The effect of extended periodic inspection of passenger cars and vans

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1. Introduction

1.1 Background and introductory explanation

On 13 July 2012, the European Commission presented its proposal for a “Roadworthiness Package on extended periodic inspection”, proposal for regulations Nos. 380, 381 and 382” (European Commission 2012). The background for the Commission’s proposal for extended periodic inspection (regulation No. 380) is that periodic inspections can reduce the number of serious road accidents by reducing the number of the technical defects in older cars. To support this, the regulation refers to a number of reports, among others AUTOFORE (2007), in the following referred to as the “Autofore report”, and the related working papers WP 400, Part A (Baas *et al*, 2006) and Part B (Baum *et al*, 2006), in the following referred to as ”WP 400” and WP 700 (Baum *et al*, 2007), in the following referred to as ”WP 700”.

1.2 Purpose

The purpose of this note is to perform a calculation of the costs and benefits of extended periodic inspection of passenger cars and vans in Denmark, provided that the first inspection of passenger cars and vans is performed after four years, then one inspection after two years and thereafter annually (4,2,1,1…) as described in the proposal of the European Commission for a “Roadworthiness Package on extended periodic inspection, proposal for regulation No. 380”.

Furthermore, the note contains a technical review of the calculations in the “Autofore report” of the baseline scenario of an older proposal according to which the periodic inspections were to be performed after four years, then after two years, then after another two years and thereafter annually (4,2,2,1,1…). This means that our baseline scenario will include one additional inspection (in year 7) as compared to the baseline scenario of the “Autofore report”. However, the ”Autofore report” includes sensitivity calculations for alternative starting years for the annual periodic inspections, including our baseline scenario.

The review examines the assumptions in the ”Autofore report” referred to by the Commission and evaluates the robustness of the Danish assumptions.

1.3 Contents of this note

This note first presents a benefit-cost calculation based on already known input data which is also studied in details. Afterwards the key assumptions and choices made in this calculations and the relation to the "Autofore report" are discussed. Finally, we present a number of sensitivity analyses and discuss the consequences of changes in the key variables.

The ”Autofore report” also contains a calculation of the benefit cost ratio of the proposal contained in regulation No. 380 (4,2,1,1…). When calculated at the EU level, the benefits amount to

2,200 million EUR in 2010, based on 2004 prices, with a benefit-to-cost ratio of 1.9.[1] (cf. the "Autofore report" p. 35). In general, average EU key figures and unit cost prices are used for the calculations, whereas the accident numbers are country-specific.

The baseline scenario in the "Autofore report" is however a somewhat older proposal with periodic inspections after 4 years, then after 2 years and again after 2 years and thereafter annually (4,2,2,1,1…). Here the benefit-to-cost ratio is at least 2, and the economic benefits amount to more than 2.1 billion EUR. In addition, the "Autofore report" also contains an example calculated for Denmark, and the calculation shows a clear welfare economic improvement from the proposal with a benefit-cost ratio of 1.5 for the baseline scenario.

In this note an updated calculation is performed with specific Danish and updated input data and key figures. For some of the elements of the analysis, the calculations are based on information and data from the "Autofore report" where specific Danish data cannot be found. It should therefore be noted that this analysis does not contain any independent empirical studies of the underlying data and material or any independent deductions from the data, but is only an updated cost-benefit analysis based on existing knowledge from already known Danish data or the "Autofore report".

The note also discuss how the updated calculations differ from the "Autofore report" and the arguments for these deviations. Furthermore, the note also critically examines some of the central assumptions used in the calculations of the "Autofore report".

This cost- benefit analysis uses 2012 as calculation year and is, among other things, based on:

- Data on expected number of personal injury accidents in 2012, based on actual data until and including 2011
- Draft key figures from DTU Transport for 2012 concerning unit costs for personal injuries in the traffic as well as emissions and fuel costs
- The car fleet's size and composition for passenger cars and vans up to 3,500 kg at the end of 2011.

The calculations do not include the effect on the number of accidents involving only material damage.

The calculated cost-benefit analysis is for a single year (2012) based on data from this year. It should be noted that the "Autofore report" considers the year 2010 and the baseline scenario for a proposal with periodic inspection after 4 years, 2 years, 2 years and thereafter annual periodic inspections (4,2,2,1,1…).

This note is also available in a Danish version in DTU Transport note series:"Effekten af udvidet periodisk syn af person- og varebiler", Notat 8, 2012.

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[1] It should be noted that the benefit-to-cost ratio in the "Autofore-report" is defined as the ratio between the total benefits and the total costs. This differs from the definition of the benefit-cost ratio normally used in the guidelines of the Ministry of Transport. For further details, see section 4.3.1

2. Key figures and assumptions

This chapter contains a review of some of the important assumptions, key figures and input data which are most essential for the result. Later in this note these assumption are discussed in detail.

2.1 Important assumptions

It is assumed

- that the car fleet's size and composition as well as the annual mileage is not influenced by this initiative
- that the technical inspection centres and garages operate under perfect competition without abnormal profits, and where the price of an inspection therefore is assumed to cover the direct costs related to the inspection.

The number of personal injury accidents has been forecasted to 2012 with a downward trend. The most recent actual data are from 2011.

It is furthermore assumed

- that the initiative will not result in additional costs for maintenance and repairs of cars.

The effect of reductions in fuel consumption and emissions is only calculated for gasoline cars. A reduction in the consumption of gasoline equivalent to the reduction in CO_2-emissions is used.

Only the reduction in personal injury accidents is calculated as the data qualityof accidents involving only material damage is too low. Furthermore, a reduction in the number of personal injury accidents is the key objective of the proposal.

2.2 Important input data and key figures

The cost-benefit analysis in the following section is based on an expected reduction in the number of personal injury accidents of 43.6 accidents per year[2]. This reduction is obtained based on approximately 770,000 additional annual periodic inspections. The reduction in the number of personal injury accidents of 43.6 is based on calculations that follow the "Autofore report", and which will be commented later in this note (Chapter 4).

Table 1 below provides an overview of important input data regarding the number of personal injuries, the number of new inspections and person-related costs for the various degrees of personal injuries used in DTU Transport's cost-benefit analyses.

[2] Among the 43.6 avoided road accidents there will be approximately 3 killed, 24 seriously injured and 22.2 slightly injured.

Table 1 Summary of important input data	
Personal injuries in accidents with passenger cars and vans (up to 3,500 kg)	**number 2012**
Number of killed	198
Number of serious personal injuries	1,562
Number of slight personal injuries	1,449
Inspection price	**2012, DKK**
The price of an inspection, including VAT and taxes	490
The price of an inspection, exclusive of VAT and taxes	373
Additional periodic inspection	**based on the car fleet 2011**
Number of additional inspections (more cars inspected)	764,597
Unit prices, injured	**2012, million DKK**
Person-related costs, including welfare loss	
Killed	18.930
Seriously injured	3.240
Slightly injured	0.490

3. Cost-benefit analysis

The result of extending the periodic inspection regime with annual inspections for cars seven years old or older is shown in this chapter.

