

Economic evaluation of road safety measures

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Contribution to the 117th ECMT Round Table, 26 and 27 October 2000,
Paris.

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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 internalized, 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.

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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*).

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

Table 1. *Socio-economic costs of traffic accidents, in 1995, in the European Union in billion euros (ETSC, 1997).*

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. Presently 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 thus 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 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").

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%	1.9 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 (5,800) 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)

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

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 coordinated 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 characterized 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 economize 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 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 maximization 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 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, 'internalized', 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 internalizing 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 internalization 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 can not 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 *raison d'être* of a government organization. This is largely due to a combination of market imperfections: a roads network is traditionally a public good, it has external benefits and its construction involves large indivisible production units. 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 motorized 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 manufactures 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 organizations 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 organizations, 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 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 internalize the external costs, not only in theory but also in practice.

However, one should realize that 'ex ante' payment of a (compulsory) insurance premium does (or could) influence other decisions than '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 than 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 internalized (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 (s.n. , 1996) even concludes that insurance premiums offer better opportunities for

such risk-differentiation than 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 internalized. 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 thus 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 motorized 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 internalizing 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 specializing 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 optimization). The question can also be framed more restricted, (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 minimization), or how a fixed budget can be allocated so as to result in the greatest possible benefit (effect maximization).

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 - as will become clear - 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 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 a.o. 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 (Brent, 1996; 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 (s.n., 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.

Costs	Benefits
<ul style="list-style-type: none"> - construction costs - modification of airspace structure - other costs (including road traffic infrastructure) 	<ul style="list-style-type: none"> - operating revenue - net revenue from passengers and freight - indirect economic effects - noise nuisance at new airport - noise nuisance at Schiphol - planning assimilation - employment opportunity - other effects
Balance: Benefits against costs:	

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

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 'un-priced 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. Freeman (1999) 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 minimization). Alternatively, it may examine how fixed resources can best be used to achieve a certain social objective (effect maximization).

In a cost minimization 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 maximization, 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 (who 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 minimization, 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 maximization, 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 maximization, 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*.

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)

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

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 organizations 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 characterized 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 can not 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.

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

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

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' column of the table.

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 minimization based on a given set of alternatives, or if it is effect maximization 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 realized 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 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 preset 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 bringing the design of each category into 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 one
- 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 stabilizing of a patient's condition, faster recovery, fewer long-term consequences)
- facilitating measures such as the organization of traffic safety policy (decentralization 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 (organizational 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 realized, 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 organization); 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 summarized 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.

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

Table 6. *Recommended valuation methods for accident 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 realized. 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 criticized, 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 analyzing 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). Also payments of premium for life insurances 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 point of discussion any more. 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 realize 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 concretized. The need for efficiency dictates that the maximum effect is achieved with the budget available, or that the package is realized with a fixed effect and at minimal cost. Since the maximization of effects is the main issue in implementing traffic safety policy rather than minimizing 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 (s.n., 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 maximizes 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 the moment 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 realized 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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