Cost-Benefit Analysis for Road Safety Investments in Belgium

Case study for a Seat Belt Reminder system

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Documentbeschrijving

Summary

Belgian and regional government attaches increasing importance to the matter of road safety. Economic analyses improve the allocation of scarce resources to improve road safety.

Two types of economic analysis, cost-benefit analysis and cost-effectiveness are discussed. A comparison of costs and benefits at different moments in time is discussed, with a focus on the discount rate which should be applied in cost-benefit analysis. The difficulties of valuing the victims of road crashes are discussed. It is stressed that international results can't be copied literally for Belgian research.

A case study is executed in which a cost-benefit analysis for a seat belt reminder system is performed. A 10 year period is taken into account. The unit costs for the seat belt reminder system are taken from Australian research. Three types of seat belt reminder systems are considered, each with a different level of extortion. Implementation costs of 63 €, 127 € and 150 € are applied. Because it is assumed that the number of accidents doesn't change, no incremental external costs (for congestion, environmental damage of infrastructure) occur.

Costs and benefits for different levels of effectiveness are calculated. It is assumed that the total number of accidents doesn't change, but the ratio between persons who do buckle up and persons who don't buckle up does change due to the seat belt reminder system. A value of 5,703 million € for a fatality is assumed. Seriously and slightly injured are valued at 0,771 million € and 0,183 million € respectively.

The net present value of the costs, for a period of 10 years is shown in the table below.

NPV Unit costs	Discount rate			
	4%	5%	7%	15%
63 Euro	285	274	254	195
127 Euro	574	552	512	393
150 Euro	678	652	604	464

The net present value of the benefits for the same period, at different rates of effectiveness and different discount rates is shown below.

	Discount rate			
Effectiveness	4%	5%	7%	15%
5%	312	295	266	180
10%	624	591	531	361
15%	936	886	796	542
20%	1.248	1.181	1.062	723
25%	1.560	1.477	1.328	903

30%	1.872	1.772	1.593	1.084
35%	2.184	2.067	1.859	1.265
40%	2.496	2.363	2.124	1.446
45%	2.808	2.658	2.390	1.626
50%	3.120	2.954	2.656	1.807
55%	3.432	3.249	2.921	1.988
60%	3.744	3.544	3.187	2.169
65%	4.056	3.840	3.452	2.349

If one considers the commonly used discount rates, one can observe the following at each of the different rates:

- if the least expensive seat belt reminder system would be chosen, the project would already be beneficial when an effectiveness of 5% would be reached.
- if the seat belt reminder system costing 127 Euro would be chosen, an effectiveness of 10% would already make the system beneficial.
- the most expensive system would only become beneficial for society when an effectiveness between 10% and 15% would be reached.

If one would apply the discount rate of 15%, the effectiveness should be higher compared to the situation of the commonly used discount rates. This is necessary for each of the three seat belt reminder systems:

- Our research shows that to make the system beneficial, 6% of the drivers and passengers who are not wearing a seat belt should install the seat belt reminder system that costs 63 Euro. The net present value of the benefits in this case would add up to 216 million Euro over a period of 10 years.
- An increase in seat belt wearing amongst non-seat belt wearing drivers and passengers of 12% is necessary to make the seat belt reminder system beneficial from society's point of view. In this case benefits would amount to 433 million Euro, which would cover the 393 million Euro of costs.
- An increase in seat belt wearing amongst non-seat belt wearing drivers and passengers of 13% is necessary to make the seat belt reminder system beneficial from society's point of view. In this case benefits would amount to 469 million Euro, which is break even compared to the 464 million Euro of costs.

Our view is that the improvements that are necessary in non-seat belt wearing are feasible. Australian research has observed an increase in seat belt wearing of 17%. Even if this percentage would be an overestimation, the system would still be beneficial if introduced in Belgium.

1. INTRODUCTION: ECONOMIC THINKING ON ROAD SAFETY

For some time now the Belgian government has been attaching increasingly more importance to the matter of road safety. And not without good reason, since this is one of the most relevant issues for today's citizens. The government has already shown that it takes road safety very seriously: a visible increase in speed checks, a 100 million Euro investment plan to tackle Flanders' black spots along with major public works in Antwerp.

