Economic analysis of traffic safety: theory and applications Short summary

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1. Introduction to the project

1.1. Context and Summary

Traffic accidents cause substantial costs to society and there is a widely accepted belief that these costs are excessive and should be reduced. Nevertheless, the number of means available to reduce accident costs is limited and so are the available resources. The project aims to contribute to the solution of this selection problem with a theoretical and empirical analysis of various traffic safety measures. For this, it uses an interdisciplinary approach, with contributions from both law and economics.

1.2. Objectives

The project analyses the potential and limitations of various transport safety measures and investigates to what extent they are complementary. The focus lies on regulatory instruments, liability rules, economic instruments, and infrastructure measures. An interdisciplinary approach is used: we aim to integrate insights from economics, and law and economics.

- In economics the focus lies on the determination of accident costs and on the evaluation of pricing, infrastructure measures and technical regulation. The legal rules are taken as given.
- The law and economic approach has two goals: (1) predicting the rational responses of individuals to changes in legal rules, (2) designing legal rules in such a manner that certain goals may be attained in a cost-effective way. Thus, the law and economics approach will be focused on the analysis of the effects of different legal rules on the behaviour of people in situations that may lead to accidents. Once a predictive model is clarified, the desirability of changes in the legal rules can be appreciated in relation to the changes that we want to attain in people's behaviour.

Both approaches can bring new insights to the problem of how to reduce the overall costs of traffic accidents in the most efficient way.

The project consists of three steps:

- In a first step we make an overview of existing and potential measures which are aimed at improving traffic safety.
- A second step considers the problem from a theoretical angle. We base ourselves on theoretical models from transport economics, and law and economics.
- In a third step we apply the theoretical insights to Belgium. We calculate the welfare effects of concrete policy packages.

The goal of the project is to provide policy guidance, based on theoretical and empirical analysis, to improve traffic safety in Belgium.

2. Overview of results

2.1. Description of tasks

The project covers five tasks: (A) coordination and valorisation, (B) overview and selection of measures aimed at improving traffic safety, (C) theoretical analysis, (D) evaluation of measures to improve traffic safety: applications, (E) policy conclusions.

a) Task A: Coordination and valorisation.

Within this task we took the following steps:

- Organisation of a scientific conference on the economic analysis of transport safety. A conference report has been published as: Louis Visscher (2003), "Werk in uitvoering: verslag van een economische conferentie over verkeersveiligheid", *Verkeersrecht*, 51(7/8), p. 225-232. (Ghent University – 26/02/2003)
- Organisation of meetings with user committees
- Organisation of a seminar by John Peirson – The economic theory of road accident externalities: why safe drivers should pay more (K.U. Leuven – 07/05/04)
- Organisation of a workshop dealing with the main results of the project (K.U. Leuven -18/04/06)
- Presentation of the results on various national and international conferences
- Publication of results in various scientific journals. For a full list of the papers we refer to the final report

b) Task B: Overview and selection of measures

For this task two papers were written.

The goal of the first paper is to give an overview of the different measures that have been taken in Belgium. We give a general overview of the current traffic safety policy, sketching the broad lines without going too much into detail. We start with a description of the current level of safety in Belgium. Secondly, we give an overview of the competences of the different authorities. Because Belgium is a federal state, the political competences are divided between the federal (national) level, the regional level and the municipalities. Next, we turn to the different measures. We discuss the main categories, i.e. we look at regulation and its enforcement, liability rules, the insurance system, education and sensitisation, economic instruments, and infrastructure.

A second paper makes a general overview of possible measures to improve traffic safety. Some instruments focus on making driving a car, riding a bike or walking safer, other instruments are aimed at a change in behaviour, for example by changing the travel patterns. In this overview we only focus on the safety effects. However, some instruments can also be used to internalise congestion, noise, and environmental costs. We discuss the following categories: regulation and enforcement, infrastructure, technology, liability, insurance, education and sensitisation, economic instruments, and "other".

c) Task C: Theoretical analysis

For this task we analysed some instruments which are aimed at improving traffic safety. The focus lies on liability rules and regulation and its enforcement.

