Cost-Benefit Analysis for Transport Policy Considerations: A European Trade-Off between Consumer Benefits, Welfare Effects and Administrative Burden

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December, 2011

Explanatory Note

Given that commas and full stops are used in different ways in different European countries for the decimal point and for separating groups of three numbers in large numbers, it is important to define and use a consistent style throughout the paper. The style adopted for this paper is:

A full stop (.) is used for the decimal point.

A comma (.) is used to separate groups of three numbers in numbers with four or more digits.

The average exchange rate for 2011 was used to transform the EURO-values into USD. The exchange rate of the Federal Reserve Bank of New York and the International Monetary Fund were used.

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Abstract

Reducing road accidents is a major policy goal within the European Union (EU or EU-27), because the annual economic loss of road accidents in the EU is 230 billion US-$ per year. Road accidents caused by technical defects of the vehicles can be significantly reduced by periodic technical inspections (PTI). Only one minimum standard for PTI defined by a Directive of the European Council exist in the EU-27. For this reason, a great variety of types of inspection regimes exist. Two Member State groups can be identified. Some States established PTI with over-compliance and the others with minimum-compliance. Different national compliance-practices in EU-27 affect the internal market, lead to environmental problems, reduce road safety and increase both administrative and transaction costs.

The paper presents cost-benefit analyses (CBA) for the inspection regime for German passenger cars and for Belgian commercial vehicles. The CBA is used as method to give empirical evidence to following primary research objectives:

Firstly, should a Member State, which over-performs the Council Directive 96/96/EC, adjust its PTI-regime to the minimum requirement? Therefore, the effects of downgrading marginally the testing frequency from an annual cycle (1-1-1-1…) to an annual cycle, which starts after year 4 of first service (4-1-1-1…), are examined for commercial vehicles in Belgium. Changing the annual testing cycle for commercial vehicles from 1-1-1-1… to a 4-1-1-1… would lead to 11 Million US-$ inspection cost savings per year, but on the other side the annual welfare losses for Belgium would be 95 Million US-$ per year.

Secondly, is the current PTI-minimum regime a best case? The way of answer is to find out what will happen in the case that the testing frequency will be marginal improved. The empirical case study is Germany for a change from the current inspection regime 3-2-2-2… to an annual inspection regime for passenger cars older than seven years. The significant result for Germany is that during the period 2010 to 2015 the average benefit-cost ratio is 1.7.

With this empirical basis the paper works out the trade-off between consumer benefits and welfare effects. Further it reassesses whether the minimum standard is advantageous or not. It shows that the political choice of retrenchment strategy combined with a minimum-standard will change the over-compliance regimes to minimum-compliance inspection regimes. The choice of two Member States addresses the problem of the different economic wealth within the economic assessment because national cost-unit rates differ from the European cost-unit rates.

Keywords: transport policy, optimal regulation, cost-benefit analysis, roadworthiness, traffic safety, emissions

JEL Classification: D61, D78, L51, R41

1. Roadworthiness Inspection Regime in EU-27

The relevant legal starting point for the **current inspection regime** of passenger cars and N1 vehicles (= vehicles used for the carriage of goods and having a maximum mass not exceeding 3.5 tons also named as light goods vehicles) is the European Council Directive 96/96/EC[1]. Directive 96/96/EC contains a minimum standard for the testing frequencies of passenger cars and N1-vehicles. Private cars and light goods vehicles have to be inspected every two years after the first inspection, which is at 4 years after first use. The purpose of roadworthiness enforcement is to ensure that the benefits accruing from the original design and manufacture of vehicles are retained, where justified, throughout the life of those vehicles. Directive 96/96/EC does not cover two-wheeled motor vehicles, light trailers or agricultural tractors, while Directive 2000/30/EC (technical roadside inspection of the roadworthiness of commercial vehicles circulating in the Community) covers only commercial vehicles. However, the minimum regulation leads to a variety of national frequencies. Table 1 gives an impression on the current diversity of inspection frequencies for passenger cars in EU-27.

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[1] Directive on the approximation of the laws of the Member States relating to roadworthiness tests for motor vehicles and their trailers

Two Member States groups can be identified: Member States with a frequency, which is close to the minimum requirement (=minimum performer) and Member States with a frequency, which is significantly better than the minimum requirement (=over performer).

- Minimum Performer: Denmark, Germany, Greece, Spain, France, Ireland, Czech Republic, Estonia, Hungary, Lithuania and Slovenia.
- Over Performer: Belgium, Luxembourg, Netherlands, Austria, Finland, Sweden, Great Britain, Italy, Portugal, Latvia, Poland, Slovak Republic, Romania.

Table 1: Passenger Car Inspection Test Cycles in the EU-27 (Status in Year 2011)

		Year after start of operation of vehicle										
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**…**
Belgium	BE				S	T	T	T	T	T	T	T
Denmark	DK				S		T		T			
Germany	DE			S		T		T		T		
Greece	EL				S		T		T		T	
Spain	ES				S		T		T		T	T
France	FR				S		T		T		T	
Ireland	IE				S		T		T			
Italy	IT				S		T		T			
Luxembourg	LU			S	T	T	T	T	T	T	T	T
Netherlands	NL			S	T	T	T	T	T	T	T	T
Austria	AT			S		T	T	T	T	T	T	T
Portugal	PT				S		T		T	T	T	T
Finland	FI			S		T	T	T	T	T	T	T
Sweden	SE			S		T	T	T	T	T	T	T
United Kingdom	UK			S	T	T	T	T	T	T	T	T
Cyprus	CY	n.a.										
Czech Republic	CZ				S		T		T		T	
Estonia	EE			S		T		T		T	T	T
Hungary	HU	S			T			T		T		T
Latvia	LV	S	T	T	T	T	T	T	T	T	T	T
Lithuania	LT			S		T		T		T		T
Malta	MT	n.a.										
Poland	PL			S		T	T	T	T	T	T	T
Slovak Republic	SK			S	T	T	T	T	T	T	T	T
Slovenia	SI			S		T		T		T		T
Romania	RO		S		T		T		T		T	
Bulgaria	BG	n.a.										
Directive 96/96/EC					S		T		T		T	

Annotations: S = First inspection after start of operation
T = Next obligatory vehicle inspection after S
n.a. = not available
UK data refer to Great Britain only

Source: CITA 2006; CITA 2011; DEKRA 2005; AUTOFORE 2007; Ghimpsuan 2011.

Altogether 13 different types of testing frequencies exist. It can be stated that within the existing common framework for PTI testing, no systematic mutual recognition of PTI due to the absence of a fully harmonized testing system is in place in Europe and the quality of national testing varies across EU countries, creating obstacles to internal market, leading to welfare losses and contributing to administrative burden. Obstacles to the internal market can be distinguished into following problem areas:

- Institutional complexity and quality losses because of non-existing systematic mutual recognition of PTI, no standard training of inspectors and different national standards for the testing equipment.
- Competition Impacts:
    - 13 different PTI-regimes but 27 different fees for a testing procedure, which should be similar in all Member States. The European consumers experience an unequal treatment, although living conditions in EU-27 should be harmonized.
    - Rental firms, leasing companies and firms using passenger cars and light trucks (e.g. courier, parcel and express industry) have in Member States with annual inspections a cost-disadvantage compared to their competitors in Member States, which only fulfill the minimum requirement.

Welfare losses result at least from avoidable exhaust and technical defects. Countries, which have less intensive inspection frequency, have a higher share of avoidable emissions. This effect leads also to an unequal treatment of citizen because in Member States with the minimum testing frequencies the citizens are exposed in urban areas to higher particulate and nitro-oxygen emissions. Worse maintenance of passenger cars and light good vehicles affect road safety. Member States with an intensive testing reduce the risk of road accidents for their residents.

The administrative burden is affected because 27 single vehicle approvals, 27 national registration databases and 27 roadworthiness databases exist. Overall the missing of vehicle administrative platform leads to insufficient data collection, which ends up in a poor input for modeling of policies in EU.