3.1 Cost-benefit analysis

In Table 2 the overall cost-benefit analysis is shown.

Table 2 CBA for extended periodic inspection of passenger cars and vans (exclusive of material costs)

All costs are calculated for year 2012		**million DKK, per year**
Reduction in external costs		***153.884***
Benefit from number of avoided killed	57.530	
Benefit from number of avoided seriously injured	77.755	
Benefit from number of avoided slightly injured	10.865	
Total benefit from road safety		*146.150*
Benefit from avoided congestion		*3.273*
Benefit from avoided air pollution		4.340
Benefit from avoided CO_2 emissions		0,121
Total benefit from avoided emissions		*4.461*
User benefits		***15.179***
Reduction in fuel consumption (including taxes)		15.179
Direct user costs		***-374.653***
The costs of additional inspections (including taxes)		-374.653
Effect on public budgets		***80.953***
Reduction in the tax revenue from a reduction in the fuel consumption		-8.505
Revenue from an increased number of inspections		89.458
Tax distortion effect		***16.191***
Tax distortion effect of the total effect on public budgets		16.191
Total value (Net value)		***-108.445***
Benefits (external costs and user benefits, exclusive of taxes and distortion)		160.559
Costs (costs, exclusive of taxes and distortion)		-285.195
Benefits/costs		**0.56**

The project's total value, the net value, is the sum of all benefits and costs (negative) of the project. The net value of a project is positive, if the benefits are bigger than the costs.

A comment should be attached to the benefit-to-cost ratio. It has been calculated as the ratio between the project's total benefits compared to the project's costs. The ratio thus shows how big the benefits are compared to the costs. This criterion is used as it is the one used in the "Autofore report". In the "Autofore report", the calculations do not include taxes and distortionary effects, and therefore these elements are similarly not included in the benefit-to-cost ratio reported in the present report, but only in the net value.

However, according to the general guidelines of the Ministry of Transport (The Ministry of Transport 2003) that follow the guidelines from the Ministry of Finance, it is another criterion that is usually referred to as the benefit-cost ratio. According to the Ministry of Transport the benefit-cost ratio is the ratio between a project's total NPV (net present value) as compared to the net public spending on the project. The NPV is the net effect of a project discounted to the starting year, and this is related to the project's net requirement for public funding. The benefit-cost ratio of the Ministry of Transport therefore shows the net benefit provided by a project per publicly spent monetary unit. For public investment projects, where the NPV is typically positive, the criterion of the Transport Ministry is relevant since public funding is normally subject to budget restrictions. Thus, all projects with a positive NPV should in principle be implemented in a situation without budget restrictions, whereas in situations with budget restrictions a prioritisation should in principle be made to obtain the biggest net benefit per monetary unit invested. With respect to analyses as the present one, where the net value of the project is negative, this benefit-cost ratio is not useful but it is sufficient to observe that the NPV is negative. For projects of a more regulatory character, as the present one, it may however be justified not to apply these criteria strictly, as well as other considerations may also always influence the prioritisation.

3.2 Discussion of the result

The cost benefit analysis based on updated Danish input data and key figures shows that the costs of extending the periodic inspection regime to annual inspections from year 7 (4,2,1,1…) exceed the expected benefits obtained by the extra inspections. The costs primarily involve the cost related to the inspection itself, whereas the benefits primarily stem from a reduction of the number of expected personal injury accidents and to a smaller degree from a decrease in emissions.

The benefit in the form of fewer personal injury accidents amounts to 146.150 million DKK in 2012 to which should be added the benefits from reduced air pollution and CO_2-emissions amounting to 4.461 million DKK and a reduction of the congestion of 3.273 million DKK. Thus the benefit arising from the external effects will be 153.884 million DKK. To this should be added a benefit to the car owners of 15.179 million DKK due to reduced fuel consumption.

The direct costs for additional periodic inspections amount to 374.653 million DKK of which 89.458 million DKK correspond to VAT and taxes. Furthermore, the public revenue is reduced by 8.505 million DKK from the reduction in the fuel consumption. Overall, the public revenue will increase. This results in a tax distortion benefit of 16.191 million DKK.[3]

[3] Explanation of tax distortion, cf. Chapter 4.

The net value of the project is now -108.445 million in 2012 DKK.

Based on the above cost-benefit analysis it is therefore not profitable to implement the proposal regarding additional periodic inspections. The benefits provided by the proposal are therefore smaller than the costs. This results in a benefit-to-cost ratio of 0.56.

3.2.1 The result of the "Autofore report" as compared to the result of DTU Transport

The result of this analysis differs from the corresponding result of the "Autofore report". The "Autofore report" states a clear net benefit from the proposal, so that the benefit-to-cost ratio in their baseline scenario is 1.5 in the base-case scenario for Denmark in the calculation in appendix WP 700 to the "Autofore report" (Baum *et al*, 2007). For EU in general a benefit-to-cost ratio of at least 2:1 is found.

This difference is due to several factors. In the case of Denmark, the "Autofore report" is based on accident data from 2002 forecasted with an annual reduction of 2 per cent which results in distinctly higher accident numbers than shown by the actual development. This leads to a calculated number of avoidable personal injury accidents of 148 which is also well above the level found in the analysis carried out by DTU Transport. The deviation with respect to the benefit-cost ratio is therefore to a high degree found in this difference. Another very important difference is found in the calculation of the costs inherent to the many additional periodic inspections. It should also be noted that the baseline scenario of the "Autofore report" differs from this calculation as it only starts annual inspections after year 7 (4,2,2,1,1…), and the results are therefore not directly comparable. This issue will be discussed in further detail in Chapter 4.

A further discussion of the various elements of the analysis will follow in Chapter 4.

3.3 Multiannual analysis and TERESA

The cost-benefit analysis in this section is carried out for one individual year, i.e. 2012. It is of course possible to perform a similar analysis for a series of years discounted to the calculation year. However, only little additional information will be obtained in this way as the effects will be rather similar each year as opposed to an analysis of for example an infrastructure project where the costs fall in the first years whereas the benefits will be obtained later.

However, it is to be expected that the result of net value and benefit-to-cost will be declining over the following years. There are two main reasons for this. If a continued declining trend in the number of personal injury accidents is expected, then the number of accidents due to technical defects, which potentially could be avoided, will probably also decline, and the benefit of extended periodic inspections will thereby be smaller. At the same time, an increase in the car fleet can be expected due to a general economic growth over the years which will result in higher costs related to the additional inspections. In this way, the net result will be more negative. With respect to the other external effects, air pollution and reduction in the CO_2-emissions, increased benefits may be expected, for instance if the annual mileage per car, the car fleet or the unit cost prices increase. These elements of the result are however – at least in the short run – still relatively small compared to the other elements and will probably not change the result.

