit of improving road safety is the prevention of casualties. The valuation of the prevention of casualties is based on the ‘willingness to pay’ approach, which was adopted for the prevention of fatalities in 1988 and for injuries in 1992. The major applications of monetary valuations of road safety are first in the general appraisal of new or improved roads, and secondly in the appraisal of specific road safety measures. Road casualty valuations are also sometimes used as benchmarks in other contexts, such as other transport modes and in industrial safety. Accident savings are an important but minority component of the benefits of new or improved roads; however, specific road accident remedial measures bring exceptionally high rates of return, typically paying for themselves in accident savings in less than a year.

1. INTRODUCTION

The transport of persons and goods by road is an essential element of modern society. At the same time such transport carries one of the highest risks of accidents of any everyday activity. Safety is therefore a very important aspect of planning for road transport.

However, although safety is important, other aims of road planning are important as well, notably the efficiency and environmental impact of road use. Achieving an appropriate balance between all three is an important aim of transport policy.

This balance may be struck informally on the basis of judgement and experience. The disadvantages of informal judgements are that they are not open to scrutiny, and that different judgements may be inconsistent, with the result that resources may not be as efficiently used as they might be.

In order to overcome these disadvantages, there is a long tradition in the use of monetary valuations in the appraisal of road investment. This tradition covers both general investment in roads, and in projects specifically aimed at improving safety. Monetary valuations make it possible to compare the value of the benefits of road improvements and road safety measures with their costs, and to identify those measures which give best value for money.

This paper aims to review the use of such methods in Great Britain. The paper continues as follows. Section 2 considers methods for valuing the prevention of road accidents and casualties. Section 3 considers the current and past valuations in Great Britain. Section 4 discusses how these valuations are used in the appraisal of new road projects and road safety projects, and - briefly - the use of the road valuations in other contexts. Section 5 is the conclusion.

2. METHODS FOR VALUING THE PREVENTION OF ACCIDENTS AND CASUALTIES

2.1. Accidents

Road accidents have several kinds of adverse effects. The most important of these is human death and injury, but accidents also cause damage to property and disruption to other road users, and they incur medical, ambulance, police and insurance administration costs.

The largest components of these losses are those stemming from human casualties, that is fatalities and injuries. Casualties are classified by severity (fatal, serious injury and slight injury), and average values are estimated for the prevention of each class of casualty.

Accidents are also classified by severity: the severity of an accident is defined to be the severity of the most severe casualty in the accident. The losses in an accident of any given severity are on average greater that the losses due to a single casualty of the same type. This is first because injury accidents on average involve more than one casualty, and secondly because there are also costs specific to accidents rather than casualties. The accident-specific losses are police and insurance administration costs, and damage.

The value of the casualties dominates the total accident loss in all types of injury accidents, but since damage-only accidents are far more numerous than injury accidents, damage contributes a material amount to the total losses from road accidents. Further details for Great Britain are given in section 3.

In so far as the losses from accidents involve marketed resources, their values can be estimated from market prices. Thus, for example, the value of property damage can be estimated from the cost either of repairing the damage or of replacing lost assets if they are damaged beyond repair. Similarly, the value of medical, ambulance, police and insurance administration costs of accidents can be estimated from the costs of providing these services.

2.2. Casualties

As noted above, the principal losses in road accidents stem from human fatalities and injuries, and the main component of these losses is the loss of life or injury suffered personally by the victim, and the pain and grief of the victim and the victim's relatives. The value of these losses is *not* observable in market transactions. It is true that part of the losses take the form of gross lost output of the casualties, which can be valued from economic data, but those losses are typically only a third of the total. Therefore a different method is needed for valuing casualties.

In the past, casualties were valued primarily by estimating the value of the output lost by their occurrence, which is the so-called 'human capital' approach. However, the major objection to the human capital approach is that most people do not value their life primarily for its contribution to output, but because it has intrinsic value to them and to their relatives. Therefore, most economists believe that valuations should be based the preferences of those who benefit from safety measures and who also pay for them, either directly or through taxation. These preferences are measured by the amounts that people are willing to pay to reduce the risk of death and injury, which is the so-called 'willingness to pay' (WTP) approach. Many countries, including Great Britain, now adopt that approach in their official valuations of road casualties.

The valuations of preventing fatalities and injuries that emerge from the WTP approach are typically much larger than those emerging from the human capital approach. Alfaro *et al.* (1994) review methods used in Europe, and Elvik (1995) provides a review of the valuations in 20 countries, some of which used the WTP approach, and some the human capital.

It should be noted that the valuations of preventing fatalities or injuries are not the value of any particular person's life or freedom from injury, but the sums of the valuations of small reductions in risk to a large number of people that can be expected on average to save one life or one specified type of injury. Thus it represents the amounts that people, or society, would be willing to pay for safety measures to reduce risk before the event. There is no presumption that the WTP value represents what should be paid in compensation for death or injury after the event. Indeed, it is reasonable to presume that there is no conceivable way of making good the loss of life once a particular person has been killed; any compensation that may be paid to relatives is at best a palliative.

2.3. The willingness-to-pay approach

Consider a road safety measure that is expected to reduce the number of deaths by n over a specified time among a large population of size P. Suppose that on average each member of the population is willing to pay a sum v for the reduction in risk to themselves. Then the total amount that the whole affected population is willing to pay for the safety measure is vP, and the willingness to pay per fatality prevented is vP/n. Under the WTP principle, this is the value of preventing a fatality (VPF). The same principle also applies to the valuation of personal injuries.

There are two broadly two empirical approaches to estimating WTP values for risk reductions. These are labelled 'revealed preferences' and 'stated preferences' (or 'contingent valuation') respectively. The revealed preference approach involves identifying situations where people do actually trade off money against risk, such as when they may buy safety measures or when they may take more or less risky jobs for more or less wages. The stated preference approach involves asking people more or less directly about their hypothetical willingness to pay for safety measures that give them specified reductions in risk in specified contexts.

The problem with the revealed preference approach is that it presupposes that people are able correctly to estimate the risks they face, and the changes in risk from safety measures or from different types of work. These typically involve small changes in small probabilities, which are notoriously difficult to estimate. A second problem in estimating WTP values from wage rates is that many other factors besides risk influence wages levels, and estimating willingness to pay to reduce risk requires disentangling the effects of risk on wages from all these other influences. A third problem is that some expenditure may have a mixture of safety and non-safety benefits, such as a higher-specification car, and it may be difficult to disentangle the safety component.

The advantage of the stated preference approach is that it is possible to ask questions directly about the trade-off between risk and money, and it is possible to consider a wider and more systematic range of trade-offs than are available in the revealed preference approach. However, it still requires respondents to consider small probabilities, and it requires people to consider the value to them of small reductions in risk. Experience has shown that people find it difficult to differentiate between a reduction in risk of, say, 1 in 100 000 and a reduction in risk of, say, 1 in 50 000, and they also find to difficult to value such reductions. Therefore they tend to state the same willingness to pay for small reductions in risk irrespective of their precise size, with the result that the implied valuation of preventing casualties depends to some extent on what question is asked; if the same absolute answer is given for the willingness to pay for the different risk reductions above, the implied valuation of preventing casualties is twice as great in one case as in the other. Moreover, even when the answers are carefully considered, they are necessarily hypothetical.

Although the great majority of the losses from a person's death or injury fall on the victims and their relatives themselves, a small proportion of the loss falls on the rest of society. Since losses to society are not borne by the victims, they are presumed not to be included in peoples' willingness to pay to reduce risk. In Great Britain, these external losses are presumed to have two elements:

1. medical and ambulance costs;
2. net lost output.

The second element above is the difference between the average discounted gross-of-tax lifetime output of people at risk, and their average discounted consumption, typically a relatively small positive figure. This difference accrues to society as a whole.

Let the total value of preventing a specified type of casualty be *V*. Let the willingness to pay component be *W*; let the lost net output be *N*; let medical and ambulance costs be *M*. Then, from the discussion above,

$$V = W + N + M \qquad (1)$$

Let gross discounted lost lifetime output be *O*, and let discounted lost consumption be *C*. Then

$$N = O - C \qquad (2)$$

Substituting for *N* from (2) in (1) gives

$$V = W + (O - C) + M = (W - C) + O + M \qquad (3)$$

Finally, it is conventional to define (*W* - *C*) as the 'human losses' from casualties, say *H*. Then

$$V = H + O + M \qquad (4)$$

Thus the total valuation of a casualty of a specified type can be subdivided into 'human losses', *H*, lost output, *O*, and medical costs, *M*. The human losses represent the value of the loss of enjoyment of life or health of the victim, and the pain, grief and suffering of the victim and the victim's relatives. It may be noted that these are not measured directly, but are inferred from the WTP valuation, *W*, and gross and net output. The main use of the breakdown in equation (4) is that it enables WTP-based valuations to be compared with valuations from 'human capital' approach, in which the main empirically estimated losses from casualties are the components *O* and *M*; a more or less arbitrary amount *H* is then sometimes added. The components of equation (4) for Great Britain are given in section 3.4.

3. VALUATIONS FOR GREAT BRITAIN

3.1. Introduction

Official valuations of casualties have been in used in Great Britain since the late 1960s. As in many countries, the original valuations were based on lost output or the `human capital' approach, but Great Britain switched to the WTP approach for valuing fatalities from 1988. After further research, the switch to the WTP approach for valuing injuries was made from 1992.

3.2. Development of valuation of preventing a fatality (VPF)

Britain accepted the theoretical argument for the WTP approach some years before actually adopting it; indeed it was recommended in a review of the appraisal of road projects as early as 1977 (Advisory Committee on Trunk Road Assessment, 1977). As part of the preparation for the adoption of the WTP approach, the Department of Transport commissioned a contingent valuation survey to estimate the value of preventing fatalities (Jones-Lee *et al*, 1985), and also a review of values from other sources (Dalvi, 1988). Both the survey and the review indicated a wide range of defensible values: about £0.5 to £1.0 million at 1985 prices. In the end, the Department adopted a value at the lower end of this range: £0.5 million, which was itself about twice the pre-existing value of £252 500 at 1985 prices, based on lost output (Dalvi, 1988). The reason for the choice of a relatively low value from the defensible range was mainly to avoid too great a change from the then existing value.

For the first year of use of the WTP valuation in 1988, the new 1985 value of £500 000 was raised in proportion to the rise in the index of average gross domestic product (GDP) per capita, to give a value in 1988 of £551 600, equivalent to about £827 000 at 1998 prices. Since then, the value has been indexed to the rise in GDP per capita, on the assumption the people's willingness to pay to reduce risk increases in proportion to their real income. The values are normally recalculated and published each year (Department of the Environment, Transport and the Regions (DETR), annual publication).

Table 1. **Valuations of prevention of road casualties: Great Britain, 1985-98**

Year	**Valuation of preventing casualties at constant 1998 prices (£)**				**Indices of valuations at constant prices (1985=100)**			
	Fatal	**Serious**	**Slight**	**Average**	**Fatal**	**Serious**	**Slight**	**Average**
1985	435 000	23 300	483	12 600	100	100	100	100
1988	827 000	25 100	510	18 300	190	108	106	145
1989	849 000	25 700	530	18 500	195	111	110	147
1990	862 000	26 100	531	18 200	198	112	110	144
1992	835 000	86 900	7 090	31 000	192	374	1 470	245
1993	845 000	95 700	7 420	30 800	194	411	1 538	244
1994	877 000	100 000	7 740	31 400	202	430	1 604	249
1995	886 000	101 000	7 820	31 700	204	434	1 621	251
1996	895 000	102 000	7 900	30 900	206	439	1 637	245
1997	926 000	105 600	8 180	31 000	213	454	1 695	245
1998	1 047 240	117 670	9 070	33 630	241	506	1 879	266

Source: Calculated by author from Department of the Environment, Transport and the Regions (annual publication, Table 1); Dalvi (1988); and the GDP deflator.

Table 1 gives the valuations for preventing fatalities and injuries over the period 1985 to 1998 at constant 1998 prices, calculated by this author using the GDP deflator to convert values for earlier years to 1998 prices. The table also gives real price indices with 1985=100. The almost doubling in real terms of the value of preventing a fatal injury between 1985 and 1988 can be seen, followed by slight further real increases in the mid-1990s, as real GDP per capita tended to rise.

By 1996, the value in current prices had risen to £847 580, equivalent to £895 000 at 1998 prices. In the late 1990s, the then Department of Transport joined a consortium of government departments, including the Health and Safety Executive, the Home Office and the Treasury, to commission further contingent valuation surveys to re-estimate VPFs for road accidents, and also to explore whether different VPFs should apply to other types of risk, specifically fatalities in railway accidents and domestic fires. The method for road accident valuations was refined from earlier studies to avoid some of the difficulties respondents encounter in contemplating small probabilities of serious risks (Chilton *et al*, 1998). The researchers inserted an intermediate step of asking respondents first to consider their willingness to pay to avoid the certainty of specific injuries, and then to rate the risk of that injury against the risk of death.

For road accidents the conclusion was:

"Thus, all things considered, any figure in the range £750 000 to £1 250 000 (at 1996 prices) could be regarded as being broadly acceptable. This range clearly encompasses the current DETR value of about £850 000, so that the research reported in this article provides a broad endorsement of the DETR figure and no change in the latter is recommended" (Chilton *et al.*, 1998, page 33).

In the event, for their 1998 update of the road VPF the DETR decided to move the value somewhat nearer the centre of that range and raised the value in real terms by about 10% compared with what it otherwise would have been, so that the latest published value is £1 047 240 at 1998 prices. This value is shown in Table 1. It can be seen that cumulative effect of the various increases since 1985 is to make the real valuation of preventing a fatality about 140% higher in real terms in 1998 than in 1985.

3.3. Development of valuations of preventing injuries

Like the valuation of fatalities, the valuation of serious and slight injuries was originally based on lost output. In 1988, when the WTP approach was adopted for fatalities, there were no research-based WTP values for injuries, so that the valuations of injuries continued to be based on lost output until 1992. However, a research programme aimed at estimating WTP-based values was concluded in 1992, a summary of which is given by O'Reilly and McMahon (1993).

It is even more difficult to design questionnaires to elicit reliable estimates of willingness to pay for the avoidance of injury than it is for fatalities, especially as the category of 'serious injury' covers a wide range of injury from conditions almost 'worse than death' to conditions from which recovery is quick and certain. After experimenting with various approaches, the Department of Transport adopted an interesting method in collaboration with Jones-Lee *et al* (1993), which values injury not in absolute terms, but relative to death, called the 'Standard Gamble' approach. The essence of the approach is the following. Respondents were asked to suppose that they had suffered a specified type of road accident injury, which, if treated in the normal way, would have a given expected medical outcome. They were then asked to suppose that a medical treatment for their injury was available, which, if successful, would return them to their normal state of health, but, if unsuccessful, would kill them. Respondents were then essentially asked to state what level of probability of success of the alternative treatment they would require for them to accept it. From the answers, it is possible to deduce the valuation of the injury under consideration relative to the valuation of a fatality.

As Table 1 shows, the values of preventing injuries were again much higher from the WTP approach than those obtained by the lost output approach. For serious injuries the values, averaged over all the different types of serious injury, turned out to be about 11 per cent of that of a fatality; for slight injuries, the value was about was 0.9 per cent of that of a fatality. The switch to the WTP approach in 1992 therefore led to the real value of preventing a serious injury being increased by a factor of about 3.3, and that of preventing a slight casualty being increased a factor of about 13. Other increases, including the smaller jump in 1998, mean that the real valuation of a serious injury was about five times greater in real terms in 1998 than in 1985, and the valuation of a slight injury was about 19 times greater.

Nevertheless, the increase in the average value of all casualties (fatal, serious and slight) was not as great between 1985 and 1998 as the increases in each separate type of casualty might suggest. This is because the numbers of killed and seriously injured casualties have fallen faster than slight casualties, so that on average casualties have become less severe: the proportion of all reported casualties that were fatal and serious fell from 24 per cent in 1985 to 14 per cent in 1998. The overall average value of preventing all types of casualty increased in real terms by a factor of about 2.7 between 1985 and 1998.

3.4. Valuations of casualties: 1998

Table 2 gives the numbers of reported fatal, serious and slight casualties in 1998, together with the WTP-based valuations of each category, and the average over all casualties. The total values, *V*, are the same as those shown in Table 1 for 1998.

Table 2. **Average valuation of prevention of road casualties: Great Britain: 1998**

Type of casualty	**Number of casualties 1998**	**Element of value per casualty (£)**			
		Human losses, *H*	**Lost output, *O***	**Medical, *M***	**Total, *V***
Fatal	3 241	686 620	360 000	620	1 047 240
Serious	40 834	95 410	13 860	8 400	117 670
Slight	280 957	6 980	1 470	620	9 070
Average, all casualties		25 240	6 790	1 600	33 630

Source: Department of the Environment, Transport and the Regions (annual publication, 1999 edition, Table 3). Components do not always sum exactly to totals due to rounding.

Table 2 shows the breakdown of the values *V* into their components *H*, *O* and *M*, given by equation (4). As noted in section 2.3, the human losses, *H*, are not observed or estimated directly, but deduced from the estimated WTP value by subtracting the discounted present value of future consumption averaged over all the population at risk. Lost output, *O*, is the discounted present value of output averaged over all the population at risk. Medical and ambulance costs, *M*, are estimated directly from accident data.

It will be seen that for each type of casualty, the human losses account for the majority of the value; for the average casualty, the human losses account for 75 per cent of the total; lost output accounts for 20 per cent; and medical and ambulance costs account for 5 per cent. This implies that the personal loss of life and health from road accidents far outweighs the output losses and other direct economic costs.

3.5. Valuations of accidents: 1998

As noted in section 2.1, accidents are classified as fatal, serious, slight or damage-only according to the most serious category of casualty involved. The value of preventing injury accidents of any specified category exceeds that of the value of the corresponding category of casualty, partly because on average accidents involve more than one casualty, and partly because some costs are related to accidents rather than casualties.

Table 3. **Average value of preventing accidents: Great Britain: 1998**
(£ at 1998 prices)

Type of accident	**Casualty-related losses**	**Accident-related costs**		**Total loss per accident**	**Casualty-related as percent of all losses**
		Damage	**Police and administration**		
Injury accidents:					
Fatal	1 199 140	7 120	1 410	1 207	99.3 %
Serious	137 970	3 240	290	670	97.5 %
Slight	11 900	1 920	110	141 490	85.4 %
Average, all injury	45 770	2 180	150	13 940	95.2 %
				48 100	
Damage only	0	1 210	30	1 250	0%
Average loss per injury accident including an allowance for damage-only accidents				66 810	

Source : Department of the Environment, Transport and the Regions (annual publication, 1999 edition, Table 3). Components do not always sum exactly to totals due to rounding.

The first column of figures in Table 3 gives the average casualty-related loss for accidents of each severity in 1998. It will be seen that the average casualty-related loss for each category of accident is about 20 per cent greater than the corresponding value for a casualty in Table 2, because of the fact that some accidents have multiple casualties. The central columns give the non-casualty-related costs, that is damage, police, and administration. In the case of injury accidents, these costs are much smaller than the casualty-related costs, ranging from 0.7 per cent of the total in fatal accidents to 14.6 per cent in slight injury accidents, and averaging 4.8 per cent for all injury accidents.

3.6. Value of preventing all road accidents: 1998

In Great Britain, the reporting of road injury accidents is done through the police. All accidents involving a vehicle on the public highway and causing personal injury are potentially reportable to the police, but there is known to be under-reporting for various reasons. James (1991) estimated that there is no under-reporting of fatal casualties, but 24 per cent of potentially reportable serious casualties and

38 per cent of slight casualties are not reported. Moreover, damage-only accidents are not routinely reported at all. In estimating the overall values of preventing road accidents in Great Britain, an estimate is made of the losses due to damage-only accidents, but the numbers of injury accidents are not adjusted for potential under-reporting. Thus, the values of the prevention of injury accidents are based only on the accidents included in the national accident database.

Table 4 gives estimates of the total valuation of the prevention of road accidents in Great Britain in 1998: the total for all categories of accident, including damage-only accidents, is put at just under £16 000 million at 1998 prices. The values of the losses from injury accidents are obtained by multiplying the accident valuations in Table 3 by the numbers of reported accidents shown in Table 4. As noted above, damage-only accidents are not included in the national road accident database, but it has been estimated from other sources that the number of damage-only accidents was about 3.6 million in 1998 with costs (mostly damage) valued on average at £1 250 per accident. These are included in Table 4.