The general research objective is whether minimum Directives in EU-27 are sufficient or insufficient. The leading question is how minimum requirements affect the overall welfare situation. It seems that in Member States, which have a more intensive inspection frequency compared to the minimum frequency, the policy pressure of consumer groups (e.g. automobile associations), courier-express and parcel industry, and automotive industry urge the replacement of the national practices by introducing the European minimum standard.[2]

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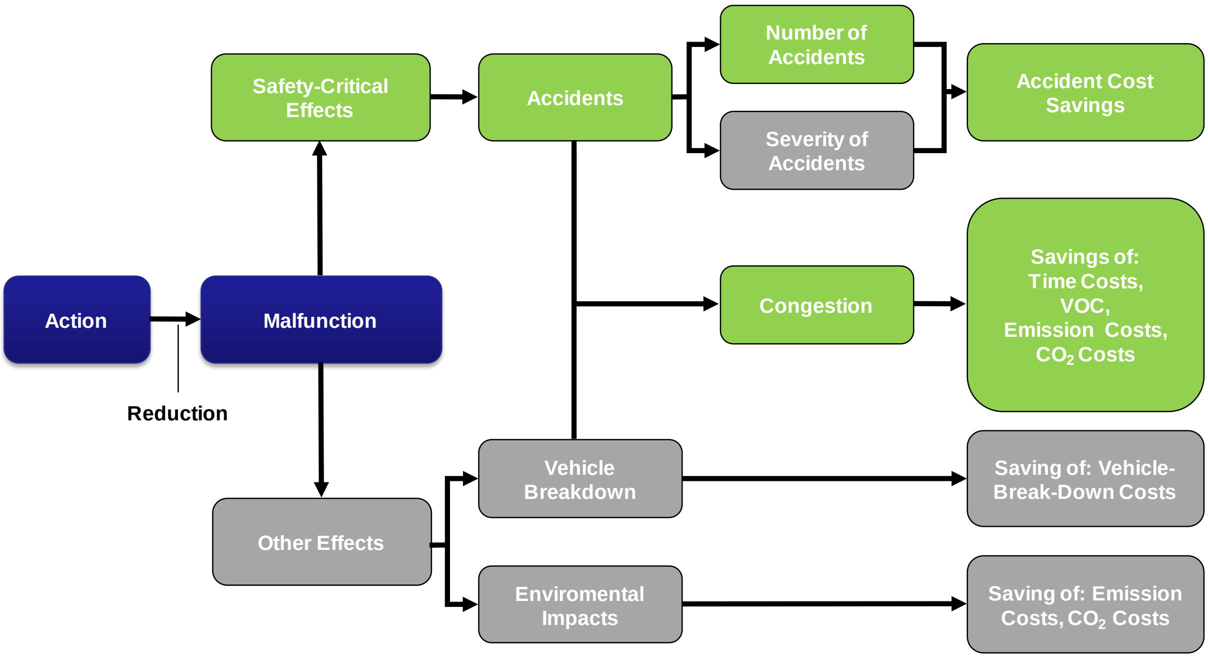
[2] Whereby the automotive industry has an ulterior strategic approach: The current inspection regime, which is mainly based on defined inspection intervals and performed by independent officially accredited inspection agencies, should be redeemed by a vehicle-kilometer based inspection using as control device the On-Board-Diagnostic (OBD), which is installed in the vehicle by the manufacturers. Then the maintaining of the car could be performed by authorized repairer. This strategy would lead to turmoil in the inspection agency industry and would also affect the competition in the car repair industry. The European Commission is blocking this strategy by demanding from the automobile manufacturers a lifetime-guarantee for the proper-functioning of the OBD. The actual willingness of the automobile industry to do so is relatively low, because of the missing long-time experiences with the technical functioning of OBD, which does not allow a cost-estimation for the lifetime guarantee.

For this background that the minimum standard will overrule better national practices the first empirical research objective is to find out, whether a Member State, which over performs the Council Directive, should adjust its PTI-regime to the minimum requirement. As empirical proof the effects of a marginal downgrading of the testing frequency for commercial vehicles in Belgium are calculated. The annual testing cycle for commercial vehicles (1-1-1-1…) will be changed in that way that the first inspection will be according to the Directive 96/96/EC in year 4 after first operation (4-1-1-1-1…).

The next empirical proof is, whether the current PTI-minimum regime is a best case. The way of answer is to find out what will happen in the case that the testing frequency will be marginal improved. The empirical case study is Germany. The current inspection regime 3—2-2-2… is changed to an annual inspection regime for passenger cars older than seven years (3-2-2-1-1…).

For both **case studies,** the impacts of PTI on the consequences of vehicle malfunctions are the basis for the calculation of the overall economic effects. The periodic technical inspection (PTI) is a vehicle measure to increase road safety. The general impact channels are shown in the following figure, whereby the green boxes represent the cause-effect relations, which can be calculated for PTI. The grey boxes indicate that due to missing empirical data these cause-effect relations cannot be calculated. A malfunction itself can lead to safety-critical effects and/or non-safety-critical effects.

Figure 1: Traffic Impact Channels of Measures improving the Technical Vehicle Condition



Source: Schulz 1998 and 2010.

Safety-critical effects include the risk of an accident occurring for example through extended braking, short stopping distances due to poor brakes, or rear-end collisions due to poor vehicle lighting.

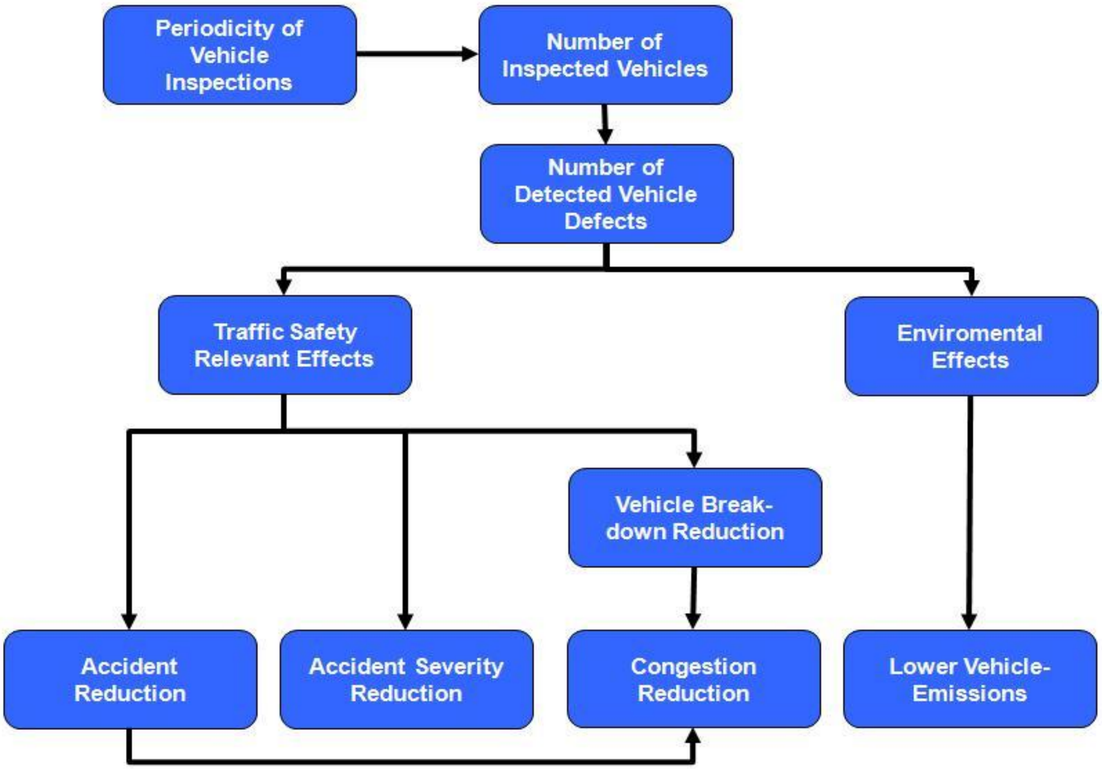
Non-safety critical effects include vehicle breakdowns and environmental impacts because of technical and exhaust system failures. Vehicle breakdowns due to poor vehicle condition result in costs to the vehicle owner (e.g. towing costs, vehicle-repair costs) and congestion (lost time, vehicle running costs, emissions and carbon dioxide). Poorly adjusted engines and exhaust systems result in higher fuel consumption. Increased fuel consumption leads inevitably to rising emission costs and carbon dioxide-costs.

2. Methodological Framework

2.1 Impact Channels for the Number of Inspected Vehicles

The impact channels of the key variable "number of inspected vehicles" are illustrated by figure 2.