TERESA, The Ministry of Transport's spreadsheet for calculation of cost-benefit analyses of transport projects, is designed for analyses of multiannual project periods (typically 30-50 years). Due to the expectations of a growing car fleet, an increase in annual mileage and a reduction in the number of accidents with personal injuries as described above, the present analysis was not performed directly in TERESA. However, the principles and elements used in the present analysis are basically the same.

4. Discussion of important assumptions and constraints

4.1 The car fleet and the annual mileage

As already mentioned, data on the car fleet is based on the number of cars in 2011 which are the newest available data. We assume that the size and composition of the car fleet is unchanged compared to 2011 and that it is not influenced by the initiative. No increased scrapping of older cars or similar effects is therefore expected due to the proposal. We have chosen not to forecast the car fleet as it corresponds to the end of 2011 and is therefore only delayed six months.

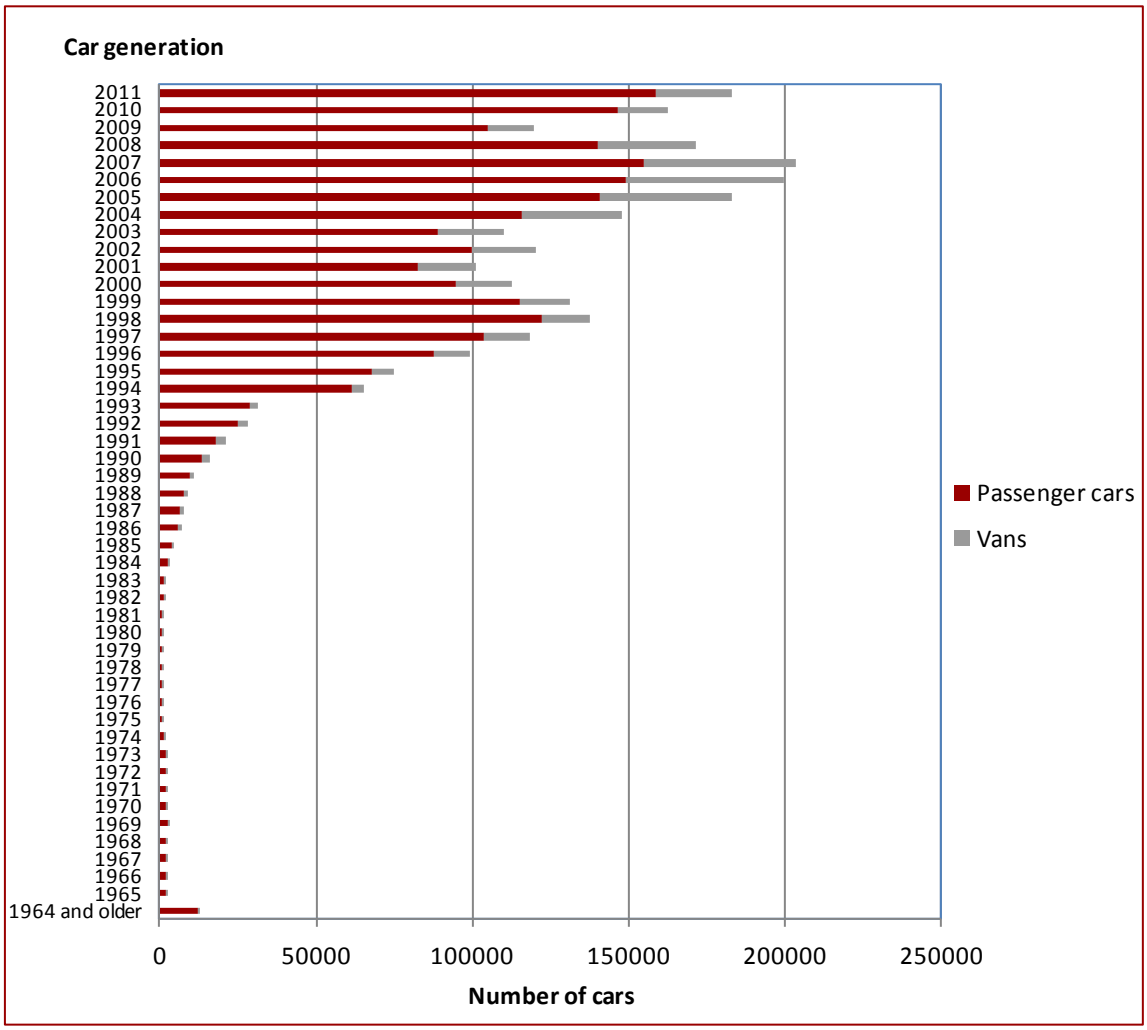

Figure 1 The car fleet, number of passenger cars and vans up to 3,500 kg sorted by car generation, end 2011
Source: DTU Transport

Similarly, it is assumed that the annual mileage is not affected by the proposal. An extension of the periodic inspection regime will therefore not influence the annual mileage of the cars. Con-

sequently, there will not be any effect on the utility obtained by the car drivers from their driving either, and thus, this is not included in the cost-benefit analysis.

The car fleet in Denmark in 2011 consists of 2.620 million cars (passenger cars and vans up to 3,500 kg), and based on this, 764,597 extra periodic inspections with the baseline scenario (4,2,1,1...) will have to be performed.

By comparison, the "Autofore report" is based on data about the Danish car fleet in 2002 where the number of cars amounted to 1.9 million which is forecasted to 2.1 million cars in 2010. This results in a need for 478,660 extra periodic inspections in the baseline scenario of the "Autofore report" (4,2,2,1,1,…).

4.2 Reduction in the number of accidents

Calculations have only been carried out for the reduction in personal injury accidents. There is no information on the extent to which accidents involving material damage only are reported to the police, and furthermore there is a lower limit of 50,000 DKK for accidents involving only material damage which must be reported to the police. Accidents involving material damage are therefore not included. Furthermore, the change in the number of personal injury accidents is regarded the more relevant, and at the same time it is the main argument behind the proposal. This applies to both the present analysis as well as to the assumptions contained in proposal No. 380 of the European Commission.

In order to be able to compute the value of a reduction in the number of personal injury accidents as a consequence of a change in the frequency of the periodic inspections, you need to know the unit price of the value of an avoided personal injury as well as an assessment of the impact of the initiative on the number of accidents. Especially the latter is a challenge.

4.3 Reduction in the number of accidents

4.3.1 Expected number of personal injuries in 2012

The "Autofore report" primarily uses old accident data as the basis of the calculations. According to "WP 700", p. 32, accident data from 2003 registered by the police are used for all personal injury accidents which are forecasted with an expected annual reduction of 2 per cent until the calculation year 2010, cf. Table 3. However, it appears from Table 4 that the annual reduction has been much higher than 2 per cent. In 2010, the actual number of personal injury accidents registered by the police was 3,498, whereas "WP 700" uses a number for 2010 of 5,859 accidents.