Road safety is also an area where eyebrows are raised when costs come into the equation. People believe that costs should not be taken into account when a life can be saved through investment in road safety, since you cannot put a value on a life. However, this is wrong since it would imply that every life-saving measure should be implemented as long as its opportunity cost is less than infinite. Today's financial resources could never reach that goal. A five km/h speed limit might well be a safety-effective measure, but it would inflict considerable damage to the economy. And that is the heart of the matter: our resources are not infinite and consequently should be allocated wisely. Moreover, since resources can only be spent once, they should be spent on those measures that increase the prosperity and safety of our citizens.

Efficiency can be pursued in essentially two ways: on the one hand, a level of expenditures in road safety has to be set, while on the other hand, careful thought has to go into how best to allocate the available resources and to which specific areas. A viable economically sound policy regarding the latter is the subject of this paper.

Assuming such an economic analysis is accepted, we are faced with the fact that no unequivocal framework exists to guarantee the optimal allocation of the resources. This paper's aim is discuss topics that deserve our attention in the event of just such an economic analysis being performed. It will become clear that several topics rightly deserve our attention and no unambiguous answer is available[1].

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[1] This on its own may already make people believe that an economic analysis is not useful.

The paper is set out as follows: the first section deals with the important difference between cost-benefit analysis and cost-effectiveness analysis, since these are the two most widely used tools in economic analysis. The following topics, important when carrying out a cost-benefit analysis, will be considered later on:

- Intertemporal comparison of costs and benefits (section 3);
- Use of results from international studies (section 4)
- Valuation of human life (section 5);

The second part of this paper covers a cost-benefit analysis carried out on the seat belt reminder system in Belgium.

2. COST-BENEFIT V COST-EFFECTIVENESS ANALYSIS

Most policy makers and economists agree that when a policy (in our case road safety) is evaluated, a comparison should be made one way or the other between the resources that are invested and the benefits accruing from the investment. Cost-benefit analysis and cost-effectiveness analysis are two ways in which to carry this out.

The main difference between cost-benefit analysis (CBA) and cost-effectiveness analysis (CEA) is the evaluation of the effects: in a cost-benefit analysis all effects are expressed in monetary units. In a cost-effectiveness analysis this is not the case, mainly because it is sometimes difficult to determine costs without discussion. The difference between these two approaches becomes clear when the results from two different studies are compared:

- Australian research shows that for a specific type of seat belt reminder system, for each dollar invested 4,2 dollars are earned[2];
- Norwegian research by Rune Elvik has shown that 3,46 fatalities and seriously injured are avoided per 1 million Swedish crown invested in a specific seat belt reminder system[3];

This difference is important for the following reason. In the Australian CBA example, decision-makers will have the information at hand to rank investments in road safety and to initiate these investments until they are no longer cost-efficient from society's point of view. Resources will be allocated as efficiently as possible. In the Norwegian example, decision-makers will not only be able to rank the alternatives based on cost-effectiveness: it will also be clear which alternative to pursue first. However, decision-makers will not know whether this first project is efficient from society's point of view (it is unlikely decision-makers have this information[4], and they might feel it wiser to invest the available resources in other fields. Above all, people who execute a CEA do not know which is the last project that can be implemented efficiently. Alternatives will be pursued for which we sacrifice resources that could be allocated more efficiently.

One could be tempted to conclude that CBA is a superior analytical tool to CEA. It is however the case that in executing a solid CBA a number of additional difficulties emerge, which a CEA does not have to take into account. For instance, there would be no valuation on a human life. CEA, compared to CBA, has the additional difficulty that one

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[2] B. Fildes, et al., *Benefits of seat belt reminder systems*, Australian Transport Safety Bureau, Report n° CR 211, 2002, p. 22
[3] Elvik, R., *Improving road safety in Sweden, An analysis of the potential for improving safety, the cost-effectiveness and cost-benefit ratios of road safety measures*, TOI Reports 490/2000, 2000, Sweden, p. 93
[4] Otherwise they probably use information from their cost-benefit analyses.

has to find a way to rank qualitative information. All this has resulted in more CEAs being carried out in road safety compared to CBAs.

3. INTER TEMPORAL COMPARISON OF COSTS AND BENEFITS

When costs and/or benefits are spread over a period of time (for example the initial investment and maintenance necessary in the following years or the number of fatalities prevented following the implementation of an initial investment) they have to be compared to one another in an objective manner. Several methods exist[5]. The method used in this analysis is the Net Present Value (NPV). Using this method, the flow of costs and benefits are reduced to one specific moment in time (most often this is the moment of the initial investment), and both costs and benefits are discounted. In a CBA, different discount rates can be applied. Choosing the correct discount rate is important: the higher the discount rate, the lower the impact of future costs and benefits when the projects are appraised.