Table 4. **Total valuation of prevention of road accidents: Great Britain: 1998 (£ million at 1998 prices)**

Type of accident	No. of accidents	Casualty-related losses				Accident-related losses		Total value
		Human losses	Lost output	Medical	Total	Damage	Police and admin-istration	
Injury accidents:								
Fatal	3 137	2 490	1 250	20	3 760	20	5	3 790
Serious	34 633	3 870	570	340	4 780	110	10	4 900
Slight	201 153	1 850	390	160	2 400	390	30	2 810
All	238 923	8 200	2 210	520	10 930	520	40	11 490
Damage only	3 600 000	0	0	0	0	4 340	130	4 470
All accidents	3 800 000	8 200	2 210	520	10 930	4 860	170	15 960

Source: Department of the Environment, Transport and the Regions (annual publication, 1999 edition, Table 5). Components do not always sum exactly to totals due to rounding.

It is interesting that the four main categories of accident - fatal, serious injury, slight injury, and damage-only - each contribute a similar order of magnitude to the total accident losses: fatal accidents account for 24 per cent of the total; serious injury accidents account for 31 per cent; slight injury accidents account for 18 per cent; and damage-only accidents account for 28 per cent. The reason for this is that the numbers of accidents increase by roughly one order of magnitude from one category to the next: thousands of fatal accidents, tens of thousands of serious injuries, hundreds of thousands of slight injuries, and millions of damage-only, while the magnitudes of the valuations move in exactly the opposite direction. Human losses account for about 51 per cent of the total value of preventing accidents, and other casualty-related costs, including lost output, account for another 17 per cent. Damage accounts for about 31 per cent of the total, and police and administration costs about 1 per cent.

Table 3 shows that the average value of preventing injury accidents was £48 100 in 1998. Most local authorities have information on all reported injury accidents in their localities, which they use when estimating the benefits of proposed accident remedial measures. However, such remedial measures also save damage-only accidents, on which local authorities generally have no information, because they are not reported. One way of taking account of the benefits of the saving of damage-only accidents is to presume that in each area they are likely to be saved at national rates *pro-rata* to savings in injury accidents. Thus the values of saving injury accidents can be increased by specified proportions to include an allowance for damage-only accidents. This enhanced valuation was £66 810 per injury accident in 1998, as shown in Table 3. It is this value that local authorities usually use when appraising local road safety measures.

4. USE OF RESULTS

4.1. Introduction

The valuation of accident savings in Britain was originally developed for the purpose of the economic appraisal of projects for new and improved roads using cost benefit analysis (CBA). The same values later also came to be used for appraising road safety measures. Finally, the same values are increasingly also being used for appraising other safety measures, such as for other transport modes, or in non-transport contexts. We discuss these applications in this section.

4.2. Appraisal of projects for new and improved roads

Projects for new or improved roads in Britain are subject to appraisal using cost benefit analysis. A standardised process has been developed over many years, including such features as standard traffic projections, standard speed-flow relationships for different types of road, standard monetary values of travel time savings, and the values of preventing accidents discussed in section 3. These assumptions and parameters are incorporated into various computer programs to calculate costs and benefits of each project, including *COBA* (from COst Benefit Analysis), *URECA* (URban EConomic Appraisal) and *QUADRO* (QUeues And Delays at ROadworks). COBA is published as part of the government's *Design Manual for Roads and Bridges* (Highways Agency *et al*, 1996).

The CBA programs were developed for the appraisal of projects related to the national highway network (so-called ‘trunk roads’), but they are now also applied to many local road projects, because these receive substantial central funding, and the government requires a CBA as a condition of such funding.

Road cost benefit analysis has been subjected to much outside scrutiny over the years, particularly by the Standing Advisory Committee on Trunk Road Appraisal (SACTRA), an outside body of experts. Although it has been repeatedly criticised by pressure groups, and although there are always ways in which it could be improved, the professionals have generally supported both its aims and its various forms of implementation, most recently in a review of the relationship between transport and the general economy (SACTRA, 1999).

Although monetary values of times savings, vehicle operating costs, accident prevention, and the capital and maintenance costs resulting from road projects are incorporated in cost benefit analyses, none of the environmental effects of projects are at present expressed in monetary terms; nor are other objectives of projects, such as transport integration and accessibility. Therefore cost benefit analyses do not reflect the full effects of road projects. However, environmental effects are reported and assessed in a separate Environmental Assessment. Decisions take into account the CBA, the Environmental Assessment, and other objectives, which are now summarised in an 'Appraisal Summary Table' (AST).

The Appraisal Summary Table is part of the 'new approach to appraisal' developed as part of the government's fundamental review of transport policy (DETR, 1998a). This new approach is being used for both central and local government projects. The AST is a one-page summary of the impacts of a project on the Government's five main objectives for transport policy, of which safety is one; the others are related to the environment, economic efficiency, accessibility, and transport integration. The information in the AST is presented so as not to give prominence to any particular objective, or to those benefits that are expressed in monetary terms. The AST does not replace the CBA and Environmental Assessment, but it aims to present the results in a form more accessible to decision-makers.

In 1998, the DETR helpfully published simultaneous ASTs for all 68 of the trunk road projects then in preparation for England (DETR, 1998b), covering their impacts on all five of the government's objectives mentioned above. Not all the projects will actually be built, but it is interesting to note that the sum of the 1994-based present values of the monetary benefits was £5 900 million, and the sum of the present value of the costs on the same basis was £1 900 million, so that the average benefit/cost ratio of the whole programme was 3:2.

Within the total monetary benefits of £5 900 million, £775 million, or 13 per cent of the total, was attributable to accident savings; this was equal to 43 per cent of the cost. Thus, accident savings are a material component of the benefits of trunk road projects, but they represent only a minority of the valued benefits. No similar assembly has been made of the appraisals of local road projects, but the proportion of benefits due to accident savings would probably be higher. As discussed below, local road safety projects typically have much higher benefit/ cost ratios, all of which are attributed to accident savings.

The estimates of accident savings within the government's CBA programs are very detailed. There are separate estimates for the road links and for the road junctions affected by a project. Road links are classified into 15 different types, ranging from dual 4-lane motorways to single-carriageway 2-lane ordinary roads, and most of these are subdivided into those with urban speed limits (30/40 miles/hour) and those with rural speed limits (50-70 miles/hour). The personal injury accident rate per million vehicle-kilometres is based on past national data, and accident savings are then calculated from the expected changes in vehicle-kilometres on each type of link.

Accident frequencies at junctions are based on formulae giving the accident frequencies at each type of junction as a function of the relevant traffic flows on each arm of the junction. These formulae are based on long-term statistical research aimed specifically at deriving them. The CBA programs distinguish 96 types of junction in all, ranging from priority 3-arm junctions between single-carriageway roads in rural areas to signalised 5- or 6-arm junctions involving dual-carriageway roads in urban areas.

4.3. Appraisal of local road safety measures

The second major application of the valuations of preventing accidents is in the appraisal of local road safety measures, usually promoted by local authorities (LAs). LAs have a statutory duty to promote road safety in their areas by all the means at their disposal, including the three 'E's': education, enforcement, and engineering. This requires close co-operation between different departments of LAs and other bodies, particularly education, planning, engineering, and the police. Most LAs produce and publish an annual *road safety plan*, which gives details of the accident performance in their areas, their proposed safety measures for the forthcoming years, and - sometimes - results of previous safety measures.

Under the government's integrated transport policy (DETR, 1998a), LAs now prepare five-year 'local transport plans' setting out their transport strategies, including strategies to improve road safety. The government has recently published new road casualty reduction targets (DETR, 2000), the highlights of which are a reduction of 40 per cent in the number of killed and seriously injured casualties by 2010 compared with the average for 1994-1998, and a reduction of 50 per cent for children. LAs' plans will be judged partly by their contributions to these targets, and the new planning system gives them flexibility as to how they achieve them.

There is no regular summary of the details of LAs' road safety projects. However, there have been occasional surveys, of which the most recent published is Tootill and Mackie (1995). These authors carried out a postal survey of LAs' road safety projects, and also interviews with officials from a sample of 20 LAs. The postal survey provided information about 42 LAs, who together initiated 860 road safety projects, with an average cost per project of £27 000. LAs use previous accident records by which to prioritise projects, and estimate rates of return using the valuations discussed in section 3.

Tootill and Mackie classified the LAs' road safety measures into ten broad groups. These were the following, in decreasing order of cost effectiveness, that is with the group with the lowest average expected of cost per accident saved at the top:

1. general treatment of links, such as signing, marking, surfacing and control of parking;
2. pedestrian facilities;
3. traffic calming on links;
4. treatment of priority junctions;
5. bend improvements;
6. treatment of routes;
7. treatment of signalised junctions;
8. treatment of roundabouts;
9. area-wide traffic calming schemes; and
10. cycle schemes

The remarkable feature of the LAs' road safety projects is their extremely high rates of return. Tootill and Mackie report that the average value of the accident savings predicted in the first year of operation of the projects reported to them was 279 per cent of the cost. However, they note that the rates of return in their report are the rates predicted by LAs, not those found after the event. These predictions might be optimistic. Moreover, it might expected that rates of return from road safety projects will fall over time, as the projects giving the highest returns are implemented first.

A more recent estimate of typical first-year rate of return from local road safety projects is given by the DETR in a 1997 strategy review:

“The Department has monitored the introduction of recent local safety schemes and this is one of the few areas where expenditure is underpinned by a considerable amount of knowledge about costs and benefits. Clear benefits can be shown, with the first-year rate of return of these schemes typically in excess of 150%” [DETR, 1997, para. 34(i)].

Such returns imply that, even if the average project produced benefits over a period of only six or seven years, the value of the accident savings would be 10 times the cost. Alternatively, this result is equivalent to saying that the average *de facto* valuation of casualties is only 1/10 of the nominal values given in section 3; for example, at 1998 prices, the *de facto* valuation of the prevention of a fatality would be not the nominal £1.05 million, but £105 000.

Some more specific illustrations of up-to-date post-implementation evaluations of certain types of local safety projects are provided in the *Road Safety Plan Annual Review 2000* of Cambridgeshire County Council (2000). Quotations from the summary are the following.

“Twelve major traffic calming schemes have been implemented in Cambridgeshire since 1989. The eleven schemes that have been in place for more than twelve months have saved, overall, 32 accidents per year. This represents an annual saving of £2.1 million at 1998 prices. The total cost of these 11 schemes was £1.1 million” (para 9).

“Eight rural priority junctions ... have been converted to roundabouts over the past eight years. ... [The accident reduction] equates to an annual saving of £3.3 million at 1998 prices. The total cost of constructing the eight roundabouts was £4.7 million” (para 10).

“Twenty-three traffic signals were installed, either wholly or partly on accident grounds, between 1990 and 1996, mainly in urban areas. A reduction of 15 accidents per year, representing an annual saving of £1 million at 1998 prices, has been achieved. The total cost of the 23 signal installations was £2 million” (para 11).

The reported costs of the projects are probably based on actual expenditure; they would on average be slightly higher at 1998 prices. Nevertheless, if we continue to assume a very modest 6/7-year life of these projects, the benefit:cost ratios are high; for the three groups of projects above they are 12:1, 5:1 and 3:1 respectively.

Another illustration of high rates of return from small-scale accident remedial measures is given in the British government's recent road safety strategy document (DETR, 2000), in this case for Scottish trunk roads:

“Since 1989 the [Scottish] Accident Investigation and Prevention team has been responsible for more than 550 accident remedial schemes on the trunk road network, cost over £16.9 million. The schemes offer an estimated saving of 600 accidents per year, worth approximately £38.8 million in accident savings and equivalent to a first year rate of return of 229%” (paragraph 5.23).

The conclusion is that there remains a very strong case for investing more resources in local road safety projects.

4.4. Other modes and other types of accident

The DETR valuations of preventing road fatalities are also used in other contexts. It is accepted that the valuation of reducing risks of other types of accident is not necessarily the same as the road value, but the road value is sometimes used as a starting point. Specifically, the Health and Safety Executive (1999), which regulates industrial and railway safety, has begun to take the road valuation as a "benchmark" when such valuations are needed.

More specifically, from the early 1990s the railways in Britain adopted the road valuation of preventing a fatality for the purpose of appraising safety measures aimed at reducing personal accidents such as falls from platforms, which are argued to be similar to road accidents. However, the railways adopt a value about three times greater for fatalities in train accidents (Railtrack, 2000). Even with this higher valuation, the proposed Automatic Train Protection system was judged to be 'not reasonably practicable' in 1995, because it was estimated to cost £11 million per fatality prevented, compared with a current valuation of £2 million.

Ironically, the use by the railways of valuations of preventing fatalities is now better known to the public than the routine use of such valuations over a much longer time period in appraising road safety measures. Their use by the railways prompted much public discussion of their ethics. The fact that the *de facto* valuations in road safety are much lower than those on the railways is still not widely understood.

One important difference between road and rail applications of casualty valuations is that the railways are under a legal obligation to implement all safety measures whose cost is less than the valuation of the casualties prevented, but the road authorities are apparently under no such obligation.

5. CONCLUSIONS

The appraisal of the prevention of road accidents in monetary terms is well established both as part of the appraisal of road investment in general and of road safety measures.

The most important components of the value of preventing road accidents are the values of preventing casualties of all types: fatal, serious and slight. Such values have been in routine use in Great Britain since the 1960s, but the methods of valuation and the values themselves have changed substantially over that period. The current approach is the so-called 'willingness to pay' (WTP), under which the values of preventing both fatal and non-fatal injuries are based on evidence concerning people's willingness to pay to reduce the risk of these injuries.

Over the long term, the valuations of preventing all categories of injuries have been raised substantially in real terms, largely as a result of adopting the WTP approach to valuation. The current British valuation of preventing a road fatality is about £1.05 million at 1998 prices; this figure is about 140 per cent greater in real terms than the corresponding figure being used in 1985. The real value of preventing the average personal injury accident has gone up by about 170 per cent over the same period. The valuations of injuries have gone up by greater proportions than this, but this has been counterbalanced to some extent by the fact that accidents have become less severe on average: the proportion of all reported casualties that were fatal and serious fell from 24 per cent in 1985 to 14 per cent in 1998.

In 1998, the value of preventing casualties represented 68 per cent of the benefits of preventing road accidents; of this 68 per cent, 17 per cent represented measurable economic losses - lost output and medical costs, and the remaining 51 was the ‘human cost’. Damage accounted for 31 per cent of the losses due to accidents, and police and administration costs accounted for the remaining 1 per cent.

The major applications of the appraisal of road safety measures are first as part of the general economic appraisal of projects for new or improved roads, and secondly in the appraisal of specific road safety measures. On the first, all major road projects are subject to economic appraisal, covering traffic, vehicle operating costs, time savings, accident savings, maintenance costs and capital costs. In the 68 major national projects recently appraised by the government, accident savings accounted on average for 13 per cent of the measured economic benefits, equivalent to 43 per cent of the costs. Thus accident savings are a material benefit of such road projects, but they account for only a minority of all benefits. No comparable analysis has been made of new or improved local roads, but it seems likely that accident savings represent a higher proportion of the benefits.

The striking feature of local road safety projects is their very high cost-effectiveness. In a review published in 1997, the typical benefit from such projects was reported to be 150 per cent of the cost in the first year alone; even if such measures were effective for only 6/7 years, that implies average benefits that are 10 times the cost. These figures are very high compared with the returns from other uses of the resources.

Because the prevention of road casualties has been valued more systematically and over a longer period than the prevention of other kinds of accidental casualty, the road valuations are often used as benchmarks in other contexts, such as in rail transport and industrial safety.

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SWEDEN

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ABSTRACT

This paper discusses the Swedish experience of developing a method for economic appraisal of road traffic investments where the prospective safety improvements are given explicit monetary values. The Swedish National Road Administration (NRA) is responsible for road maintenance and road construction and for the execution of cost-effective road-construction projects. In developing a method for investment appraisal, which would withstand an economic-theoretical examination, NRA has consulted economists on several occasions. Several major revisions in NRA's way of valuing safety have resulted. For example, the average cost per fatality increased from SEK 4.2 million (about US$0.5 million) in 1985 to SEK 7.4 million (US$0.9 million) in 1989 and to SEK 14.3 million (US$1.7 million) in 1999. This value is currently under debate in light of preliminary results of ongoing research in Sweden.

1. INTRODUCTION

The Swedish National Road Administration (NRA) is responsible for road maintenance and road construction and for the execution of cost-effective road-construction projects. Since the second half of the 1960's, the Swedish NRA has applied more or less conventional social cost-benefit analysis in their framework for investment appraisal. The NRA is the only Swedish authority that makes such capital budgeting on a routine basis, and these are made by order of the Swedish Riksdag and Government.

Within this investment framework, prospective safety improvements are given explicit monetary values. These values are then considered together with other costs and benefits, such as the value of travelling time and changes in vehicle operating costs. In developing a method for investment appraisal that would withstand an economic-theoretical examination, NRA has consulted economists on several occasions which has led to several major revisions of NRA's way of valuing safety. The purpose of this paper is to present the Swedish NRA's measure of the value of safety that is used in their economic appraisals and provide a short historical review of approaches used for valuing life and safety in Sweden. We hope that this can provide readers with some understanding of roughly 20 years of development and improvement in methods for valuing risk and safety in the transport sector. Finally, we will also provide some discussions and suggestions based on experiences from ongoing work.

2. THE SWEDISH NATIONAL ROAD ADMINISTRATION'S VALUE OF SAFETY

The NRA's method for evaluating the effects of new roads and alternative safety measures on traffic safety implies that an average casualty is given an average cost or value. This average cost per casualty is divided into material costs and the cost of risk-reduction per se. The material costs consist of health care costs, lost production, cost of property damage and administration. The cost of risk-reduction per se was initially a measure of how much society is willing to pay on top of the material costs for improved traffic safety. Improved safety implies a reduction in the risk and savings in the costs of casualties. The average cost per casualty aims to be a measure of society's benefits of one casualty avoided.

Casualties are divided into three categories: fatal, severe and light casualty. For a specific investment project, the expected change in the number of each category of casualties is multiplied by the corresponding average cost. The NRA has revised their project evaluation manual for cost-benefit analysis several times. The models used for economic appraisal have been adjusted to incorporate the most recent research findings.

Table 1. **The 1999 version of NRA's valuation of safety**
Average cost per casualty by type of casualty, SEK, 1999 prices

	Material costs (health care costs, net lost production, costs due to property damage and administration)	**Value of risk reduction *per se* (including the value of consumption due to premature death)**	**Average cost per casualty**
Fatality	1 300 000	13 000 000	14 300 000
Severe casualty	600 000	2 000 000	2 600 000
Slight casualty	60 000	90 000	150 000
Property damage only (per accident)	13 000	-	13 000

Source: The Swedish States' Institute for Communication Analysis (1999).

3. THREE APPROACHES USED FOR ESTIMATING CURRENT COSTS PER CASUALTY

The *material costs* are estimated by use of the cost-of-illness approach (COI), see for example Persson (1992). Under this approach the economic costs associated with a disease or injury are divided into two principle categories: direct costs and indirect costs. Direct costs represent the value of resources used for prevention, detection, treatment, rehabilitation and long-term care due to the existence of illness or injuries. Cost estimates are obtained by summing up the expenditures on each category attributable to the disease or injury of interest. Indirect costs represent the value of the goods and services that would have been produced if a person had not fallen ill or been injured. For this valuation the “human capital” approach is used, whereby the estimation of the lost output is based on the wages that could have been earned by individuals if the illness or injury in question had not happened. To estimate costs, observed market prices of goods, services and labour force are used.

The *value of risk-reduction per se* is estimated using the individual willingness-to-pay (WTP) approach. Individual valuations reflect what people would be willing to pay (or sacrifice) to obtain benefits or to avoid costs. Concerning valuation of safety, it is assumed that an individual prefers a low probability of death or injury to a high probability. Then, we can assume that the individual would be willing to sacrifice some of his present income or wealth in order to reduce the probability of death or injury. The WTP approach assumes that individuals are willing to pay for small improvements in their own and others safety. Therefore, an aggregation of these amounts across all individuals affected reflects the overall value of the safety improvement in question. The resulting figure tells us how much the safety improvement is worth to the affected group in relation to other ways of spending their limited resources.