Table 3 Forecast of number of personal injury accidents in "WP 700", 2003-2010

Year	2003	2004	2005	2006	2007	2008	2009	2010
Number	6,749	6,614	6,482	6,352	6,225	6,101	5,979	5,859

Source: Baum et al., 2007

Table 4 Actual number of personal injury accidents in Denmark, 2003-2010									
Year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Number	6,749	6,209	5,412	5,403	5,549	5,020	4,174	3,498	3,525

Source: Statistics Denmark

Apart from the insufficient reduction in the forecast, it was decided to base "WP 700" on the total number of personal injury accidents, including accidents with road users and vehicles that are not comprised by the regulation regarding extended periodic inspections, as this regulation only comprises passenger cars and vans up to 3,500 kg (European Commission, 2012).

The calculations in this note only include personal injury accidents *with passenger cars and/or vans up to 3,500 kg registered by the police*. We therefore start at an even lower level of number of personal injury accidents which potentially could be avoided if extended periodic inspection of passenger cars and vans up to 3,500 kg is introduced, thereby resulting in a lower number of cars with technical defects, cf. Table 5.

Table 5 Personal injury accidents with passenger cars and/or vans up to 3,500 kg in Denmark, 2003-2011									
Year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Number	5,476	5,040	4,386	4,440	4,574	4,135	3,478	2,888	2,931

Source: DTU Transport

This gives a substantially lower number of expected accidents with personal injuries even in the baseline situation without extended inspection. Thus, in 2010 the actual number of personal injury accidents with cars and vans up to 3,500 kg was 2,888, whereas the "Autofore report" uses a number for 2010 of 5,859. Apart from the modified forecast, the deviation, as already mentioned, is also due to the fact that the "Autofore report" has not deducted the accidents caused by vehicles which are not comprised by the proposal for new inspection rules.

As earlier mentioned, the calculation year used in the present calculations is 2012 and the expected number of personal injury accidents with passenger cars and vans up to 3,500 kg in 2012 has been forecasted to 2,844 accidents using linear regression based on the period 1997-2011.

The following three figures show the development in the number of killed, seriously injured and slightly injured persons in personal injury accidents with passenger cars and/or vans up to 3,500 kg registered by the police. With respect to killed persons, the data comprises the period 1997-2011, whereas the data on personal injuries only uses the period 2004-2011, as another distribution between serious and slight personal injuries was used in the period 1997-2003. The number of personal injuries has been forecasted to 2012 using linear regression, so that the number of expected personal injuries in 2012 in accidents with passenger cars and/or vans up to 3,500 kg is 198 killed, 1,562 serious personal injuries and 1,449 slight personal injuries, cf. the following three figures.

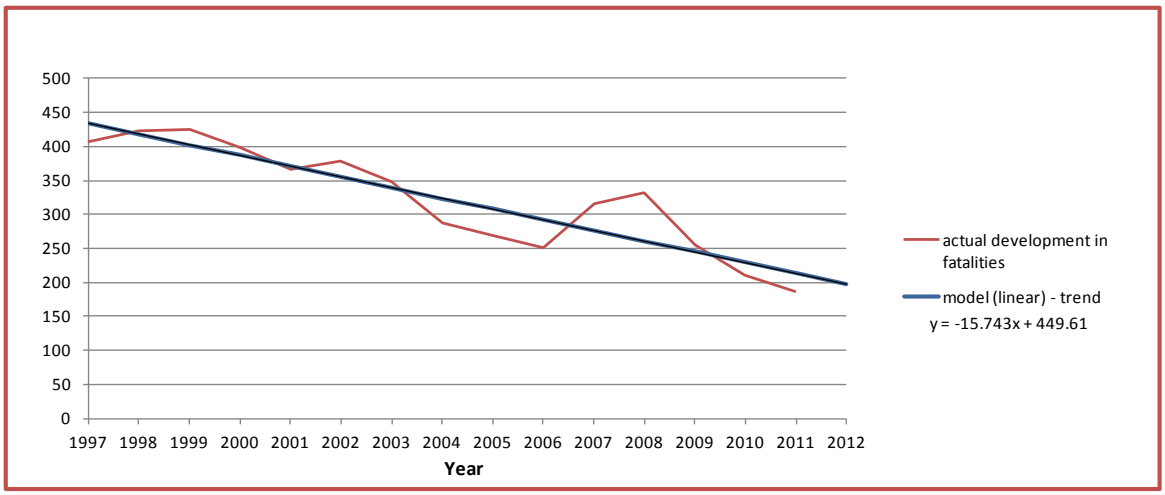

Figure 2 Killed persons in personal injury accidents with passenger cars and/or vans1997-2011
Source: DTU Transport

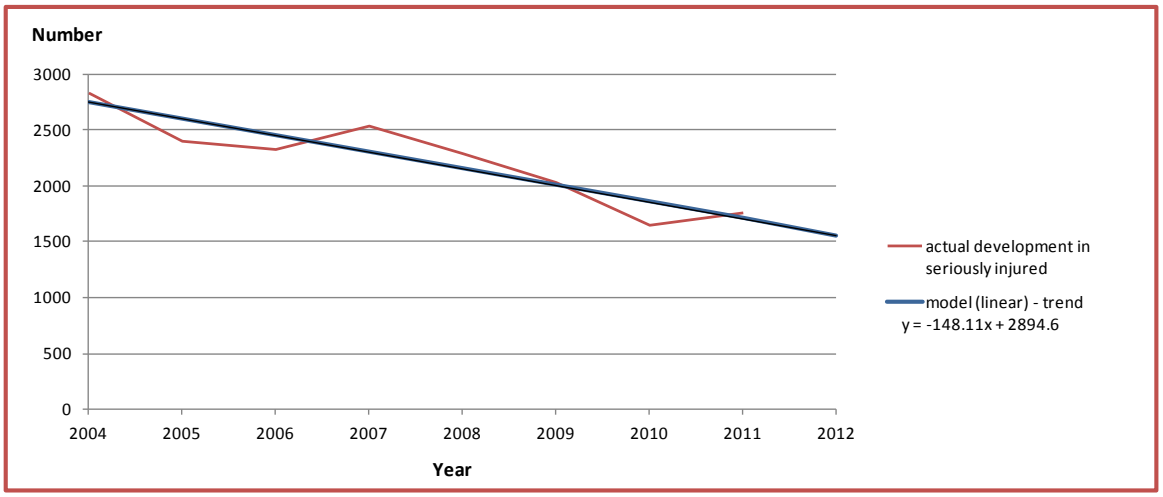

Figure 3 Seriously injured in personal injury accidents with cars and/or vans, 2004-2011
Source: DTU Transport

