ČESKÉ PRIORITY

Zvýšení rychlostního limitu na dálnicích

Cost-benefit analýza pro dálniční síť v České republice

Upozornění:
Toto je předběžná verze analýzy, která bude dále rozšiřována. Výsledky obsažené v této verzi vycházejí primárně z dat roku 2019 a nejsou finální. Text zatím neprošel korekturou ani jazykovou úpravou.

Tento dokument slouží jako ukázka využití společenské CBA v oblasti dopravní infrastruktury.

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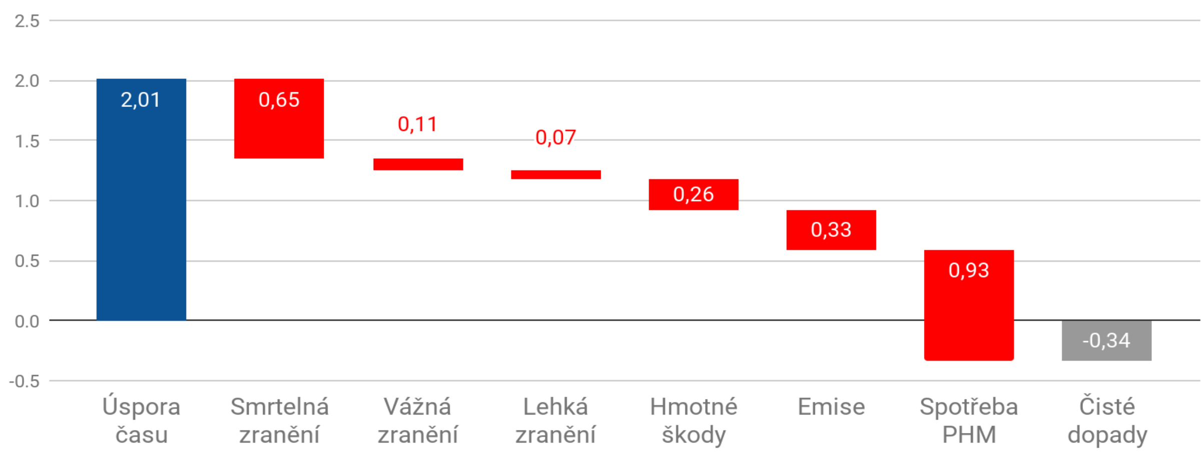
Dopady zvýšení rychlostního limitu na dálnicích

Manažerské shrnutí

Předběžnou analýzou přínosů a nákladů (CBA) jsme vyčíslili očekávatelné celospolečenské dopady zvýšení rychlostního limitu o 10 km/h. Parametry dopadů vychází z vyspělých zemí s kvalitní infrastrukturou a zvyšování rychlostí v menším měřítku. Jsou tedy použitelné proporcionálně i kdyby se zvýšení rychlosti týkalo jen vhodně vybraných úseků dálniční sítě.

Dopady obsažené v této CBA obsahují ušetřený čas, vyšší nehodovost s následky, nárůst emisí a spotřeby PHM. Prezentované výpočty vycházejí z hodnot roku 2019 a nebyly nikterak navýšeny. Výpočet nezahrnuje mimo jiné exponenciální dopad spotřeby a nehodovosti, a vyšší míru dopravní kongesce. Nebylo též zohledněno stáří vozového parku ČR, který je pátý nejstarší v EU. Nezahrnuté položky mohou znamenat ztráty v řádech stovek milionů ročně nad rámec uvedeného výsledku.

Přínosy a náklady zvýšení rychlostního limitu na dálnicich o 10 km/h (za rok, mld. Kč)



Dle předběžné analýzy lze při zvýšení maximální rychlosti na 140 km/h očekávat:

- **Úsporu času** 11,2 mil. člověkohodin, ceněných společností na více než 2 mld. Kč.
- Nárůst nehodovosti, který by podle dat z 23 studií obdobných zvýšení znamenal:
  - **Nárůst smrtelných nehod o 23,1 %** a tedy ztrátu více než 7 lidských životů a celkovou společenskou škodu 654 mil. Kč.
  - Více jak 16 vážných zranění, 135 lehkých a 666 nehod bez zranění, tyto nové nehody způsobené vyšší rychlostí znamenají ztrátu 433 mil. Kč.
- **Dodatečné emise** (m.j. 170 tisíc t COx) způsobující společenskou škodu 331 mil. Kč.
- **Nárůst spotřeby PHM o 926 mil. Kč** ročně.