NRA uses the concept of the *value of a statistical life*. As an illustration of the concept, suppose that 100 000 people enjoy a safety improvement that reduces individual probability of death by 1/100 000. The expected number of deaths within that group (during a defined period) is then reduced by one. Thus, the safety improvement can be described as involving the avoidance of one statistical death (or the gain of one statistical life). Now suppose that the affected individuals are willing to pay approximately SEK 130 for the 1/100 000 reduction in the probability of death. The aggregate willingness-to-pay for the safety improvement is then SEK 13.0 million. It should be observed that this is equal to the average willingness to pay SEK 130, divided by the individual risk reduction of 1/100 000. This ratio is defined as the individual’s *marginal rate of substitution, m*, of wealth for risk. Under the willingness-to-pay approach, the value of a statistical life is given by the mean marginal rate of substitution of wealth for risk, calculated over the affected population of individuals.

The traditional measure of medical outcome has been survival. This is not surprising as it is easy to measure and as most people desire to live longer. However, people are also interested in the quality of extra life years. Some might sacrifice a little life expectancy in order to improve their quality of life, while others would be willing to sacrifice quality of life to increase their lifetime. Both life expectancy and quality of life need to be measured. If we had an instrument to measure health or quality of life, we could study the issue of trade-off between life expectancy and quality of life. For example, three years rated at 0.67 would then mean approximately the same value as two years of full health rated at 1.0. Under the concept of *health indexes*, there have been several attempts among economists and other disciplines to find such a composite benefit measure of health.

4. DATA USED FOR ESTIMATING THE CURRENT COSTS PER CASUALTY

All three approaches, i.e. the COI-, the WTP- and the health-index approach, have been used in Sweden to estimate values of safety in the transport sector. The most recent estimates of material costs have used data taken from three different studies. First, information on resources used for hospital care, physician consultations and nurse visits (including rehabilitation physical therapy) have been collected in a 3- to 4- year follow-up study of about 2 000 non-fatal casualties from four hospitals in Sweden, Persson *et al.* (1998). This study also includes information about missed work during the follow-up period of 3 to 4 years after accident occurrence.

Second, information of the use of drugs, medical appliances, transportation services, social services and home care are taken from another study by Cedervall and Persson (1988). This study also includes estimates of indirect costs, i.e. costs for lost production, calculated with information on early retirement and death before retirement age. Third, costs of property damage, insurers' administrative costs and resources used by the police and the courts to investigate accidents are taken from a study from Persson and Vegelius (1995). All these costs have been deflated to 1999 prices with price indexes and composed to reflect average material costs per fatal-, severe- and slight- casualty, Nilsson *et al.* (1999).

The value of risk-reduction per se is estimated from the results of two Swedish studies. The first study is a WTP-study that investigates the relationship between individuals' WTP value and factors like initial risk level, size of the risk reduction, income and age, in a nationwide sample of 1 000 individuals aged 18-74, living in Sweden, Persson and Cedervall (1991). The second study investigated the relationship between individuals' WTP values for a reduced risk of several non-fatal traffic injuries of different degrees of severity, Persson *et al.* (1995). Data for both studies were collected using a postal questionnaire that included background questions, risk perception questions and valuation questions. Both studies used an open-ended WTP-format. In the study by Persson and Cedervall respondents were also asked about their own subjective risk of death due to traffic accidents and the relative risks associated with travelling with different mode of transports. Based on their own subjective risk estimates the subjects were than asked about their WTP for 50, 25 and 10 per cent risk-reductions, respectively.

Like the results of many other empirical investigations, the results from the two surveys produce a variety of estimates of the value of safety and the value of statistical life. However, analysis indicated some important properties of the marginal rate of substitution. One such property is that the marginal WTP was found to be a decreasing function of the size of risk reduction. Consider, for instance, individuals at the baseline risk level of 20/100 000; they were willing to pay SEK 279 for a 10 per cent risk reduction. At the same baseline risk level, the WTP amount was SEK 583 for a 25 per cent risk reduction and SEK 908 for a 50 per cent risk reduction.

For 10, 25 and 50 per cent risk reductions, thus the ratios of the WTP amount and the risk reduction (WTP/risk reduction) at the initial risk level of 20 in 100 000 are SEK 13.9 million, SEK 11.7 million and SEK 9.1 million, respectively. Incremental risk reductions from 10 to 25 per cent and from 25 to 50 per cent would be valued at SEK 9.7 million and SEK 5.3 million, respectively. Furthermore, our empirical findings indicate that the marginal rate of substitution is an increasing and concave function of the size of the risk-reduction.

The results from Persson *et al.*'s (1995) non-fatal WTP study did only produce estimates on the valuation of reducing the risk of a limited number of non-fatal events. Persson *et al.* estimated values for two examples of a serious disabling injury, two examples of a serious temporary injury and one example of a slight injury. The examples of disabling and temporary severe injuries were used to calculate a weighted average of the value of risk reduction for an average serious casualty. To calculate an average value of risk reduction for a slight casualty, distribution of different injuries was considered, Persson and Vegelius (1995).

Information on the distribution of the degree of severity was collected in a specially designed study at Lidköping hospital, Berntman *et al.* (1996). All traffic injuries occurring in 1991 and treated at Lidköping hospital were registered and followed for 3 to 4 years. Patients' loss of health were registered during the follow-up period and measured by use of a health index from the UK, Rosser's three dimensional health index, the Index of Health-related Quality of Life (IHQL), Rosser *et al.* (1993). For the relative valuation, weights were taken from Rosser *et al.*'s study. Valuation of the health states in the IHQL-index, were obtained using standard gamble technique for states of one year's duration. Thus, values of health estimates from a UK survey were combined with Swedish data of health loss due to traffic accidents. The loss of health for an average slight traffic casualty was calculated and compared to the monetary valuation of reducing the risk for a fractured wrist, which was the example of a slight casualty in Persson *et al.*'s (1995) WTP-study. It was shown that the loss of health due to an average slight casualty was only about half as much as much as for a fractured wrist. Therefore, Persson and Vegelius (1995) recommended a valuation of the risk reduction for an average slight casualty to about half of the monetary value of reducing the risk for a fractured wrist estimated in Persson *et al.*'s WTP-study.

5. REVISIONS OF THE SWEDISH NRA'S COSTS PER CASUALTY

NRA has revised their costs per casualty measure to be consistent with the most recent research results. The following table shows the values used in NRA's road investments appraisal.

Table 2. **Costs per casualty in thousand SEK, current prices**

	1985	1990	1993	1997	1999
Fatality	4 200	7 200	12 100	14 200	14 300
Severe injury	600	1 050	2 250	2 600	2 600
Slight injury	40	70	95	150	150
Property damage only	9	12	15	13	13

Source : NRA

Table 3. **Costs per casualty in thousands SEK, 1997 prices**

	1985	1990	1993	1997	1999
Fatality	6 317	8 582	12 225	14 200	14 300
Severe injury	902	1 218	2 273	2 600	2 600
Slight injury	46	781	96	150	150
Property damage only	13	13	15	13	13

Source : NRA

In Table 3 the average costs presented in Table 2 are deflated to 1997 prices using the net price index. Note that the values for fatalities and for severe injuries were increased heavily between 1990 and 1993. During this time the results from the first comprehensive WTP study on risk-reduction in transport sector were published by Persson & Cedervall (1991). The value for slight injuries was upgraded in later years. The revision of the value for slight injuries correlate with the publication of the study on non-fatal injuries by Persson *et al.* (1995) and information from the ongoing study on health care costs and the loss of health from four hospitals in Sweden, published later in Persson *et al.* (1998). Results from these two studies were used in the revision of NRA's valuation of costs per casualty to 1997 prices. Information on expenditures paid by the insurance companies show that the average costs for average property damage have decreased, Persson & Vegelius (1997).

Two of the revisions are interesting generally and should be discussed in more detail. Firstly, we will consider a revision of the values set on avoiding non-fatal casualties related to the corresponding values set on fatalities. The second example deals with the adoption of the value of a statistical life based on the Willingness-to-Pay approach.

Briefly, the NRA's traditional approach to estimating the value of preventing a fatality was based on the costs avoided, i.e. the material costs plus a more or less arbitrary sum to reflect pain, grief and suffering. This extra cost referred to as the *"human value"* was originally equivalent to the discounted present value of the future health-care consumption of a totally disabled individual. It was argued that this amount reflect the resources that society allocates to support these people and, therefore, reflected society's minimum amount assigned to their continued survival. However, results of a study based on the health index approach, Persson (1983), were used by the NRA to reassess the relative severity of different categories of road traffic casualties. The study indicated that the sum of the human value and the cost of lost production of a severe casualty should be increased from about 4 to 10 or 11 percent of the corresponding cost for fatality. According to the same study the corresponding ratio of a minor casualty should be decreased from about 2 to less than 0.5 percent.

On the basis of this study, the NRA increased the human value of a severe casualty 2.5 fold compared to the relative value used for the previous planning period. At the same time the relative weight of the human value of a slight casualty was decreased. There was also new information on the material costs of traffic accident that was considered in the process of NRA's revision of the values. Therefore, the average cost for a severe casualty was only increased from 10.0 to 14.3 percent of the average cost for a fatality.

The result of the NRA's decisions was that accidents involving a high proportion of severe injuries were revalued upwards. In practice, this led to a higher priority for measures to reduce the risk of accidents for pedestrians and cyclists. Building new motorways would also yield great economic benefits as head-on collisions and accidents at road crossings would become less frequent. Efforts to prevent a few severe casualties would now generate more benefits to society than efforts to prevent a large number of minor casualties. Given scarce resources, these changes meant that NRA had to devote fewer resources to things like wildlife fences (which mainly reduce the number of minor casualties).

NRA's second revision that we would discuss in more detail is the revision of the value of a statistical life, partly in 1990 and full in 1993. The NRA's traditional way of estimating the value of a statistical life, before the 1990 revision was to use an indirect approach, Jonsson (1975). A value was estimated on the basis of a trade-off between safety and increased value of travelling time. In 1976, the government maintained a maximum speed limit of 70 kilometres per hour on certain roads. To justify this maximum speed limit, the cost of traffic accidents must be valued at least 50 percent higher than the present material costs, i.e. the sum of health-care costs, gross production, costs due to damage to property and administration.

This extra value was called the human value and set to SEK 1 million for a fatality in 1976 prices. Adjustment for inflation resulted in values of a human life for a fatality of SEK 1.7 million and SEK 3.7 million in 1980 and 1985 prices, respectively (in Table 2, the cost of a fatality in 1985 of SEK 4.2 million includes also a material cost component of SEK 0.5 million). Before the planning period starting in 1990, the NRA considered preliminary results from the Swedish WTP study by Persson and Cedervall, results from a British questionnaire-based study reported in Jones-Lee *et al.* (1983 and 1985), and a review of the literature, Jones-Lee (1985).

NRA decided to abandon their former indirect valuation-based procedure in favour of the WTP approach for the pricing of a statistical life for road risks, NRA (1989). The new value in 1990 prices, was set at SEK 7.4 million, containing material costs of SEK 0.9 million and a value of risk-reduction (including lost consumption) of SEK 6.5 million. The latter value was set 30 percent higher than an ordinary price and income revaluation. As the valuation attached to different non-fatal injuries were based on relative weights in proportion to death, this meant that the absolute valuations of severe and minor injuries were also increased by 30 percent. Later on the Swedish WTP study was published in 1991 and results indicated that the value of a statistical life, estimated with a risk-reduction of the size of 30 percent (the same as the average risk reduction when building new roads), would yield a value of about SEK 12 to SEK 13 million in 1990 prices.

This revaluation had also practical consequences. For example, with a value of a fatal casualty of SEK 7.4 million, it is profitable to build motorways when traffic flows exceed 10 000 vehicles per day. With an increased value of a fatal casualty up to SEK 12 to SEK 13 million, it became profitable to build motorways when traffic flows exceed 7 400 vehicles per day.

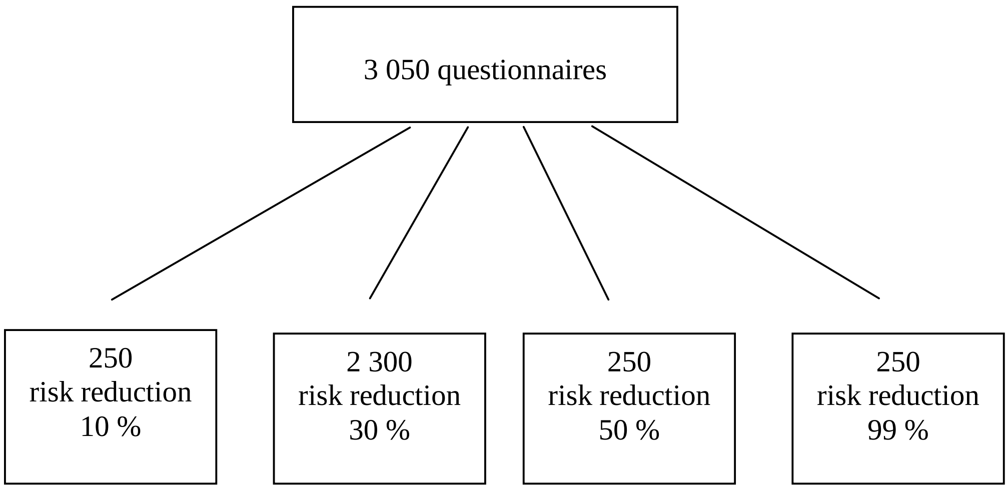
6. ONGOING RESEARCH ON COST OF TRAFFIC ACCIDENTS AND VALUE OF TRANSPORT SAFETY IN SWEDEN

Recently, a new WTP-study was conducted in Sweden, Persson *et al.* (1999). The study used hypothetical questions of WTP in a survey, the so-called contingent valuation (CV) concept. The data was collected using a postal questionnaire sent to 5,650 individuals between the ages 18 and 74. Before conducting the main study, the questionnaires were tested in a focus group and a pilot study was performed including 280 individuals.

The main study, conducted in 1998, was broadly divided into two sets of questionnaires, one with the main purpose of estimating the value of a risk reduction for a *fatal injury*, i.e. the value of a statistical life (VOSL) and one with the main purpose of estimating the value of a risk reduction for *non-fatal injuries*, both in the road traffic sector. The first set was sent to 3 050 individuals and the second set to 2 600 individuals. The division for the first set is described in Figure 1. The first division concerned the size of the risk reduction being valued: 10, 30, 50 or 99 percent. These samples were then further divided into 14 sub-samples to test for different kinds of bias (not shown in the Figure). The second set, valuing non-fatal injuries, was divided in a similar manner into 16 sub-samples.

Individuals in a few sub-samples in the second set valued a risk reduction for a fatal injury in addition to the non-fatal injuries. All individuals in the study (i.e. both sets) were asked about background factors such as gender, age, household income, level of education, etc.

Figure 1. **The value of a risk reduction for a fatal injury**



The sub-samples in the first set were informed of the average annual risk of being killed in a road traffic accident for an individual in his/her 50s, which is 5/100 000. The risk was visualised in a pictorial presentation consisting of 100 000 squares, each illustrating one individual. Five of these squares had been blacked out to represent the number of killed individuals. The respondents were then asked to estimate his/her own baseline risk:

> *In an average year the risk of dying in a traffic accident for an individual in his/her 50s is 5 in 100 000. What do you think of your own annual risk of dying in a traffic accident? Your risk may be higher or lower than average. Consider how often you are exposed to traffic, what distances you travel, your choice of transportation mode and how safely you drive.*
>
> *I think that the risk is ………… in 100 000.*

Then, the individuals in the first set were asked to state how much he/she was willing to pay for a certain reduction in the risk of being killed in a traffic accident. There was a strong demand in trying to avoid showing respondents contributing to a WTP amount for a public good because this could be, just a reflection of a desire to acquire a sense of moral satisfaction, rather than a concern with the actual quantity of the good itself. It was stressed that the safety improvement would take the form of a private good and that the safety improvement was not confounded by any other economic or quality related complications. Therefore, first the individuals were asked to consider the following issues:

- *The risk reduction only affects the risk of being killed in a road traffic accident. The risk of being injured is not affected.*
- *The safety device is not inconvenient, ugly or complicated to wear. Actually, you do not notice it. However, it is only you personally who can benefit from it.*

- *The risk reduction has a duration of just one year. After that time, you must make another payment if you want to continue the risk reduction.*
- *An accident will not have any impact on your financial situation as we assume that all expenditures and financial losses will be covered by the insurance system.*
- *The amount of money that you pay for the risk reduction will leave less money to consume on other goods and services.*

In the main case the willingness to pay referred to a 30 percent risk reduction, while other sub-samples valued risk reductions of 10, 50 or 99 percent. The question on willingness to pay[1] had the following appearance:

> *How much would you at the most be willing-to-pay for reducing by one third your own annual risk of dying in a traffic accident?*
>
> *SEK …………… per year*

In order to stress the importance of the budget constraint the respondents were asked to indicate what current consumption they would reduce in order to afford the (hypothetical) expenditures for the safety device. Examples of categories were listed in the questionnaire.

The second set of questionnaires, for estimating the value of reducing the risk of non-fatal injuries included descriptions of 7 different non-fatal injuries: two types of disabling injuries, two temporary serious injuries and three slight injuries. The initial risks corresponded to the real risks that road-users run. These risks were given in a pictorial representation where the appropriate number of squares had been blacked out on a piece of paper containing 100 000 squares. For the non-fatal casualties, individuals were not asked to estimate their own subjective annual risk in the same way as they were for the risk of death. For each type of injury, the respondents should state their WTP either for a 50 percent or a 30 percent reduction in the initial risk.

7. RESULTS FROM THE NEW SWEDISH CONTINGENT VALUATION (CV) STUDY

Of the 5 650 postal questionnaires sent out, 2 884 were answered. This equals a response rate of 51 per cent. A drop-out questionnaire was sent to those individuals who had not answered the questionnaire or informed us they did not want to participate. The response rate of the drop-out questionnaire was 25 percent. Individuals who answered the main questionnaire had a higher income, higher education and drove/rode in a car more than individuals in the drop-out questionnaire and more than the Swedish average. However, age and availability of a car in the household were about the same. Gender distribution was about the same for the main questionnaire and Sweden as a whole, while women were over-represented in the drop-out questionnaire.

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1. We consider one-third equivalent to a 30 per cent risk reduction.

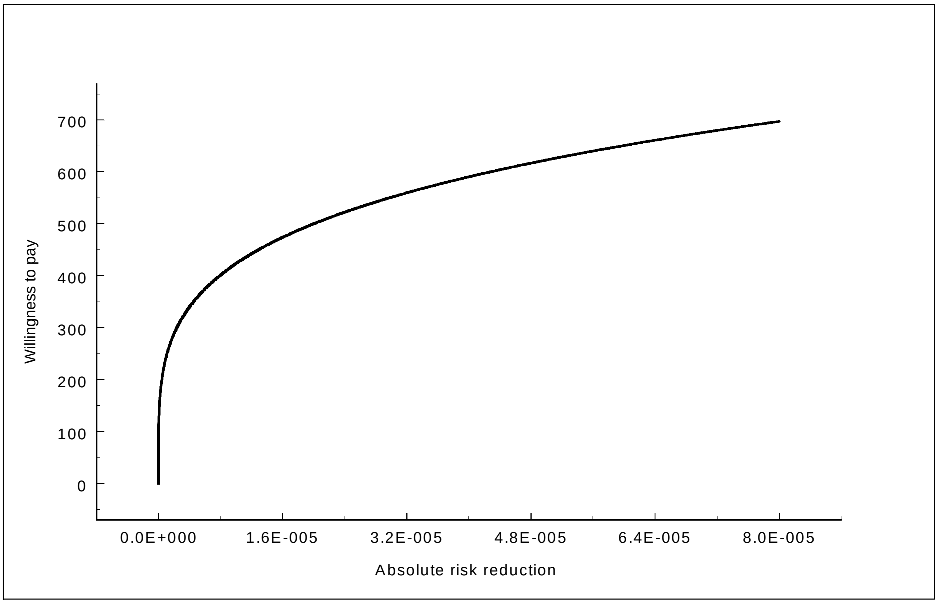
In the groups that valued a 30 percent risk reduction of being killed in a traffic accident, the own estimated baseline risk had a median value of 3/100 000 and a mean value of 11/100 000.