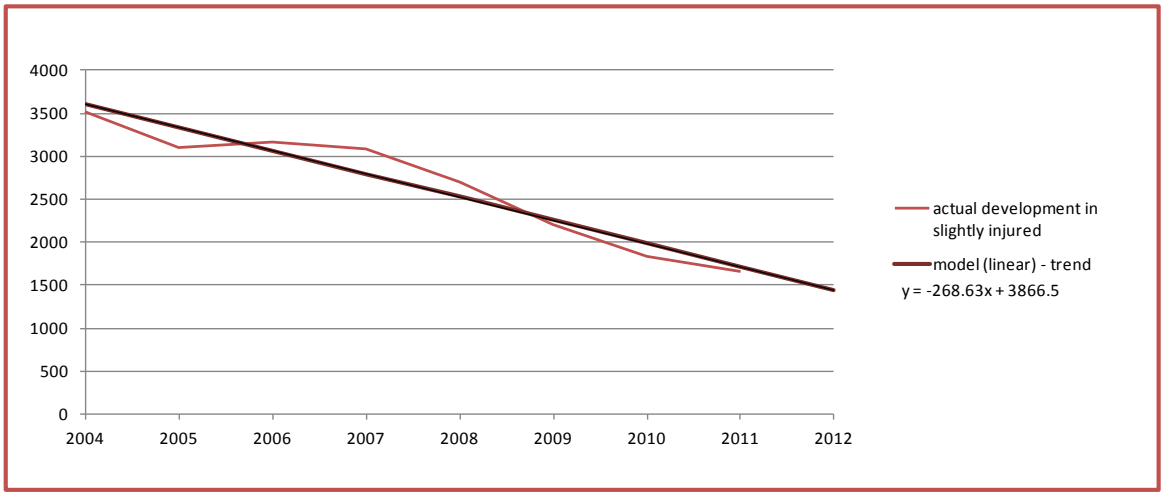

Figure 4 Slightly injured in personal injury accidents with cars and/or vans, 2004-2011
Source: DTU Transport

The “Autofore report” used a forecasted total number of personal injury accidents in 2010 of 5,859 whereas the actual number for 2010 turned out to be 3,498.

In this document we have, as earlier mentioned, chosen to study only the reduction in accidents involving vehicles whose roadworthiness could be affected by extended periodic inspection. We therefore use the forecasted number of personal injury accidents with passenger cars and/or vans in 2012, i.e. 2,844 accidents. The projected number of killed persons in 2012 is 198, the projected number of serious personal injuries in 2012 is 1,562 and finally the forecasted number of slight personal injuries is 1,449.

4.4 Reduction in the number of accidents

4.4.1 The effect of extended inspection on the number of personal injury accidents

It is not easy to establish the effect of extended periodic inspection on the number of personal injury accidents. In the cost-benefit analysis, we apply the procedure used in the “Autofore report”. The method is described in “WP 400” and the calculations are explained in “WP 700”.

The “Autofore report” uses the following relation to calculate the number of personal injury accidents that can be avoided if annual inspection of vehicles older than 7 years is introduced (4,2,2,1,1,…).

$$N_{red\ acc} = A_{cc} \cdot TD \cdot RED \cdot RAT \cdot DefVeh$$

The elements in the formula for reduction in the number of personal injury accidents are described in Table 6.

Table 6 Elements of the formula for reduction in the number of personal injury accidents

Variable	Explanation
$N_{red\ acc}$	Reduction in number of accidents
A_{cc}	Number of accidents with passengers cars in Denmark
TD	Percentage share of accidents caused by technical defects
RED	Empirical derived reduction ratio for the percentage share of accidents, which can be reduced by annual inspection
RAT	Ratio for number of additional inspections
DefVeh	Percentage share reflecting how many of all defect passenger cars belong to the period with annual inspections

The parameter *TD* represents the percentage share of the actual personal injury accidents that are caused by technical defects. The “Autofore report” states 5.8 per cent as a mean value between the extremes of 2.5 per cent and 9.1 per cent. The two percentages stem from an older German report (Bönninger *et al*, 2002) in which the total number of accidents in Germany is

stated. Two undocumented figures for the total number of personal injury accidents supposed to be due to technical defects are also mentioned. The lower figure refers to a German report, BASt-Studie 1986, and the higher to another German report, DEKRA Unfallsforschung 200. Unfortunately, it has not been possible for us to get access to the two references by contacting BASt and DEKRA. As the 2.5 per cent and 9.1 per cent is the result of dividing the two extremes for the total number of personal injury accidents in Germany which are supposed to be due to technical defects of the cars with the total number of accidents in Germany. Neither the extremes nor the mean value is sufficiently documented in the "Autofore report".

A further comment should be attached to the mean value of 5.8. The share represents the accidents where technical defects are stated as an accident factor. However, it cannot be concluded whether the accidents could have been totally avoided, if the technical defect had not been present. It must therefore be assumed that the use of this percentage leads to a certain overestimation. In many cases it will probably not be possible to avoid the accidents completely, but the severity level would be reduced.

Another important component is *RED* which states how many accidents that can relatively be avoided by introducing the proposed periodic inspection regime. However, it is not easy to find the background of this parameter. According to "WP 400"[4] and "WP 700"[5], reference is made to some German and Swedish "failure rates" in connection with the inspections, but it is not easy to find a more detailed background for this parameter and thus it is not easy to evaluate the robustness of this component either.

The parameter *RAT is a*nother challenge. In the "Autofore report", *RAT* is calculated as the ratio between the number of additional periodic inspections (using new practice minus unchanged practice) as compared to the number of inspections with unchanged practice. In the "Autofore report" this gives a *RAT=0.86*. This, however, appears a little unclear. It will for instance give a big difference in *RAT* from year to year, if the composition of the car fleet changes from one year to another. Furthermore, in case of very frequent periodic inspections, you can find a *RAT* bigger than 1 which does not seem logic. It is however totally dependent on how *RED* has been derived empirically as compared to *RAT*, but this is not easy to evaluate.

We therefore choose to define *RAT* a little differently. We set *RAT* to the change in the frequency of the inspections, i.e. *RAT is set* to ½ due to the change from biannual inspections to annual inspections. In this way our *RAT* also becomes independent of the actual distribution of the car fleet.

DefVeh is the parameter that ensures that calculations are only carried out for relevant cars, i.e. those with defects and which are older than six years old, i.e. the cars that will be comprised by the proposed regulation regarding periodic inspection. *DefVeh* data originates from "WP 700" which is based on a Swedish database[6]. In "WP 700" *DefVeh* is 84% for cars older than 7 years.

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[4] 'WP 400' p. 27

[5] 'WP 700' p. 33

[6] See p. 34 in "WP 700"

As we are looking at cars that are 7 years old and older *DefVeh* is instead set at 88.2% which also comes from "WP 700".

In connection with the above considerations, it is also worth noticing that a slightly different approach is used in another of the "Autofore report's" appendices, "WP 400".

