Standing in cost-benefit analysis of road safety measures:

A case of speed enforcement vs. speed change

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ABSTRACT

Elvik (2006) discussed the appropriateness of including the benefits that offenders get when violating traffic laws. While concluding that these benefits could not be given standing, Elvik resorted to argumentation from normative theories outside the schools of economic theory. In this article, we present arguments for omitting violators' benefits, or lost benefits, based on normative stands within economics school of thought. By means of two examples, we illustrate the distinction between a project of increased/improved enforcement of existing speed limits, where violators' time losses should not be included – compatible with Elvik's point of view – and a project of reduced speed limits, where the time loss should be included. This clarification of standing in cost-benefit analysis of road safety measures is based on the economics school of thought, where cost-benefit analysis is regarded as a decision tool operating within social constraints and where speed limits are considered as absolute institutions.

Key words: absolute institutions, neo-classical economic theory, social constraints

1. Introduction

In an important paper on cost-benefit analysis (CBA) of road safety measures, Elvik (2006) discusses the appropriateness of including benefits offenders get when violating traffic laws, particularly speeding, in CBA of police enforcement. He refers to just one school of the economics of crime, that of Becker (1968), who argued that criminals should have standing in CBA of measures affecting their "industry" and that theft was transfer/redistribution beyond the CBA. Measures reducing crime yield reductions in the disutility related to crime (bother, fear, etc.) at the expense of reduced utility for criminals facing curtailment of their activity, and, according to Becker, the decreased utility of law offenders should be included in any CBA of law enforcement measures. Elvik (2006) introduces deontological ethics as an opposite to Becker's view, finding that speeding can be treated as unconditionally wrong, such that benefits from violating speed limits should not be included in CBA.

However, several leading economists do not share Becker's view on criminals' standing in CBA. There might therefore be no reason for taking refuge in argumentation from ethical theory rather than the economics school of thought for the issue of standing in CBA of road safety measures. CBA is based on an aggregation of individual preferences, as pointed out by Elvik (2006). Neo-classical (welfare) economic theory does not normally assess the correctness of individual preferences, i.e. whether tastes are good or bad, according to some societal standard. This relates to one of the normative principles of economics and CBA – consumer sovereignty – that each individual is best placed to judge what is good for him/her. A second principle almost follows from the first: economic values are based on willingness-to-pay, manifested either through competitive market prices or by means of valuation methods when goods or services are not priced in markets (Mishan, 1988). However, regarding crime and preferences, there is a further principle that is important: CBA is a decision-making tool that necessarily operates within social constraints. Social constraints include institutional settings that dictate whether some activity is legal or illegal, and "criminal laws are absolute, not tolerant, institutions" (Trumbull, 1990, p. 212). It follows from the issue of social constraints that increased enforcement of existing speeding laws on a section of road is a different project from reducing speed limits on that road section. In the former, the benefit loss of violators should not be included in the CBA; they

don't have standing. When a new or adjusted social constraint is introduced, however, such as the speed limit reduction on a road section, the time loss given from the old limit to the new limit should be included in CBA.

We illustrate this issue of standing in CBA of speed enforcement and speed limit change by presenting a real example from Austria, more precisely the section-based speed enforcement (section control) in the Kaisermühlen tunnel on the A22 road in Vienna. In addition to CBA of the actual speed enforcement (Stefan, 2006), we provide an alternative CBA for the hypothetical case of a speed limit reduction, assuming similar speed reduction effects as the actual speed enforcement. These actual and hypothetical CBA examples illustrate the potential differences in benefit estimates based on the two approaches to violators' standing.

2. Treatment of violator benefits in cost-benefit analyses of road traffic enforcement and road traffic law changes

Elvik (2006, p. 379) states that: "Economic theory does not normally ask what preferences ought to form the basis for public policy; it does not try to assess whether certain preferences should carry more weight than other preferences because of their higher moral value." To the extent that these preferences do not imply any external effects on others, most economists would agree with this statement. However, the utilitarian moral philosophy at the roots of neo-classical economic theory does not imply any disregard of the impact of my preferences and choice/behaviour on the utility of other persons. Economists have long focused on external effects and public goods (Samuelson, 1954). Clearly, preferences with respect to choices/behaviours in the public space, or in the private space, that still have impact on others (pollution, noise or other impact) will complicate the issue of accepting any preferences at face value. Transport provides a rich set of examples of preferences and behaviours that oscillate around a borderline dividing social behaviour from antisocial behaviour; the exact borderline differing somewhat between individuals and

cultures (Poulter and McKenna, 2007). This applies to norms and rules for public transport as well as for car drivers and cyclists on roads.