Figure 2: Effects of the changes of the "Number of Inspected Vehicles"



Source: own figure.

The number of detected vehicle defects and the number of malfunctioning vehicles could be reduced by increasing the annual tested number of vehicles.

The reduction of vehicle defects has a positive effect on both traffic safety relevant and environmental aspects.

- The detection and repair of combustion defects eliminates inefficient burning and directly lowers the exhaust emissions (direct environmental effects).
- Increasing traffic safety relevant aspects has direct effects: The number of accidents is decreased, the severity of injuries is less and the number of vehicle-breakdowns can be reduced (direct traffic effects).
- The positive, indirect traffic effects of congestion reduction caused by the direct traffic effects, clearly shows that accident reduction and vehicle-breakdowns leads to less congestion.

The total amount of inspected vehicles depends in EU-27 on the national regulatory regime for periodic vehicle inspections. This means changes to the periodicity of the test cycles directly leads to the reduction of vehicle defects.

2.2 Cost-Benefit Analysis

Cost-Benefit Analysis (CBA) is based on welfare-economics where the increase of the overall economic production potential is used as a standard for evaluating a technology. The costs of this new technology are confronted with this overall economic or social effect. The benefits are defined in terms of productive resources saved within an economy.

In theory, the principle of allocative efficiency is determined by the situation that by introducing any kind of technology at least one individual is made better off and no individual is made worse off. This is called the Pareto optimum. Since a consequent application of this principle is impractical due to the impossibility of identifying winners and losers, a potential Pareto optimum, called the Kaldor-Hicks criterion, is generally applied (Kaldor 1939;

Hicks 1939). This criterion considers a new measure (technology) acceptable if the amount of gain by certain people is greater than the amount of loss suffered by others. Hence, a net-benefit needs to be reached, by compensating losses of others by winners of the measure. Therefore a measure may be efficient if some people incur losses as long as it generates enough benefits to compensate this. The Kaldor-Hicks criterion is commonly accepted and widely applied in welfare economics as well as in managerial economics. The criterion serves as the rationale in the CBA.

The CBA is a traditional method to ensure efficient use of public financial means (maximization of the optimal national product), by summarizing direct (=internal) and indirect (=external) costs and benefits. A measure is advantageous to the national economy if the economic benefits are greater than the costs, (i.e. the cost-benefit difference is greater than zero or the benefit-cost ratio is greater than 1) (SeiSS 2006; Litman 2005).

Setting absolute numbers for the costs and benefits ensures that the Benefit-Cost Ratio (BCR) is a reliable indicator of the cost-effectiveness of different roadworthiness enforcement strategies. This provides an objective economics-based method of maximizing/minimizing the benefits/costs and helps to avoid wrong decisions and poor investments. The BCR can be expressed as follows:

$$BCR = \frac{\sum_{t=0}^{T-1} Bt(1+i)^{-t}}{\sum_{t=0}^{T-1} Ct(1+i)^{-t}}$$

With:

BCR:	Benefit-Cost-Ratio
t:	Examination time period
Bt:	Benefits per year t
Ct:	Costs per year t
i:	Interest rate

In order to assess the benefit, the saved costs are determined (costs as loss of benefit). The economic success scale is the saving of resources. The benefits can occur on both a microeconomic and macroeconomic level. It is, however, decisive that the resource saving is not included twice.

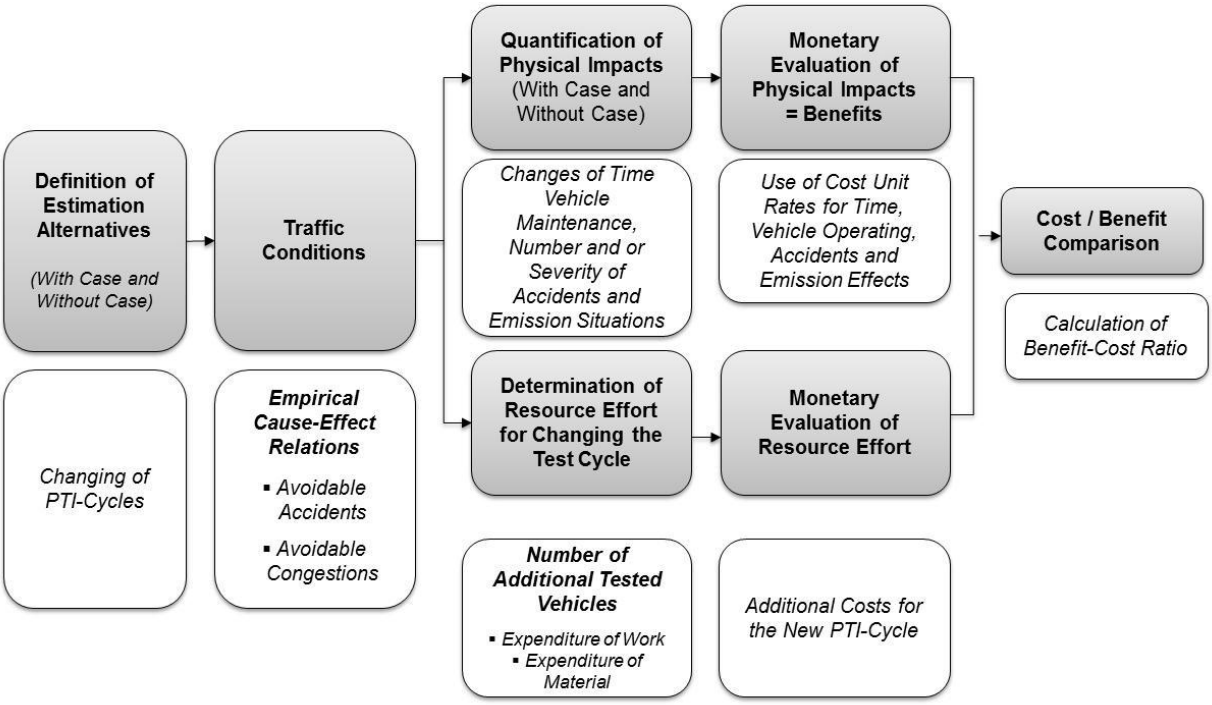
The determination of the cost-benefit ratio depends on the assumed time projection. In the case of PTI both benefits and costs are given as annual values. Therefore the CBA can be performed for selected years.

2.3 Research Steps

The methodical procedure for the determination of the costs and benefits is represented schematically in figure 3. The procedure is as follows:

- In the **first step** the change of the PTI-cycle its effect channels are described. With case and without case are defined and modeled.
- In the **second step** the relevant data (traffic situation, environmental impacts, and vehicle fleet) are recorded. Empirically protected interdependencies must be established to determine which resource effort can be saved and which effect intensity is attainable.
- The **third step** contains the quantification of the physical effects for both with case and without case. This then shows the quantity changes of the resource consumption. Identified on the cost side are the cost types that are relevant for the execution of the measure.
- In the **fourth step** the quantity effects are both multiplied by the appropriate assessment rate on the benefit and cost side. By this monetary transformation the different amount parameters can be added up.
- The final **fifth step** finally confronts the benefit with the costs. In order to do this the benefit-cost quotient is formed.

Figure 3: Cost-Benefit Approach for Changes of Periodic Technical Inspection Cycles



Source: own figure.

2.4 Examination Period

The CBA for Belgium is performed for the year 2009. The CBA for Germany is performed for the time period from 2010 to 2015. These different time periods are the consequence of the availability of traffic and accident data.

2.5 Accident Costs

Associating a monetary value to the loss of human life or an injury may seem immoral and often provokes strong reactions on ethical groups. However, it is worth to reduce the probability of death (Schelling 1968). Without monetization of fatalities and injuries, road casualty reduction measures cannot be weighted properly in relation to resource allocation. Resources are limited; therefore estimates of crash cost-unit rates by severity class can be used to ensure that best use is made of any investment through economic appraisal. Potential economic benefits can be estimated based upon predicted crash savings.

Foremost, a consistent framework of assessment criteria is required for the considered countries which include information about the following items:

- Standardized definition of the considered accident impacts,
- Common monetary evaluation method,
- Uniform cost components included in the cost-unit rate.