In this CV-study on traffic safety in Sweden, observations from 656 individuals were used to estimate a non-linear relationship between the willingness to pay and the absolute risk reduction. This generated a value of a statistical life in the road traffic sector of SEK 21.8 million (US$2.5 million) (if income adjusted: SEK 20.2 million [US$2.4 million]) at an absolute risk reduction of 2.4/100 000.

To test whether results from WTP-studies comply with expectations from economic theory we performed two simple validity tests. First, higher respondent incomes should be associated with higher WTP. This was confirmed by results from our regression analyses and income elasticity was estimated to about 0.24. Second, risk reduction could be assumed as a desired good and therefore WTP should be positively associated with the magnitude of the risk reduction. Moreover, the more a positively valued good that is supplied by a programme, the greater should the WTP be, although the marginal utility of additional units of benefit is likely to decline. In our case, WTP should not be proportional to the change in probability – assuming decreasing marginal utility. However, WTP should be "nearly" proportional to the change in probability. This second principle has been referred to as the scope test.

From 656 observations a non-linear function was estimated by use of the "minimum absolute deviation" (MAD) method, Figure 2. MAD is different from the ordinary least square (OLS) as the deviations from the mean value in the estimation are not squared in the former, thus extreme values will not have that great an impact on the regression (see Greene, 1997). In order to minimise the influence of out-liers on the WTP estimate, the MAD-method is statistically more appropriate for a material with a dispersion such as ours.

Figure 2. **The relationship between the willingness to pay (WTP) and the absolute risk reduction (N=656, incl. wtp=0, excl. abs.risk.red.=0)**



Source: Persson *et al.* (forthcoming).

The appearance of the non-linear function of this shape, with a steep slope for small risk reductions and a rather less pronounced increase in the WTP values for larger risk reductions, indicates that the respondents, at very small risk reductions, have a disproportionately high WTP. Using the definition of the marginal rate of substitution between income and risk would generate substantial values of statistical lives when the absolute risk reduction is small, and quite lower values of statistical lives when the absolute risk reduction increases. In Table 5 it is illustrated how the estimation of the value of a statistical life is affected by the size of the risk reduction; the value of a statistical life will equal SEK 27.1 million (US$3.2 million) at an absolute risk reduction of 1.8/100 000 and only SEK 12.5 million (US$1.5 million) at the absolute risk reduction of 5/100 000.

Table 5. **The value of a statistical life estimated with the non-linear MAD-model**
SEK 1998, millions (US$ 1998, millions, in brackets, US$1=SEK8.5)

The size of the absolute risk reduction	Δp= 1.8/100 000	Δp= 2.4/100 000	Δp= 5/100 000
Non-linear MAD N=656	27.1 (3.2)	21.8 (2.6)	12.5 (1.5)

Estimated from the relationship between WTP and the absolute risk reduction.
Source: Persson *et al.* (forthcoming).

All values being presented in Table 5 are values of risk reductions or VOSL calculated by using the concept of the value of a statistical life, i.e. the marginal rate of substitution between income and risk is approximated with the WTP divided by the change in initial risk (i.e. the absolute risk reduction). However, the VOSL of SEK 21.8 millions (US$2.6 millions) should be interpreted as an average VOSL only for the individuals responding the questionnaire of this study. As the household income in this study is about 30 percent higher than the Swedish average, the value of a statistical life should be adjusted. Moreover, the income elasticity was found to be 0.24. Thus, the WTP in the CV-study is overestimated by 7 percent (0.3*0.24=0.07) and we adjust the value of a statistical life with the factor 0.93. This results in the income-adjusted value of a statistical life of SEK 20.2 millions (US$2.4 millions).

The values of risk reductions for non-fatal casualties were calculated by using the concept of marginal rate of substitution between income and risk in the same way as for estimating VOSL. The ratio between the marginal rates of substitutions for the different injuries and the VOSL show how the non-fatal injuries are valued in relation to a fatal casualty.

From Table 6, it can be seen that a 30 percent risk-reduction of a serious temporary injury is valued as 0.113 of a 30 percent reduction of a fatal injury. A 30 percent reduction of a slight injury is worth about 1 to 2 percent as much as a 30 percent reduction in the risk of death.

Table 6. **Comparison of valuations of non-fatal injuries with a fatal injury, 30 percent risk-reduction**

Injury	VOSL and Values of risk-reduction for non-fatal injuries, median, SEK million 1998 prices	Valuation of injury in relation to a fatal injury
Death	21.8	1 000
Serious disabling injury: Amputation, needing wheel chair, etc.	8.8	0.404
Serious disabling injury: Fractured thigh-bone, pain, lameness and reduced capacity of moving the arm, etc.	8.8	0.404
Serious temporary injury: Fractured thigh-bone, fully recovered after 12 months	2.9	0.133
Serious temporary injury: Fractured thigh-bone, fully recovered after 6 months	2.9	0.133
Slight injury: Whiplash	0.4	0.018
Slight injury: Fractured wrist	0.4	0.018
Slight injury: Concussion	0.2	0.009

Source: Persson *et al.* (1999).

7.1. Inadequate sensitivity to scale and scope differences in the risk

Findings from the new Swedish CV-study, reported in Persson *et al.* (forthcoming), show that stated WTP seems to be less sensitive to the size of the risk-reduction than expected from economic theory. For example, estimates of VOSL from our regression will be extremely sensitive to the size of the absolute risk reduction. Absolute risk reductions of 5/100 000 produce estimates of VOSL of SEK 12.5 million and for a smaller risk-reduction of 2.4 in 100 000 our risk function will produce VOSL estimates nearly twice as large, i.e. SEK 21.8 million. For smaller levels of risk reductions estimates of VOSL increase even more rapidly.

This insensitivity in the stated WTP for the size of the good being valued might generally be referred to as scale embedding, in contrast to temporal embedding which occurs when respondents do not adequately differentiate between a one-time payment and a series of payment for the item being valued, Stevens *et al.* (1997). Insensitivity to the scenarios being valued has been referred to as scope embedding by Norinder *et al.* (forthcoming publication). Insensitivity to scope or scale as well as to payment schedules, are important and have been observed in several prominent WTP-studies.

For example, the problem has been noticed in Beattie *et al*. (1998), where a corresponding insensitivity to scale and scope in the WTP was found. They reported results from two studies that cast serious doubt on the reliability and validity of WTP-based monetary values of safety using the direct CV approach. In the discussion on their results Beattie *et al.* are concerned about the respondents' absence of experience of explicit money/risk trade-offs for transport safety devices. They thought that "in seeking to decide how much this "good thing" is worth", … "many respondents then report an amount which, if foregone, would not seriously disrupt their normal expenditure and savings patterns, which for many people seems to be a sum in the region of £50-£200 per annum". This amount corresponds to about SEK 675-SEK 2 700 (assuming £1 = SEK 13.5) and is covering most of our estimates for mean and median WTP for reducing the risk for fatal- or non-fatal casualties.

In order to help respondents with the trade-off between money and the risk of death, Carthy *et al.* (1999) tried another approach, breaking the task down into a number of simpler and more manageable steps. They called it a "chained" approach. They tried to forge a link between money and health impairment at a level of less awesome and emotive injury than death and then chain together responses to CV and standard gamble (SG) questions to estimate VOSL. Results from their main study, including data from 167 respondents in the United Kingdom, included more positive features than Beattie *et al.*'s study. For example, Carthy *et al.*'s respondents displayed clear sensitivity to injury severity in their WTP responses. Internal consistency tests show that there is more to be said on this CV/SG "chained" approach before we can have greater confidence in the robustness of the estimates. Carthy *et al.* reports a point estimate of about £1.3 million (US$2.1 million) for the roads VOSL. However, at the end their recommendation to the project's sponsors was that a figure in the region of £1.0 million (US$1.6 million) would be appropriate.

Recently the WTP for health protection and its insensitivity to scale was also discussed in a paper by Hammitt and Graham (1999). They conclude that "research to improve methods for communicating changes in risk is needed, and future studies of stated WTP to reduce risk should include rigorous validity checks".

7.2. Conclusions to be drawn from the new Swedish contingent valuation (CV) study

Preliminary results from this new Swedish WTP-study have been considered in the recent process of revision of the NRA's cost per casualty figures. However, a committee of representatives from NRA and the Swedish States' Institute for Communication Analysis decided to stay with the former values of risk-reduction per se. According to a report from the Swedish States' Institute for Communication Analysis (1999) there were three reasons. First, results indicate large increases in the current figures and there are still some doubts on how reliable the new estimations on VOSL are. Second, additional analysis within the current project is ongoing and should be considered before revisions are made. Third, current values are in accordance with results published in international literature.

From a scientific point of view, study results provided important information of how sensitive WTP amounts in CV studies would be to various magnitudes of risk reductions, sensitivity to scale. As this study involved 30 independent sub-samples we could analyse the sensitivity in WTP to magnitudes of risk when respondents have no chance to check or calculate the right answer. To the author's knowledge, this study is designed and exposed to more reliability and validity tests than any other CV-study in transport safety. However, perhaps the design without reference points for other magnitudes of risks, the split sample and sensitivity tests on WTP amounts involves strong requirements on respondents. We should remember that there are several examples in literature where neither the WTP nor the revealed preference estimates, in real marketing situations, would pass such strong validity tests for scale and/or scope. Stevens *et al.* (1997), refer to a number of research projects, where "implicit discount rates of observed behaviour can vary from negative to several hundred percent per year" This was found for teachers who choose to be paid in 12 as opposed to 9 monthly instalments. Annual discounts rates of hundreds percent have been associated with purchase of electric water heaters, freezers and gas water heaters, respectively.

Our study, also provide some insight on how sensitive WTP is for differences in the scope of risk. For example, we expected a fixed risk reduction for a non-fatal injury with duration of 12 months to yield a higher WTP than the WTP for reducing the risk for the same injury but with a shorter duration of only 6 months. Comparing independent samples indicated a higher WTP for the injury with the longer duration but the difference was not significant. Then comparing WTP amounts from the same individuals (dependent samples) we found significant different valuations for non-fatal casualties of different degrees of severity, indicating that respondents were sensitive to scope.

Concerning WTP for reducing the risks for non-fatal casualties, the design of the study did not permit the same comprehensive test of scale embedding. However, our tests of scope embedding indicate that people have difficulties in separating the relevant risk reduction per se, from changes in risks for other related types of injuries and/or other consequences.

Comparing the results from the new Swedish study with the CV-study prepared 1986/87, by Persson and Cedervall (1991), indicate an overall increase in WTP over time and a decrease in the individuals' subjective estimate of annual risk of death by traffic accidents. Even if we have several indications in our study that WTP amounts are not sensitive enough for scope or scale, and therefore almost certainly suffered from some limitations highlighted in Beatty *et al.* (1998) and Hammitt and Graham (1999) we also found positive features, indicating high level of validity. For example, regression analysis shows clear evidence of a positive relationship between income and WTP and an "inverted-U" life cycle relationship, expected from economic theory.

In summary, we have so much confidence in the estimates that emerge from this CV-study, and related results from ongoing work (not reported in this paper), with the conjoint analysis, the standard gamble- and risk-risk approach, (Trawén *et al.*, 1999), that we would recommend the NRA increase both the VOSL and the values of risk reductions for an average severe and slight casualty. For VOSL, a figure in 1999 prices in the region of SEK 15 million to SEK 20 million (US$1.7 million to US$2.3 million) would be appropriate. An average severe casualty in Sweden seems to be less severe and includes several less severe outcomes than a simple average of the four injury types included in the non-fatal CV-study, Persson *et al.* (1998). A weighted average indicates a valuation of reducing the risk of an average severe casualty by 30 percent to about SEK 3.3 million or about 15 percent of the value for a fatal casualty. For a slight casualty the valuation of a 30 percent risk reduction can be estimated to about SEK 0.3 million or in the region of 1.0 to 1.5 percent of the value for a fatal casualty.

8. SOME SUGGESTIONS FOR FUTURE STUDIES ON THE VALUE OF TRAFFIC SAFETY

Despite all the difficulties with data collection, the CV-approach is aiming to provide an answer to the relevant question, i.e. what is the individual's value of safety *per se* for use in cost-benefit analysis for road traffic investments. Conjoint-analysis or risk-risk analysis, or any other alternative approaches, might not easily solve our problems with scale and scope embedding. Risks of bias due to embedding are appearing also when applying these alternative approaches.

Scale and scope embedding are probably two of the most serious risks of bias when conducting WTP-studies. Effort should be spent in order to avoid scale and scope embedding. Scale embedding is related to the fact that we have relatively small magnitudes of risks for road traffic fatalities, that the respondents' have conceptual problems with such small risks and that they have limited experience of trading-of money for such small risks. Scope embedding is related to the problem of eliminating the influence of all other types of consequences from the consequence we are intended to value. Therefore, outcomes described in terms of changes in probabilities, i.e. risks, should also be as "clean" as possible from all confounding consequences. An approach where trade-of between money and risks can be made for more familiar market transactions and "chained" to fatality risks in further steps, would be desirable, see for example Carthy *et al.*'s (1999) interesting multi-stage approach for estimating the value of statistical life for road risks.

An alternative approach might be to ask the respondents, in a first step, to trade off income to reducing the risk for a composite outcome, including all types of physical transport risks in one single hypothetical market transaction. In a second step, the WTP for the composite outcome should be broken down in its components. However, in that case we will probably see other new conceptual difficulties and problems when creating hypothetical market situations that could be considered as credible by the respondents.

Other alternatives might be to find out what share of the respondents WTP is not related to the change in risk *per se*. How much of the WTP amount should be considered as a charity for something like a "good thing". In our study we found a higher WTP for risk reduction of traffic death than for risk reduction for an overall death risk, Norinder *et al.* (forthcoming). The traffic death WTP-question might be regarded by the respondents as more transparent than the overall death scenario and therefore result in an upward bias. Moreover, there could be a sample selection bias because of the response rate of only 50 percent and/ or a focus bias, since the title of the questionnaire clearly indicated that it concerned risk of traffic accidents.

It could also be interesting to discuss if reference prices *should be used* for providing respondents with information of prices for other safety commodities on the market. For example, in the study by Persson *et al.* (1995), there was a question included in the questionnaire, whether or not the respondent would install an airbag at an annual price of SEK 500 in his/her car. The purpose of including this question was to give an example of a situation in which the respondent behaves as if he/she was on the market. Furthermore, in the early nineties, SEK 500 was a reasonable cost per year (assuming 5 years capitalisation) of such an installation in a new car. In that CV-study we saw the typical right skewed distribution, but it was anchored around a median WTP of SEK 500 and not very widely spread. In CV-studies using open-ended question formats evidence of anchoring bias of the follow-up question has also been found, Hjalte *et al.* (forthcoming). Providing respondents with information of the actual risks for different outcomes seems to be accepted in CV-studies. However, when information of prices for safety are given in CV-studies they are often considered as potential risks for anchoring bias.

Perhaps, it should be accepted, in the same way as for risks, to provide respondents with much more information of real prices, or of annual payments, for risk reductions that already exist in the real market.

At present, no single approach can answer the NRA's question: what is the benefit to society of reducing the risk of death and traffic injuries by building new roads?

Monetary values of safety *per se* for use in cost-benefit analysis of investments in new roads or new safety programs in the road traffic sector should be defined in a way to reflect the preferences for safety of members of the affected population. The CV-approach is one method to analyse the sums that they would individually be willing to pay or to accept as compensation for pre-specified variation in safety. Standard gamble, risk-risk and conjoint analysis are other methods that can and have been used in combination with the CV-method to estimate safety values in the transport sector. Real market transactions can also be used to estimate the trade off value. Implicit value of statistical life has been estimated by analysing prices of new automobiles and their corresponding accident risks (see for example Viscusi, 1993).

The human capital approach has been used in Sweden and in other countries for estimating the value of resources not produced due to short-term illness, early retirement, and death before retirement age. For estimating other resources lost, property damage, administrative costs, health care costs, etc., market prices have been used in Sweden and other countries. A combination of approaches discussed can answer NRA's question. However, under each approach there are several different ways to proceed. None of the approaches discussed in this paper is in itself superior to others. They are not even competing, but rather complementary. However, to answer a precise question, one can argue that one method or a combination of methods is more relevant than others.

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OTHER CONTRIBUTIONS

During the Round Table, several participants submitted written contributions. These contributions are reproduced below as complementary information.

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INTRODUCTION

This paper summaries comments to four invited papers presented at ECMT Round Table 117, economic evaluation of road traffic safety measures, held in Paris on October 26 and 27, 2000. The four papers presented are commented in the following order:

1. Baum and Höhnscheid
2. Wesemann
3. Evans
4. Persson

In preparing the comments, I have chosen to concentrate on two questions:

Is the current theoretical basis for estimating road accident costs satisfactory, or do unresolved problems remain?

Are estimates of road accident costs valid and reliable, or are currently used methods for estimating road accident costs inadequate from a methodological point of view?

1. COMMENTS TO THE PAPER BY BAUM AND HÖHNSCHEID

The paper presents general points of view concerning methods for costing of road accidents and economic valuation of improvements in road safety. Recent estimates of road accident costs in Germany are presented. These estimates are applied to illustrate the costs and benefits of selected road traffic safety measures.

The paper by Baum and Höhnscheid differs from the other papers presented at this Round Table by not endorsing use of the willingness-to-pay approach in order to estimate the economic benefits to society of improving road safety. A distinction is made in the paper between “subjective” and "objective" cost elements. It is argued that cost estimates should be confined to the objective cost elements, because the subjective cost elements cannot be assessed scientifically. The paper argues for relying on "a completely objective process, geared to actual economic losses" when estimating accident costs.

The meaning of the subjective/objective distinction made in the paper is not entirely clear. Economic theory, including welfare theory and demand theory, is ultimately subjectivist in the sense that it applies the concept of utility (satisfaction of preferences) to explain consumer behaviour.

The notion of utility is entirely subjective – it refers to the tastes and preferences of each individual. Different tastes can lead two individuals to make entirely different choices under identical "objective" conditions (same income, same prices, etc). On the other hand, of course, the prices facing the individuals are objective in the usual sense of the word. Moreover, the objections made by Baum and Höhnscheid to surveys designed to elicit the willingness to pay for improving road safety are by and large correct (see my comments below to the paper by Persson). In short, the problem is that there does not exist any unambiguous way of testing the truthfulness of answers given in willingness-to-pay surveys. One might of course opt for revealed preference studies rather than stated preference surveys. However, the problem of not being able to test the validity of a model of the preferences underlying the choices studied is, from an epistemological point of view, more or less the same in revealed preference studies as it is stated preference studies. The "preferences" revealed by actual choices are not necessarily the true preferences of the actor, but may rather reflect an incentive structure that favours choices that are individually, but not collectively, rational.

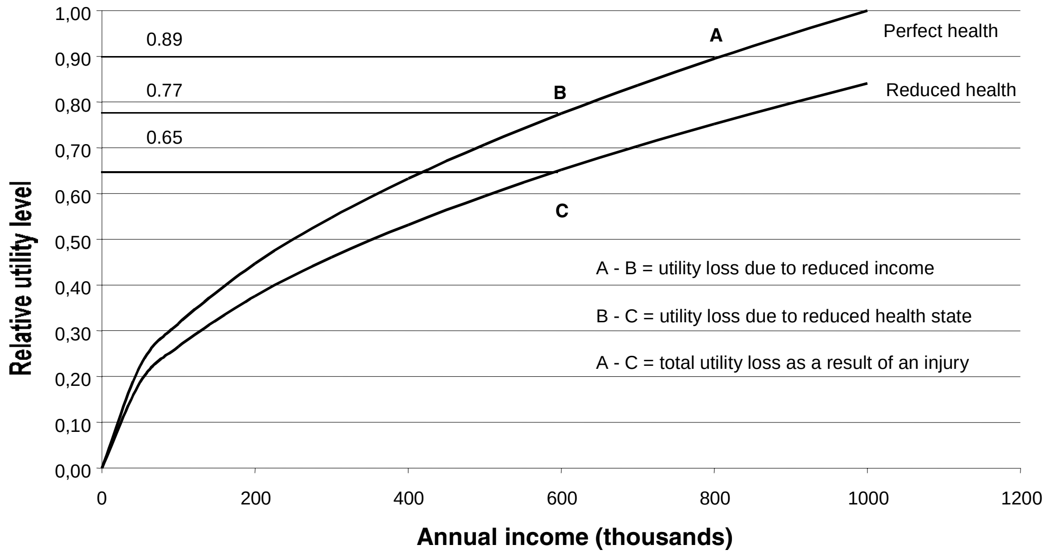
The paper seems to suggest that so called human costs of accidents – losses of welfare in the widest sense – arise only when there are material losses as well. This is evident from the following statement: "Where there is no loss of resources, the human consequences of accidents should not be taken into account in calculating the costs arising from accidents. These mental problems will only be factored in when costs are incurred."