Předběžné výsledky této CBA tedy mluví pro **nezvyšování maximální povolené rychlosti** na dálnicích. I při konzervativním přístupu je **celková společenská ztráta 340 mil. Kč ročně.**

Vypracovaná analýza v anglickém jazyce v další části textu detailně popisuje jednotlivé předpoklady a dopady. Veškeré zdroje i detailní kalkulace jsou dostupné na vyžádání u autorů.

ČESKÉ PRIORITY

Speed Limit Increase:

Cost-benefit Analysis for Highways in the Czech Republic

Disclaimer:
This is a preliminary draft analysis and a work in progress. Some values used were not indexed to 2019 prices and a sensitivity analysis has not been included so far. Therefore, the results presented here are not final. Also, proofreading and text editing is pending.

This document can serve as a demonstration of CBA and similar approaches in the transport infrastructure and interventions.

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1. Overview

This cost-benefit analysis (CBA) estimates the social impact of an increase in speed limit from 130km/h to 140km/h on Czech highways for individual car transport. The utility and heavy vehicles are ignored as their speed is lower and motorcycles are omitted for simplicity reasons.

A rather conservative approach was chosen for calculation of costs. The literature does not provide a good overview of a general speed limit increase in the range we considered but from the small scale studies it is evident that all the considered impacts, e.g. accidents, emissions and fuel consumption increase more than in the linear manner that was used in this analysis here.

The scope of included cost items was purposely conservative as some costs mentioned in the literature were omitted (e.g. higher fetal death rate). Moreover, the unit valuation of severe injuries used is rather low, considering the internationally recommended valuation of a statistical life used in the analysis, yet the results are negative. This leads to the strong conclusion that the speed limit should not be increased.

The structure of the analysis is as follows. The impacts are introduced after which a brief overview of the literature review is given. The individual impacts follow, each one with its separate review, calculation and results subsections. The analysis closes with discussion, conclusions and bibliography which lists all sources used both in the text and in the linked sheet Speed - Sources and Calculations.

1.1 Impacts included in CBA Light

For CBA Light these impacts are included and monetized so far:

- **Time savings**
  - Increase in speed limit will lead to shorter traveling time on the highways.
- **Accidents**
  - Higher speed limit means higher speed and that brings a substantial loss of life, health and an increase in material damages.
- **Emissions**
  - Increase of speed limit generally leads to increase in a range of emissions.
- **Fuel consumption**
  - All studies on the topic confirmed that an increase in speed limit brings higher consumption of fuel.

1.2 Additional impacts under consideration

- **Noise annoyance**
  - Higher levels of noise are sometimes connected with higher stress levels and cardiovascular health issues.
- **Traffic congestions increase**
  - Proper modeling of the possible increase in the number of traffic congestions as the result of more accidents and higher speed generally.
    - The higher the difference in speed of individual cars, the higher the likelihood that a congestion will form.
  - Time spent in a traffic congestion is valued significantly higher and this was not included in the analysis so far.
  - Fuel consumption,accidents and emissions increase as a result of more congestions.
- **Effect of vehicle roadworthiness on crash incidence and severity**
  - The Czech car fleet is substantially older than in countries that provided the data for this CBA. Detailed data on the effect of the vehicle age are provided for example by the US Department of Transportation (2013) or Rechnitzer, Haworth & Kowadlo (2000).
- **Increased depreciation of road vehicles and infrastructure**
  - Depreciation is the second major component of operating costs of driving a vehicle. Unlike fuel it is rather fixed and insensitive to small changes in speed (see Kockelmann, 2006 p. 29), so omitting it here seems acceptable.
- **Increased accident rate on nearby routes**
  - Routes where the limit was not changed but are near the highway where the speed was increased.
  - This impact is highly speculative for now.
- **Higher fetal death rates**
  - Benthem (2015) includes 9% higher fetal death rates around the affected freeways in reaction to the 10 mph speed limit increase.
- **Need for enforcement**
  - Dijkema (2008) shows that only after strict enforcement of a given speed limit reduction did the emissions drop sharply (by 32%).
- **Personal joy from higher speed driving**
- **Costs of implementation of the policy**