Table 2 gives an overview over the used accident cost unit rates for Belgium. In this study the values for fatalities, serious injuries, slight injuries and property damages were derived for the economic situation in 2004. These values have to be updated to the year 2009. The updating of these cost-unit rates considers real GDP-growth and inflation (eurostat):

- The average annual GDP-growth between 2004 and 2008 in Belgium was 0.4% per year. The maximum growth value was in this time period +1.1%. The minimum value was a decrease of the GDP by -2.1%.
- The inflation rate increases on average in the time period between 2004 and 2008 by 2.2% per year. The maximum price increase was 5.9% and the minimum value was a price decrease by -1.7%.

However, the study does not cover the additional congestion costs of accidents.

Table 2: Accident Cost-Unit Rates for Belgium

	Cost-Unit Rates in USD	
Per Casualty	**Year 2004**	**Year 2009**
Fatalities	$2,790,947	$3,165,077
Serious Injuries	$1,010,009	$1,145,402
Slight Injuries	$29,155	$33,063
Per Accident		
Property Damage	$3,579	$4,122

Source: de Brabander, Vereeck 2007; own calculation.

The next table shows the cost-unit rates for accidents used by the European Commission. These values are lower than the national Belgian values because they reflect the average welfare situation of the EU-27. In order to prevent a different evaluation of road accidents within the EU, the European Commission suggested fixed cost rates in 2003. The calculation for the year 2009 is based on the EU-growth and EU-inflation – contrary to the national accident cost-unit rates for Belgium. For the German case study, the EU cost-unit rates are used.

Table 3: Accident Cost-Unit Rates for EU-27 (Personal damages)

Accident Type	Cost-unit Rates in USD	
	Year 2003	**Year 2009**
Fatal	$1,392,133	$1,614,233
Serious	$187,938	$217,951
Slight	$20,882	$24,216

Source: European Commission 2003; eIMPACT 2008; HEATCO 2005; own calculation.

2.6 Congestion Costs

The accident cost-unit rate usually contains only cost components directly linked to the vehicles and persons involved in a crash. Primarily, this covers reproduction costs (= medical costs, hospital visiting costs) and resource losses. Crashes on motorways are regularly accompanied by congestion caused by a temporary reduction of road capacity (e.g. blocking of a lane on a motorway). Congestions lead to time losses, higher fuel consumption, higher air pollution and CO_2-emissions. Therefore, these effects have to be considered.

Available studies feature a broad range of values for congestion costs in the course of accidents. Table 4 illustrates the results of three selected studies on travel delay costs per accident. Blincoe et al. identified different cost-unit rates for each injury level, which rise with increasing severity level. The same correlation is evident for the results of the other studies. Apparently, the different cost-unit rates reflect the proportion of police and/or rescue time at the crash scene depending on the accident severity. The estimates of ICF Consulting mark the upper limit for fatal and injury accidents. In contrast, Parry's analyses resulted in travel delay costs for a fatal injury accident of nearly $6,961 and for an injury accident of about $1,392. Only the American studies covered congestion travel delay cost caused by property damage only (PDO) accidents. The ICF-study refers to the economic and traffic situation of the EU-27, therefore these monetary values are used.

Table 4: Average congestion costs caused by accident type in USD per congestion (Year 2005 price)

Average Congestion Costs Caused by Accident Type in € per Congestion (2005 price)				
Study	**Fatal Injury Accident**	**Serious Injury Accident**	**Slight Injury Accident**	**PDO[4] Accident**
Blincoe et al. (2002)[1,5]	$17,853	$2,142	$1,789	$1,962
ICF Consulting (2005)[2]	$21,578	$6,961	$6,961	$1,392
Parry (2004)[3,5]	$6,915	$1,380	$1,232	$1,147

Source: Blincoe et al. 2002; ICF Consulting 2003; Parry, I. W. H. 2004; own calculation.

1 Estimates are classified in MAIS (Maximum Abbreviated Injury Scale by victims); adjusted to: MAIS 0 to 1 = slightly injury, MAIS 2 to 4 = serious injury, MAIS 5 to 6 = fatal injury

2 No differentiation between slight and serious injury

3 Original severity classes adjusted to: disabling injury = serious injury, evident and possible injury = slight injury

4 PDO means "Property Damage Only", costs on a per damaged vehicle basis, adjusted with the average number of involved vehicles in a crash in the USA for the year 2000 (1,439) (Blincoe et al.: 28)

5 Original unit-costs on per person basis, adjusted with number of fatalities (1,15) or injuries (1,36) per accident (ICF Consulting: 11) n.a.: not available

Table 5 shows the congestion cost-unit rates for year 2009.

Table 5: Congestion Cost-Unit Rates

Congestion Costs	**Cost-Unit Rates in USD**	
Per Casualty	**Year 2005**	**Year 2009**
Fatalities	$21,578	$23,863
Serious Injuries	$6,961	$7,697
Slight Injuries	$6,961	$7,697
Property Damage	$1,392	$1,540

Source: Blincoe et al. 2002; ICF Consulting 2003; Parry, I. W. H. 2004; own calculation.

2.7 Relevant Costs of PTI-Cycle Changes

Within the framework of the CBA it is only allowed to calculate with costs that represent the consumption of resources. Thus, taxes and profits are not considered as costs of the measure.

In addition, it is important to note that reparation charges for repairing technical defects, which were discovered during the general inspection, must not be assigned to the general inspection.

Those costs, which the owner of a motor vehicle must meet in order to repair the technical defects, discovered during the general inspection, cannot be assigned to the general inspection itself, because the technical defect of the vehicle should have been repaired irrespective of the general inspection. The car owner is in a dilemma situation because he has to fulfill the legal requirements of proper functioning of his passenger car, but the passenger car itself is a credence good (Darbi, Karni 1973). The term 'credence good' expresses the fact that the user or the purchaser of the goods does not have all information at his disposal (information asymmetry) in order to evaluate the condition of the goods. There are different causes for information asymmetry:

1. The seller has information about the goods at his disposal, but does not reveal all of them to the purchaser voluntarily.
2. The seller has information about the goods at his disposal, but only gives the purchaser some specific information. As a general rule, the seller gives the information to the purchaser that is useful for him in order to sell the goods. On the other hand, he conceals information about bad qualities of the goods. Markets, in which sellers act as described above are called ‘lemon markets’.
3. It is impossible that the seller has received all information from the manufacturer of the goods because the manufacturer simply acts as described under point 1 and 2.
4. Normally, the purchaser does not have sufficient expert knowledge in order to recognize all properties in a single inspection. If the purchaser had sufficient expert knowledge about the vehicle, it would not be called credence good in economic theory but rather a good of inspection.

This basically means that the average user or owner of a motor vehicle does not have sufficient expert knowledge and thus cannot evaluate the technical condition of his vehicle appropriately. That is why motor vehicles must be regarded as credence good. If no general inspections were done, the owners of vehicles would need to purchase expert knowledge in order to guarantee that his vehicle is a functional condition regarding legal standards.

At this point the question arises whether it can safely be assumed that the owner of a vehicle is so dutiful, or that the market offers enough incentives to the owner in order to have his vehicle inspected by a qualified garage before technical defects even arise. There is considerable empirical and theoretical evidence that inspections on a voluntary basis do not have the same efficiency as a general inspection:

- In the field of road safety there is discrepancy between subjective and objective risk evaluation regarding accident likelihood. Drivers systematically underestimate their personal accident risk. Of course this also regards the risk of having an accident due to a technical defect. Thus, the systematic risk underestimation of drivers simultaneously implies an elevated accident risk for other road users (Schulz 2004).
- If, however, the accident risk can be decreased through general inspections, then all road users would profit from a smaller accident risk and smoother traffic flow, without monetarily reimbursing the owner of the vehicle, who had the technical defect repaired. Anyway, since this kind of compensation does not take place and the accident risk is still systematically underestimated, there simply is no real incentive to eliminate technical defects voluntarily (Schulz 2001).

The information asymmetry when purchasing a motor vehicle, the properties of the vehicle as a credence good during the useful life, the systematic underestimation of the accident risk as a consequence of technical defects, as well as the interdependency of one’s own behavior and the accident risk of other road users are economic facts that are due to market failure (Akerlof 1970). Dulleck, Kerschbamer and Sutter (2011) systematically defined overtreatment, under treatment and overcharging as further types of inefficiencies of credence goods and explained those inefficiencies with the example of a car owner bringing his vehicle to a garage for repair.