I find this point of view difficult to defend. Surely, a person who is confined to a wheelchair has a reduced level of utility, compared to a healthy person, even if his or her economic wealth is fully maintained. This notion is embodied in the idea of utility functions that depend on health-state. Total utility is assumed to depend both on material wealth and health-state, for example in the form of the following compound utility function:

$$\text{Utility} = W^{0.5}H^{0.25}$$

W is wealth H is health. The exponents indicate the shape of the utility function. It has been assumed, which seems reasonable, that aversion to losses of health is stronger than aversion to pure monetary losses. Figure 1 shows a graph of such a utility function.

Figure 1. **Utility functions that depend on health-state**



Source: Viscusi, W.K. & Evans, W.N., 1990.

The upper curve shows the utility of income in a state of perfect health. The lower curve shows the utility of income in a state of reduced health. If, for example, income is reduced from 800 to 600, utility level is reduced from 0.89 to 0.77. If, in addition to the loss of income, health is impaired, utility is further reduced from 0.77 to 0.65.

These ideas are very basic and are accepted by almost all economists working in the areas of health- and safety economics. It stands to reason that abstract concepts like utility, or even the concept of health, are difficult to measure empirically. However, the theoretical arguments for including a monetary valuation of the loss of utility due to loss of health in road accident costs are compelling. Any estimate of road accident costs that does not include this component is therefore incomplete, and strictly speaking, unsuitable for use in cost-benefit analysis.

The way accident costs are estimated in Germany does not appear to be consistent with the principle of limiting costs to actual economic losses. Firstly, it has been argued that the loss of output due to accidents is limited to the time it takes to find a replacement on the labour market (the "friction cost" method). Hence, an estimate of the present value of these losses for the remaining life expectancy of an accident victim will greatly overstate the actual losses, as recorded in the economy. Secondly, including a valuation of losses in non-marketed household production in the accident costs is also inconsistent with the principle of confining cost estimates to what can be observed in market transactions. It is true that unpaid household work generates utility, which is lost if this kind of work can no longer be carried out, or is carried out at a lower standard. But this effect of accidents is only rarely evident in market transactions (only the very rich can afford to buy household services that they used to do on their own).

Notwithstanding all these critical comments, let me end by fully supporting the plea made in the paper for transparency in data sources and methods used to calculate road accident costs. Any estimate of road accident costs must be easy to understand and check. Otherwise it will lack credibility.

2. COMMENTS TO THE PAPER BY WESEMANN

The paper takes a more macro-oriented approach than the other papers. It contains an interesting discussion of why the market mechanism cannot provide an optimal level of road safety. Moreover, the paper gives a clear description of the roles of cost-benefit analysis and cost-effectiveness analysis in road safety policy making.

I agree with most of the points of view expressed in the paper. In my opinion, there are four main reasons why government intervention is needed to provide an optimal level of road safety from a societal point of view:

- Road users have imperfect knowledge of accident risk, and are likely to underestimate it (very many drivers think that they are better than the average driver).

- The costs of accidents in part external from the road users' point of view, which means that these costs are likely to be disregarded by road users.

- Road safety is to a large extent a pure public good, which means that there are no strong individual incentives to produce it. As an example, a driver who keeps to speed limits will, by his or her own actions, not contribute materially to improving road safety, and will experience a lot of negative reactions from other road users.

- It is impossible to fully internalise the costs of accidents by means of insurance schemes or other market devices. Insurance systems, in particular, are hampered by asymmetric information, moral hazard problems and imperfect price discrimination. It is therefore difficult to see how market solutions can be found that will provide an optimal level of road safety.

In this context, it is perhaps instructive to spell out explicitly the conditions that must be fulfilled for market solutions to lead to a social optimum, as defined in economic theory (i. e. a Pareto-optimum). These conditions are very restrictive indeed, and nowhere near being fulfilled in any actually existing economic system. The conditions are:

- Free competition in all markets for goods and services (very many suppliers and very many consumers, which means that no single producer or no single consumer can affect the market price by unilateral actions);

- Equilibrium in all markets – no lasting structural problems (e. g. no unemployment);

- There are no external effects in either production or consumption (prices reflect all social costs, including those relating to the consumption of items for which a market does not exist);

- There are no increasing returns to scale in production (i. e. in no case does marginal cost pricing result in financial losses to the producer);

- Producers and consumers are equally and perfectly informed (no cases of asymmetric or incomplete information);

- Producers and consumers always act as rational utility maximisers (e. g. no weakness of will);

- There are no public goods (joint supplying, non-rivalry in consumption);
- The distribution of income does not matter – whatever distribution results from market transactions is accepted.

These conditions are not fulfilled as far as the provision of road safety is concerned. Government action is therefore needed.

The implications for monetary valuation of non-market goods of the fact that current economic systems are very far from fulfilling the conditions for applying market solutions to maximise social welfare have not been adequately studied in economic theory. These implications cannot be deduced theoretically, at least not to the extent that they refer to the conditions of preference formation. Economic theory takes preferences for granted, it does not ask what their sources are. But preferences are very much formed within a social context, an important part of which is individual perceptions of the opportunities for choice.

Let us take up the case of speed choice once more. It is, in principle, possible to estimate an implicit monetary valuation of safety by studying speed choices. But, at the same time, it is fully possible that not all speed choices reflect individual preferences. Some drivers may feel a pressure to drive faster than they really want to, because they try to keep up with traffic and want to avoid the many negative reactions they may get if they drive more slowly. Hence, the monetary valuation of safety, derived from speed choice, does not reflect the individual preferences of these drivers.

3. COMMENTS TO THE PAPER BY EVANS

The paper gives a nice and clear exposition of the British approach to cost-benefit analysis of road safety measures. I do not have many comments to this paper.

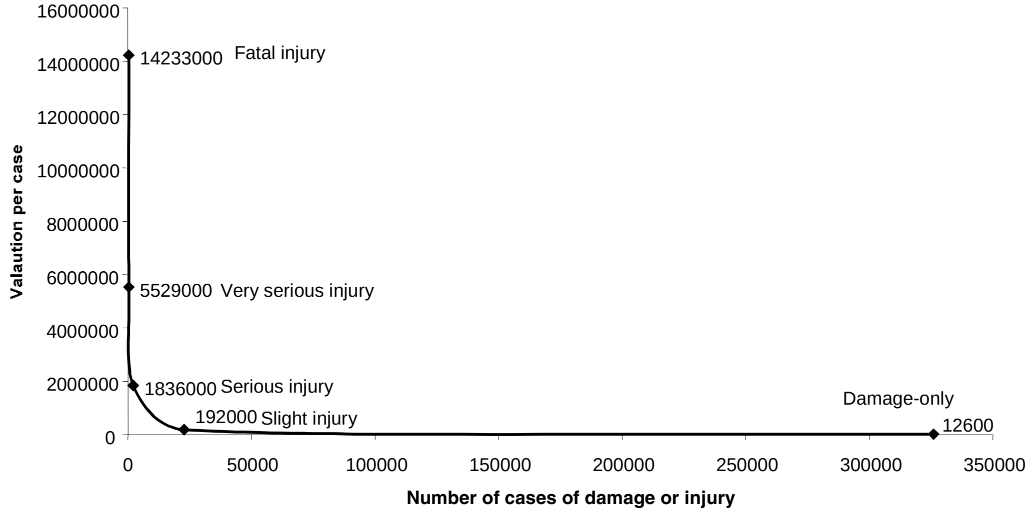
Evans suggests in section 3.6 that there is a “law-like” regularity in the relative valuation of injuries of different degrees of severity:

“It is interesting that the four main categories of accident – fatal, serious injury, slight injury, and damage-only – each contribute a similar order of magnitude to the total accident losses: fatal accidents account for 24% of the total; serious injury accidents account for 31%; slight injury accidents account for 18%; and damage-only accidents account for 28%. The reason for this is that the numbers of accidents increase by roughly one order of magnitude from one category to the next: thousands of fatal accidents, tens of thousands of serious injuries, hundreds of thousands of slight injuries, and millions of damage-only, while the magnitudes of the valuations move in exactly the opposite direction.”

This observation inspired me to investigate whether a similar relationship holds for other countries as well. The relationship hinted at by Evans is a logarithmic function. If the natural logarithm of the number of accidents at each level of severity (measured on a discrete scale like the one used in the United Kingdom and other motorised countries) is plotted against the natural logarithm of the monetary valuation of accidents at each level of severity, the data points should fit a straight line sloping downwards from left to right.

Figure 2 shows the relationship between the number of accidents or injuries in Norway, and the monetary valuation of each accident or injury, measured in natural units. A line has been drawn in the figure to connect adjacent data points.

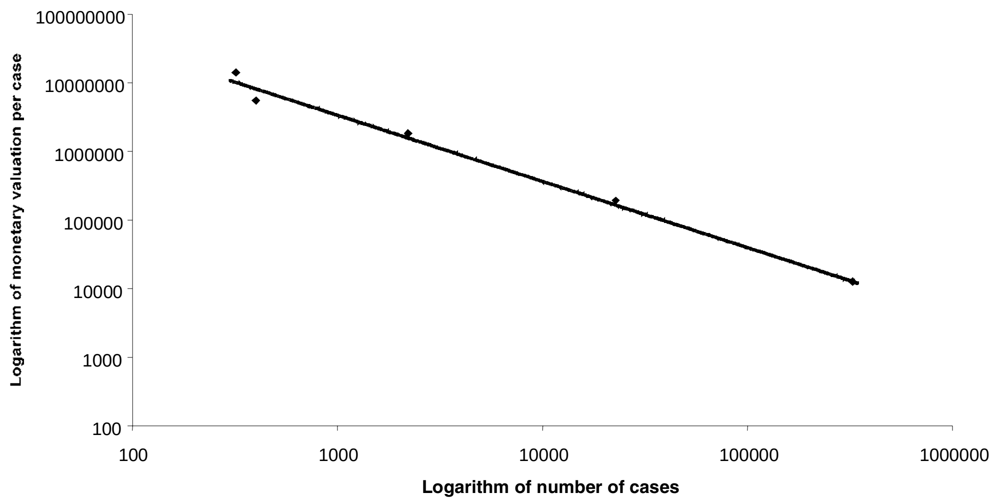
Figure 2. **Relationship between number of accidents and monetary valuation of each accident or injury in Norway (1991)**



Source: Elvik, R., 1993.

It can be seen that the curve for the valuations of injuries at different levels of severity almost touches the axes of the diagram. Figure 3 shows this curve plotted on a double log scale.

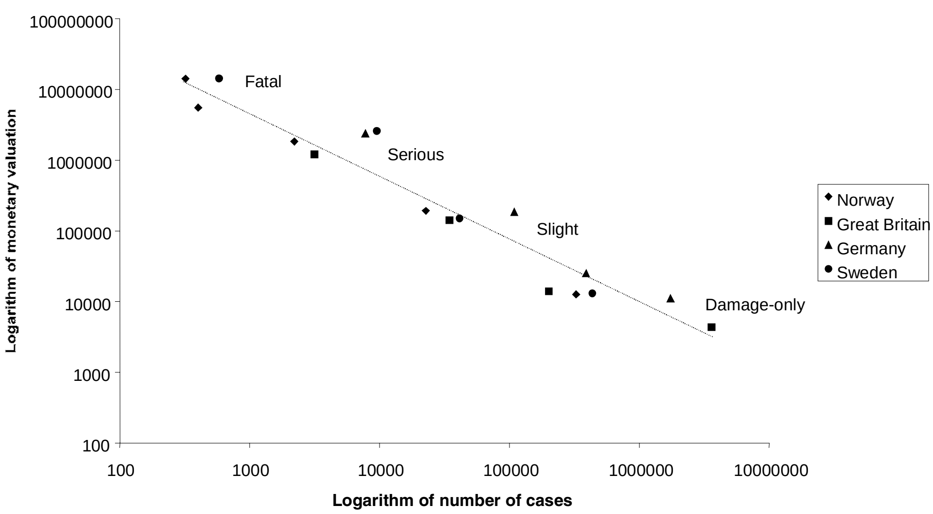
Figure 3. **Monetary valuation of injuries at different levels of severity in Norway, plotted as a function of the number of cases on a double log scale**



Source : Elvik, R., 1993.

Figure 4 shows a similar double log plot for Great Britain, Norway, Sweden, and Germany. It is seen that the monetary valuations fit the logarithmic function rather closely for all countries.

Figure 4. **Monetary valuation (log scale) of injuries at different levels of severity as a function of the number of cases (log scale) in four countries**



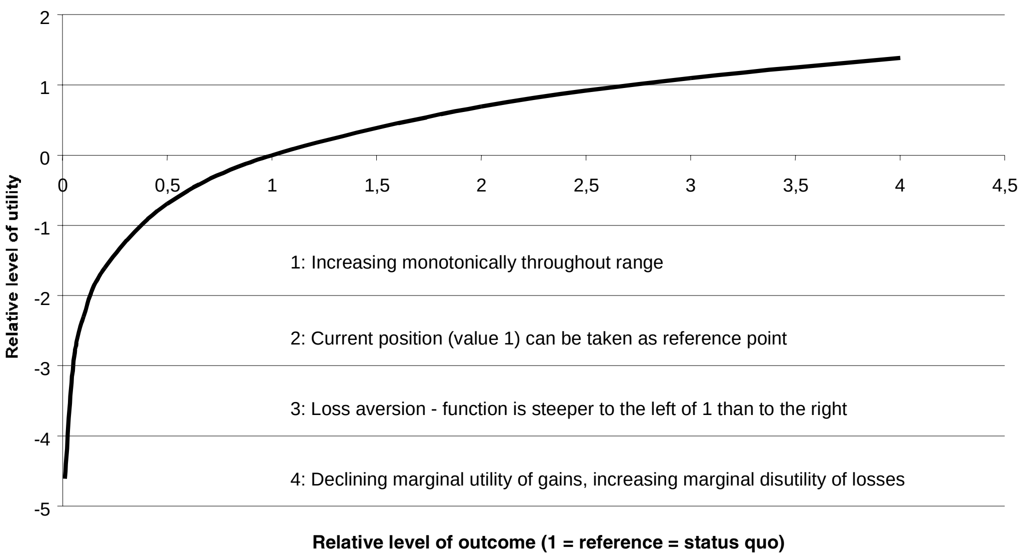
Source: Elvik, R., 1993.

Now, an interesting question is whether this pattern is really law-like, or just a coincidence. Psychological research suggests that the logarithm is a quite general model of human perception and utility evaluation. Figure 5 briefly lists some attractive features of the logarithm, interpreted as a generic utility function.

The logarithm increases monotonically throughout its range. It takes on the value of 0 at when the argument is 1, which can be interpreted as a reference point used for utility evaluation. Points to the right of 1 represent gains, points to the left of 1 represent losses. There is loss aversion, shown by the fact that the slope of the function is much steeper at the value of 0.5 than at the value of 1.5. These changes correspond to a loss of 50% and a gain of 50%, respectively. The loss of utility resulting from a loss of a given size in the argument variable (a loss of income, for example) becomes successively larger as the point of 0 is approached (everything is lost).

While it is obviously wrong to state that the logarithm is a universally valid model of human utility functions, versions of it appear to be applicable to a wide range of perceptual and cognitive evaluations.

Figure 5. **Interpretation of the natural logarithm as a generic utility function**



The paper by Evans briefly touches on the issue of how well people understand changes in very low levels of risk. This issue will be discussed below, in the context of comments to the paper by Persson.

4. COMMENTS TO THE PAPER BY PERSSON

The paper presents the official approach to the estimation of road accident costs in Sweden.

The paper gives an interesting discussion of methodological difficulties in WTP surveys. In my opinion, the problems uncovered in a number of WTP surveys should lead researchers to abandon the contingent valuation method – as practised up to now – to reveal the demand for road safety.

What is wrong with the contingent valuation method?

There is evidence showing that people are too insensitive to small changes in very low levels of risk, and may not understand what these changes mean.

The context of the valuation task does not match the context in which the results are to be used - safety should be valued in conjunction with travel time, travel comfort and environmental impacts.

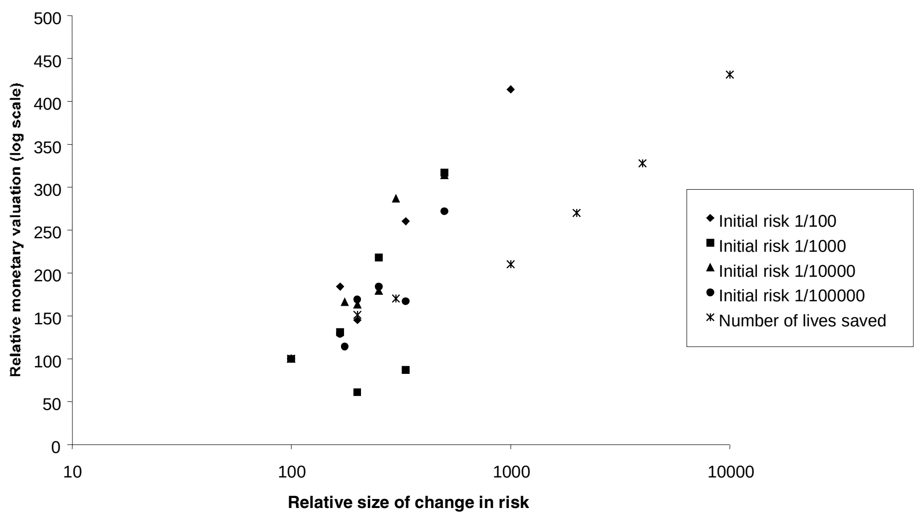
The valuation task is entirely too hypothetical – it refers to a non-existent safety device, which is not very precisely described and has purely imaginary effects on safety.

It is wrong to present road safety as an individual good, when it is in fact a public good.

"Warm glow" effects can be avoided by an appropriate study design, even when public goods are valued – but any WTP study is likely to reflect an element of idealism in respondents.

Evidence of insensitivity to the scale used for changes in fatality risk is provided by a number of contingent valuation studies that have probed willingness-to-pay for changes in very low levels of risk. Figure 6 summarises the results of some of these studies.

Figure 6. **Results of contingent valuation studies of willingness-to-pay for reduced fatality risk**



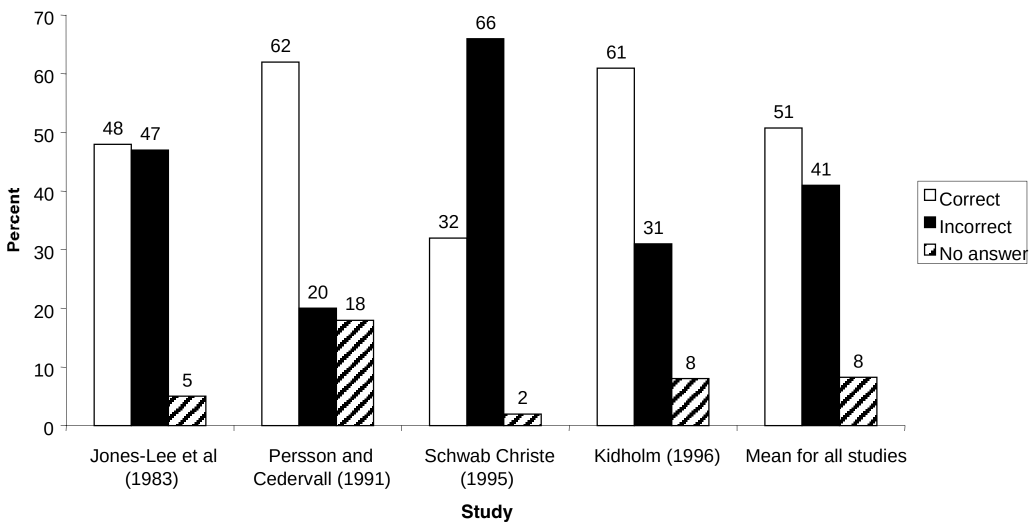
Source: Elvik, R., 1995.