2. Literature review

An overview of studies on the topic was provided in the sheet Sources. The individual impacts of comparable and complete CBAs with lists of their impacts and their magnitude was provided in the sheet CBAs Review including a relative size of the impacts with respect to one another.

The strong conclusion from the above mentioned literature is that the benefits generated by an increase in speed limit, that is saved time, do not outweigh the increased costs, mostly associated with accidents, but also air and sound pollution or fuel consumption. While two exceptions were identified, they are mostly irrelevant to the Czech Republic since the studies were conducted in environments very different to ours.[1]

The literature reviews for individual effects considered in the analysis follows in individual chapters.

[1] First exception was reported in Japan with the increase of the limit from 80 km/h to 100 km/h on the high speed road that was originally designed for the speed of 120 km/h (Morichi, Masuda, Acharya & Hibino, 2005). The second exception is from Norway where the costs of reducing the speed limit on a rural road from 80 to 60 km/h outweigh the modest environmental gains (Folgerø, Harding, Westby 2017). The later case can be explained by the car economy that loses efficiency at rather higher speeds near the shift to the highest gear.

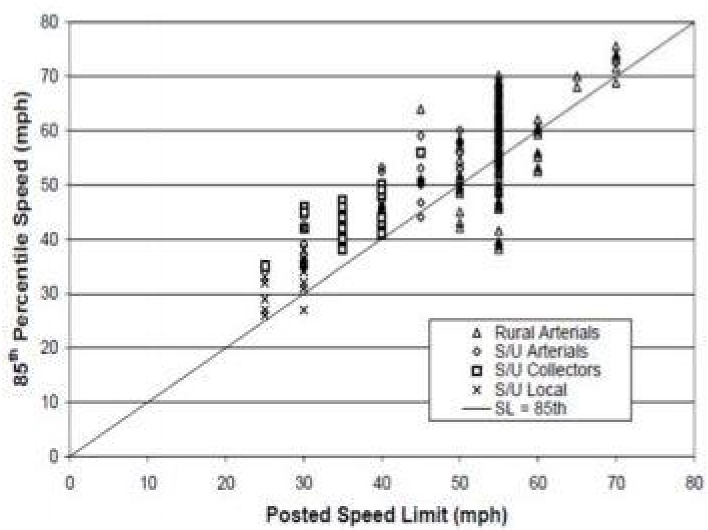
3. Impacts of the speed limit increase

3.1 Time savings

Time savings are the only included benefit of an increased speed limit and likely the largest impact to be considered. Knowing how many vehicle kilometers are driven on Czech highways, the average number of people in a car, the average speed and how people value their time spent on a highway, a monetary assessment of the time spent on a highway can be calculated.

3.1.1 Review

It is not possible to calculate the time savings without an estimate of the change of real speed resulting from the change in speed limit. As specifically Czech data are not available, we are using a conclusion from (Fitzpatrick et al. 2003) that the increase in average speed is linear, relative to the increase in the speed limit. All other inputs for this part of the analysis are provided in Time Savings sheet.



Source: Fitzpatrick et al. (2003).

3.1.2 Calculation

The data for how many kilometers is driven on Czech highways is known but to our knowledge not stated publicly. We calculated it knowing the number of deaths on the highway and the 1,9 deaths per billion kilometers on the highway indicator published by CDV.