The outcome of this is that a voluntary system of self-control for the technical inspection of motor vehicles does not work. Economically speaking, the general inspection is an element of regulation that ensures the operational capability of the market in order to eliminate technical defects of motor vehicles. Thus, the general inspection does not create repair costs, but are an institutionalized extension to the market of quality assurance.

3. Benefit and Cost Assessment for Belgium (Case Study I)

Within the benefit assessment it is only possible to calculate the effects of a changed period of technical inspection on the number of accidents and the consequences on congestions. Environmental effects and effects on the vehicle-breakdowns could not be addressed because empirical cause-effect relations are not yet available.

3.1 Accident Analysis

The next table illustrates how the safety effects for a change of the PTI-cycle from 1-1-1-1… to 4-1-1-1… are calculated for the year 2009.

The calculation procedure is as follows:

- In the year 2009 the number of inspected N1 vehicles is 492,652. The age distribution of these vehicles is shown in figure 4. The vehicle-age distribution allows determining how many vehicles will not be inspected due to the change of the inspection cycle from 1-1-1-1… to 4-1-1-1….
- Changing the cycle hypothetically for the year 2009 means that only 298,728 N1 vehicles will inspected. 193,924 inspections could be avoided.
- The share of detected vehicles with defects is 22.02% in 2009 (GOCA 2010). Assuming that this rate also can be used in the case of a changed PTI, this would mean that 42,703 vehicles

with a defect will not have been detected because they are not inspected.

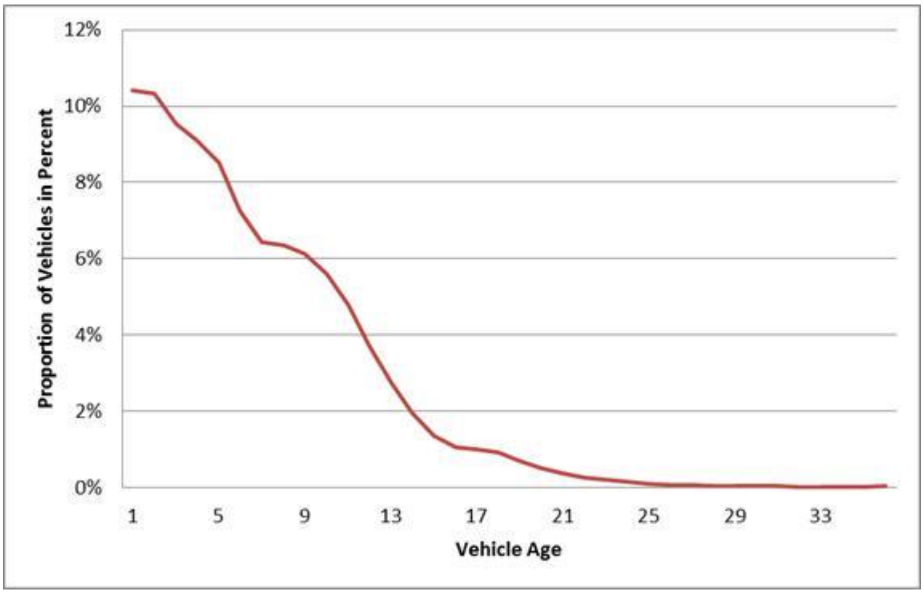
- Other studies on commercial vehicles show that an empirical relation exists between the number of avoided accidents and the number of inspected vehicles having a defect (AUTOFORE 2006; FMCSA 2002). The relation is 0.0053, which can be interpreted for example that 10,000 inspected commercial vehicles with a defect lead to an avoidance of 53 injury accidents. However, this relation could also be interpreted that 10,000 commercial vehicles with a defect will lead to 53 accidents. For Belgium this relation leads to the result that 226 injury accidents with N1 vehicles in the year 2009 could be not avoided.
- Knowing the number of avoidable accidents it is possible to calculate the casualties. Per injury accident, there are 0.0313 fatal, 0.1886 seriously injured and 1.1876 slightly injured casualties (AUTOFORE 2006; de Brabander , Vereeck 2007; NIS 2004).
- The relation between accidents with only property damage and injury accidents is 9.31 (de Brabander, Vereeck 2007; NIS 2004).

Table 6: Safety effects of changing the inspection cycle from 1-1-1-1 to 4-1-1-1 in the year 2009

	Inspection Cycle		Reduced Number of Inspected Vehicles	Consequences of lower Number of Inspected N1 Vehicles	
	1-1-1-1…	4-1-1-1…			
Inspected N1 Vehicles	(1) 492,652	(2) 298,728	(1) – (2) =(3) 193,924		
			Undetected Vehicles with Defects	Accidents per inspected Vehicles with Defects	Unpreventable Accidents with Injuries
Vehicles with Defects	(4) 108,482	(2)*(5)=(6) 65,780	(4) – (6) =(7) Or (3) *(5)=(7) 42,702	(8) 0.0053	(7) * (8) = (9) 226
Defect Detection Rate	(4)/(1)= (5)		0.2202		
Additional Fatalities	(9) * (10)		7	(10) 0.0313 Fatalites per Accident	
Additonal Serious Injuries	(9) * (11)		43	(11) 0.1886 Serious Injuries per Accident	
Additional Sligth Injuries	(9) * (12)		269	(12) 1.1876 Slight Injuries per Accident	
Additional Property Damage Accidents	(9) * (13)		2,104	(13) 9.31 Property Damages per Accident	

Source: own calculation.

Figure 4: Vehicle-Age-Distribution of N1 Vehicles in Belgium (2010)



Source: own figure.

3.2 Congestion

For the calculation of congestion costs it is necessary to know the number of accidents for each accident type. The number of accidents with property damages is calculated within the accident analysis. In 2009 the number of accidents with only property damage is 2,104.

The number of 226 injury accidents is also calculated in the accident analysis. But for the total number of injury accidents their distribution to accidents with fatalities, serious injuries and slight injuries is needed. Table 7 shows the calculation procedure:

Table 7: Transforming casualties to accidents

Accident Type	Number of Casualties	Relation Casualties per Accident	Number of Accidents
Fatal	7	0.8762	6
Serious	43	0.8121	35
Slight	269	0.6880	185

Source: de Brabander, Vereeck 2007; NIS 2004; own calculation.

3.3 Cost Estimation

The next table shows how the inspection costs for N1 vehicles in Belgium are composed. For the cost-benefit analysis the inspection costs without VAT have to be used because taxes represent only resource shifting.

Table 8: Inspection costs for N1 vehicles in Belgium (price basis January 1st 2010)

Inspection Elements	**Inspection Costs in USD**	
	With VAT	**Without VAT**
Basic Inspection	$43.16	$35.67
Pollution Check Diesel	$17.40	$14.38
Sticker	$6.26	$5.18
Total	$66.82	$55.23

Source: www.goca.be

The VAT is a resource shift from the buyer of a product or service to the government. Therefore the economic relevant resource price for N1 vehicle inspections is $55.23.

This value represents the resources needed to maintain the inspection, which are for example labor costs, working materials, raw materials and supplies, depreciation of used capital equipment.

As stated before, it is at this stage not possible to calculate the additional emission effects for the case that less N1 vehicles are inspected. Therefore, $14.83 for the pollution check has not to be considered for the accident effects.

3.4 Cost-Benefit Results

Table 9 presents the benefit-cost results for the year 2009. The result – as stated above – can be interpreted in two ways:

- Changing the PTI-cycle from 1-1-1-1 to 4-1-1-1 will lead to cost savings of $10.7 million due to reduced number of inspected vehicles. However, this cost saving leads to an increase of economic resource losses in the dimension of $93.6 million. For $1 recovery society has to pay a price of $8.7.

- The current inspection regimes offer a societal benefit of $8.7 for $1 invested into the inspection of a N1-vehicle.

Table 9: Benefit-Cost Results for Changing PTI-Cycle of N1 Vehicles from 1-1-1-1… to 4-1-1-1… (Year 2009)

Year 2009	Valued Effects in Million USD			Total (Million USD)
Benefits	Accident Avoidance	Fatalities	$22.4	$93.6
		Serious Injuries	$48.9	
		Slight Injuries	$8.8	
		Only Property Damage	$8.5	
	Congestion Avoidance	Fatalities	$0.1	
		Serious Injuries	$0.3	
		Slight Injuries	$1.4	
		Only Property Damage	$3.2	
Costs	Inspection Costs			$10.7
Benefit-Cost Ratio of the current 1-1-1-1… PTI Cycle				8.7
Benefit-Cost Ratio for the change to 4-1-1-1… PTI Cycle				0.2

Source: own calculations.