In "WP 400" p. 28, the number of avoidable accidents is calculated as $A_{cc} \cdot TD \cdot RED \cdot N_{7old}$ where N_{7old} is the share of accidents with personal injuries that are due to technical defects caused by cars older than 7 years, i.e. that is part of the formula instead of *RAT* and *DefVeh.* Thus it is examined how big a share of the accidents that are due to technical defects caused by the cars that will now be comprised by the additional periodic inspections. This share is set to 70%.

Furthermore, the approach used in "WP 400" has the advantage that you do not have to address the annual mileage of older cars as compared to the one of newer cars. It is well-known that older cars typically have a lower annual mileage, and this fact therefore ought to be included in the situation where you only examine how big a share of the technical defects are found in this part of the car fleet (as when you use *DefVeh*). Apparently, this has not been taken into considerations in the calculations in "WP 700", and in this way the effect may be overestimated.

With these input and with the number of expected accidents in 2010 the "Autofore report" concludes that 148 personal injury accidents can be avoided in 2010, with a total of 9 killed, 86 serious personal injuries and 98 slight personal injuries.

As it appears, the above formula and the data used are quite important for the result of the cost-benefit analysis. However, the robustness of the different input to the formula is somewhat uncertain. Unfortunately, we do not have at our disposal any Danish estimates for these central parameters or studies which we can use here, and we must therefore use the assumptions from the "Autofore report". In total, this gives us the parameters shown in Table 7.

Table 7 Elements of the formula for reduction in the number of personal injury accidents

	"Autofore-report" 2010	**DTU Transport 2012**
A_{cc}	5,859	2,844
TD	0.058	0.058
RED	0.6	0.6
RAT	0.86	0.5
DefVeh	0.84	0.882
Number of avoided killed persons Number of avoided seriously injured persons Number of avoided slightly injured persons	9 86 98	3.0 24.0 22.2
Number of avoided accidents	148	43.6
Benefit from the reduction of personal injury accidents	EUR 24 million	DKK 146.150 million

In Chapter 5, a number of sensitivity analyses on these variables are carried out.

4.4.2 The value of avoided personal injuries

When it comes to the price of avoiding an accident, such unit cost prices have for several years been a standard element of many analyses, and the Ministry of Transport has official key figures for these.

The key figures are found using different valuation methods. The unit cost for reduction in the number of killed, seriously injured and slightly injured, respectively, is taken from the draft version of the 2012 "Unit prices in transport economics" (DTU Transport, 2012). From this report we use the following values:

Table 8 Person-related accident costs	2012 prices
DKK	DKK
Killed	18,932,533
Seriously injured	3,243,622
Slightly injured	488,588
Reported personal injury accidents	5,197,540

It should be noted that these unit costs are considerably higher than the prices of the personal injuries which were used in the "Autofore report". They are 1,000,000 EUR, 135,000 EUR and 15,000 EUR for a killed, seriously injured and slightly injured person, respectively (based on 2004 prices)[7]

4.5 Total value of the effect of personal injury accidents

In the present analysis, DTU 2012, we find a total benefit from a reduction in the number of personal injury accidents of 146.150 million DKK in 2012. In the "Autofore report", the benefits for Denmark are found to be 24 million EUR (in 2010 for the baseline scenario).

When the "Autofore report", despite considerably lower unit costs, nonetheless finds bigger benefits from the proposal, it is due to the considerably higher expectations on the reduction in the number of personal injury accidents.

4.6 Technical inspection centres and garages

This note does not represent an analysis of the competitive conditions among the technical inspection centres. It is therefore assumed that the technical inspection centres operate under perfect competition without abnormal profit. This means that the price of a periodic inspection is expected to cover the direct costs inherent to the inspection. Consequently, it is not necessary to study the changed income conditions and profits of the technical inspection centres due to the extension of the number of periodic inspections.

[7] The Danish unit prices were methodogically updated in 2010 which resulted in a significant increase as compared to earlier.

Additional costs in connection with visits to the garages to repair the defects found at a periodic inspection are not included either. It is assumed that these defects, if any, would have been detected and repaired at the next ordinary visit to the garage, and the repair of these defects therefore, does not represent an additional cost. However, these costs are slightly advanced as compared to the baseline situation. However, these costs are not included in the analysis as we do not have the basis to calculate these costs and furthermore the value of this advance is also expected to be rather low. In this way, we also follow the "Autofore report" that similarly does not include the above elements.

4.7 The price of a periodic inspection

Another of the essential components of the analysis is the unit price of one periodic inspection. This price is relatively important for the outcome. However, it is not quite simple to establish this price. Periodic inspections are carried out in a number of private, but officially authorised technical inspection centres. As already described, we assume that the technical inspection centres operate in a competitive market where no abnormal profits are found. It could thus be expected that the price of a periodic inspection was more or less the same for the various technical inspection centres. By studying the homepages of the technical inspection centres, we have however in practice found significant price differences. For instance, there appears to be geographical differences with generally lower prices for periodic inspections in Greater Copenhagen. It is, however, not straight forward to evaluate whether these prices in practice also cover exactly the same service. It is not possible for us to go further into details with these prices. To establishing a reasonable unit price to be used in our cost-benefit analysis, we will use different judgements.

First, we will look at the distribution of the periodic inspections among different actors (Table 9).

Table 9 Market shares distributed on periodic inspection of passenger cars and vans in the period 1/1-2012 to 12/11-2012

Place of inspection	Number of inspections	Market share
Applus Bilsyn	253,465	29.5%
A-inspection	55,050	6.4%
FDM	36,195	4.2%
PAVA	44,225	5.2%
Andre	469,647	54.7%
Total	858,582	100.00%

Source: Danish Transport Authority

As "Others" is assumed to cover various individual actors with a market share below that of the mentioned companies, we cannot go into further details with this market share. This is of course a problem, as "Others" perform more than half of the periodic inspections. Initially, we therefore choose to look into the prices of the four biggest actors.

When studying the homepages of the four biggest actors it also turns out that the prices vary between the different technical inspection centres within the same firm. In the lower price range we have found the following prices:

Table 10 Prices of periodic inspections (as of 25/11-2012)

Place of inspection	**Price, DKK**
Applus Bilsyn	539
A-inspection	499
FDM	440
PAVA	450

A weighted average of the prices of these four actors gives a unit inspection price of 514 DKK.

Another way to obtain an estimate of the inspection prices is the homepage www.bilsynpriser.dk that shows the actual prices of the various technical inspection centres within a geographically determined area.