For **liability rules** we first made an overview of the literature and analysed some of the fundamental gaps in the theory of liability. Next, we applied the theory on liability rules to the traffic situation. We considered one specific case, more specifically bike/car accidents. We looked in particular at how liability rules influence the behaviour of cars and vulnerable road users. We found that the current policy of having strict liability for car drivers for this type of accidents is not optimal.

Subsequently, we compared **liability rules with regulation**. We argue that regulation is intrinsically superior to tort liability because the mix of probability and magnitude of the sanction can be freely set at the optimal level, while tort law relies on a mix set by nature, as the probability of the liability sanctions equals in general the probability that an accident occurs, and the magnitude of the sanction corresponds with the magnitude of the harm.

We then analysed theoretically the joint use of **liability, regulation, and insurance.** In fact, given the argument that regulation is superior to tort liability, we use insurance as the sole method of removing tort liability as an incentive device.

Next, we analysed the joint use of **liability, regulation, and a km tax**. This paper focused on two specific determinants of accidents: speed and the number of kilometres people drive. If there is no government intervention, people do not take into account the full cost of their driving and they will drive too fast and too much. The government can use three imperfect instruments or a combination thereof: strict liability, a speed limit, and a kilometre tax. We analysed the effect on speed and activity theoretically[1] and illustrated this numerically for 3 types of roads – urban, interurban, highway, and three types of users – business, commuters and others. We calculated the private and social optimal levels of speed and activity and the levels of speed and activity under the different instruments. The welfare losses determine the choice of the instrument. We find that the combination of regulation and a km tax is optimal on urban and interurban roads and that strict liability and a km tax together are optimal on highways.

Regulation is widely used in traffic. Think, for example, of speed limits, technical regulation, mandatory seat belts, etc. However, regulation alone is not enough. There is a need for enforcement of regulation. We focus on the enforcement of repeated speed offenders and on the choice between probability of detection and the level of the fine. A first paper makes an overview of the literature on repeated offenders.

A second paper applies this literature to **repeated speed offenders**. When we consider the current practice in Belgium, we find evidence that fines for traffic offences are indeed increasing with the number of previous offences. However, the first paper made clear that the literature on this is mixed. We start from the idea that there is a positive relationship between previous convictions and the probability of being involved in an accident. The idea behind it is the following. Drivers differ in their skills, risk taking, … This makes that drivers differ in their probability to have an accident. This means that, for the same level of speed, the probability of being involved in an accident is higher for a "bad" driver than for a "good" driver. The government does not know who the bad drivers are, but previous speeding violations may act as a "signal" for being a bad driver. Moreover, enforcement exists of two

[1] The model is based on Shavell (1984), A model of the optimal use of liability and safety regulation, *Rand Journal of Economics*, Vol. 15 (2), 271-280.

elements: the probability of detection and de magnitude of the fine. Optimally[2] the probability of detection and the fine should be such that

$$\text{fine} = \frac{\text{expected damage due to speeding}}{\text{probability of detection}} \quad (1)$$

We conclude that the optimal fine is a function of speed and equals the expected accident costs due to speeding, corrected for the probability of detection. For the same speed and same probability of detection, bad drivers have higher expected accident costs, and should therefore be fined more severely.

A third paper deals with the **political economy of the fine structure for speeding**. In Europe, we currently see large variations in the magnitude of the fines and the probability in detection. Moreover, we see that in general the public debate emphasises increasing the probability of detection instead of increasing the fines. This conflicts with theory[3] prescribing that fines should be set at the highest level and that monitoring, given the costs, should be set as low as possible. We can think of two reasons why enforcement is as it is. Firstly, high fines are not a very popular measure. Politicians, who want to be re-elected, take this into account in setting their policy. A second reason is that there are lobby groups at work. Think, for example, of the automobile industry, vulnerable road users action groups, etc. We use the second approach and analyse the choice between the inspection probability and the level of the fine for speeding given the existence of lobby groups. We first calculate the socially optimal fine and then analyse the different combinations of the probability of detection and the level of the fine subject to this socially optimal expected fine. Following Dixit et al. (1997)[4] we derive three equilibriums by maximising an objective function equal to a weighted sum of a social welfare function and the utility functions of the lobbying groups. In the benchmark case, lobbies have no influence. In the other two extreme cases, first the vulnerable road users get all the weight and subsequently, the strong road users. We find that, if only vulnerable road users are taken into account, the fine is much higher and the inspection probability lower than when only car drivers are taken into account.