In terms of CBA, we consider benefits and costs related to policies aimed at reducing antisocial or illegal behaviour, and then the main benefits in the CBA are, for example, the prevented violations resulting from increased control and enforcement. CBA has also been applied for the assessment of legal changes, seeking the same purpose of reducing antisocial behaviour, but the legal change might be necessary for implementation of the policy (Vlakveld et al., 2005; Veisten et al., 2013). Thus, while in the former case we consider enforcement of a social constraint, in the latter the social constraints are adjusted before enforcement can take place. Elvik (2006) takes the school of Becker, maintaining that (lost) benefits of violators should be included in social CBA, as representing mainstream neo-classical economics, and contrasts this position with two alternative approaches to CBA based on ethical arguments:[i] "Three options can be imagined with respect to the treatment of violator benefits in cost-benefit analyses of traffic enforcement. The first option, which is the one that is most consistent with the principles of welfare economics as usually applied to cost-benefit analysis, includes violator benefits from violations, but excludes outlays for traffic tickets, treating these outlays as transfers only. In the second option, outlays for traffic tickets is interpreted as a measure of the value of deterrence per se, and is therefore included in cost-benefit analyses as a benefit to society. The third option, perhaps the one most consistent with normative ethics, leaves out both violator benefits and outlays for traffic tickets from cost-benefit analysis" (p. 381). An alternative to the first option, not specified by Elvik (2006) but consistent with economic theory (Stigler, 1970; Trumbull, 1990), is to exclude violator benefits from violations (Table 1).

Table 1: The three approaches (options) to CBA of enforcement of speed limits presented by Elvik (2006), compared to our approach based on a normative school within economics

	Approach to CBA	CBA of enforcement of speed limits [a]
Three approaches	Economics school following, e.g., Becker (1968) and Polinsky and Shavell (2000)	Include violator benefit loss

analysed by (Elvik 2006)	Approach to CBA of enforcement where deterrence is valued *per se* [b]	Include violator benefit loss
	Approach to CBA of enforcement consistent with normative (deontological) ethics [b]	Exclude violator benefit loss
Our approach	Economics school following, e.g., Stigler (1970) and Trumbull (1990)	Exclude violator benefit loss

[a] Current speed limits are considered as absolute institutions, such that speeding is considered as an act of crime.

[b] We consider options two and three from Elvik (2006) as being based on approaches outside neo-classical economics.

Building on Buchanan (1962), Stigler (1970) and Roberts (1973), Trumbull (1990) clarifies the issue of standing in CBA, stressing that CBA is a decision tool that necessarily operates within social constraints. Societal institutions act as social constraints. Roberts (1973, p. 392) made a distinction between *absolute* and *tolerant* institutions. While the former sets insurmountable limits on individuals' activity, the latter either sets a price that must be paid for the activities or sets limits to combinations of activities. With respect to road safety, in many countries there are insurmountable limits to drink-driving and speeding, thus absolute institutions; while for emission of pollutants to air many countries have implemented a payment of pollution fees, e.g., normally as taxes on fuel, representing a tolerant institution.[ii] If the institution were to be tolerant, speeding would be "a right" against a payment that reflected the external costs related to increased risk of injury and increased emissions. Then the tax could serve as the policy measure influencing each driver's choice of optimal speed.[iii] However, current speed limits are absolute institutions; there is no consent in violating speed limits against a payment, even if the penalty for "small violations" might be perceived as such. There is no right to exceed the speed limit; this is an illegal activity for which society prescribes a punishment. In several countries, speeding is perceived as antisocial behaviour, and, in the UK, Poulter and McKenna (2007) found that, in residential areas, also "travelling immediately above the speed limit on residential roads [is] unacceptable" (p. 384).

Even if drink-driving below certain blood alcohol content (BAC) levels and speeding below certain limits are punished with a penalty, “the penalty under the absolute institution is not simply a price that is paid for the right to pollute past the limit [to speed or drink-drive] ... Punishment does not imply retrospective consent” (Trumbull, 1990, p. 212, wording in brackets added). Certainly, distinctions can be made between extreme offences like murder or rape and others such as speeding and drink-driving. While speeding and drink-driving might lead to road deaths, they do not qualify as premeditated evil, like homicide or sexual assault. The social constraints can be adjusted for speeding and drink-driving; the legal BAC level or the speed limit can be reduced or increased. When a law or a limit is changed, the social constraint is changed. Since CBA considers changes, if the CBA is applied to a measure involving speed limit reduction, speed above the existing (former) limit *cannot* be considered as violating social constraints. If the CBA considers a measure involving enforcement of an existing speed limit, speed above the existing limit *can* be considered as violating social constraints.