The recent estimate for average speed on Czech highways was not found even after an intense search. The 2004 number of 127 km/h was used. This is again not ideal as better data must exist. A recent CDV study does an excellent job on other kinds of roads so at least some data are likely to exist on highways as well. Assumption of linear change in real speed relative to the change in speed limit was used. With the average speed of 127 km/h, speed limit increase of 10 km/h from 130 km/h to 140 km/h and linear reaction of actual speed this translates to the new expected average speed of 136,8 km/h. That means time savings of 2,03 seconds per kilometer.

Knowing the average number of persons (1.3) in the car, average speed and kilometers driven and assuming an increase in real speed proportional to the increase in speed limit, we calculated that over 9.6 million hours less would be spent in the cars on the highways as a result of the speed limit increase. This is almost 1100 years saved a year assuming that higher speed would not have other negative side impacts.

These unaccounted negative side effects could include an increase in the occurrence of traffic congestions and more delays in traffic, due to the additional accidents, which is an impact that may not be fully captured in the average speeds that were used for the calculations here.

Regular traveling time on a highway valuation used in the analysis was 179 CZK (Máca et al., 2017). The fact that time spent in a traffic congestion is valued more, specifically at 251 CZK, and that traffic congestions are more likely with higher speed limit, was not used in the analysis. Not including higher cost of congested time is in line with the conservative approach of the study.

3.1.3 Results

The cost of an hour on the highway was taken from the detailed study Máca et al. (2017). It was calculated that the cost of time spent on the highway currently is 24.11 bil. CZK of which 1.72 bil. CZK can be saved with a speed limit increase to 140 km/h. Alternatively the cost of decreasing the speed limit to 120 km/h was evaluated to be 2.01 bil. CZK.

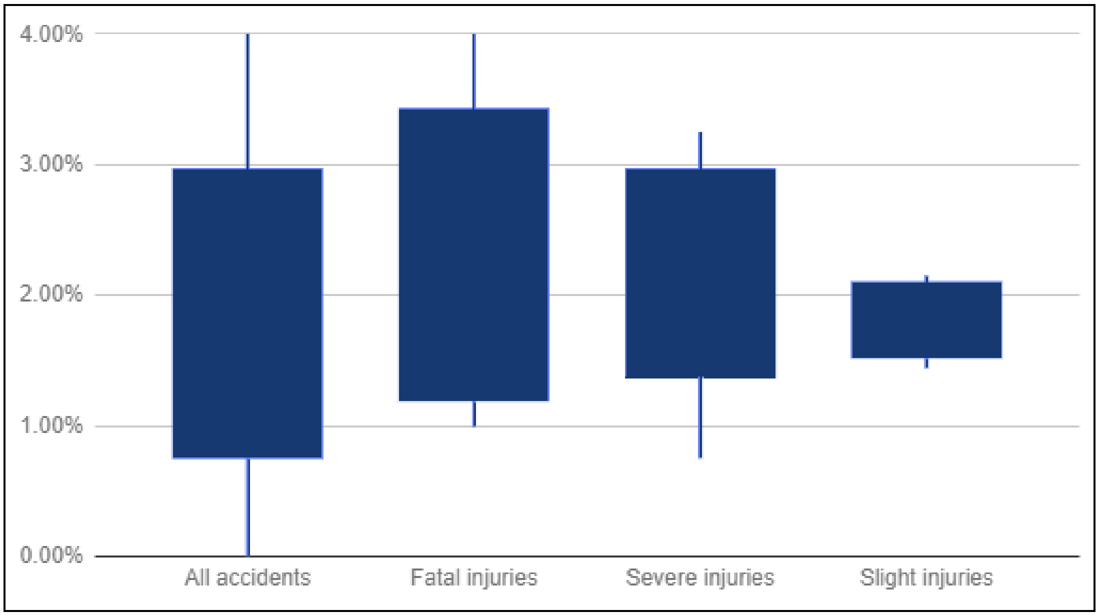
3.2 Accidents

There is solid evidence that higher speed limits mean higher speed and higher accident rates. Knowing the number of accidents, expected increase in their rate and the evaluation of different types of accidents, a monetary evaluation can be done.