d) Task D: Evaluation of measures to improve traffic safety: applications

[2] For an overview of the literature on optimal enforcement we refer to Polinsky and Shavell (2000), The Economic Theory of Public Enforcement of Law, *Journal of Economic Literature*, Vol. 38, 45-76.

[3] Becker, G.S. (1968), Crime and Punishment: An Economic Approach, *Journal of Political Economy* **76(2)**, 169-217

[4] Dixit, A., Grossman, G.M., Helpman, E. (1997), Common Agency and Coordination: General Theory and Application to Government Policy Making, *Journal of Political Economy* **104(4)**, 752-769

Besides the applications which illustrate the theoretical research, two papers were written. Both deal with the evaluation of safety measures. In order to be able to conduct a good safety policy, a good evaluation of potential measures is required. This means that one should look at all the benefits and the cost of the measures and only implement them if their benefits are larger than their costs.

The first paper deals with the calculation of a potential benefit, i.e., the total and marginal external accident cost. The aim of this paper is to present a methodology for the calculation of accident costs. This needs to be done both for the total accident cost and for the marginal accident cost. Moreover, a distinction is made between external and internal accident costs. We base ourselves on the theoretical model of Lindberg (2002)[5] to derive the total and marginal external accident costs. From this analysis the different components for calculating the accident costs are derived. Next, we explore how these components can be calculated. For each of the components we make an overview of the existing literature, present an example and make some recommendations. The result of this work can be used as an input.

The second paper gives an example of a social cost-benefit analysis of a concrete safety measure, which is very popular in Belgium nowadays. We look at the change of a crossing with traffic lights into a roundabout. We found that the change of a crossing with traffic lights into a roundabout provides a net social benefit. The transformation makes traffic smoother and safer. The benefits of this are larger than the increased environmental cost and the cost of rebuilding. A sensitivity analysis shows that the results are very robust for changes in accident, time, and infrastructure costs. Note that the same framework can be used to make a cost-benefit analysis of other measures.

e) Task E: Policy Conclusions

Based on our research, we make the following policy conclusions. We first want to stress that a more coherent traffic safety policy is only possible if the competences are less widespread. Moreover, this will also improve the quality of the data, which is needed in order to be able to establish a good traffic safety policy. Note that a good cost-benefit analysis requires taking into account all effects of a measure, not only the safety effects. Secondly, we want to stress that more research is required with respect to influence of combined measures. Measures are never used independently; hence one must take into account their interaction effects. Thirdly,

[5] Lindberg (2002), Deliverable 9, Marginal accident costs-case studies. UNITE (UNIfication of accounts and marginal costs for Transport Efficiency) Deliverable 9. Funded by the 5th Framework RTD Programme. ITS, University of Leeds, Leeds, July 2002

our research also showed that - in general - regulation will work better than tort law in a traffic safety context. It is therefore not surprising that we see so much traffic regulation. Fourthly, we plead for increasing fines for repeated offenders or for the introduction of a demerit point system. A central offenders database may in any case be worthwhile. Fifthly, we show that the current strict liability rule for accidents involving a car and a vulnerable road user is probably best replaced with the general negligence rule. Our illustrations show that if we only take into account traffic safety, it is optimal to lower the speed limit on interurban roads from 90 km/h to 70 km/h and to abolish speed limits on highways, as is the case in Germany. Finally, we want to stress that more research into the social aspects and the social acceptability of traffic safety and measures to improve traffic safety would be very worthwhile. Social acceptability is important because in the end only acceptable measures will be implemented; social aspects are important because they may plead for, for example, income dependent fines.