3. An actual case study: section control in the Kaisermühlen tunnel of the A22 in Vienna

3.1. A real speed limit enforcement case

Part of the A22 motorway, the Kaisermühlen is a 2.15 km long urban tunnel running alongside the Danube through Vienna. It is in separate tubes with three to four lanes of traffic in each direction and entrance and exit ramps within. The *average annual daily traffic* (AADT) is currently close to 100,000,[iv] approximately 5% being heavy goods vehicles (HGVs) with a considerable share carrying flammable liquids to or from a nearby tank farm. Since stationary, manual speed enforcement methods require substantial human resources, a system for automatic speed enforcement is in place. At the entrance on each side a radar curtain detects the vehicle, its size and speed, and a photograph is taken from behind, automatically detecting the licence plate. On exiting the tunnel, another radar curtain recognises licence plate information, registers time-use on the 2.3 km section and calculates the average speed of the vehicle (Figure 1).

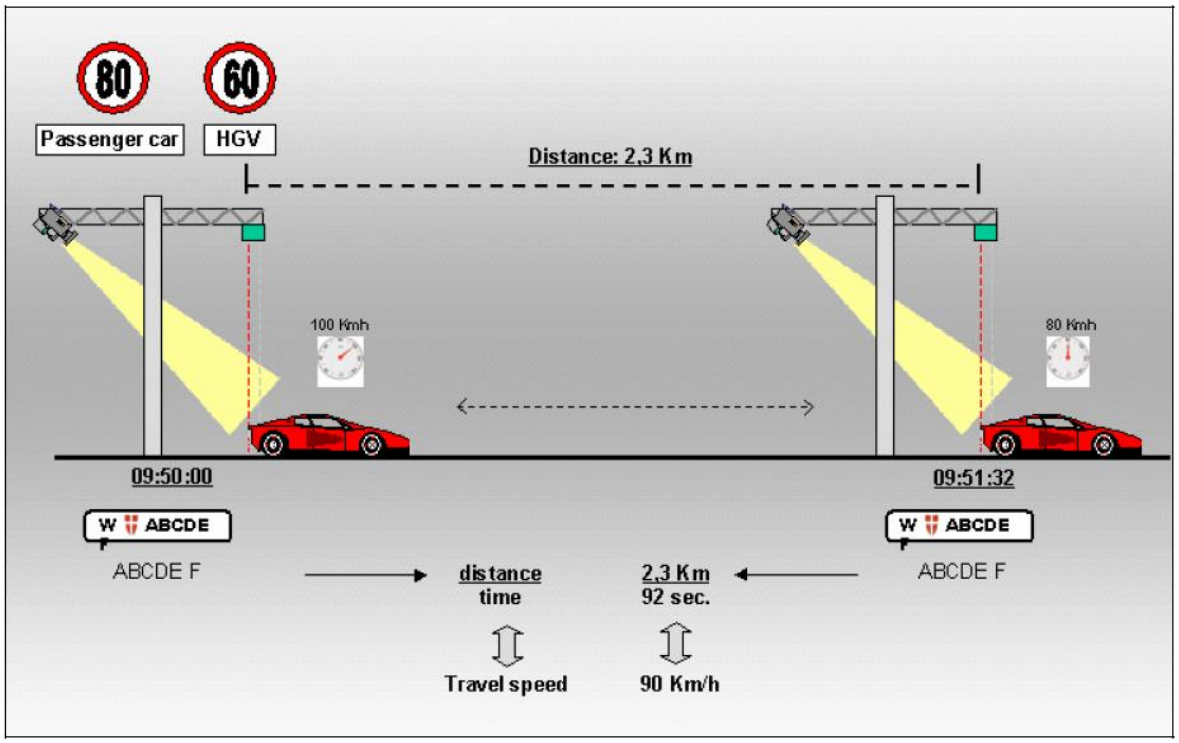

Figure 1: Scheme of the Section Control in the Kaisermühlen Tunnel (Source: Vienna Municipal Department 34; Stefan, 2006)

If the calculated speed is over the limit, photographs and data are transferred to the relevant authorities; if not, the speed data are immediately deleted. The speed limit was 60 km/h for lorries over 7.5 t (HGV) and 80 km/h for all others. The average actual speed, however, was 89 km/h, i.e. 70 km/h for HGV and 90 km/h for passenger cars. Both lorry and passenger car drivers exceeded the speed limit by approximately 10 km/h.

