Socio-economic impact assessment

L3Pilot Final Event

Afsaneh Bjorvatn
Per Heum
Karl Rolf Pedersen

SNF
CENTRE FOR APPLIED RESEARCH AT NHH

Outline

- Research question
- Analytical approach
- Results
- Conclusion

Overall research question

What is the overall impact of level 3 automated driving functions (ADFs) for the society?

- Do the benefits of ADFs outweigh their costs?

Analytical approach

Assessing the net welfare effects of ADFs for the society

- Method for investigating ADF impacts
- Data to assess the socio-economic value of ADF impacts

➡ Cost-benefit analysis

Method

Snapshot approach for cost-benefit analysis

- What would be the annual impact of ADFs if they could be installed in a fraction of passenger cars in the current traffic situation?
  - Nothing happens except for the introduction of L3 cars in existing passenger car fleet: 5%,10% and 30%
  - Advantage of snapshot approach:
    - Avoid uncertainty in prediction of scenarios with & without ADFs for the next 10-20 years
    - Build on the most recent and established statistics

Data

- Data from the impact assessments on safety, efficiency and environment provided the basis for the scaled up estimates at EU27+3, which are used in the socio-economic analysis:
  - Impacts on safety: Motorway and Urban ADFs
  - Impacts on travel time: Motorway ADF
  - Impacts on fuel consumption and CO_2 emissions: Motorway ADF
- The socio-economic impact assessment (SEIA) calculates the monetary value of these impacts by applying established measures for the average social value for one unit of each of the estimated impacts

Assigning monetary values to estimated safety impacts

- Safety impacts are estimated as the expected annual reduction in the number and severity of accidents due to ADFs
    - Fatal accidents
    - Serious injury accidents
    - Slight injury accidents

- The accident unit costs from society's point of view is based on calculation of five major cost components: Human costs, medical costs, production loss, administrative costs and material damage costs

Assigning monetary values to estimated efficiency and environmental impacts

- Travel time impacts are estimated as the expected annual change in travel time
  - In the SEIA, travel time is categorized according to the different types of travel (business, personal and heavy-duty)
  - Standard unit cost for travel time is calculated for different travel types, reflecting their social costs
- Fuel consumption impacts are measured as the expected annual change in the use of petrol, diesel and liquified petroleum gas (LPG)
  - Standard unit cost for fuel is calculated based on production costs
- CO_2 emission impacts are measured as the expected annual change in tons of CO_2
  - Standard unit cost for CO_2 emission is applied according to EU's targeted emission costs

Social costs of ADFs

- Social costs of ADFs are the costs of producing and installing each ADF for car manufactureres
- From society's point of view, the costs of developing ADF systems should be considered as sunk
- Estimates of producer costs of ADFs are provided by non-disclosed industry experts
- In the SEIA, cost estimates are annualized assuming:
  - 15 years lifetime
  - 10% maintenance costs
  - 3% discount rate