A classical view is that the discount rate that has to be used should equal the interest rate of government bonds. When they are adjusted to fall in with inflation and taxes, they are a good indicator for the compensation consumers ask for postponing their own consumption. If this view is followed, a discount rate of 4% should be used.[6]

Another opinion is taking into account opportunity costs. The government can choose to invest the resources allocated previously for road safety (and other resources) into private companies. By doing this, the government expects a return in the same way any other shareholder would. The government would only be interested in investing in other companies if the return it gets is higher than the revenue from government bonds. We assume a moderate return of 3%, on top of the nominal interest rate from government bonds. This nominal interest rate was on average 6% for the last 10 years. A private company also has to pay taxes. Let's say this company needs to pay 40% taxes on its revenues. An inflation rate, assumed in this example 2%, should also be taken into account. The discount rate that should be applied in this case would be: ((6%+3%)/(1-0,4))/1,02=14,7%.

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[5] For an overview, see for example Staes, H. and B. De Brabander, *Inleiding tot economische afwegingsmethoden op Verkeersveiligheidsmaatregelen*, Steunpunt Verkeersveiligheid bij Stijgende Mobiliteit, Diepenbeek, 2002.
[6] This is also the discount rate which is applied by the government in "het mobiliteitsplan Vlaanderen" (*Ontwerp Mobiliteitsplan Vlaanderen, bijlage: nota macro economische toetsing*, p. 24)

In our cost-benefit analysis, a series of calculations were made with a discount rate of 15% to see how this would affect results.

It is important to note that a discount rate which has been derived from opportunity cost for private investment may only be applied if the government would actually invest in private companies given these resources are not allocated for investments in road safety.

A third, more theoretical view, concerns social time preference. It is reasonable to assume that a discount rate from an individual perspective is higher than a discount rate taken from a common perspective. Since cost-benefit analyses are drawn up from the standpoint of society as a whole, this should be taken into consideration. Two reasons that bear this out are:

- individuals expect compensation because consumption is delayed. However, this postponement of consumption brings with it external benefits that are not considered by the individual;
- as citizens we value the future more than we do as consumers. This leads to a lower time preference and a lower discount rate.[7]

These considerations lead to a discount rate which takes society into consideration that should be lower than a discount rate taken from an individual perspective. It is, however, not clear how this can be put into practice.

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[7] Research from Cropper et al shows, however, that regarding a human life a higher discount rate should be applied, in other words more value is attached to a present life than a future one. (Cropper, M.L., S.K. Aydede, P.R. Portney, *Rates of time preference for saving lives*, American Economic Review, 1992, 82 (2), 469-472

4. INTERNATIONAL RESULTS APPLIED TO BELGIAN COST-BENEFIT ANALYSIS

Applying results from international research to Belgium is not without its dangers: it cannot be assumed that effectiveness and efficiency of measures are similar in different countries. A number of reasons account for this:

- The efficiency of a measure depends on the value of a human life. Various parameters are needed to arrive at a certain value. These are discussed in section 5.

- Former investments also play a role. After all, they determine the risk level of accidents. This can result in country A, where a lot of crossroads already have traffic lights installed, benefiting less from the building of new roundabouts than country B, where fewer traffic lights have been installed at crossroads. It would be reasonable to say that the effectiveness and the efficiency of new roundabouts will not be the same in the two countries.

- Driving behaviour influences the effectiveness of new measures. Let us say that in country A drivers are more respectful of speed limits than drivers in country B. Let us assume that in both countries the speed limit on motorways is simultaneously dropped from 120 km/u to 110 km/u. One can expect, ceteris paribus, that the effectiveness and efficiency of this measure in country A will be greater than in country B.[8]

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[8] The reasons why drivers in country A obey speed limits are not important because we assume that everything else remains constant. It would be different if the new speed limit would be enforced more strongly in country B than in country A.