Willingness to pay is shown on a log scale, with the value found for the smallest change set to 100. The size of the changes in risk used to elicit willingness-to-pay are also shown on a log scale. The data points have been sorted according to the level of initial risk used in the studies, which ranges from 1 in 100 to 1 in 100 000. It can be seen that there is a wide dispersion of the data points.

Tests made in a number of contingent valuation surveys show more direct evidence of a lack of understanding of small changes in low levels of risk. Figure 7 shows the results of such tests made in four studies, as well as the mean result of those four studies.

In each study, respondents were given a choice between reducing risk A, which was high, and risk B, which was low. Choosing to reduce the higher risk was classified as a correct answer. Figure 7 shows that the percentage of correct answers in the four surveys varied from 32% to 62%. The mean percentage of correct answers was 51%. When interpreting this finding, one should take into account the fact that if respondents were merely guessing it might be expected that 50% would guess correctly. The answers do not, therefore, indicate an understanding which is very much better than simple guessing would imply.

Figure 7. **Results of tests of understanding of small changes in low levels of risk in four contingent valuation surveys**



Source: Jones-Lee, M. W., Hammerton, M. & Abbott, V., 1983.

It is possible to improve the design of the valuation task. There are two pitfalls that should be avoided:

– Never ask people to state directly their willingness-to-pay for a non-market good, and

– Never ask people to relate their willingness-to-pay for improved safety to small changes in very low levels of risk.

In addition to this, it is desirable to obtain valuations of all non-market goods in conjunction, rather than on a one-by-one basis. This is important because transport policy making involves tradeoffs between a number of non-market goods, and because it has been shown that if such goods are evaluated in isolation, the valuations tend to be too high. One possible study design is shown in Table 1.

Table 1. **Possible design of a study in which road safety, travel time and air pollution is valued at the same time**

	Alternative road transport systems	
Attributes	**System A**	**System B**
Accident fatalities	300	200
Rural speed limit (km/h) – strictly enforced	80	70
Fuel price (NOK/litre)	10	15
Premature deaths attributable to pollution	200	150

This study design asks people, acting in the manner of policy-makers, to make a choice between system A and system B. System B is better than system A in some respects, but worse than system A in other respects. This is a deliberate feature of the study design, which is intended to force people to realise that they cannot get everything, but have to make tradeoffs between conflicting policy objectives.

Furthermore, monetary valuations are obtained for effects as observed or estimated at the policy-making level, not at the level of individual consumer behaviour. When drafting policy designed to provide non-market goods, it is precisely this sort of opinions with respect to different policy options that policy-makers are looking for. The fact that these opinions can also be represented as demand functions with respect to the provision of these goods is likely to be less important. Such a representation of individual preferences is a nicety for economists to enjoy. Policy-makers want to know which policy options are supported, and which are not.

CONCLUDING REMARKS

Economic evaluation of road traffic safety measures can definitely be a useful contribution to road safety policy making. Recent studies made in Norway and Sweden show that current policy priorities are rather inefficient. Substantial improvements in road safety could, in principle, be attained in both countries if the priorities given to different road safety measures were based more strictly on cost-benefit analyses. This shows that the efficiency of road safety policy can be improved by applying cost-benefit analysis.

On the other hand, it is obvious that the current monetary valuations of road safety are neither very precise nor very valid in a strict scientific sense. The methods used to obtain willingness-to-pay for road safety seem to have hit a dead end and need a critical reassessment. Fortunately, it is likely that better methods can be found, and that more valid and reliable estimates of accident costs can be obtained.

Unresolved problems nevertheless remain in the theoretical foundations of safety economics. In empirical studies designed to estimate willingness-to-pay for road safety, much attention has been devoted to testing how well respondents understand the questions they are asked, and how rational the pattern of responses is. As noted above, these tests show that current estimates of WTP should be treated with considerable scepticism. Not everybody understands the valuation task, and not everybody solves this task according to the consistency axioms of economic theory.

At a deeper level, however, it can be argued that even if respondents were perfectly informed and perfectly consistent, applying the results of WTP-surveys to policy making involves a number of unresolved problems. These problems are mostly attributable to paradoxes that can arise when individual preferences are aggregated. An extended discussion of these paradoxes, and how they should be solved (if indeed solutions are possible), would be interesting, but is beyond the scope of this round table.

POLAND

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ALGORITHM OF AN ESTIMATION OF ROAD ACCIDENTS COSTS IN POLAND

This algorithm has been used since 1993 in “Temporary instructions of the evaluation of economic effectiveness of road and bridge undertakings” which is updated annually with more detailed data and prices of individual elements of analysis.

The following components are the basis for estimates of road accidents:

- Existing numbers of road accidents according to police statistics for the last three years, if the data is available.
- Tables of accident coefficients according to road features.
- Unit costs of accidents in zlotys per accident.

Unit costs of accidents cover material losses and losses due to injuries and fatalities. These costs are broken down as follows:

1. Losses due to fatalities including:
   - Estimated average loss of GDP (less the consumption in age groups of road accident casualties).
   - Average medical treatment costs.
   - Average funeral costs.
   - Average compensation for a fatality (together with payment from insurance).

2. Losses resulting from injuries in road accidents that include:
   - Serious accident with permanent crippling.
   - “Moderately” serious accidents.
   - Slight accidents.

These losses include:

- Estimated average loss of GDP.
- Average cost of medical treatment and rehabilitation.

3. Estimated material damage costs per accident.

4. Estimated operational costs.

Unit costs of accidents were introduced as variables in the period of analysis with assumed growth of GDP by 5% annually.

Forecasted numbers of accidents in the period of analysis are established for each variant W”O” and WI. Forecasted numbers of accidents in each next year are multiplied by respective unit cost of accident in built-up and outside built-up areas in Poland and streams of accident costs in both variants are given.

Road accident costs are counted on the basis of recorded and forecasted number of accidents on an analysed stretch of a road counted by means of respective coefficients taking different road and mobility conditions into account by means of the following formula:

$$Kw = L \cdot W\mathit{wa} \cdot kw \cdot 365 \cdot \sum_{J=1}^{5} (SDR\mathit{j} / 100\,000)$$

Where:

Kw – annual accident costs in PLN

Kw – unit accident cost in PLN per accident

1 USD = 4.5 PLN

1 death = 0.1 million ECU

W*wa* – accident ratio, number of accidents per 1 000 000 vehicles/km according to road and traffic conditions **a**

SDR*j* – annual average daily traffic of number *j* of vehicles in vehicles per day

L – length of the road section in km.

Accidents are forecasted according to traffic intensity and type of road (existing vehicles) in each year of the analysed period.

Basic road accidents data in Poland according to a sex and age considering the area (built-up and outside built-up) are presented in Table 1.

For the purpose of economic analysis of road projects, annual estimations of road accidents costs in Poland are performed on the basis of data from Police Headquarters publications (see Table 2), National Statistics Office annual publications, Official Journals, working data of Motor Transport Institute and Road and Bridge Research Institute. Results of estimations of road accidents’ costs are presented in the Table 3.

Table 1. **Road accident casualties in Poland in 1999**

Men in built-up areas							
	Fatalities			Injuries			
Age	Total	*On the spot*	*After 30 days*	Total	*Serious*	*Moderate*	*Slight*
0 to 17	198	*116*	*82*	7 661	*1 435*	*1 435*	*4 791*
18 to 45	1 336	*901*	*435*	19 672	*3 966*	*3 966*	*11 740*
46 to 64	702	*480*	*222*	5 823	*1 324*	*1 324*	*3 175*
65 and over	425	*212*	*213*	2 646	*671*	*671*	*1 304*
Total	**2 661**	**1 709**	**952**	**35 802**	**7 396**	**7 396**	**21 010**
Men outside built-up areas							
	Fatalities			Injuries			
Age	Total	*On the spot*	*After 30 days*	Total	*Serious*	*Moderate*	*Slight*
0 to 17	182	*132*	*50*	2 086	*445*	*445*	*1 196*
18 to 45	1 959	*1 571*	*388*	12 398	*2 844*	*2 844*	*6 710*
46 to 64	667	*520*	*147*	2 737	*671*	*671*	*1 395*
65 and over	229	*156*	*73*	756	*186*	*186*	*384*
Total	**3 037**	**2 379**	**658**	**17 977**	**4 146**	**4 146**	**9 685**
Women in built-up areas							
	Fatalities			Injuries			
Age	Total	*On the spot*	*After 30 days*	Total	*Serious*	*Moderate*	*Slight*
0 à 17	145	*72*	*73*	5 174	*933*	*933*	*3 308*
18 à 45	238	*150*	*88*	9 366	*1 575*	*1 575*	*6 216*
46 à 64	117	*63*	*54*	2 966	*594*	*594*	*1 778*
Plus de 65	397	*173*	*224*	3 831	*955*	*955*	*1 921*
Total	**897**	**458**	**439**	**21 337**	**4 057**	**4 057**	**13 223**
Women outside built-up areas							
	Fatalities			Injuries			
Age	Total	*On the spot*	*After 30 days*	Total	*Serious*	*Moderate*	*Slight*
0 à 17	124	*81*	*43*	1 668	*325*	*325*	*1 018*
18 à 45	320	*239*	*81*	4 585	*934*	*934*	*2 717*
46 à 64	119	*85*	*34*	1 043	*222*	*222*	*599*
Plus de 65	152	*108*	*44*	757	*169*	*169*	*419*
Total	**715**	**513**	**202**	**8 053**	**1 650**	**1 650**	**4 753**
	Fatalities			**Injuries**			
	Total	***On the spot***	***After 30 days***	**Total**	***Serious***	***Moderate***	***Slight***
	7 310	***5 059***	***2 251***	**83 169**	***17 249***	***17 249***	***48 671***

Table 2. **Accidents, motorization and population of Poland, 1980-1999**

Year	Number of accidents	Number of fatalities	Number of injured	Number of vehicles (000)	Number of passengers cars (000)	Population	Fatalities / population (millions)	Accident severity (fatalities/ 100 accidents)	Motor-ization (Cars / 1 000 population)
1980	40 373	6 002	46 245	5 496	2 383	35 735	168	15	67
1981	43 755	6 107	51 365	5 853	2 634	36 062	169	14	73
1982	38 832	5 535	45 693	5 996	2 882	36 399	152	14	79
1983	40 454	5 561	47 463	6 417	3 179	36 745	151	14	87
1984	35 768	4 980	41 325	6 850	3 426	37 063	134	14	92
1985	36 100	4 688	42 290	7 089	3 671	37 341	126	13	98
1986	37 133	4 667	43 150	7 476	3 964	37 572	124	13	106
1987	36 433	4 625	42 272	7 795	4 232	37 764	122	13	112
1988	37 538	4 851	43 626	8 214	4 519	37 885	128	13	119
1989	46 338	6 724	53 639	8 596	4 846	38 038	177	15	127
1990	50 532	7 333	59 611	9 041	5 261	38 183	192	15	138
1991	54 038	7 901	65 242	9 860	6 112	38 309	206	15	160
1992	50 989	6 946	61 046	10 207	6 505	38 418	181	14	169
1993	48 901	6 341	58 812	10 438	6 771	38 505	165	13	176
1994	53 647	6 744	64 573	10 858	7 153	38 581	175	13	185
1995	56 904	6 900	70 226	11 186	7 517	38 609	179	12	195
1996	57 911	6 359	71 419	11 766	8 054	38 639	165	11	208
1997	66 586	7 310	83 169	12 284	8 533	38 650	189	11	221
1998	61 855	7 080	77 560	12 710	8 891	38 661	183	13	232
1999	55 106	6 730	68 449	13 200*	9 400*	38 700*	171	12	243

* approximate figures
Source: Police headquarters.

Table 3. **Road accident costs in Poland in 1999 en PLN (1 USD = 4.5 PLN)**

	Unit cost of fatality	Unit cost of injured	Annual costs of fatalities	Annual costs of fatalities	Annual costs of casualties	Unit accident cost per person	Unit cost of material losses	Unit cost of accident
1	2	3	4	5	6	7	8	9
IN BUILT-UP AREAS								
Men	550 927	120 176	1 466 016 747	4 302 547 056	5 768 563 803			
Women	257 543	102 575	231 016 071	2 188 634 964	2 419 651 035			
Total	*404 235*	*111 375*	*1 697 032 818*	*6 491 182 020*	*8 188 214 838*	*171 005*	*26 525*	*197 530*
OUTSIDE BUILT-UP AREAS								
Men	642 908	157 033	1 952 511 596	2 822 979 290	4 755 490 886			
Women	403 768	125 958	288 694 120	1 014 340 682	6 078 525 688			
Total	*523 338*	*141 495*	*2 241 205 716*	*3 837 319 972*	*6 078 525 688*	*325 003*	*30 321*	*355 324*
AVERAGE COSTS								
TOTAL	**463 787**	**126 435**	**3 938 238 534**	**10 328 501 992**	**14 266 740 526**	**214 260**	**27 591**	**241 852**

UNITED KINGDOM

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THE EMPIRICAL ESTIMATION OF PREFERENCE-BASED VALUES OF SAFETY

The purpose of this note is to summarize the findings of three related studies carried out recently in the United Kingdom by the author and others[1] aimed at estimating preference-based values of safety in four different contexts, namely roads, rail, domestic fires and fires in public places.

More specifically, the first study (reported in detail in Carthy *et al*, 1999) was commissioned jointly by the UK Health and Safety Executive (HSE), the Department of the Environment, Transport and the Regions (DETR), the Home Office and HM Treasury and was intended to re-estimate the willingness to pay (WTP)-based monetary value for the prevention of a statistical road fatality (VPF).[2]

The second study (reported in Beattie *et al*, 2000a) was also carried out as part of the HSE/DETR/Home Office/HM Treasury project and was intended to provide estimates of preference-based VPFs for rail, domestic fires and fires in public place *relative to* the corresponding roads VPF. Essentially, the reason for focusing on valuation relativities rather than attempting to obtain direct WTP estimates for the non-roads contexts was that baseline annual fatality risks are so low in these contexts that direct estimates of WTP-based VPFs would be potentially prone to unacceptably wide margins of error.[3]

In turn, the third study (reported in Burton *et al*, 2000) was commissioned by the HSE following the rail accident at Ladbroke Grove in October 1999 in which 29 passengers and 2 train drivers died. This study was intended to assess the impact of a major rail accident on the perceptions and attitudes to risk of members of the public and especially regular rail users. For this reason the study was carried out some three months after the Ladbroke Grove accident and was conducted in the London commuter area. However, in all other respects the procedure used in the study was intended to replicate that used in the earlier roads/rail/domestic fires/fires in public places relativities study and employed precisely the same protocol and questionnaire, though a brief discussion of the impact of the Ladbroke Grove accident on perceptions and attitudes was also included at the very end of the focus group sessions.

1. THE ROADS VPF STUDY[4]

Originally it had been intended that the re-estimation of the WTP-based roads VPF would be undertaken using direct contingent valuation questions of the type employed in the 1983 Department of Transport study and reported in Jones-Lee *et al.* (1985). However, during early piloting the research team devoted a good deal of attention to a problem which is quite common in contingent valuation studies, namely a tendency for an uncomfortably large proportion of respondents to be insufficiently sensitive to the size of the risk reduction under consideration. In particular, in each of two phases of piloting, approximately 40% of respondents reported *identical* willingness to pay for two risk reductions, one of which was three times as large as the other. In addition, a further 40% reported a willingness to pay for the larger risk reduction that was only between one and two times their willingness to pay for the smaller risk reduction. The problem this causes is that the estimate of the VPF derived from one set of responses is liable to be significantly different from the estimate derived from the other set of responses, even though both sets come from the same sample of people.

For example, suppose that the average stated willingness to pay for a risk reduction of 1 in 100 000 is £25, on which basis the VPF would be £25 x 100 000 = £2.5m. But suppose that the average stated willingness to pay for a risk reduction of 3 in 100 000 is only a few pounds more – say, £30. Since this £30 per head is to prevent *three* deaths for every 100 000 people, it works out at £10 per head for each death prevented – i.e. a VPF of £10 x 100,000 = £1m. So if individuals' responses to survey questions are insensitive to the difference between two rather small risk reductions, we can end up with very different VPFs, depending upon which size(s) of risk reductions the researchers happen to present to people. Clearly, such disparities in the VPF can lead to very different conclusions concerning the attractiveness of any given safety project or the desirability of one project relative to another.

What gives rise to this insensitivity? Listening to tape recordings of individual interviews and post-interview focus group meetings suggests: (a) that many people find the risk reductions so small that they are difficult to get a real "feel" for, so that this information tends to be marginalised; (b) that this is compounded by the fact that *any* safety improvement is seen as a "good thing", with the precise magnitude of the risk reduction being treated as of only secondary importance (and in some cases, no importance at all); and (c) that when considering how much this "good thing" is worth, many respondents simply report an amount which, if foregone, would not seriously disrupt their normal expenditure and savings patterns – which for many people seems to be a sum in the region of £50-£200 per annum.

All this suggested that in order to obtain more robust estimates of WTP-based values of road safety it would be necessary to proceed in a less direct, more highly structured way, breaking down the money/risk trade-off into less daunting, more manageable steps. Subsequent piloting therefore aimed to refine an approach which essentially involved four stages, namely:

i. Respondents were first presented with contingent valuation questions designed to elicit (a) their willingness to pay (WTP) for the *certainty* of a quick and complete cure for a particular *non-fatal* road injury, I, of lesser severity, and (b) their willingness to accept compensation (WTA) for the certainty of sustaining the same injury.[5]

ii. On the assumption that a respondent's underlying preferences obey minimal conditions of consistency and regularity, these WTP and WTA responses can then be used to infer the broad order of magnitude of the rate at which the person concerned is willing to trade-off wealth against risk of the non-fatal road injury, I.[6]

iii. Respondents were then presented with a question aimed at eliciting their willingness to trade off risk of the non-fatal injury, I, against the risk of death.

iv. Finally, the estimated rate of trade-off of wealth against risk of the non-fatal road injury derived from stage (ii) is "chained" to the "risk-risk" trade-off results obtained at stage (iii) in order to infer the respondent's implicit rate of trade-off of wealth against risk of death.

This four-stage approach has several advantages over the procedure that was employed in the first two pilot studies. In stage (i), the contingent valuation questions, as such, relate to a non-fatal injury of a type that most respondents can more readily conceptualise on the basis of their past experience of injury and illness. Moreover, these questions do not require respondents to trade off money directly against risk. To the extent that respondents *are* required to think about risk, the task involved in the "risk-risk" question in stage (iii) is framed entirely within the domain of physical risk and is therefore a comparison of "like with like" - and is similar in principle to the kind of judgement entailed by many decisions about health care treatments which are intended to improve people's health, but carry at least some risk that the patient could end up worse off.

Later pilot work on the four-stage approach suggested that the vast majority of respondents found the various questions much more manageable than appears to have been the case with the direct money/risk of death trade-offs in the earlier pilot study questions. In addition, responses showed clear evidence of sensitivity to variations in the severity of the non-fatal injury to which the questions related, as well as evidence of a broadly acceptable level of internal consistency.

On this basis, a main study was carried out during the latter half of October and the first half of November 1997, and involved a quota sample of 167 respondents selected by professional market research organisations on the basis of gender, age and social class quotas specified by the research team to reflect OPCS national breakdowns. The sample was drawn from Newcastle (45 respondents), York (43 respondents), Brighton (54 respondents) and Bangor (25 respondents) and interviews were conducted on a one-to-one basis by members of the research team.