4. Benefit and Cost Assessment for PTI-Cycle Change of Passenger Cars in Germany (Case Study II)

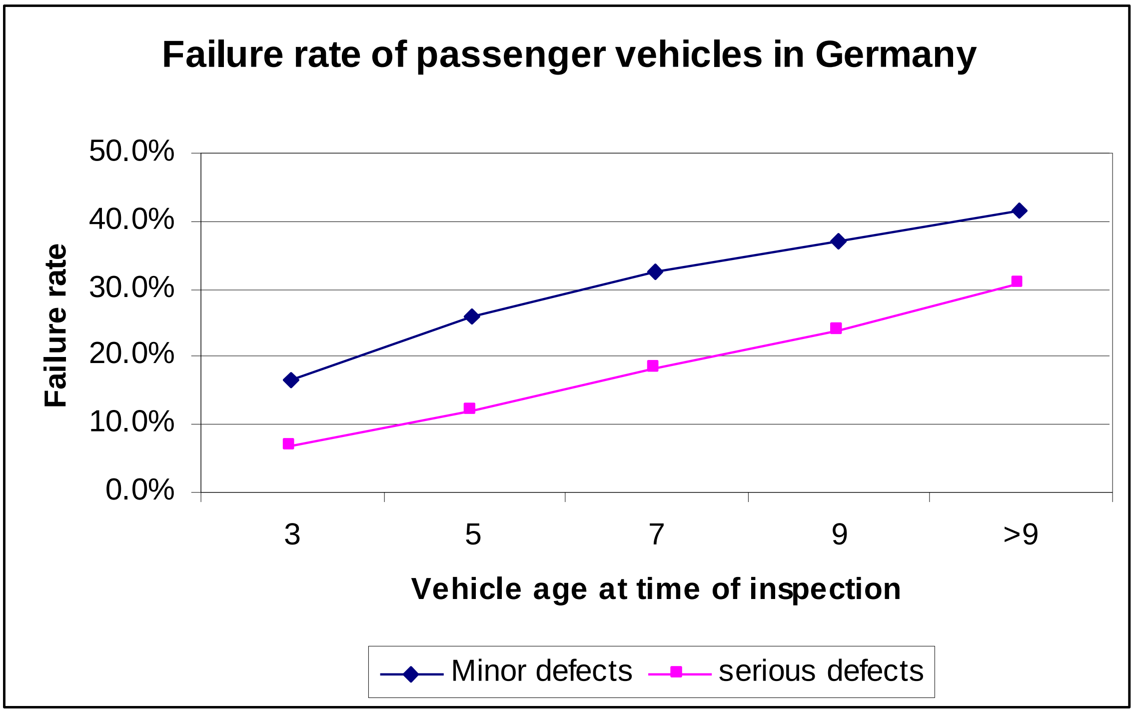
The determination of the accident cost savings is oriented on the systematic steps of the CBA.

4.1 Technical Defects and Vehicle Age

In order to evaluate the effect of the general inspection, the connection between the year of manufacture and the number of technical defects per vehicle is an important factor.

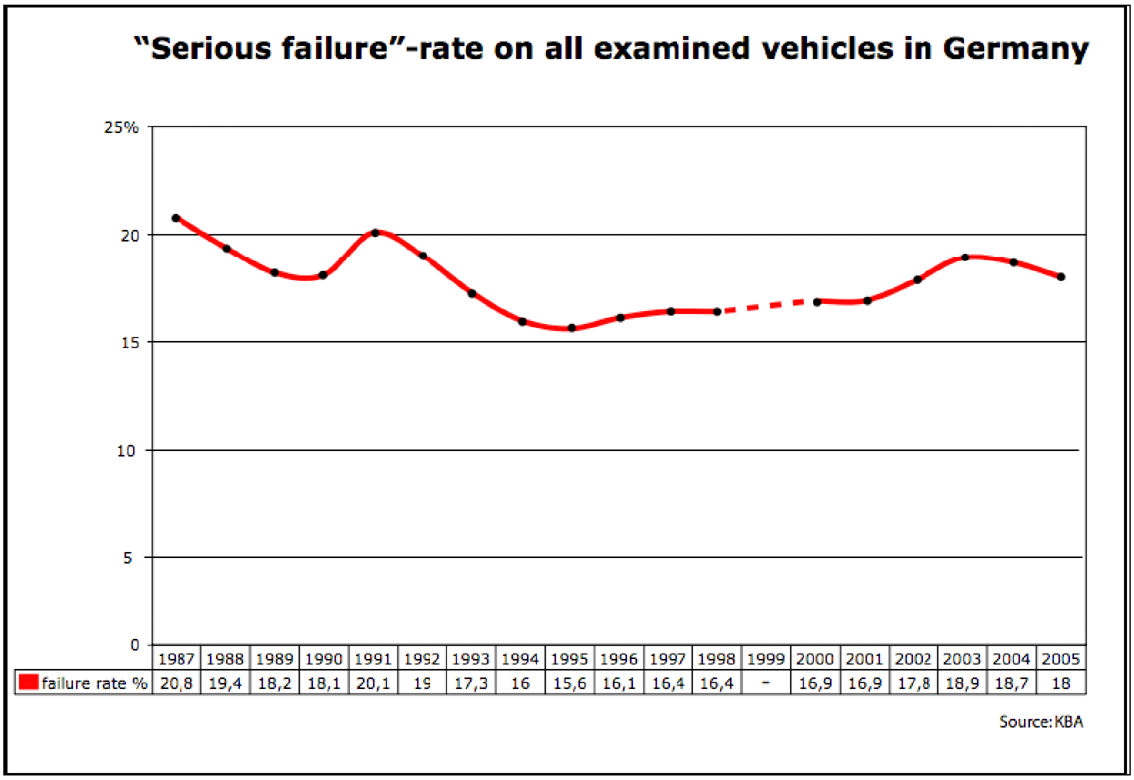
Figure 5 shows that, for 3 million passenger vehicles inspected in Germany in 2004, more than 10% of the vehicles as old as 5 years old at the time of inspection, had serious defects. This increased to over 31% for vehicles older than 9 years. Figure 6 shows the overall rate of serious defects for all vehicle types in Germany from 1987 to 2005. This also shows that the average failure rate has not decreased significantly over time. Elvik (2004) comes to similar results for the passenger cars in Norway and referring to other studies (Fosser, Ragnøy 1991) Elvik derives a general functional relation for vehicle age and technical defects. Figure 7 shows the result for this adaptation.

Figure 5: Failure Rates of Passenger Cars in Germany



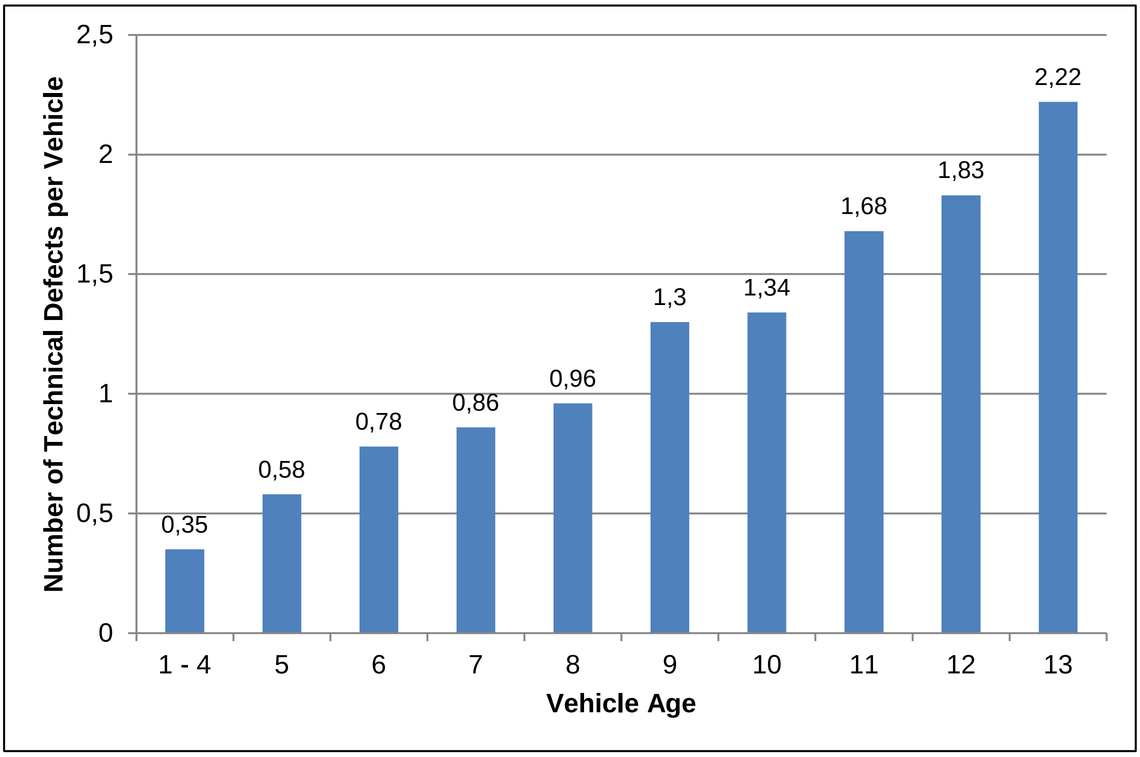
Source: AUTOFORE 2006, DEKRA 2001.