Table 11 Inspection prices

Area	Number of inspection places in the database	Lowest price, DKK	Highest price, DKK	Re-inspection Lowest price, DKK	Re-inspection Highest price, DKK
Copenhagen	47	250	549	0	349
North Zealand	23	298	550	198	349
South of Copenhagen	10	295	548	250	349
South Zealand-Stevns	12	299	539	199	349
Lolland-Falster	9	399	539	250	349
Central and West Zealand	11	299	539	175	349
Roskilde	13	295	548	198	349
Bornholm	3	530	539	340	349
Central Fionia-Faaborg-Nyborg	9	349	539	250	349
Odense-Assens-Middelfart	21	349	539	240	349
North of Aalborg	11	440	539	250	349
Aalborg	21	400	539	250	349
Hanstholm	11	400	539	250	349
Hadsund	12	400	539	150	349
Viborg	17	400	539	250	349
Århus	31	400	650	200	350
Silkeborg-Horsens	20	399	539	250	349
Herning	17	400	539	250	349
Esbjerg	17	470	539	250	349
Vejle	19	275	539	250	349
Haderslev	8	425	539	250	349
Sønderborg	16	350	539	249	349

We do not have the information to distribute the number of inspections on geographical areas or specifically between the different technical inspection centres and therefore we cannot provide the actual average price of an inspection.

However, by studying the simple averages among these regions it is possible to get an indication of the price. A simple average based on the lowest price in each region gives a unit price of 369 DKK whereas it is 546 DKK for the highest prices. Expectedly, the average of the highest prices is too high to use as average whereas the average of the lowest prices is not necessarily a lower limit for the average as the share of inspections may be relatively higher in the cheapest inspection centres. On the other hand, not all car owners use the cheapest technical inspection centre in their area, and 369 DKK must therefore also be expected to be a low average price. At the same time we can see that the four biggest technical inspection centres all maintain a price that is markedly higher than 369 DKK.

Apart from the price of one periodic inspection, a number of the cars will have to undergo re-inspection. Re-inspection has to take place when defects have been detected in connection with the ordinary inspection of the vehicle which are important for the road safety or the environment. For re-inspections, the prices range from 0 to 350 DKK, with 0 DKK being an exception. We therefore estimate a fair the value of the price of a re-inspection at approximately 200 DKK. According to the Danish Transport Authority, 24.13% of all passenger cars and vans had to be re-inspected in the years 2006-2011. Here, the share is lowest for the brand new cars and highest for cars 20-30 years old. Therefore it does not seem unrealistic to add 50 DKK to the average price of one periodic inspection to cover the price of an average re-inspection.

We choose a relatively low unit price for the periodic inspection which should however also be representative. We therefore choose to use a unit price of 440 DKK which is equivalent to the price paid by the members of FDM (Federation of Danish Motorists). With the inclusion of 50 DKK for re-inspection, the final average price amounts to 490 DKK.

A periodic inspection is subject to VAT and taxes. The taxes represent 19 DKK which are also accountable for VAT.

At a price of 490 DKK including VAT, the resource costs thus amount to 373 DKK whereas the taxes amount to 19 DKK and the VAT to 98 DKK. In total, this provides an additional cost for the additional inspections of 374.70 million DKK including taxes of which taxes amount to 89.5 million DKK.

By comparison, ”WP 700” (p. 21) states a price for a periodic inspection in Denmark of 53.8 EUR exclusive of taxes whereas a unit price of 35 EUR (EU average) equivalent to approximately 260 DKK is used in the calculation. The ”Autofore report” thus finds an additional cost of 16.75 million EUR equivalent to 124 million DKK in their baseline scenario.

4.8 Other externalities

4.8.1 Emissions and fuel consumption

It is assumed that an expansion of the periodic inspections will lead to a reduction in the emissions from cars as well as improved fuel efficiency and thereby also reduced CO_2-emissions.

The “Autofore report” provides the values for the relative reductions shown in Table 12.

Table 12 Emissions and fuel consumption	
Reduction in CO	13%
Reduction in HC	12%
Reduction in NO_x	6%
Reduction in CO_2	0.2%

In this study as well as in the “Autofore report”, only reductions from gasoline cars are included in the calculations as these are the only cars for which information is available. This will probably result in an underestimation because the air pollution from diesel cars is typically bigger and we generally lack this information. However, gasoline cars still account for the majority of the cars comprised by the new proposal for extended inspection, so the underestimation is probably limited.

The report states the reduction in the CO_2-emissions as a consequence of reduced fuel consumption. The value of this reduced fuel consumption constitutes a consumer benefit which we take into account in this study.

This provides a total benefit from reduction in emissions of 4.46 million DKK and a reduction in the fuel consumption of 15.18 million DKK, including taxes of 8.51 million DKK, in 2012.

The “Autofore report” states “other benefits” (avoided emissions and fuel consumption) for Denmark of 0.6 million EUR.

4.8.2 Congestion

Road accidents, both minor accidents and serious accidents, will typically affect the operation of the other traffic, and serious road accidents will often give rise to significant queues and delays. If the number of serious road accidents can be reduced congestion costs will also be saved. The “Autofore report” uses a unit cost for congestion due to personal injury accidents of 10,000 EUR. This unit cost has been chosen as the average of 15,000 EUR and 5,000 EUR as a unit cost for road accidents with fatalities and other personal injuries, respectively. In this calculation we use the same unit cost.

On this background, DTU Transport obtains a benefit from avoided congestion of 3.27 million DKK whereas the “Autofore report” states 1.48 million EUR.

4.9 Inconveniences suffered by car owners due to periodic inspection

The cost-benefit analysis only includes the direct cost for car owners due to the introduction of additional periodic inspections. However, the individual car owner also suffers other inconveniences due to additional inspection. First and foremost, time is needed to drive the car to the technical inspection centre to have it inspected. This cost should also be included. It could be argued that we already have a value for this time via the general Value of Time used by the Ministry of Transport and DTU Transport to evaluate travel time savings in transport projects. However, this Value of Time value is not a universal value for time, but an expression of the

travellers" willingness to pay for travel time savings. We therefore cannot be sure that the same value will apply to, for instance, the time used for a periodic inspection.

In the baseline analysis we have therefore chosen not to include this inconvenience effect. The baseline calculation shows that the initiative is not profitable. The inclusion of an inconvenience cost will unequivocally draw the result further in this direction. It can similarly be argued that additional gasoline is needed to drive to the technical inspection centre which will also be an additional cost.

However, in Chapter 5 we have chosen to carry out a sensitivity calculation with the inclusion of an inconvenience cost. Instead of using the time value, we have chosen a fixed inconvenience value of 100 DKK per inspection, i.e. it is assumed that car owners would be willing to pay 100 DKK to avoid the inconvenience of a periodic inspection. This amount is not empirically founded, but solely chosen based on a general consideration of what could be a fair illustrative cost of including the inconvenience inherent to the inspection itself.

4.10 Loss from distortion

The loss from tax distortion is the general cost of financing public expenditure by means of taxes as taxes *distort* the population's behaviour, for instance to supply less labour than would otherwise be the case. Normally, this loss from distortion is assessed at 20% of the costs to be financed by public funding. Correspondingly, when projects, as in this case, result in an overall benefit to the public budgets, less money will have to be collected by means of other taxes, and savings in connection with the distortions will be obtained.