The cost of installation of the section control was approximately EUR 1.2 million (2002 prices), with an expected technical lifetime of 10 years and annual maintenance costs of EUR 60,000. With an interest rate of 4%, and an annuity factor of 8.4353, this yields total annuity costs (investment plus maintenance) of approximately EUR 200,000.

The immediate effect of the section control on average speed was a decrease from ca. 89 km/h to 70 km/h, but then levelling out at approximately 74 km/h (75 km/h for passenger

cars and 55 km/h for HGVs). The section control enforcement measure therefore brought the average speed down slightly below the speed limit (Stefan, 2006).

Speed reduction has effects on road safety, on emissions of air pollutants and on time-use. The time loss per vehicle through the tunnel distance of 2.3 km at 74 km/h rather than 89 km/h is 18.86 seconds. For 100,000 vehicles this is 524 hours, and over a year sums to a time loss of more than 190,000 hours. For the reduced emissions to air from speed reduction, Stefan (2006) calculated monetised benefits of ca. EUR 80,000 per year resulting from reductions in NO_X, CO_2 and PM_{10} (the most valuable effects), CO and SO_2, while VOC emissions increased.[v]

The average annual numbers of fatalities, serious injuries and minor (slight) injuries (and number of injury accidents) over a period of six years before implementation of the section control measure were, respectively, 0.5, 0.5 and 9.8 (and seven injury accidents). These figures were hardly affected by a correction procedure taking into account AADT changes over the years and re-estimating from calculated risk figures: yielding 1 fatality or serious injury and 10 slight injuries per year (Stefan, 2006).

Given (reliable) data about injuries and fatalities in the pre-speed change period, the expected reduction in injuries and fatalities can be calculated using the so-called "power model" (Nilsson, 2004). We apply the following formulas of the power model, where *V* refers to speed, *IA* to injury accidents, *F* to fatalities, *SI* to serious injuries, *SlI* to slight injuries, *PD* to property damage (only), and subscripts 0 and 1 to the pre-speed and post-speed change periods, respectively (Elvik, 2005; 2009):

$$IA_1 = \left(\frac{V_1}{V_0}\right)^{1.5} IA_0$$

$$F_1 = \left(\frac{V_1}{V_0}\right)^{4.3} F_0$$

$$SI_1 = \left(\frac{V_1}{V_0}\right)^3 SI_0$$

$$SliI_1 = \left(\frac{V_1}{V_0}\right)^{1.3} SliI_0$$

$$PD_1 = \left(\frac{V_1}{V_0}\right)^1 PD_0$$

Stefan (2006) proposes an additional formula for calculating the safety effects:

$$\text{Safety effect (\%)} = 1 - \frac{\frac{X_1}{E(m_0)}}{\frac{C_1}{C_0}}$$

where X_1 refers to the recorded number of accidents or injuries/fatalities in the post-speed change period, $E(m_0)$ to the expected number of accidents or injuries/fatalities in the pre-speed change period (the correction procedure), and C_1 and C_0 to number of comparison group accidents or injuries/fatalities, respectively, in the post and pre-speed change periods. That is, C_1 is the number of observed comparison group accidents in the "after" period and C_0 the number in the "before" period. Table 2 summarises the predicted effects of speed change from both this model and the power model.

Table 2: Road safety effects of average speed reduction, from 89 km/h to 74 km/h

	Pre-speed change	Post-speed change			
		Model from Stefan (2006)		Model from Nilsson (2004), Elvik (2005; 2009)	
Injury accidents	7	-33.3%	-2.33	-24.45%	-1.71
Fatalities	0.5 [a]	-48.8%	-0.24	-55.23%	-0.28
Serious injuries	0.5 [a]	-48.8%	-0.24	-42.92%	-0.21
Slight injuries	10	-32.2%	-3.22	-21.57%	-2.11

[a] Stefan (2006) has presented aggregated estimates for fatalities and serious injuries.

The Austrian unit values of the road safety effects were EUR 949,897 per prevented statistical fatality, EUR 51,439 per serious injury, and EUR 4,359 per slight injury (Stefan, 2006).[vi] This yields a road safety sum of ca. EUR 285,000 annually based on the power model and ca. EUR 255,000 based on Stefan's model.