3.2.1 Review

Altogether 23 parameters from 10 studies listed in a sheet Sources-Accidents were used to calculate the average changes in the rates of fatal accidents, accidents causing severe and light injuries and accidents causing material damage. The calculations were done in a Side Calculations sheet.

Changes in accident rates in reaction to a 1km/h change in speed limit



	All accidents	Fatal injuries	Severe injuries	Minor injuries
Average	1.86%	2.31%	2.17%	1.81%
Median	1.65%	2.18%	2.11%	1.82%
Standard deviation	1.10%	1.11%	0.79%	0.28%
Min	0.00%	0.99%	0.75%	1.44%
Max	4.00%	4.00%	3.25%	2.15%
Sample size	23	9	8	4

Source: CP calculations

3.2.2 Calculation

The data from the literature review provided changes in accident rates as a reaction to a 1km/h change in speed limit. Those changes were calculated from different limit changes at different original speeds. This approach is based on the assumption of linearity which is common in the literature. It is worth noting that these numbers can easily be considered high as they are calculated for a 1km/h change in the limit and the speed limit change under consideration is 10km/h.

Once the impact of the change is known, the rest of the calculation is rather straightforward. As the baseline number of accidents an average from the last five years is used to limit the randomness of the specific year. The unit costs of the injuries and material damage along with the detailed calculations are provided in a sheet Accidents.

To assess the cost of the accidents, the unit costs for the value of statistical life (VSL) and injuries were taken from Czech Priorities General Assumptions as recommended by OECD and RIcardo-AEA (in 2019 prices). The data for average cost of material damages are from CDV.

Highway accidents with their expected increase and costs

	Yearly average of accidents (2014-2018)	Increases in accidents per 10 km/h limit change	Additional accidents	Unit Cost (mil. CZK)	Cost (mil. CZK)
Fatal injury	30.8	23.1%	7.11	91.954	654.2
Severe injury	76.2	21.7%	16.54	6.649	109.9
Slight injury	727.6	18.1%	135.33	0.483	65.4
Number of accidents	3583.8	18.6%	666.59	0.386	257.6
Total					**1087.1**

3.2.3 Results

The overall valuation of additional accidents caused by the increase of speed limit exceeded billion CZK with the valuation of 1087 mil. CZK.

3.3 Emissions

The speed limit increase generally leads to higher emissions and vice versa. The literature review clarified the magnitude of the increase. Knowing the pollution from the individual car transport in the whole country and the share of the distance traveled on highways, the pollution produced on the highways was calculated. The studies on the matter lead to the average coefficients for increase of individual emissions.The increase in emissions was calculated and its impact monetized using existing valuation of wide environmental impacts.

3.3.1 Review

The magnitude of the relationship between speed and emissions was taken from Benthem, A.V. (2015), Dijkema et al. (2008), Goncalves et al. (2008), Keller et al. (2008), Baldasano et al.(2010) and Keuken et al. (2010). Studies generally agree that speed is a key factor determining the amount of emissions. The fluency of the traffic has also a significant impact, especially for low speed areas. As the speed levels are generally high on highways and as the changes in fluency affect the average speed that is used, the average speed is the only input taken into account. The overview of the numerical sources for emissions can be found in the sheet Sources-Emissions.

3.3.2 Calculation

The data from various sources and their use are provided in the sheet Emissions. The level of emissions and their respective increase in reaction to a 1km/h change in speed limit was identified for COx, NOx, CH4, PM2.5 and PM10 and is presented in a separate sheet Sources-Emissions. Using the literature the COx equivalent of CH4, as well as the equivalent between PM1, for which some studies measured the increase, and PM2.5 that has the monetary value attributed to it by Ricardo-AEA (2014), this study is recommended and used internationally[2] and the values in it covers a wide range of impacts, from mostly global impact of the carbon dioxide to the more local one of PM.. The key steps of the calculation include determining the emissions caused by individual car transport on a highway.

Emissions caused by individual car transport on highways (tons)

COx	1,516,627
NOx	306
CH4	197
PM2.5	1,030
PM10	1,308

That were monetized with the use of Ricardo-AEA (2014) data and total 7.15 billions CZK.