5. THE VALUE OF A HUMAN LIFE

Valuing a human life is probably one of the most controversial issues in cost-benefit analysis for road safety. A valuation is, however, necessary to make an objective evaluation of different projects. This becomes clear when one project, whereby one human life is saved, is compared to another where there are social benefits but where no life is saved. Should we automatically opt for the project in which 1 life is saved? And what if the project, which saves 1 life, is 10 times more expensive than the other project, which might bring a benefit to 1,000 people? If everyone still feels that the first project should be initiated, then by the same token every house should be protected by an expensive fire alarm system. Since this isn't the case, it is clear that there is a certain trade-off between investments in road safety and the risk people are willing to run.

Road safety measures are there to save lives. International literature dealing with cost-benefit analysis has already devoted a lot of attention to the valuation of a human life. Besides road safety, the valuation of human life is also important in public health and environmental investments, for example.

Research results however vary greatly, and this could lead to scepticism. There are, however, a number of reasons why results differ. de Blaeij et al[9] and Takeuchi[10] have both carried out a meta analysis on the value of a human life. They both discovered structural reasons that explain the different results.

5.1 Different components

An initial reason is the difference in the components that are included in the calculation. Two major approaches are important here: the *human capital* approach and a group of techniques that use *willingness to pay*, and value human life on the basis of a change in the mortality risk.

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[9] de Blaeij, A., et al., *The Value of Statistical Life in Road Safety: A Meta-Analysis*, Tinbergen Institute Discussion Paper TI 2000-089/3.
[10] Takeuchi, K., *A Meta-analysis of the Value of Statistical Life*, Discussion Paper F-2000-2, Institute of Social Sciences, Meiji University, Japan.

In the human capital approach, human life is valued on the basis of future productivity that would benefit the national economy. One's own consumption could be substracted. This method has a number of problems on board: what is the value of an unemployed person? The human capital approach uses market prices that don't necessary reflect the overall *benefit* that society as a whole experiences[11]. Human suffering of relatives or family members is generally not taken into consideration. Compared to methods based on the willingness to pay approach, this approach results in lower values for a human life. It is generally accepted that the human capital approach is insufficient to value a human life.[12]

In the willingness to pay methods, research is carried out into how much someone is willing to pay to reduce a specific level of risk (for example 1%). Based on the amount people are willing to pay, one can calculate how much society is willing to pay to save 1 life.

One can arrive at a difference in this WTP method between research into the *revealed* WTP and the *stated* WTP. de Blaey concludes that the value of a human life calculated using the revealed WTP method systematically leads to lower values compared to the case of a human life calculated from a stated WTP.

5.2 Type of measure

Another cause quoted by de Blaeij and Strand[13] that leads to differences in valuation is the type of measure that is proposed: when this concerns private adjustments (a technical adaptation on the car, for example) then it appears that the WTP is higher compared to a public good (for instance, an improvement to infrastructure)

5.3 The level of initial risk

Takeuchi has concluded that the type of risk that is studied plays an important role. Unfortunately, road safety was not part of his research. Another cause of differences in

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[11] Market prices do reflect the real benefit on individual level

[12] Trawén has carried out an international comparison for valuing human life. In 1990 several countries used the human capital approach. In 1999, when this study was repeated, a number of countries didn't use the human capital approach anymore, as recommended by the European Union. See Trawén, A., et al, *International comparison of costs of a fatal casualty of road accidents in 1990 and 1999*, in Accident Analysis & Prevention, 2002, 34, 323-332

13 Strand, J., Public- and private-good values of statistical lives: results from a combined choice-experiment and contingent-valuation survey, 2001, Oslo, Norway

valuation of a human life includes the initial risk of an accident and the risk reduction that are taken into consideration.

Takeuchi[14] refers to research from Beattie et al. that shows that the level of risk reduction is of limited importance.

5.4 Income elasticity

Income elasticity also plays a role. To obtain a clear picture of the impact of income elasticity, Hammitt[15] conducted research over a long period of time in a fast growing economy, that of Taiwan. His research shows an income elasticity between 2 and 3. This means that an increase in earnings of 10% leads to an increase in spending on risk reduction of 20% to 30%.

These differences in results make it clear that it is not possible to adopt international research results from another country simply like that. Data over Flanders and/or Belgium are the most appropriate in this situation. Furthermore, it would be interesting to compare results for Flanders and/or Belgium with different methodologies. This would allow a number of different versions to be calculated in the cost-benefit analysis.