On the whole, the main study findings point towards a roads VPF in a range from about £500 000 to £1 500 000. As tends to be the case in this sort of study, the distribution of individual responses is widely spread, with the implied wealth/risk trade-off rates differing (often substantially) from one respondent to another. In addition, while the majority of respondents are located at the lower end of the distribution, a minority at the upper end have very high rates of trade-off (i.e. in statistical parlance, the distribution is heavily "skewed to the right"). In view of this, it is not surprising that the median (or middle) response is substantially smaller than the mean (or average), with the roads VPF based on the median in the region of £500 000 and the figure based on the mean in the £1 000 000 to £1 500 000 range.[7]

To the extent that aggregate willingness to pay for safety is reflected in mean rather than median responses, there is clearly a case for placing somewhat more emphasis on the range of VPFs entailed by the mean responses. On the other hand, there is an argument that, if anything, people's responses to hypothetical willingness-to-pay questions may overstate what they would *actually* be prepared to pay, which would suggest giving at least some weight to the median response. Thus, all things considered, any figure in the range £750 000 to £1 250 000 could be regarded as being broadly acceptable. In view of this, the DETR elected to effect a modest upward revision to its existing WTP-based VPF, setting the figure at £1 047 million in 1998 prices. The figure has since been updated to £1 089 million in 1999 prices.

2. THE FIRST RELATIVITIES STUDY[8]

Following extensive pre-pilot and pilot work, the first relativities study was carried out between September and December 1998 and involved a quota sample of 130 respondents selected by professional market research organisations, as in the roads study. While the locations for the study were again Newcastle, York, Brighton and Bangor, in this case focus groups (each comprising four participants in addition to the group moderators), rather than individual interviews, were employed.

Broadly speaking the focus group meetings, which typically lasted between 1½ hrs and 1hr 45 minutes, took the form of a structured preliminary discussion of key issues related to safety in the contexts of roads, rail, domestic fires and fires in public places, followed by completion (on an individual rather than group basis) of a questionnaire involving qualitative questions concerning various factors that might be expected to influence relative valuations. Finally, focus group participants were asked to complete a second questionnaire (again on an individual basis) involving *quantitative* relative valuation questions aimed at determining the number of fatalities in one context whose prevention the respondent would regard as being "equally as good as" the prevention of a given number of fatalities in another, on the assumption that the prevention in both contexts would be at the same cost and would take place over the same period of time. From the answers to such questions it is then possible to infer the respondent's implied VPF for one context relative to their implied VPF for the other.[9]

Denoting the VPF for roads by V_{RD}, for rail by V_{RL} for domestic fires by V_{DF} and for fires in public places by V_{PF}, the ratio $\frac{V_{RL}}{V_{RD}}$, for example, can either be obtained directly from responses to the relative valuation question concerning roads and rail (if, as was typically the case, roads were viewed as the highest priority context) or indirectly by, say, chaining the roads/domestic fire responses to the domestic fire/rail responses. The results from these two alternative estimation procedures were as follows:

Relative Valuations	**Direct**	**Chained**
$\frac{V_{RL}}{V_{RD}}$	0.834	0.800
$\frac{V_{DF}}{V_{RD}}$	0.926	0.881
$\frac{V_{PF}}{V_{RD}}$	0.923	0.921

As can be seen, responses to the relative valuation questions were such as to entail discounts for the VPFs relative to the roads figure in *all three* of the other contexts, though by far the most pronounced effect is in the case of rail. While several factors appear to have contributed to the generation of such discounts relative to the roads value of safety, in the case of rail three considerations are particularly noteworthy. First, some 60% of the sample reported an annual rail mileage that was below the UK national average which, at some 350 miles per annum, is already well below the national average annual road mileage. Second, though this is strictly speaking almost certainty *not* a good reason for prioritising the prevention of n road deaths relative to the prevention of n rail deaths, several respondents cited the very much higher baseline road risk as a reason for such a prioritisation. Third, at the time at which the study was undertaken it had been over a year since the occurrence of a major rail accident in the UK. And finally, in the case of domestic fire risks, a pervasive view was that relative to road risks, domestic fire risks are very much more under people's own control and very much more their own responsibility.

A further factor that has undoubtedly contributed to the modest context effects reported above is the procedure by which we have elected to analyse the relative valuation data. Thus, in contrast to the inferential approach that we have employed in earlier studies[10] which arguably involved an inherent upward bias in deriving context premia relative to a baseline such as the roads, the approach which we would now favour and which we employed in arriving at the figures reported above, involves no such bias.[11] Thus, for example, if the London Underground relative valuation data reported in Jones-Lee and Loomes (1995) are re-analysed using our now- preferred inferential procedure, then the Underground context premium falls from 50% to about 18% relative to the roads figure.

3. THE POST-LADBROKE GROVE RELATIVITIES FOLLOW-UP STUDY

In view of the fact that at the time at which the first relativities study was carried out it had been over a year since the occurrence of a major rail accident in the UK[12] and given the relatively low rail use of the majority of the study sample, one is bound to wonder to what extent the study's findings would have differed if (a) the study had been carried out in the immediate wake of a major rail accident and (b) the sample had contained a larger percentage of regular rail users.

With these questions in mind, following the Ladbroke Grove accident in October 1999, the HSE commissioned a follow-up relativities study which was intended to replicate the 1998 study in every respect save that a minimum of 40% of the sample was to comprise regular rail users.[13]

Accordingly, such a study was carried out by members of the original research team, assisted by other experienced university researchers, in late January and early February 2000 in Guildford, Reading and St Albans (all of which are in the London commuter belt) and involved a sample of 150 respondents selected by a professional market research organisation on the basis of age, gender, occupation and rail-use quotas. The study was once again conducted on a focus-group basis and employed exactly the same protocol and questionnaires as were used in the 1998 relativities study, the only difference being that at the end of the focus group session a brief discussion was held to assess the impact of the Ladbroke Grove accident on perceptions of and attitudes towards rail safety.

While responses to qualitative questions concerning factors that might be expected to influence relative valuations - as well as the free discussion of the Ladbroke Grove accident - indicated a marked rise in the priority given to rail safety and a generally heightened concern about rail safety relative to safety in the other contexts considered in the study, the rail/roads valuation relativity did not increase dramatically, the follow-up relativities results being as follows:

Relative Valuations	Direct	Chained
$\frac{V_{RL}}{V_{RD}}$	1.003	0.948
$\frac{V_{DF}}{V_{RD}}$	0.890	0.844
$\frac{V_{PF}}{V_{RD}}$	0.960	0.911

These results are for the follow-up study sample taken as a whole. However, if one focuses on the subsample of respondents who had travelled 1000 miles or more by rail in the preceding 12 months then the rail/roads VPF relativity is 1.16, which it will be recalled is very similar to the underground/roads relativity that is implied by the findings reported in Jones-Lee and Loomes (1995) under our now-preferred inferential procedure.

4. CONCLUSIONS

Psychologists have provided extensive evidence indicating that the public's perceptions of and attitudes to risk may vary substantially over different hazards, reflecting differing degrees of perceived voluntariness, control, responsibility, dread and so on (see, for example, Slovic *et al*, 1981, or Thomas, 1981). In view of this, it might have been expected that a preference-based VPF for rail would stand at a significant premium in relation to its roads counterpart. The fact that the first relativities study, carried out in 1998, yielded a rail/roads VPF relativity of *less* than one was, therefore, *prima facie* somewhat surprising. Nonetheless, on reflection it did seem that three factors served to offer at least a partial explanation for this finding. First, only a relatively small proportion of the sample were regular rail users. Second, many respondents focused on the baseline levels of risk on the two modes. And third, at the time at which the study took place it had been over a year since the occurrence of a major rail accident in the UK.

For these reasons it was felt appropriate (if somewhat uncomfortable) to conduct a follow-up relativities study following the train accident at Ladbroke Grove in October 1999. Furthermore, it was decided to concentrate the follow-up study in the London commuter area so as to ensure that the sample contained a substantial proportion of regular rail users. Under the circumstances, it might therefore have been expected that the rail/roads VPF relativity that would emerge from the follow-up study would show a substantial increase over the relativity generated by the first relativities study. However, again somewhat surprisingly, while the figure did increase to some extent, it did not do so dramatically, rising to about one for the sample as a whole and entailing a premium of only about 16% for the rail VPF relative to the roads figure for those who were regular rail users.

Finally, it is worth noting that, contrary to popular wisdom, the possibility of large-scale loss of life in a single rail accident does not appear to have been a factor that weighed with a majority of respondents in arriving at their rail/roads safety prioritization. Thus, when asked whether such a consideration should constitute an argument in favour of prioritizing a rail safety programme over a road programme that would in aggregate prevent the same number of deaths at the same cost over the same period, in both the first *and* the follow-up relativities studies a majority of those who regarded rail as being more likely to produce multiple fatality accidents thought that this should *not* constitute an argument in favour of prioritizing the rail safety programme.

NOTES

1. The other members of the research team were: Jane Beattie, Tony Burton, Trevor Carthy, Sue Chilton, Judith Covey, Paul Dolan, Helen Gilbert, Lorraine Hopkins, Graham Loomes, Nick Pidgeon, Angela Robinson, Anne Spencer and Jo Twist.

2. Prior to the re-estimation, the DETR WTP-based roads VPF of £902 500 in 1997 prices was essentially an update of a "consensus" figure arrived at in 1988 following a comprehensive review of the then-existing WTP empirical literature, followed by a period of consultation with experts in the field. The literature showed a wide range of empirical estimates and the figure chosen - £500 000 in 1987 prices – was set at the lower end of this range in order to temper a radical change of methodology (i.e. adoption of the WTP approach in place of the former output – loss based methods) with an element of caution.

3. Given that direct estimates of WTP-based VPFs are typically obtained by dividing mean reported willingness to pay for a given risk reduction by the risk reduction itself, even small "errors" in WTP responses will be "blown up" to unacceptably wide error bands if the risk reduction concerned is minuscule, which will inevitably be the case if baseline risks are already very low.

4. This section is based on Chilton *et al*, (1998).

5. Here, the term "compensation" is being used in the sense of "just making up for" rather than a legally-determined court award.

6. In fact, it can be shown that an individual's rate of trade-off of wealth against risk of the non-fatal injury, I, can be expressed as a *weighted average* of the WTP and WTA responses elicited at stage (i), with the relative weights depending on the structure of the individual's underlying preferences and attitudes to risk. The research team therefore explored the implications of various different assumptions concerning these preferences and attitudes and based its estimates of the rate of trade-off on a range of representative "middle cases". Details of the argument, which is somewhat technical, are given in Carthy *et al*, (1999).

7. The range for the mean reflects alternative assumptions concerning the structure of underlying individual preferences and attitudes to risk. As far as the figures based on means are concerned, it should be noted that these have been calculated with the two most extreme responses at the upper end of the distribution trimmed out. This was done because these responses were *very* much larger than the rest, giving rise to serious doubts about their reliability, especially as they may well be the result of a compounding of errors in the four-stage estimation process. In addition, in computing means it was also necessary to omit a few cases in which responses to the "risk-risk" trade-off question, literally interpreted, did not allow finite wealth/risk trade-off rates to be computed.

8. This section is based on Jones-Lee (1999).

9. Of course it has to be acknowledged that in answering such questions respondents *may* have had regard to a wider set of “social” considerations than seems likely to have been the case for the “own risk only” questions posed in the roads VPF study. Indeed it was for this reason that respondents were explicitly invited to answer the quantitative relativities questions in much the same way as they cast their votes in a national or local election i.e. with as much narrowly-focused self interest on the one hand, or widely-cast social concern on the other, as they wished. However, since it seems likely that for any given respondent’s much the same degree of altruistic social concern (or lack of it) would be applied to *both* contexts in a pairwise comparison of the type involved in the quantitative relativities questions, the actual valuation relativity that would emerge from the respondent answer to the question would be largely unaffected by the degree of social concern (or lack of it) brought to bear in answering the question.

10. See, for example, Jones-Lee and Loomes (1995).

11. For a detailed discussion of this approach, see Beattie *et al* (2000b), Appendices 3 and 4.

12. This occurred at Southall on 19/9/97 and involved 7 fatalities.

13. For the purposes of sampling, a regular rail user was defined as someone who travelled by rail three or more times per week.

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SUMMARY OF DISCUSSIONS

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1. METHODOLOGICAL OVERVIEW OR HOW TO CHOOSE BETWEEN ACCURATE MEASUREMENT OF A NON-RELEVANT CONCEPT AND INACCURATE MEASUREMENT OF THE PARAMETER TARGETED

The economic appraisal of road safety measures poses the basic problem of determining which method to use for the valuation of road safety measures. Given that road safety or, to be more precise, lack of road safety is measured in terms of the total number of fatalities and injuries, either slight or severe, the economic calculation can be based on the value of human life and the estimated cost of injuries. There are two methods of valuation that can be applied at this stage: the so-called "human capital" approach and the approach based on the "willingness to pay" for the prevention of injury. Use of these two approaches is mutually exclusive, despite the fact that they are significantly complementary. They are briefly described below:

– The **human capital approach** consists in valuing damage (death, serious injury) in accordance with its economic impact, i.e. in terms of lost output (net of future consumption in the event of death), remedial costs (healthcare in the case of injury) and reconstruction costs (material damage). To these are added working hours lost and the impact on the "grey" economy, i.e. undeclared work, household work and DIY. In order to value output losses accurately, account is taken of age and activity rates within each age cohort. This makes it possible to take account of unemployment, although it is also possible to evaluate the loss of potential production compared with the full utilisation of resources in order to assess the virtual damage to the economy. A fair degree of experience has been acquired in the use of this method which is still commonly applied in some countries but which has the disadvantage of not providing an accurate measurement of the parameter targeted, namely, the intrinsic value of the damage in cases where there is loss of life or suffering caused by serious injury. It was the realisation of this shortcoming in particular which gave rise to the "willingness-to-pay" approach.

– The **willingness-to-pay approach** consists in estimating the value that individuals attach to human life by means of surveys aimed at determining the amount of money that individuals would be prepared to pay to reduce the risk of loss of life. The same principle applies to injury, where an attempt is made to determine the monetary value which individuals would be prepared to pay to, in effect, reduce the risk of injury. Selected groups within the population are given a questionnaire describing situations in which the individual has the choice of spending a certain sum of money or exposing himself to a given risk. This approach is based on the preferences of those concerned. By adopting an approach based on the prevention of accidents and damage, it is possible to balance a risk against given sums of money and thereby obtain an inferred value of human life and serious injury. To ensure that economic damage is also taken into account, the following are added to the value thus obtained: net lost output, medical costs, administrative costs, etc., which are precisely the values of human capital. Logically, the willingness-to-pay approach yields values far higher than those based solely on the value of human capital. The willingness-to-pay approach, which is a concept that has been used for some years by a small number of countries, provides an imprecise valuation of the very parameter we are attempting to determine.

There are many reasons for the **lack of precision** of the willingness-to-pay approach, and these were briefly reviewed by the Round Table. First, by seeking to determine the value to assign to reduction of a given risk, the persons surveyed felt that they were themselves involved, that they were directly concerned by the valuation. However, **personal experience**, i.e. whether or not a person had actually had an accident, does have a role to play. In one of the first applications of this method, the results of the survey produced a multiplier of ten, depending upon whether the persons surveyed had or had not had an accident. In addition, in terms of the method used to present a notional risk to the persons surveyed, it would seem that survey respondents are relatively insensitive to **small variations in risk**; it is therefore difficult to derive a coherent value for human life from the results. However, to avoid this problem, researchers have constructed a questionnaire in which risk is broken down into highly precise stages, that is to say, a progressive analysis. In this way, scenarios are constructed on the basis of hypothetical safety schemes designed to measure the willingness to pay for variants of the same risk; respondents are thus able to answer questions where it can be shown that it is probable that the person injured will recover from the injury.

The Round Table also took note of the fact that **income and age** have an impact on willingness to pay. Willingness to pay does not vary linearly in accordance with age. It is at the age of forty that the highest value is placed on saving human life; it is also the age at which the sense of altruism and respect for the safeguard of other people's lives is the greatest. In terms of the impact of income, an elasticity in willingness to pay to income in the order of 0.3 has been observed. This problem can be circumvented by reducing the willingness to pay of the wealthiest and by increasing the willingness to pay of those with the least resources. In order to isolate this effect with regard to altruistic behaviour, efforts can be focused on variations in the risk for the individual surveyed, to the exclusion of all other individuals. Moreover, as a general rule, extreme values can be discarded in favour of the median in order to take account of the spread of willingness to pay within a sample.

These corrections illustrate the fact that willingness to pay is a method that is sensitive and therefore difficult to put into practice, but it is nonetheless a highly attractive procedure in that **it precisely targets the objective aimed at**. It must also be said that it is a method which still requires further refinement, although this does less than justice to the advances that have already been made and the relative consistency of the results obtained so far. Thus, for example, to illustrate the intrinsic problems with the use of this procedure in the valuation of loss of life or injury, the propensity of certain persons to engage in reckless driving reflects an implicit acceptance of risk and therefore modifies the willingness to pay. However, this approach is subject in particular to variations in the two factors of income and age mentioned above, two factors that we can in part correct. In addition, this method, if all due precautions are taken in its application, produces **relatively stable results**. The contingent valuation approach uses hypothetical marketed measures whose impact on road safety can be described and compared with market values. Parasite factors can thereby be almost eliminated, although care must be exercised over the non-transitivity of choices. At another level, **a choice must be made between wide-ranging samples and individual interviews that are more restricted in scope**. In the case of a large sample, the response rate is obviously lower and it has been noted that not all questions were properly understood. The answers are always simple, but the questions are complex. In addition, again with large samples, respondents tend to be men with senior positions who are major car-users and who have already had an accident. The results therefore need to be adjusted. With in-depth interviews of a small sample of people, the response rate is always very high and questions are better understood, but the restricted size of the sample means that it may not be representative.

One point to emerge from the Round Table was that there is undoubtedly a need for **practical guides to methodology** which set out the conditions for constructing and using methods. Communication between researchers has certainly improved, but it would nonetheless be helpful to draw up a document which summarised good practices and the rules of the art, even if studies have shown that estimated values do not vary enormously from one method to another.

A more basic criticism that can be levelled at the willingness-to-pay approach is that **it fails to provide a market value**. The estimate of value solely reflects what people are prepared to pay in order to avoid damage and does not provide a comparison, as in a market, with a composite supply of safety-related instruments which would produce an equilibrium value. However, to counter this objection, it can be argued that the willingness-to-pay approach is simply a philosophical principle. As a method, it reveals the preferences of the public. These preferences must not dictate the content of legislation, but they can be taken into account in the decision-making process.