We carry out the cost-benefit analysis, including taxes, and obtain a positive net effect on the public budgets of 80.95 million DKK as a result of taxes from the additional periodic inspections and lost taxes due to saved fuel consumption.

These taxes are neutral in itself in the analysis as the user's expense corresponds to the income obtained by the effect on the public budget. The distortion effect of 16.19 million DKK is however a real additional benefit. This effect is not included in the "Autofore report".

5. Sensitivity analyses

5.1 Sensitivity analyses with different parameters

As earlier mentioned, we have carried out a number of sensitivity analyses of essential parameters and assumptions. The results are shown in the below Table 13.

Table 13 Sensitivity analyses

Parameter	Parameter value	Net value,	Benefit-to-cost ratio
Basis assumptions	*Cf. table 2*	-108.445	0.56
Sensitivity of parameters influencing the expectations on avoided accidents			
Share of accidents due to technical defects, *TD*	2.5% => *18.8* avoided personal injury accidents	-193.462	0.26
	9.1% => *68.5* avoided personal injury accidents	-23.429	0.86
The effect of the inspections is calculated for all cars, *RAT*	1 => *87.3* avoided personal injury accidents	40.978	1.09
Parameter for share of technical defects found in cars seven years old and older (instead of *RAT*DefVeh*)	70% => *69.3* avoided personal injury accidents	-20.689	0.87
Sensitivity of parameters not influencing the expectations on avoided accidents			
Costs of materials are included	Unit price per reported personal injury accident (including costs of materials) 5.20 million DKK	-54.964	0.77
Introduction of inconvenience cost inherent to the inspection	100 DKK	-184.905	0.44
Lower inspection price	300 DK (and no re-inspection)	1.962	0.95

It should be noted that the net value of the analysis with the lower inspection is slightly positive, even though the cost benefit ratio is smaller than 1. In this case, it is due to the inclusion of the distortion effect.

Not surprisingly, it appears that the apparently most decisive components with respect to the outcome are the price of a periodic inspection and the expected reduction in personal injury accidents. However, the price of a periodic inspection needs to be considerably lower – approximately 300 DKK per inspection, including average re-inspection, than our baseline price – to obtain break even (i.e. the point where the benefits equals the costs). Correspondingly, almost a doubling of the accident reduction is needed to obtain break even as compared to our baseline scenario.

Overall, the sensitivity analyses indicate that relatively large parameter changes are needed to obtain break even. The conclusion therefore seems to be qualitatively quite robust.

When comparing with the "Autofore report", it is worth noticing that the baseline in the "Autofore report" provides a total benefit-to-cost ratio of 1.6 for EU. Reference is made to problems with underestimation of the number of accidents in the official statistics, and the benefits are therefore revised with a factor of 1.3, which results in the final total benefit-to-cost ratio of 2.1[8]. This revision is thus the result of an assumption that only 70% of the total number of the actual road accidents in the EU is registered in official databases[9]. In this context it is worth noticing that the "Autofore report" is based on the total number of personal injury accidents, and not only on personal injury accidents with passenger cars and vans of up to 3,500 kg as done in DTU Transport's calculations, and which generally are more likely to be registered than for instance road accidents with bicycles and pedestrians. We have therefore chosen not to include this revision in the analysis for Denmark.

5.2 Sensitivity report using the "Autofore report's" basis for number of periodic inspections

We have also carried out an analysis of the proposal on which the calculations in the baseline scenario of the "Autofore report" were originally based, i.e. 4,2,2,1,1… When calculating the benefits, the *DefVeh* must be reduced to 0.84 as compared to 0.882 in our baseline scenario[10]. The other empiric parameters are maintained. With respect to particularly *RED* and *TD* it should be noted that they are independent of the period. This proposal will result in 616,933 additional inspections which will give rise to additional costs of 302.297 million DKK. The benefit of improved road safety is assessed at 41.6 avoided personal injury accidents[11] equivalent to 139.190 million DKK, and including emissions and congestion, the total external benefits amount to 146.121 million DKK. This gives a total net value of -65.306 million DKK and a benefit-to-cost ratio of 0.66, i.e. a more positive evaluation of extended periodic inspection than the baseline scenario.

It was recently suggested to evaluate the consequence of changing the regime and introducing periodic annual inspections from the 10th year instead of from the 7th year as used in the above analysis. However, it is not directly possible to calculate the consequence hereof, as it is not known how the parameters and variables used in the calculation of the possible avoidable accidents are affected by this change. It is therefore not possible to carry out a proper cost-benefit analysis of this proposal based on the actual data. Instead, an ad hoc analysis is carried out to evaluate whether it makes sense to proceed with this proposal.

In this calculation, the effect on avoidable personal injury accidents is maintained which results in an overestimation, whereas the number of cars subject to additional inspections is reduced. In this way, the additional number of annual inspections is reduced to 496,671, resulting in a cost of 243.369 million DKK. At the same time the benefits from emissions, fuel consumption

[8] See "WP 700" p. 47-48.

[9] See e.g. "WP 700" p. 22.

[10] See "WP 700".

[11] Including 2.9 killed, 22.8 seriously injured and 21.2 slightly injured.

and CO_2-emission are reduced which is also included in the calculations. This, however, is of minor importance for the result. With these changes, a net value of -24.657 million DKK is obtained and a benefit-to-cost ratio of 0.81 in the baseline scenario. It is considered to be an overestimation of the benefits and thereby an overestimation of the benefit-to-cost ratio.

6. Final comments and conclusions

In this note, we have reviewed the calculations in the “Autofore report” and carried out an updated cost-benefit analysis for Denmark for 2012 of the proposal for periodic inspection after 4 years, then after 2 years and thereafter annually (4,2,1,1…). We have found a total value of the proposal of -108.445 million DKK and a benefit-to-cost ratio of 0.56.

We have thus found that the expected costs inherent to the proposal exceed the expected benefits from the proposal.

By comparison, the “Autofore report” has found a total benefit-to-cost ratio in 2010 of at least 2:1 at the European level, for an evaluation of the original proposal 4,2,2,1,1,...

The most important differences are particularly found in the data material on personal injury accidents and thereby for the expected possible reductions in the number of personal injury accidents, but also in the estimation of the inspection costs. However, in our opinion the benefit from avoided personal injuries is not undervaluated as only personal injury accidents comprised by the extended inspection regime are included, just as the costs for additional inspections should be based on the actual present car fleet size.

Again, it is worthwhile noticing that this note does not represent a real empiric evaluation of the proposal for a regulation and of the effect of periodic inspections or a real review of the data material or the calculation methods used for the derivation of the reduction in the number of accidents. Furthermore, the underlying assumptions for the variables are somewhat uncertain. It would therefore be useful to carry out a real independent empiric analysis of the effect of periodic inspections by analysing the effect on personal injury accidents and their degree of severity. This analysis could start with an empiric analysis of the effect of the introduction of the present periodic inspection regime.

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