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[14] In his own meta analysis, he doesn't find this solution.
[15] Hammitt, J.K., et al, *Survival is a luxury good: the increasing value of a statistical life*, 2000

6. CASE STUDY: A SEAT BELT REMINDER SYSTEM

6.1 Assumptions

In our analysis, we have investigated the efficiency of 3 types of seat belt reminder systems. These systems were installed to protect all the occupants of a 4-wheel vehicle. For convenience, the systems have been adopted from Australian research[16]:

1. A simple flashing light and 65dB tone along the lines of that specified by Euro-NCAP. This would require a buckle switch to detect non-compliance and an additional sound generator with an additional presence detector switch. It is assumed that this device would run continuously once initiated until the buckle is clicked in or the ignition is switched off. This system costs 63€.
2. The same as above, but including a speed monitor, where the flashing rate and tone intensifies as the vehicle's speed increases. This system costs 127€.
3. The same as the second device above, but a more sophisticated belt-wearing sensor system is used, as well as an "external second phase intervention" (for example: flashing hazard lights). This system costs 150€.

In our analysis, we assume that the ratio of drivers and passengers wearing a seat belt is the same. Results of BIVV-research show the following percentages of drivers and passengers wearing their seat belts:

Table 1: % of people wearing seat belts in Belgium, 2001

	Driver	Passenger (front)	Average[17]
Motorway	63 %	64 %	63 %
In built-up areas	47 %	51 %	49 %
Others	58 %	59 %	58 %

Source: BIVV, Evalutie "Tot ziens? Klik ze vast. Altijd", p. 4

6.2 Seat belt reminder: Effectiveness

A solid cost-benefit analysis uses clear-cut effectiveness measures. Two remarks are worthy of mention in order to assess the effectiveness of new technology:

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[16] Fildes, B., et al, *Benefits of seat belt reminder systems*, Australian transport safety bureau, Report N° CR211, 2002

[17] Arithmetic average. This will not drastically change the outcome of our cost-benefit analysis.

- it is important to know the total number of accidents/victims that can be reduced by the new technology. In this case, it is worth mentioning that it is unlikely that seat belt reminder systems affect the number of injured pedestrians. On the other hand, if we assume that drivers not wearing their seat belt do so because they feel it unnecessary or inconvenient, then it stands to reason that these drivers may become more of a danger on the road, in which case the number of casualties among pedestrians might increase.

- it is important to know whether the use of new technology might lead to more dangerous driving behaviour, resulting in a decrease in the reduction of casualties amongst drivers and passengers, which might be attributed to the new technology. This is the so-called moral hazard problem. This means that not only the number of so-called target accidents should be considered, one also has to have an open mind and consider other types of accidents which might increase or decrease.

6.3 Efficiency of different types of seat belt reminder systems

Our starting point was the number of persons involved in road accidents in 1999 in Belgium, reported by the National Institute of Statistics (NIS). Only the persons involved in accidents that concerned 4-wheel motorised vehicles were taken into account. From this number, were omitted the persons who were not in the vehicles, from which we've assumed that a seat belt reminder system would not have an effect on the outcome of the accident[18]. This resulted in our final group of 84,750 persons as driver and/or passenger involved in an accident in a 4 wheel motorised vehicle.

Because we assume that the outcome of accidents is dependent on the type of road, the speed limit and whether persons were wearing their seatbelt, a further distinction is made regarding the type of road, namely motorways, primary roads, secondary roads and other roads. The BIVV study also showed that the proportion of people wearing a seat belt differs when considering the different types of roads.

In our analysis, we made calculations for different results concerning effectiveness. Our analysis starts with an assumed effectiveness of 5%. This means that 5% of persons not wearing a seat belt before the installation of the seat belt reminder system[19] will do so

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[18] We assume that the outcome of an accident for those persons involved in an accident who are neither driver **n**or passenger (e.g. a pedestrian) would not have been changed if somebody in the 4 wheel motorised vehicle would have buckled up (due to the seat belt reminder system), if he or she wasn't doing so before.

[19] As recorded in the NIS-data. This is probably an underestimation which we ignore in this analysis. Effectiveness may be assumed higher, but is not included in our analysis.

after it has been installed. Our analysis will use an effectiveness of 50% for the most aggressive seat belt reminder system.

Different discount rates were applied to the analysis. Rates of 4%, 5% and 7% were used, along with a discount rate of 15% to see how results would vary.[20]

6.3.1 The number of casualties avoided

Table 2 gives an overview of the total number of casualties avoided by the seat belt reminder system at different effectiveness rates per year, per type of injury[21].