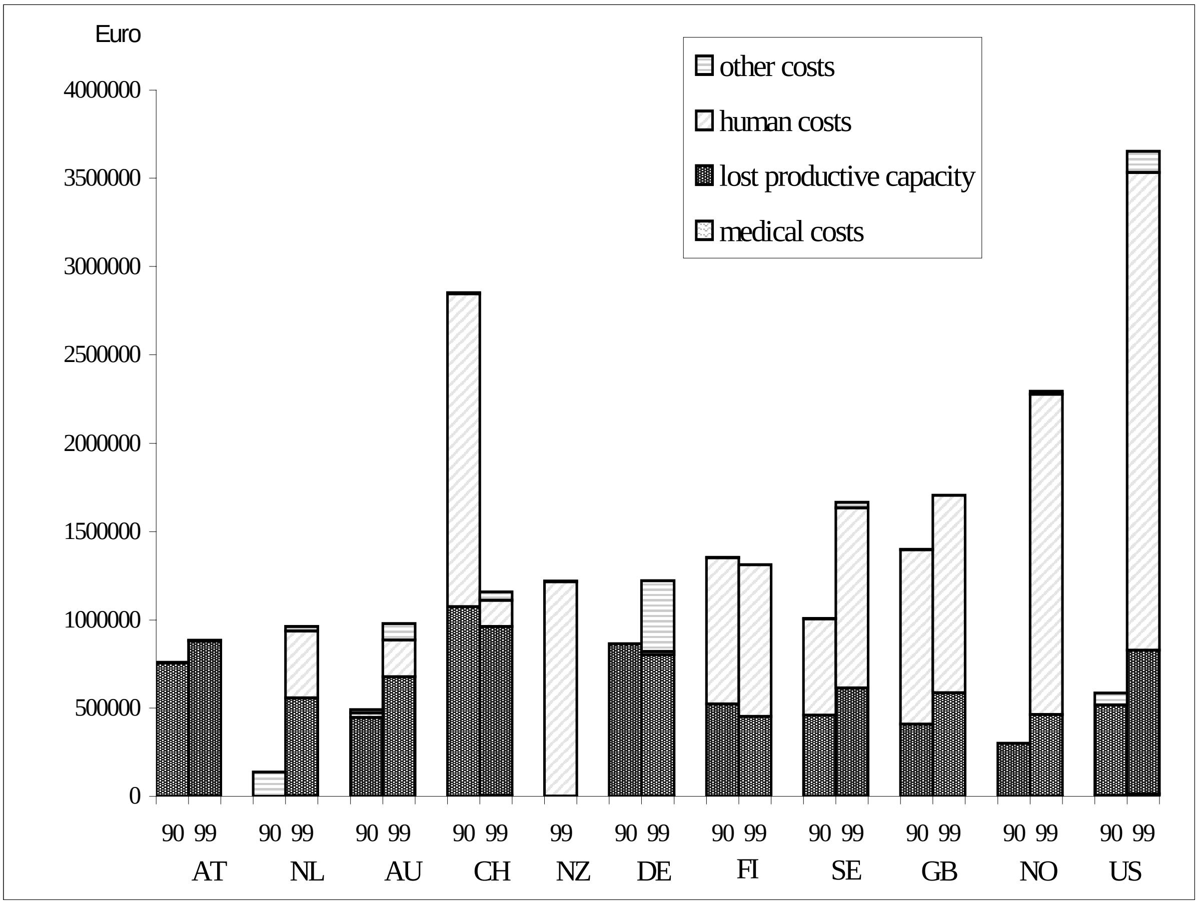
By comparison, the human capital approach, with which economists have greater experience, is not entirely free of inaccuracies either. For example, in order to determine net output losses, a coefficient must be used to escalate the value of future output, which does not in itself pose any insuperable problems were it not necessary at the same time to estimate future growth in per capita GDP. In new ECMT Member countries, projecting growth rates is particularly difficult as they are erratic and usually tend to be higher than the European average during periods of economic expansion. Underestimating values in new Member countries would suggest that road safety measures would not be economically justified, whereas they could have a major impact in terms of the number of lives saved. The conclusion to be drawn from this is that while it is possible to measure human capital, it is not possible to do so with any absolute degree of accuracy.

With regard to the willingness-to-pay approach, it would be wise to conduct surveys in which **respondents are contacted again** to see whether, for example, five years later the results are the same. Countries which have conducted such surveys have so far been able to show that results have remained stable. Generally speaking, we now have a better understanding of contingent analysis. Scientists have started to work together and countries which initially produced low values have seen them rise while countries whose values were above average have seen them fall closer to the average. This **convergence in values**, which values a life saved at 1.1 to 1.3 million euros, of which 80 per cent in terms of willingness to pay and the remainder in net losses, returns the theoretical debate to a proper footing. It should be noted that differences still remain over the ratio between the value placed on human life and that of the avoidance of serious injury, due to differences over the definition of what constitutes serious injury. It would seem that solely 1 per cent of injuries are actually very serious, and in this regard it would be helpful to draw up a breakdown of injuries in which the term "serious" is not applied to injuries that simply mean that the person involved has to receive hospital treatment.

The Round Table noted that if surveys and analyses are conducted with all due rigour, the willingness-to-pay approach provides results in terms of **values for human life that are highly comparable from one mode of transport to another**, in addition to which the values are also close between countries at comparable levels of economic development. This near-perfect match in terms of willingness to pay, regardless of the mode of transport, contrasts starkly with the policy differences noted ex post facto. Tolerance for low safety levels is far lower with regard to public air or rail transport than it is for the private car mode.

Unless a consensus is reached on which method to adopt -- some experts remain faithful to the human capital method -- hopes over forging a European method remain based on anticipated advances in the formulation of the willingness-to-pay approach, which is attracting increasing support from researchers. In addition, one result to emerge from the Round Table was that none of the experts objected to placing a value of 1.1 to 1.3 million euros on human life within countries whose standard of living is higher than the European average, which would put the European average at **1 million euros**. A confirmation of this figure can be seen in Figure A which summarizes research from different sources.

Figure A. **The costs per person killed in a road accident 1990 and 1999, divided into cost elements, € 1999 prices**



Source : COST 313, Socio-economic cost of road accidents. Final report of the action. Commission of the European Communities, Luxembourg 1994 and data on file collected in an international survey by Trawén, A. *et al.* at the Department of Technology and Society, Lund University, Lund, Sweden.

Note : We have used the Euro foreign exchange rates at 15 December 1999 (European Central Bank) where €1 = USD1.0 = GBP0.6 = SEK8.6 = NOK8.1 = CHF1.6 = NZD2.0. The consumer price indices used are between 1990 and the third quarter 1999. (OECD Main Economic Indicators for various years).

2. INCORPORATING EVALUATION METHODS INTO ROAD SAFETY POLICY

Are evaluation methodologies used in analytical studies of the effectiveness of road safety measures?

First, the methods described above are used to **ensure a rational basis** to the public decision-making process relating to road safety. If we return briefly now to the arguments made against the methods outlined above, the main one would seem to be that the human capital approach is easier to explain and to justify to decision-makers -- since it values losses to society -- than the willingness-to-pay approach, which uses an artificial means to determine the value that individuals themselves place on life or avoidance of injury. There is therefore a very real need for researchers to explain how these approaches work, not only to policy-makers but also to the general public, since both audiences are mutually interdependent.

These methods have been incorporated into analyses of the advisability of actions or investment for which they provide inputs in the form of a value assigned to a life saved or serious injury avoided. It is briefly worth recalling here that these broader procedures are both cost-benefit analysis, which consists in producing a report indicating the benefits in monetary terms compared with the economic costs of a measure, and cost-efficiency analysis which, for its part, consists in measuring the cost of the provisions adopted compared with the saving of human life. These analyses or procedures are available to politicians **to guide them in the use of an array of measures**.

It should be noted that, in general, as has certainly been the case for many years although to a lesser extent now, no attempt has been made to rationalise public decisions; decisions regarding road safety are routine decisions taken without the aid of appropriate instruments. The budget was determined by the higher echelons of government. While such practices are not ostensibly opposed to assigning high priority to road safety, it can simply be stated that economic analysis can at present help to **guide policy-makers in their choices**.

In an ideal world of economic theory, valuation methods can help to determine the budget for road safety in that adopting all measures whose cost-benefit ratio is greater than one will **determine the budget envelope for road safety**. In such a world, cost-benefit analysis should be the norm. However, because the data needed to quantify all impacts of road safety provisions may be missing, cost-efficiency analyses can be used to marshal an array of measures. Priority could therefore be given to all measures whose costs are low compared with the number of lives saved. In such cases, such an analysis would be needed to calculate to cost of a life saved, which would then obviously make it possible to classify measures.

As a general rule, it would be wise to carry out more cost-benefit or cost-efficiency studies **in all areas of public action** so that measures can be ranked against each other and budget envelopes determined for different forms of action. In this context, **road safety would probably be assigned higher priority and higher levels of funding than it usually receives at present**. There would at least be a degree of reassignment of funds within the transport sector.

The answer that is given to the question "do we invest enough in road safety?" is that road safety measures can be highly effective. Greater resources could therefore be assigned to this issue, although this does not hold true for other modes of transport. For example, investments are sometimes made to improve the accessibility of regions located far from the major economic centres. Traffic levels in these regions are low and therefore accident rates are low too; besides which, the economic return of the investments aimed at opening up regions is not always as high as could be hoped. By analogy, therefore, it would be fair to say that road safety is not accorded the **priority it deserves**, since in this instance human lives are at stake.

However, even considering road safety alone, these remarks need to be qualified in certain respects in that **significant sums of money are spent on measures that are not particularly effective**. Priorities are poorly identified. For example, the three offences of drink-driving, speeding and failure to attach seat belts, on which most countries concentrate the bulk of public action, account for less than 50 per cent of road deaths.

All the discussions on road safety show that actions can indeed be classified according to their effectiveness, since analysis shows that the rate of return on road safety measures is higher than that in other sectors even though marginal rates of return are falling. However, under current road safety budgets, all the measures which cost-benefit ratios suggest would be profitable could be implemented. It was therefore clear to the experts at the Round Table that **before considering increases to investment, priority should be given to ensuring that investment is better targeted**.

With a view to "better" investment, not only forecasting studies but also **retrospective analyses** are required. It would therefore be highly advisable to have estimates of the results of road safety measures, estimates that could be drawn up by calling on the services of experts such as psychologists specialised in human behaviour and road traffic engineers. Ex post facto calculation of the number of lives saved through investment or road safety measures provides a precise evaluation of the effectiveness of the actions chosen and thus makes it easier to convince the public of the appropriateness of such actions. It is therefore important to carry out ex post facto evaluations and not simply halt programmes without giving consideration to performing valuations once the programme has been completed. There are ample grounds on which to justify the time and cost of in-depth research designed to avoid "extrapolation" without "verification", which is the case when an insufficient number of surveys are made of the results obtained.

In the same vein, it is essential to have **follow-up on the ground**. A map is therefore needed of the frequency and severity of accidents throughout the entire national territory. Such a map shows where investment is a priority. In this respect, the Round Table took note of the fact that local road investment to eliminate accident black spots, for example, by building roundabouts instead of intersections, have an extremely high cost-benefit ratio that is far superior to many actions in the public domain. The rate of return on these actions suggests that when insufficient data are available to carry out a proper cost-benefit study, which would thus make it possible to set a budget, there is no need for a set budget but rather a stated objective and to introduce all the measures that would help to achieve this objective on the basis of the findings of the cost-effectiveness and retrospective analyses.

However, to consider one example of the inherent ambiguity of evaluation techniques, a cost-benefit analysis of speed restrictions in rural areas with relatively low traffic densities fails to show significant gains due to the time lost by road users forced to travel at lower speeds. The goals of economic efficiency, the environment and road safety may therefore be mutually conflicting. This would seem to indicate, apart from methodological considerations, the need to **make road safety a national priority**, which would be feasible given the number of lives which could potentially be saved; some experts at the Round Table felt that a measure is justified even if it saved only one or two lives. This shows the importance of acknowledging that the fact that policy-making is an independent activity does not mean to say that aberrant policies will be pursued but rather that such policies will, in all likelihood, exhibit shortcomings unless evaluation methodologies are used to support them.

It should also be noted by researchers that it is important to carry out **exploratory studies** on the effectiveness of road safety measures even if such studies are not held to be of value by politicians. Experience has shown that sooner or later most measures become important issues. Policy-makers may also be looking for new actions to promote and it is highly desirable for researchers to be in a position to provide an evaluation of measures as soon as they appear on the political agenda. At such junctures, researchers can play a major role in ensuring the political and social acceptability of measures under review or consideration by demonstrating their relevance, as we mentioned earlier.

3. A NUMBER OF POINTS TO BEAR IN MIND WHEN IMPLEMENTING A ROAD SAFETY PROGRAMME

The Round Table recalled a number of basic tenets which emerge from an economic evaluation of road safety measures and which are illustrated below:

– Road safety policy must not consist in disparate, disjointed measures but in a co-ordinated body of measures forming a coherent whole, that is to say, a **judicious assembly of constituent parts**. The aim should not be to prefer one measure to another but to implement a series of measures whose effectiveness is based on synergy. Thus if all measures exhibiting a cost-benefit ratio greater than one were to be implemented systematically, the number of road deaths in most countries would be cut by half.

– The issue of **social acceptability** must not be neglected. A policy will not be successful if it is not properly understood by the population. It is commonplace for the policies which are the most effective to be those which are rejected, as in the case, for example, with on-board systems designed to automatically restrict the speed of vehicles according to the type of carriageway on which cars or HGVs are travelling. While perfectly feasible in technical terms, the introduction of these measures is opposed by manufacturers in particular but also by the public. For these various reasons, the advantage afforded by evaluation methodologies is that they can sway public opinion by providing direct evidence of the number of lives that could potentially be saved.

– In connection with the comment made above, it is important when **communicating with the public to always present matters in layman's terms**, that is to say, by explaining issues clearly and simply. Stating clearly how many lives could potentially be saved is a compelling argument that will convince individual members of the public. By the same token, information campaigns that draw attention to the effectiveness of certain measures must be sustained and not simply repeated at intervals or limited over time, since the aim is to influence behaviour, which calls for continuous action over the long term. Clearly stated rules must apply to the organisation of such information campaigns.

– Those who infringe regulations and drive without complying with the highway code are predisposed towards anti-social behaviour. **Awareness campaigns and driver re-education courses** generally have a positive impact on drivers who systematically infringe regulations and choose to behave recklessly. Such actions are, at all events, more acceptable to drivers and no less effective than punishment of offenders, which is slow to have an effect if it goes against ingrained behavioural patterns.

- In particular, when responsibility for the actions to be pursued lies with several Ministries, it is of the utmost importance to ensure that the **actions of the various Ministries concerned are properly co-ordinated**. In this respect, setting up a National Road Safety Council can provide the requisite linkage between the actors involved and ensure that together they can achieve results which alone would not be possible for them.

- The actors who are involved in road safety must also be considered in terms of their **personal strategies**. There is no point in involving the police if the latter consider road traffic policing to be a minor duty offering little in terms of returns. In such cases, it would be better to set up special police forces assigned to such tasks and thus restore their badge of honour. In this way, road safety would have to comply with the rules of actors whose strategy must be understood in all its complexity.

- The **private sector has a role to play**. It could, for example, be assigned the task of monitoring traffic flows. It could also play a role in the introduction of innovative technologies; what springs to mind here are the advances that have been made in vehicle technology aimed at both preventing and alleviating the consequences of accidents. As mentioned above, however, we need to remain vigilant. Car manufacturers have a strategy and most of them only started to show concern over vehicle safety once public opinion had shown itself to be sensitive to the shortcomings of vehicles. It might therefore be advisable to focus efforts on influencing public opinion through open dialogue.

- **It is easier to adapt infrastructure than it is to change patterns of behaviour**. However, most road safety measures continue to target driver behaviour. It would be wiser to integrate road safety into the evaluation of infrastructure projects and ensure that road safety is a factor that is taken into road investment. Even though much progress has been made in this respect, however, much still remains to be done.

- **Measures should not be rejected because they cannot be evaluated**. This comment recognises the primacy of politics and the importance of innovative measures. Obviously all Ministries seek funding and it is easier to argue that a policy is well-founded if it can be shown that funding will produce tangible results. Scope nonetheless remains for measures that cannot be evaluated; the fact that a measure cannot be evaluated often reflects its innovative nature. Experts also recognise the benefits of early action with inventive measures.

- Lastly, road safety policy must be rooted in compliance with the rules of **total strategic quality management**, rules that have been taken from management theory. No reticence should therefore be shown in treating road safety policy as an integral issue which is amenable to evaluation and which must meet criteria applied to strategic quality management. To further this objective, the benchmarking of road safety policies and measures could be undertaken at the European level.

4. CONCLUSIONS

There are several ways in which to estimate and take account of the value of human life or serious injury as part of an economic appraisal of road safety measures. This is not a new development and we are starting to accumulate a significant amount of experience in the application of these methods. Opting for the human capital approach is not conceptually sound. The willingness-to-pay approach, on the other hand, focuses on the correct parameter but its measurement of that parameter may be significantly flawed. Although there was no consensus, in this respect the experts at the Round Table felt that it was better to obtain an approximate measurement of the right parameter than to obtain an accurate measurement of the wrong parameter, particularly in view of the body of experience we are now starting to acquire in the use of the willingness-to-pay method. From this standpoint, it would be helpful to draft a manual on the correct use of the willingness-to-pay method in that a practical guide to the rules of the art in this area would bring it to the attention of a wider audience.

Even though the value obtained by means of the willingness-to-pay procedure is not a market value in the economic sense of the term, the values obtained are convergent from one country to another and, even more surprisingly, from one mode of transport to another. The average value assigned to human life within Europe would therefore be 1 million euros. The fact that there is virtually no change in this value from one mode of transport to another is in striking contrast to policy practices, since the investment in accident prevention in the public transport sector is much greater than that in the road sector, given that the authorities are liable for accidents in the public transport sector. This means that individuals would be willing to see government take charge of road safety with the same forcefulness in the road sector as in the rail and air sectors, an approach that is not reflected in the collective values commonly used.

Clearly, these values can serve as a basis for cost-benefit or cost-effectiveness analyses that would help to introduce greater rigour into policies that sometimes appear to have been framed on an ad hoc basis. The social acceptability of measures poses an acute problem, but although it is admittedly a determining issue, it is not one that arises systematically. In view of this, road safety policy should be a strategic process that takes account of the interplay of actors, their complementarity and the need to inform and consult with the public. The public must be given simple messages and efforts must be made to ensure a better balance between measures, in that although spending on road safety is already adequate, the money is not spent "wisely". In addition, the implementation of measures must follow the principles of total quality management and, in order to avoid secondary effects such as possible impacts on social equity, ex post facto studies need to be carried out to determine the effectiveness of measures. Furthermore, actions whose effectiveness cannot be assessed should not be dismissed out of hand. We need to approach the issue of road safety with an open and receptive mind.

Lastly, apart from the guidelines outlined earlier in this report, the Round Table did not systematically discuss each measure individually to determine its relevance, but it did point out that investment in infrastructure produced results faster than attempting to bring about major changes in human behaviour. In contrast, the Round Table proposed that, once it had completed its work, it should carry out a survey, in the form of a questionnaire addressed to the Round Table experts, to determine which were, in the opinion of the latter, the most effective road safety policies. Readers of the present draft conclusions of the Round Table will find the results of this survey in the final proceedings of the Round Table.

ROUND TABLE SURVEY ON MORE EFFECTIVE ROAD SAFETY MEASURES

As requested by the Chairman, the Secretariat conducted a survey of the experts attending the Round Table to ask which road safety measures they considered to be the most effective. Twenty experts filled out the questionnaire which asked them to rank the four most effective measures out of a total of 14.

The measures most often ranked as the most effective were then rated from the most to the least effective, in the opinion of the experts. The ratings are given in Table 1. They show that the most effective measure is stricter speed limits or speed limit checks. Next are investment programmes aimed at eliminating infrastructure black spots. Drink-driving measures were rated third and compulsory seatbelts fourth. Extensive information campaigns on basic safety issues were ranked fifth. Of the first five most effective measures, three are behaviour-related (speed limits, drink-driving, and wearing seatbelts), three areas in which the public authorities could impose checks and penalties, while two (eliminating infrastructure black spots and extensive road safety information campaigns) are directly related to investment by government. One can therefore conclude that while behaviour is emphasised as a factor in road accidents, it would also appear that action by governments is essential.

It is worth noting that information technology was ranked only tenth, probably reflecting difficulties in implementation. Even promoting public transport was ranked as more effective. Improving vehicle safety was ranked only in ninth place, after sliding insurance scales based on driver performance and penalty-point licences.

Developing the motorway network was ranked as the least effective measure. However, this type of infrastructure appears to be less dangerous than the conventional road network, according to the statistics published by certain countries. This said, the experts at the Round Table were consistent in the rankings they gave since they also rated measures to prevent speeding as the most effective and speeds are certainly higher on motorways.

Some experts viewed stricter speed limits as part of an integrated strategy aimed at stepping up checks, promoting traffic calming in built-up areas and having a genuine road safety management strategy.

To conclude this brief overview, it is important to note that the rankings by experts from both new and long-standing Member countries tallied. This tells us that the measures that need to be implemented are no different for new member countries!

ANNEX

1-12-2000

Participants of Round Table 117, Economic evaluation of road traffic safety measures:

Could you please indicate below the four measures which you consider the most important, in order of priority (e.g. Measure 1, Combating alcoholism; 2, License with penalty points system, etc.).

Reinforce speed limits	1
Combating alcoholism	3
Wearing of seatbelts	4
Driving licence with penalty points system	7
Reinforce vehicle safety	9
Variable insurance premiums according to driver	8
Increase cost of private car use	11
Promote public transport	6
Local programmes for eliminating black spots	2
Develop motorway networks	14
Regular training courses for drivers	13
Probationary licence	12
Technologies based on ITT	10
Massive information campaigns on the essential themes	5
Other:	

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