3.2. A hypothetical speed limit change case

As an illustration, we present a hypothetical law change case that is assumed to have exactly the same effect on speed as the actual enforcement case. That is, we assume that the reference speed limit in that case is 70 km/h for HGV and 90 km/h for passenger cars; and that 89 km/h is the average speed in the reference case. By regulation, the speed limit is then reduced to 55 km/h for HGV and 75 km/h for passenger cars, and again we assume, for simplicity, compliance of the new speed limit of 74 km/h as the new overall average speed. Thus, we have exactly the same effects on time-use, air pollution and road safety as in the law enforcement case.

The particular difference in this hypothetical case of speed limit change is that the time loss due to speed reduction is monetised and included in the CBA. This is because in this hypothetical law change case we consider a change from a particular subset of social constraints (speed limits 70 and 90 km/h) to a new one (speed limits 55 and 75 km/h). The monetised value of time depends on travel purpose. For Austria, the 2002 values were approximately EUR 57.40 for business travel, ca. EUR 14.40 for commuting and leisure travel, and ca. EUR 25.50 for freight transport (Odgaard et al., 2005). Shires and de Jong (2009) applied the following approximate transport shares for The Netherlands and other European countries: business 0.03, commuting 0.48, leisure 0.43 and freight (HGV) transport 0.06. For Austria, we assume the same business share, at 0.03, and having given an HGV share of 0.05 the remaining share for commuting and leisure becomes 0.92. Referring to the time effects stated under section 3.1, this yields monetised values of ca. EUR 0.08 per average passing vehicle, ca. EUR 8,380 per day (for AADT equal to 100,000) and slightly above EUR 3,000,000 annually.

In the hypothetical law change case, there is no section control investment and maintenance costs. There are, however, costs related to law changes (Vlakveld et al., 2005). Retaining simplicity, we assume that these law change costs are equal to the section control costs. That is, for zero maintenance costs a law change "investment cost" of EUR 1.7 mill. would yield an annuity of EUR 200,000.[vii]

4. Results

The following table displays the CBA for the real law enforcement case as well as for the hypothetical speed limit change case.

Table 3: Cost-benefit analyses – speed reduction from 89 km/h to 74 km/h, a real speed limit enforcement case vs. a hypothetical speed limit reduction case (annuities, EUR 2002)

		Enforcement	Law change
Benefits	road safety	285,000	285,000 [a]
	air pollution	80,000	80,000 [a]
	time loss	0	-3,000,000 [a]
Costs	investment/maintenance	200,000	200,000
Net benefits (benefits minus costs)		165,000	-2,835,000
Benefit-cost ratio (benefits divided by costs)		1.8	not defined

[a] When the sum of benefits is negative, the benefit-cost ratio is not defined (Mishan, 1988).

There is a striking difference between the result of the real law enforcement case and that of the hypothetical speed limit law change case. While the safety and environmental benefits of the section control render this enforcement measure cost efficient, the hypothetical change in societal constraints, the speed limit, implies inclusion of a time loss, which is a negative benefit that outweighs the safety and environmental gains.[viii]

For the enforcement case, if we were to follow the school of Becker (1968), as indicated by Elvik (2006), we should also in this case have included the lost benefits of violators, the time

loss of speeders. Then we would have obtained exactly the same result for the enforcement case as for the law change case.

5. Discussion and Conclusions

We have shown cases of road safety measures that illustrate the application of (neo-classical) CBA bound within social constraints (Roberts, 1973; Trumbull, 1990), and we have clarified that it is not necessary to resort to normative argumentation beyond the schools of economics, e.g. from deontological ethical theory (Elvik, 2006; van Wee, 2012), in establishing that any benefits offenders get through violating traffic laws should not be included in CBA of enforcement. Speed limits represent absolute, not tolerant, institutions (Trumbull, 1990), thus giving no consent in violating speed limits against a payment, even if the penalty for "small violations", or penalties in general for the opulent, might be perceived as tolerant. Yet, in many European countries (currently 20), and in other countries in the world, repeated speed violations result in a temporary withdrawal of the driver's licence based on penalty point systems (Elvik et al., 2009; Castillo-Manzano and Castro-Nuño, 2012).