The results in Table 2 assume that all cars are equipped with a seat belt reminder system. Two options are available when implementation is considered:

- only new cars are equipped with the seat belt reminder system;
- cars already on the market have to be returned to the distributor to have a seat belt reminder system installed. Besides the fact that this would increase costs, it cannot be excluded that for certain older car models a seat belt reminder system cannot be installed due to technical limitations.

In our analysis only new cars are equipped with the seat belt reminder system. We also assume that people don't postpone their purchase of a new car because of the cost of this seat belt reminder system[22]. With this in mind, we can conclude that 536,000 new vehicles are available on the market each year[23]. These cars will gradually replace the 5,608,237 vehicles now on Belgium's roads.

It will take ten and a half years to replace all the present vehicles. This will affect the number of fatalities and injuries avoided. After the first year of introduction, 9,9% of all cars will be equipped with the seat belt reminder system and the number of fatalities and injuries avoided will be 9,9% of those mentioned in table 2. After two years this will be 19,8%, and so on.

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[20] 4% and 5% being commonly used discount rates, 15% regarding the impact of opportunity costs for the government.
[21] See appendix for the detailed calculation.
[22] This is an acceptable assumption since the absolute costs of the seat belt reminder system are limited.
[23] Febiac, yearly average based on 1995-2002.

Table 2: Absolute decrease in number of victims, at different rates of effectiveness of a seat belt reminder system, Belgium, 1999, all types of roads aggregated

	Effectiveness (% decrease in non-seat belt wearing)					
	10%	15%	20%	30%	40%	50%
Fatalities	21	32	42	63	84	105
Seriously injured	28	42	56	83	111	139
Slightly injured	16	24	31	47	63	78
Uninjured	-65	-97	-129	-194	-258	-323

It can be seen from the table above that at every rate of effectiveness the number of fatalities and injuries decreases[24]. Since the *number* of accidents and the *number* of persons involved in an accident would not have changed because of a seat belt reminder system, it stands to reason that the total number of fatalities and seriously and slightly injured persons is counteracted by the number of uninjured, since a seat belt reminder system doesn't alter the incidence of the accident itself[25].

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[24] This is only true on an aggregate level. If one would investigate the results per type of road, one would encounter an increase in the number of slightly injured persons on motorways. This is, however, only true in a limited number of cases.

[25] Except when driving behaviour would change due to a seat belt reminder system. In this analysis we have assumed that this is not the case.

6.3.2 The value of the number of lives saved and injuries avoided

In our cost-benefit analysis, we need a monetarisation of the number of lives saved and injuries avoided. It has been stated earlier that using international values of human life is inadvisable for various reasons. However, at present, research using Belgian data is not available. The values used in this cost-benefit analysis are based upon research carried out by I. Mayeres. A discount rate of 4% has been used to express the monetary value in 2003 prices. The results of this research are partly based on international literature. The values that are used in this analysis are stated in Table 3.

Table 3: Monetary value of fatalities and injuries in road safety, Belgium, 2003 prices

	Monetary value (in Euro, 2003 prices)
Fatalities	5,703 million
Seriously injured	0,771 million
Slightly injured	0,183 million

The monetary value of the seriously injured and slightly injured is based on European research carried out by ETSC. This research shows us that the value of seriously injured people is 7,4 times less than a fatality. The value of a slightly injured person is 31,1 times less than the value of a fatality.

In our analysis, we have calculated the NPV of the value of the casualties avoided. We have done this because the value of life is based upon a willingness to pay, revealed from citizens' surveys. This willingness to pay represents a monetary value expressed by the respondents, which has to be discounted.

6.3.3 Seat belt reminder: implementation costs

One of the things to consider is the implementation strategy. Contrary to infrastructure measures or enforcement, one can choose to implement new technology for road safety measures only in new cars. This means that for a longer period of time not all cars would have, in this case, the seat belt reminder system.

Depending on the type of seat belt reminder system, implementation costs would fluctuate between 63 Euro and 150 Euro. These costs are based on Australian research that uses the manufacturer's best available information at present. It does not consider economies of scale when production is increased. Thus, the costs used in this cost-benefit analysis might be considered as maximum costs for each type of seat belt reminder system. Since the costs of the seat belt reminder system occur in consecutive years, these costs have to be discounted as well.