Cost of emissions caused by individual car transport on highways (CZK)

COx	1,483,260,971
NOx	165,475,589
CH4	8,477,379
PM2.5	3,842,706,119
PM10	1,649,492,293
Total	7,149,412,351

Knowing the impact that the increase in speed has on the emissions, an increase in emissions was calculated.

Increase in emissions caused by the increase in speed limit (tons)

COx	169,666.1
NOx	16.8
CH4	22.0
PM2.5	25.8
PM10	47.2

[2] It is the prime source recommended for example by Hodnota za Peniaze (SK).

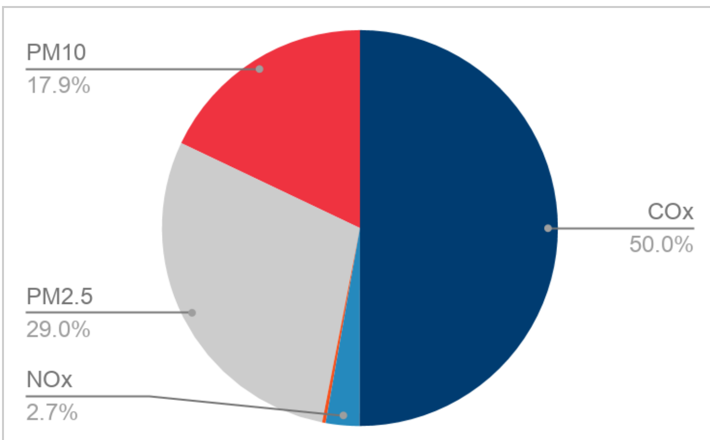
3.3.3 Results

The final valuation of the increase in emissions from individual car transport on highways is 330 mil. CZK. and its composition is as follows with the increase in carbon oxides as the leading factor.

Cost of increased emissions (CZK)

COx	165,933,483
NOx	9,097,857
CH4	948,371
PM2.5	96,192,356
PM10	59,488,781
Total	**331,660,848**

Cost breakdown of increased emissions (%)



3.4 Fuel consumption

The studies support the fact that the fuel consumption increases more than linearly, which is especially true after a certain threshold, which roughly corresponds to the beginning of the highest gear speed of a vehicle. For this analysis an extrapolated linear estimate of the increase in consumption between average speeds was used. It is worth noting that some studies suggest a nonlinear relationship. Namely, Song & Wang (2009), and Heide & Mohazzabi (2013). These papers suggested the fuel economy decreases more than linearly at higher speeds, but were omitted on account of small sample sizes.

3.4.1 Review

The summary of the studies examining the magnitude of the relationship between speed and fuel consumption is provided in the sheet Sources-Fuel Consumption, while more general data such as the number of kinds of cars and kilometers driven are provided in the Fuel Consumption sheet.

3.4.2 Calculation

The calculations are provided in the Fuel Consumption sheet. The number of cars with gasoline and petrol was used as a proxy for determining the shares and the number of kilometers driven on a highway for each engine type. Knowing this, the average speed, average consumption. corresponding consumption increase with speed and the prices of fuel, the rest of the calculations was possible.

Fuel consumed in individual car transport on highway (litres)

Gasoline cars	611,168,059
Diesel cars	272,957,021
Total	884,125,080

The data used to calculate the impact of the 10 km/h speed limit increase on fuel consumption were mostly based on increases in slightly lower speed ranges, so the increase in consumption that is used is actually a very conservative estimate as the literature based on much smaller sample sizes suggests an even higher increase is to be expected at higher speeds.

10 km/h speed limit increase impact on fuel consumption on highways

Gasoline cars	8.20%
Diesel cars	7.95%

For the purpose of CBA the price of fuel used does not include the value added tax (VAT, [Daň z přidané hodnoty]) nor the excise duty [spotřební daň]. These taxes do not affect the result of a social CBA as they are paid by one party but received by another. For a distributional analysis of the budgetary impact of the intervention, those would have to be taken into account. The current yearly consumption of individual car transport on highways is valued at 26.91 bil. CZK with taxes or at 11.4 bil. CZK without taxes.