The theoretical fundament of CBA regarding the inclusion or not of criminals' gains and losses, either following what Elvik (2006) terms the school of Becker (1968) or the school of Buchanan (1962), Stigler (1970), Roberts (1973) and Trumbull (1990), does have an impact on CBA results. The real enforcement case in the Kaisermühlen Tunnel in Vienna would not have indicated cost efficiency if we included the lost benefits of violators, the time loss of speeders. Then we would have obtained exactly the same result for the enforcement case as for a law change case. However, we follow the school of thought presented by Trumbull (1990), regarding CBA as a decision-making tool that operates within social constraints, and considering speed limits as absolute institutions, such that the time loss of those speeding should not be included in the CBA.

Certainly, some might argue that speed reduction in the enforcement case is beyond the speed limit, e.g. driving at 55 km/h instead of 60 or at 75 instead of 80.[ix] Thus, some of the time loss might not be violators' loss but law abiders' loss. While a more detailed calculus could reveal some law abiders' time loss in the enforcement case, this does not really affect the main idea of our stylistic and simplified example: CBA of enforcement of a law (an existing social constraint) is different from CBA of a project implying alteration of a social constraint.

Moreover, based on our Kaisermühlen Tunnel example, economists and others might raise the question whether really the speed limits of 55-60 km/h for HGV and 75-80 km/h for others are indeed correct or economically optimal (Ghosh et al., 1975; Lave, 1985; Elvik, 2002). We do not adhere to the idea of economists refraining from calculation of potential gains and losses from alterations of societal constraints. However, assessment of the optimality of laws in general from a purely neo-classical approach will involve several problematic issues, e.g. ethical, as pointed out by Elvik (2006; see further, e.g., Kornhauser, 2011). When the issue of the analysis is a law enforcement measure, we believe the main approach should be CBA within social constraints, not including violators' gains or losses.

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manuscript are those of the authors and do not necessarily represent those of our supporters. The usual disclaimer applies.

[i] At the end of his paper, Elvik (2006) does state: "There is no agreement among economists regarding the treatment of violator benefits in cost-benefit analyses of enforcement. Becker (1968) and Polinsky and Shavell (2000) include violator benefits, whereas Stigler (1970) and Lewin and Trumbull (1990) argue for leaving out these benefits." (p. 383). As pointed to by an anonymous reviewer, those arguing for leaving out violators' benefits in CBA might find normative support in the utilitarian philosophical roots of economics, as some utilitarian philosophers will argue that only inoffensive welfare should be taken into account in CBA (see, e.g., Martens and Golub, 2012).

[ii] Markets in general are tolerant institutions (Roberts, 1973; Trumbull, 1990), as consumption of any single unit is normally considered as a positive activity; it is the environmental impact of the aggregate consumption that is regulated and curbed by pricing and taxes. An emission limit given to firms represents an absolute institution (Trumbull, 1990).

[iii] Possibly, technology will enable a tolerant institution for speeding in the future, a kind of automatic tax payment when surpassing the speed limit (Elvik, 2010).

[iv] Available at: http://www.asfinag.at/unterwegs/weitere-services/dauerzaehlstellen/2011 (accessed 15 January 2013).

[v] Stefan (2006) applied unit values from Germany (FGSV, 1997) and Norway (Elvik, 1998), given either as 1995 values of German marks (DEM) or as Norwegian kroner (NOK). To arrive at Euro 2002 prices, values in DEM and NOK were first converted to Austrian shillings (ATS) at the year of the source and were then brought to a 2002 price level of EUR using official inflation rates. The CO valuation was based on one ton of CO being equal to 0.003 tons of NO_X equivalents (FGSV, 1997, p. 41).

[vi] The official Austrian injury costs were increased in 2008 to EUR 2.944.994 for a prevented statistical fatality, EUR 348.510 for a serious injury and EUR 25,003 for a slight injury (BMVIT, 2011).

[vii] Vlakveld et al. (2005) assumed a cost of 2 million EUR related to roadside breath-testing and reduction in the legal alcohol limit for young drivers. We believe that even 1.7 million EUR is on the high side of what would be the speed limit change costs in Austria, but a lower law implementation cost would not really affect the conclusions in our case.

[viii] The new official Austrian injury costs that came into force in 2008 (BMVIT, 2011) would increase the annual road safety gains from 285,000 to approximately 930,000. However, this would not alter our main results.

[ix] Our main assumption in the hypothetical law change case was that drivers would adapt to the new speed limits in about the same way as to the current speed limits before the enforcement with section control. That is, we tried to match the new speed limits and the estimated new actual speed to the situation that was observed before the installation of the section control. Thus, we did not assume that drivers on average would become more (or less) compliant when speed limits were changed.