6.3.4 External benefits and costs

Traditionally, a number of external benefits come up when investigating road safety measures.

Congestion costs: the seat belt reminder system does not reduce the number of accidents themselves[26]. Thus, a seat belt reminder system does not influence possible congestion after an accident.

Environmental costs: a seat belt reminder system could influence environmental costs. It could be possible that certain drivers would drive faster when a seat belt reminder system has been installed. We assume that this only applies to the number of drivers who do not buckle up at all at present.[27] Because of the lack of data (how much will speed increase?), these specific costs are not included.

Infrastructure costs: we assume that by the seat belt reminder system has no effect on external costs since the number of accidents themselves do not change.

6.4 Results

6.4.1 Costs

Depending on the discount rate applied in the analysis, the following costs will occur. The net present value of the costs is illustrated in table 4.

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[26] We have assumed that driving behaviour does not change (positively or negatively) in such a way that more accidents happen because of the seat belt reminder system.
[27] This implies that we assume that inconsistent seat belt wearers don't change their speeding behaviour because of the seat belt reminder system. This appears fairly reasonable to us.

Table 4: NPV of costs of the seat belt reminder system, at different discount rates, Belgium, 2003, in mio Euro

NPV Unit costs	Discount rate			
	4%	5%	7%	15%
63 Euro	285	274	254	195
127 Euro	574	552	512	393
150 Euro	678	652	604	464

6.4.2 Benefits

The discount rate most commonly used in cost-benefit analysis for road safety, lies around 4%. The net present value of the benefits is outlined in the table below for several rates of effectiveness of the increase in use of seat belts. Results for the different types of casualties are aggregated. A 10 year period is taken into account for the calculations.

Table 5: NPV of benefits, in 2003 prices, in mio Euro, at different discount rates and rates of effectiveness

	Discount rate			
Effectiveness	4%	5%	7%	15%
5%	312	295	266	180
10%	624	591	531	361
15%	936	886	796	542
20%	1.248	1.181	1.062	723
25%	1.560	1.477	1.328	903
30%	1.872	1.772	1.593	1.084
35%	2.184	2.067	1.859	1.265
40%	2.496	2.363	2.124	1.446
45%	2.808	2.658	2.390	1.626
50%	3.120	2.954	2.656	1.807
55%	3.432	3.249	2.921	1.988
60%	3.744	3.544	3.187	2.169
65%	4.056	3.840	3.452	2.349

Source: own calculations

6.5 Conclusions

In this paper, a number of issues have been considered that influence the decision processes of investments in road safety. A cost-benefit analysis for 3 different seat belt reminder systems was performed to see what the return would be of each of these systems. Three commonly used discount rates (4%, 5% and 7%) were used in the analysis and one discount rate of 15% to reflect the impact on the results when one would use an interest rate which reflects the opportunity costs for the government. The effectiveness ratios which are mentioned indicate the percentage decrease in the number of people involved in an accident who didn't buckle up before the installation of the seat belt reminder system, do so after the seat belt reminder system is installed.

In this paper the following assumptions were made:
- the absolute number of casualties reduced by the seat belt reminder system can be reached each year, above the reduction in casualties which can be expected from the trend;
- the demand for new cars is not affected by the extra cost for the seat belt reminder system;
- the avoided cost of a fatality is valued at 5,703 million euro. A seriously injured person is valued at 0,771 million euro, a slightly injured person at 0,183 million euro.
- Depending on the type of seat belt reminder system, its costs are valued at 63, 127 and 150 euro. This cost is a best guess, which does not take into account possible economies of scale;
- each year 536.000 new cars will be equipped with a seat belt reminder system;
- A 10 year period is taken into account for the calculation of costs and benefits;
- drivers and passengers which are using their seat belt due to the seat belt reminder system don't change their driving behaviour;
- drivers buckling up due to the seat belt reminder system don't face comfort costs.

If one considers the commonly used discount rates, one can observe the following at each of the different rates:
- if the least expensive seat belt reminder system would be chosen, the project would already be beneficial when an effectiveness of 5% would be reached.
- if the seat belt reminder system costing 127 Euro would be chosen, an effectiveness of 10% would already make the system beneficial.
- the most expensive system would only become beneficial for society when an effectiveness between 10% and 15% would be reached.