Figure 6: Serious Failure Rate of all Inspected Passenger Cars in Germany for the Time Period from 1987 to 2005



Source: AUTOFORE 2006.

Figure 7: Modified Number of Technical Defects per Vehicle in Connection with the Age of Vehicles



Source: Elvik 2004; Fosser, Ragnøy 1991, own calculations.

4.2 Accident Analysis

The initial point for the determination of the accident avoidance potential is the 2008 statistics (Statistisches Bundesamt 2009; Statistisches Bundesamt 2006). Table 10 shows the number of accidents caused by technical defects and impacts for the year 2008.

Table 10: Number of Accidents caused by Technical Defects and Impacts for the Year 2008 (Absolute)

	Number of Accidents		
Technical Defects	With Fatality	With Injuries	Only Property Damages
Lighting	1	54	31
Tire Equipment	20	771	552
Brakes	0	144	66
Steering	2	69	35
Towing Device	1	24	14
Other Defects	1	300	139
All	**25**	**1,362**	**837**

Source: Statistisches Bundesamt 2009.

Altogether, there were 25 road accidents with at least one fatality, which were caused by passenger cars with technical defects in 2008.

The low number of technical defects in the official statics is due to the fact that it is complicated for policemen to detect technical defects in the case of road accidents. However, a detailed analysis of road accidents in Germany suggests that 2.5% or rather 9.1% of road accidents are caused by passenger cars with technical defects. (Arbeitsgruppe 2002) For this study the average case with a value of 5.8% is used.

Table 11 and 12 outline the approach that was taken to determine the number of accidents that happened due to technical defects in 2008.

Table 11: Determination of the Number of Accidents with Injuries caused by Technical Defects

Accident Statistics 2008	▷ 320,614 Accidents with Injuries ▷ 64% with Passenger Cars = 205,193 Passenger Car Accidents with Injuries
Accidents with Injuries due to Technical Defects	11,901 Accidents

Source: Statistisches Bundesamt 2009; own calculations.

Table 12: Determination of the Number of Accidents with Property Damages caused by Technical Defects

Accident Statistics 2008	▷ 1,954,844 Accidents with Property Damages ▷ 86% with Passenger Cars = 1,681,166 Passenger Car Accidents with Property Damages
Accidents with Property Damages due to Technical Defects	97,507 Accidents

Source: Statistisches Bundesamt 2009.

Table 13 distinguishes between the evaluation variants of accidents due to technical defects depend on the type of technical defect (lighting, tire equipment, brakes, steering, towing device and other defects) and the effect of the accident (fatalities, injuries, only property damages).

Table 13: Number of Accidents caused by the Technical Defects and Impacts for the Year 2008 (Average)

	Number of Accidents		
Technical Defects	With Fatality	With Injuries	Only Property Damages
Lighting	9	464	3,612
Tire Equipment	172	6,616	64,306
Brakes	0	1,236	7,688
Steering	17	592	4,077
Towing Device	9	206	1,631
Other Defects	9	2,602	16,193
All	**216**	**11,716**	**97,507**

Source: Statistisches Bundesamt 2009; own calculations.

However, it cannot be determined from the accident statistics how many persons have been killed. In the average case there were 9 accidents with fatalities due to lighting defects. This only shows that at least one person was killed per accident. It is also possible that the number of fatalities actually exceeds 9 persons. How many persons were killed is hard to determine and can only be determined by approximation. Moreover, it must be assumed that accidents with fatalities also include seriously and slightly injured persons. The accident statistics do not distinguish between seriously and slightly injured persons, but only shows injured persons.The accident statistics neither tells how many persons got injured in accidents with injured persons.

4.3 Inspection Costs

Per inspected motor vehicle costs of $65.4 are charged. (DEKRA 2009) Additional costs for different cycles of the inspection result as follows:

- For each year the number of motor vehicles with general inspection of the old cycle and the number of motor vehicles with general inspection of the new cycle are evaluated.
- The difference between the fleet of vehicles with and without general inspection tells us the number of additional vehicles. These vehicles are then multiplied by the costs of the general inspection (after adjustment for tax and profit surcharge).
- Since the calculation results show the price level from 2009.

4.4 Cost-Benefit Results

During 2010 and 2015 the average vehicle age will increase by 3.2% from 8.7 years to 9.0 years. The change of the inspection regime leads to an increase in the number of inspected passenger cars on average by the factor 1.6. This does not result in a proportional reduction of accidents. A disproportionate reduction of accidents is reached because on average the factor is 1.9. This non-linear dynamic is the result of predicting the change of the vehicle-age on an annual base.

Table 14: Average Vehicle Age, Number of Inspected Cars and Preventable Accidents for With Case and Without Case", 2010-2015

Year	**Development of the Average Vehicle Age**	**Number of Inspected Cars in Million**		**Number of Preventable Accidents in Thousand**	
		3-2-2-2 "Without case"	**3-2-2-1** "With case"	**3-2-2-2** "Without case"	**3-2-2-1** "With case"
2010	8.73	18.34	29.68	62	118
2011	8.79	18.49	30.12	62	119
2012	8.84	19.15	30.65	64	120
2013	8.90	18.44	30.22	63	120
2014	8.96	19.28	31.20	65	122
2015	9.01	18.62	30.37	64	121
Average	**8.87**	**18.72**	**30.37**	**63**	**120**

Source: own calculations.

During 2010 and 2015 the average benefits by accident savings for the two cases increase by 15.7% for the without case and 16.8% for the with case. Therefore, the additional benefit increases within 2010 and 2015 by 18.1% from $838 million to $990 million. This is an annual average of $915 million over these years.

Table 15: Benefits by Additional Avoided Accidents in Million EUR, 2010-2015

Year	Benefit by Avoided Accidents in Million USD		Additional Benefit (Difference) in Million USD
	3-2-2-2 "Without case"	**3-2-2-1** "With case"	
2010	$948.5	$1,786.9	$838.5
2011	$970.2	$1,848.1	$877.9
2012	$1,021.5	$1,914.3	$892.8
2013	$1,034.4	$1,969.6	$935.2
2014	$1,083.1	$2,043.8	$960.7
2015	$1,097.6	$2,087.5	$989.9
Average	$1,025.9	$1,941.7	$915.9

Source: own calculations.

Further benefits can be reached by avoiding congestion costs (see table 16). The percental increase for the without case will be 15.6%, and for the with case the increase is 16.8%. The change of the inspection regime leads on average to additional benefits of $135 million.

Table 16: Benefits by Additional Avoided Congestions in Million EUR, 2010-2015

Year	Benefit by Avoided Congestions in Million USD		Additional Benefit (Difference) in Million USD
	3-2-2-2 "Without case"	**3-2-2-1** "With case"	
2010	$139.8	$263.3	$123.5
2011	$143.0	$272.3	$129.3
2012	$150.5	$282.0	$131.6
2013	$152.4	$290.1	$137.7
2014	$159.5	$301.1	$141.6
2015	$161.6	$307.5	$145.9
Average	$151.2	$286.1	$134.9

Source: own calculations.