3.4.3 Results

The final valuation of an increase in consumption due to a higher speed is nearly 926 mil. CZK a year.

Fuel consumption cost increase (prices without taxes in CZK)

Gasoline cars	628,713,707
Diesel cars	297,201,792
Total	**925,915,499**

4. Discussion

Several factors may have a significant impact on the results

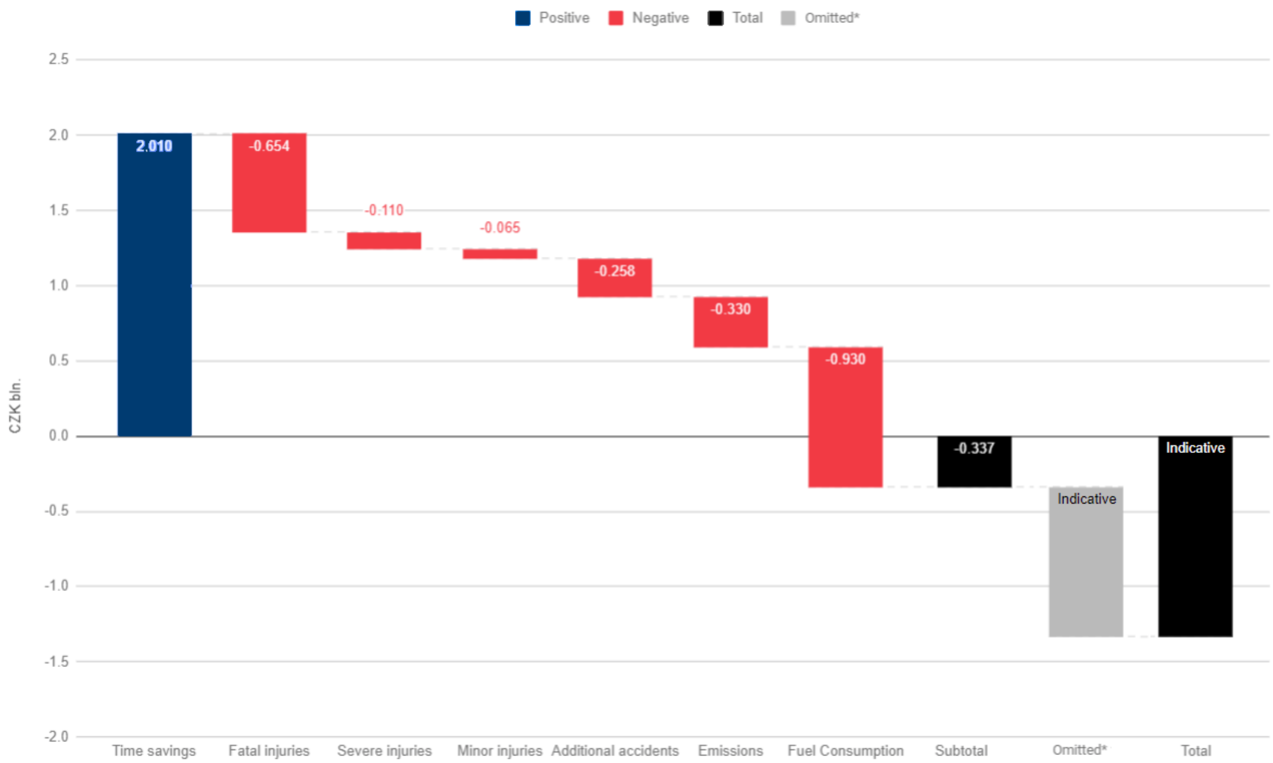
- Valuation of life, injuries and material costs of accidents
    - The values used reflect the latest developments and international standards. Using lower values, more commonly used in past valuations in the Czech context, would shift the results in the direction of the overall result so that it might be less negative or even positive. It should also be noted that even much higher values were suggested for the risk related deaths.[3]
- The unaccounted impacts of higher speed
    - We are not certain about the degree to which the increase in the accident rate, emissions and fuel consumption includes the fact that traffic congestions are more likely to occur with higher speed limit, as this would increase the difference in speed between the really fast and slow vehicles and this is one of the key elements in congestions formation.
    - This would also mean a decrease in the only included benefit, time saving. This drop could easily be significant as Máca et al. (2011) assess that people value the time spent in congestion roughly 40 % more than the normal travel time (the valuations were 179 CZK for an hour on a highway in normal traffic and 251 CZK for an hour in the traffic congestion).
- The age and quality of Czech vehicle fleet
    - The average age of a vehicle in the Czech Republic in 2019 was close to fifteen years and is thus more than double that in neighboring Austria. There is no doubt that this can have a negative effect on the level of fatalities and serious injuries at higher speeds. In 2022, the average age increased to 15.6 years. The Czech Republic thus has the fifth oldest vehicle fleet in the European Union and lags significantly behind its average of 11.8 years (Svaz dovozců automobilů, 2022).
- The infrastructure quality
    - The calculations presented here were done for a general increase in the speed limit but are more relevant when used only for intentionally selected parts of the highway network. The reason for this is that values for effects used in calculations come exclusively from small scale speed limit changes primarily in countries with high quality infrastructure. Therefore, increasing the speed limit on the whole network would likely lead to even worse outcomes than presented here.