If one would apply the discount rate of 15%, the effectiveness should be higher compared to the situation of the commonly used discount rates. This is necessary for each of the three seat belt reminder systems:

- Our research shows that to make the system beneficial, 6% of the drivers and passengers who are not wearing a seat belt should install the seat belt reminder system that costs 63 Euro. The net present value of the benefits in this case would add up to 216 million Euro over a period of 10 years.
- An increase in seat belt wearing amongst non-seat belt wearing drivers and passengers of 12% is necessary to make the seat belt reminder system beneficial from society's point of view. In this case benefits would amount to 433 million Euro, which would cover the 393 million Euro of costs.
- An increase in seat belt wearing amongst non-seat belt wearing drivers and passengers of 13% is necessary to make the seat belt reminder system beneficial from society's point of view. In this case benefits would amount to 469 million Euro, which is break even compared to the 464 million Euro of costs.

Our view is that the improvements that are necessary in non-seat belt wearing are feasible. Australian research has observed an increase in seat belt wearing of 17%. Even if this percentage would be an overestimation, the system would still be beneficial if introduced in Belgium.

Research by BIVV in Belgium has shown that seat belt wearing in Belgium in 2001 varied between 47% and 64%, depending on the type of road and whether it concerns a driver or a passenger. This would imply that the effectiveness rates necessary would be attainable.

In our analysis, we started with the data provided by the N.I.S. This accident data shows a much lower rate of non-seat belt wearing: on average 4% among the accidents processed in the N.I.S. data. It could be possible that data on drivers or passengers not wearing their seat belt when involved in an accident was not always processed. This would imply that the benefits would only increase and the systems become more beneficial.

In cost-benefit analysis for road safety investments the most important benefit is the number of casualties avoided. The value of these casualties used in the analysis is therefore of crucial importance. The determination of this value is not without discussion in the international literature. Therefore additional research will be performed and will be available in a future report. This future report will also address the issue of moral hazard, which was ignored in the present paper. This additional research is necessary before making a final conclusion on the effectiveness and efficiency of the seat belt reminder system.

Cost-benefit analysis is one part of the evaluation that has to be made when considering implementing new technology. It is obvious that the population's acceptance of this new technology should be investigated before it is implemented, whether or not the cost-benefit analysis shows higher or lower returns.

Cost-benefit analysis is a tool for decision-makers; it doesn't replace the decision process itself. A return lower than 1 does not necessarily mean that a certain project should not be pursued. It does however provide the insight how much resources could be used in a more beneficial way. The goal of a cost-benefit analyst should be to provide information to decision-makers and calculate the loss/gain of resources.

Our research shows important benefits from a seat belt reminder system. This doesn't imply that such a system should be pursued at all costs. Not only should these results be compared to other technological improvements in cars, a comparison with other investments in road safety (enforcement, infrastructure) is also necessary to make a profound decision.

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8. APPENDIX

Number of persons involved in an accident		
	Absolute number	Relative number
Accident in which driver doesn't buckle up		
Fatalities	A	AA
Serously injured	B	BB
Slightly injured	C	CC
Uninjured	D	DD
Accident in which driver buckles up		
Fatalities	A'	AA'
Serously injured	B'	BB'
Slightly injured	C'	CC'
Uninjured	D'	DD'

An effectiveness of Z**%** means:

Total number of persons involved in accidents

Accident in which driver doesn't buckle up	=A+B+C+D
Accident in which driver buckles up	=A'+B'+C'+D'

Change in number of persons involved[28]

Accident in which driver doesn't buckle up	**(100-Z)%** of (A+B+C+D) (this is called "X")
Accident in which driver buckles up	(A'+B'+C'+D') + (A+B+C+D) - **(100-Z)%** of (A+B+C+D) (this is called "Y")

Accident in which driver doesn't buckle up

Fatalities	AA * X
Serously injured	BB * X
Slightly injured	CC * X
Uninjured	DD * X

Accident in which driver buckles up

Fatalities	AA' * Y
Serously injured	BB' * Y
Slightly injured	CC' * Y
Uninjured	DD' * Y

This results in a total number of fatalities/injured saved (this is the result in table 2):

Fatalities	= A+A' - AA*X - AA'*Y
Serously injured	= B+B' - BB*X - BB'*Y
Slightly injured	= C+C' - CC*X - CC'*Y
Uninjured	= D+D' - DD*X - DD'*Y

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[28] The changes apply to the number of persons who buckle up vs not buckle up. The total number of persons involved in accidents doesn't change.