The costs for the different inspection regimes are shown in table 17. During 2010 and 2015 the additional costs decreases within 2010 and 2015 by 18.7% from $705 million to $593 million. This is an average of $653 million over these years.

Table 17: Costs for Inspection Regimes in Million USD, 2010-2015

Year	Costs for Vehicle Inspections in Million USD		Additional Costs (Difference) in Million USD
	3-2-2-2 Without case	**3-2-2-1** With case	
2010	$1,140.0	$1,844.7	$704.7
2011	$1,102.7	$1,796.0	$693.3
2012	$1,095.3	$1,753.4	$658.1
2013	$1,012.2	$1,658.4	$646.2
2014	$1,015.1	$1,642.9	$627.7
2015	$940.5	$1,534.1	$593.6
Average	$1,051.1	$1,704.9	$653.9

Source: own calculations.

The cost-benefit results are presented in table 18. During 2010 and 2015 the overall benefits increase by 181% from $962 million to $1,050 million. The benefit-cost ratio increases by 35.7% from 1.4 to 1.9. This is an average within 2010 and 2015 of 1.7 and an annual increase by 0.1.

Table 18: Costs, Benefits and Benefit-Cost Ratio in Million USD, 2010-2015

Year	Accident-Cost Savings in Million USD	Congestion-Cost Savings in Million USD	Overall Benefits in Million USD	Costs in Million USD	Benefi-Cost Ratio
2010	$838.5	$123.5	$962.0	$704.7	**1.4**
2011	$877.9	$129.3	$1,007.2	$693.3	**1.5**
2012	$892.8	$131.6	$1,024.3	$658.1	**1.6**
2013	$935.2	$137.7	$1,072.9	$646.2	**1.7**
2014	$960.7	$141.6	$1,102.3	$627.7	**1.8**
2015	$989.9	$145.9	$1,135.8	$593.6	**1.9**
Average	$915.9	$134.9	$1,050.8	$653.9	**1.7**

Source: own calculations.

From an overall economic point of view a change of the current inspection regime is beneficiary.

5. Conclusions

5.1 German Case Study

This research is a first and rough approach to give insight into the economic effects of changing the inspection cycle for passenger cars. As stated before, within the European Union the general rule for inspecting passenger cars is a minimum inspection cycle. Germany has, due to the traffic volume, the amount of vehicle kilometers and the number of cars a high pressure to increase road safety. Based on this it has to be asked in which fields contributions to an increased road safety can be reached. One of the main fields is the reduction of road accidents of passenger cars caused by technical defects. Compared to other accident reasons such as weather, human failure and other effects or defects, it seems to be possible to avoid technical defects by a standardized inspection procedure. It is clear that the solution cannot be a permanent testing. It seems also clear that an annual testing from the first year does not make sense because new cars have lower technical defects than older cars. Therefore the quest for an optimal time schedule has to consider the following aspects: development of passenger car fleet, change of years of vehicle usage, correlation between number of technical defects and vehicle age, and weak willingness-to-repair of the car owner to maintain his car properly by increasing vehicle age. For these reasons it makes sense to start the annual inspection only for passenger cars which are older than seven years. On average a benefit-cost-ratio of 1.7 is reached. In 2010 the initial benefit-cost ratio is 1.4 up to 2015 the benefit-cost-ratio increases by 35.7% to 1.9.

Due to the lack of empirical data it was not possible to quantify all benefit components of changing inspection regime. Especially, the change of the severity of accidents (for example by repaired brakes) would lead to a significant reduction of accident costs. Furthermore, the economic savings by avoiding vehicle breakdowns could also reach a significant amount. On the other hand the costs of the change of the inspection cycle are completely covered. This means that a more realistic benefit-cost ratio is higher than the average of the benefit cost ratio of 1.7.

The clear recommendation for Germany is that the test cycle “3-2-2-1” is more efficient than “3-2-2-2”. A change of the test cycle is desirable because in the future an increase of technical defects can be expected. The reasons are:

- Over time the vehicle age will increase, due to the economic situation. The lowering of the real income increases the necessity for households to lengthen the usage-period of their cars.
- The expected real income losses of households in the next two decades lower the possibilities for adequate repair and inspection behavior.

This means more technical defects by increasing vehicle age and at the same time a decreasing share of voluntarily repaired passenger cars.

It makes sense for the inspection agencies to carry out cost-benefit-analyses for all possible test-cycles with focus on the empirical relation between technical faults and vehicle age. In the best case this has to be done on the European level because that guarantees a common efficient solution for all member states.

5.2 Belgian Case Study

The current practice of 1-1-1-1 inspection of N1 vehicles in Belgium is under overall economic terms more than justified because the benefit-cost ratio is 8.7. This BCR is an excellent value. All benefit-cost ratios above 3 are quoted as excellent (SeiSS 2006), which means that measures with this high ratio should be supported and enforced by the government.

The cost-benefit analysis was performed using overall conservative assumptions:

- On the cost-side there is an overestimation of the inspection costs, because the costs of the diesel engine tests still remain in the inspection cost-unit rate.
- On the benefit-side it was not possible to calculate all benefits as a result of the inspection. Other benefits result from lower number of vehicle-breakdowns and also from emission reduction due to the control of the diesel engine.
- One main effect of inspection is also missing. It is the pressure of the inspection itself to the vehicle owner to repair vehicle-defects. That means that the obligatory vehicle-inspection generates a pressure to the vehicle owner to repair obvious vehicle defects before the inspection. For example, 54% of all passenger cars with an age of 7 years have a vehicle defect. At the inspection-day only 16.9% of the 7 years old passenger cars have a defect. The number of defect vehicles is reduced by 37.1 percentage points, because of the ex-ante repairs (AUTOFORE 2006).

- For commercial vehicles the ex-ante defect rate can be expected to be more than three times higher than the detected share of vehicles with defects at the inspection day (AUTOFORE 2006). Taking this empirical fact into account the benefit-cost ratio for the current inspection regime of N1 vehicles in Belgium will be increased to 24.

Changing the inspection cycle to an inspection cycle with longer intervals between the inspections will lead to more fatalities, injuries, congestions, and emissions.

Frequently it is argued that reducing the number of inspections increases consumer welfare. This argument is based on the idea of the single market benefits. This means the consumer (=vehicle owner) has not only the savings of the inspections costs, which he does not have to pay, but further he also has the savings of repair costs. The argumentation goes on with the fair-argument: it is not fair to calculate accidents, congestions and emissions, and then only focus on the inspection costs.

Obviously, this argument ignores that the car owner has to keep his vehicle in a condition without safety-critical defects. In a perfect world with good-behavior of the vehicle-owner, indeed, inspections are not needed because he will always detect defects in time and he has a high willingness to repair these defects. However, the world is not perfect and the road vehicles are credence goods. In the case of commercial vehicles, especially, the vehicle owner has a trade-off between repair costs of the vehicle and higher profits per vehicle-usage. That is the reason why inspection is necessary. Furthermore, this shows that the costs of repairing detected defects are not in a causal relation to the inspection as the repair costs still exist in a world without inspections, where they have to be paid.

5.3 General Conclusions

Both case studies support that the minimum test-cycle is not the best case. The diseconomies for EU-27 result from the different national regimes, which lead to an unequal treatment of consumers and industries. The case of N1 vehicles in Belgium has shown that Member States with more intensive inspection cycle will be under pressure to establish the minimum standard because the cost savings of lower inspections are tangible for example to car owners and parcel, courier and express industry, but the reduced risk of road accidents and the lower exposure to emissions are intangible to those groups. The costs of road accidents and emissions cost are at this stage only tangible for the government. For the emissions it is easy to argue that the emission costs are externalities and they have to be internalized. The outweighing part of road accident costs are internal costs, because they are paid in advance as insurance premiums. The insurance industry calculates the premiums on the objective risk to have a road accident, but the driver underestimates his objective risk. The discrepancy between subjective risk and objective risk and the credence character of road vehicles give the economic reason for governmental regulation.

The empirical relation between technical defects and vehicle age shows like the CBA results for Germany that the current minimum PTI-regime is inefficient. These findings give evidence to transport policy to use the instrument of cost-benefit analysis to identify for each Member State the optimal PTI-cycle and the optimal PTI-cycle for the EU-27. Applying this optimal PTI-cycle on EU-level makes only sense by introducing it as an obligatory standard.

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