[3] Ščasný estimated CZK 222 millions (in 2019 prices) in a wage risk study.

5. Conclusions

We find the existing evidence strongly convincing for not increasing the speed limit on highways, as it would be a net loss for society. Even if not all impacts were accounted for, the conservative approach to the costs of the increased speed limit leaves little doubt that the overall impact is negative.

Results



On the benefit side, the time was included using existing data on the valuation of traveling time on the highway and the only omitted impact is the joy of a faster ride. We do not dismiss this impact entirely but we also do not think it would be appropriate to assess it monetarily and also do not suppose it could outweigh the omitted impacts on the cost side.

The main reason why we think that the increase in speed limit does not pay off is the fact that we used linearity for all major impacts as proper data with large enough sample sizes for higher speeds are lacking, but the existing data suggest that the accidents, emissions and fuel consumption increases even more than linearly so the actual costs are even higher than those stated here. Also the negative overall result would be much higher with an even higher speed limit than 140 km/h considered here.

Impacts of the speed limit increase from 130 to 140 km/h on individual car transport on highways

	Real impact		**Monet. impact**
	Value	Unit	(CZK bln.)
BENEFITS			
Time savings	11,224,869	Hours saved for cars on highways.	**2.01**
COSTS			
Accidents	7.11	Fatal injury - Expected number of additional accidents	0.654
	16.54	Severe injury - Expected number of additional accidents	0.110
	135.33	Minor injury - Expected number of additional accidents	0.065
	666.59	Number of accidents - Expected number of additional accidents	0.258
			1.09
Emissions	169,666.1	Increase in tons of COx from individual car transport on highways.	0.166
	16.8	Increase in tons of NOx from individual car transport on highways.	0.009
	22.0	Increase in tons of CH4 from individual car transport on highways.	0.001
	25.8	Increase in tons of PM2.5 from individual car transport on highways.	0.096
	47.2	Increase in tons of PM10 from individual car transport on highways.	0.059
			0.33
Fuel Consumption	50.1	Gasoline cars - increase in consumption (mil. liters)	0.629
	21.7	Diesel cars - increase in consumption (mil. liters)	0.297
			0.93
Total costs			2.34
NET BENEFITS			-0.34
BCR	0.86	Benefits to Costs Ratio (unitless number)	

Technical state of Czech highways that are not fully designed for higher speeds could also play a role as results for higher speeds mostly come from developed countries with a well designed and maintained network of highways such as Germany and Japan. Similarly the higher speeds may lead to more traffic congestions and more delays in traffic due to the accidents, which is an effect that may not be fully captured in current calculations. Hence the results presented here are more fit for a scenario with only a selected set of sections of highways, otherwise the impacts are likely to be even worse.

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