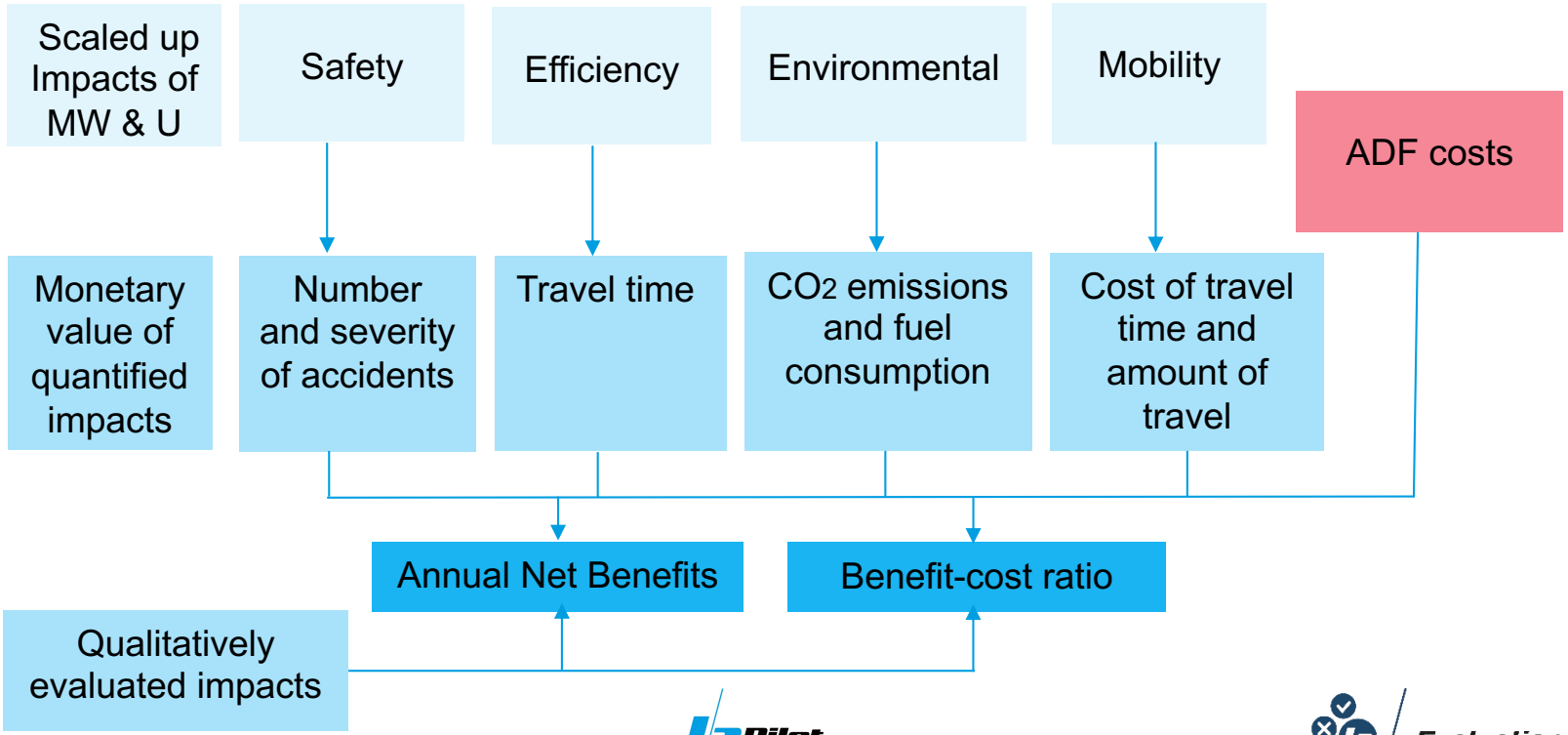
Extending the basis for the socio-economic impact analysis

Other impacts related to	Comment
Safety	
• Accidents with property damage only	Calculated and quantified
• Accident impacts outside ODD	Qualitatively evaluated
• Perceived risk of accidents	Qualitatively evaluated
Travel time	
• Accident-induced congestion	Calculated and quantified
• Travel time reliability	Qualitatively evaluated
• Travel time cost savings	Qualitatively evaluated

Assigning values to qualitatively evaluated impacts

- Impacts such as perceived risk of accidents, travel time reliability, etc are assigned signs for showing the degree of their effects:
  - + (significant positive effect), ++ (strong positive), +++ (very strong positive effect)
  - 0 (no significant difference from baseline)
  - - (significant negative effect), -- (strong negative), --- (very strong negative effect)

Overview of the socio-economic impact assessment



Results

Socio-economic impacts of ADFs

- Quantified impacts
- Qualitatively evaluated impacts

Cost-benefit analysis of Motorway ADF

		5%	10%	30%
Quantified impacts in million €				
Safety	Accidents	499	1,078	3,285
Efficiency	Travel time	-93	-295	-416
	Accident-induced congestion	9	19	57
Environment	CO_2 emissions	-11	-45	21
	Fuel costs	-15	-73	35
∑ Net quantified benefits		**389**	**683**	**2,982**
Cost of Motorway, million €		**2,461**	**4,923**	**14,768**
NET BENEFIT/COST-RATIO		**0.16**	**0.14**	**0.20**
QUALITATIVELY EVALUATED IMPACTS				
Safety	Impacts outside ODD	0/+	+	++
	Perceived risk of accidents	0/+	0/+	0/+
Efficiency	Travel time reliability	0/+	0/+	0/+
	Travel time cost savings	0/+	0/+	+
Other	Obedience to speed limits	0/+	0/+	0/+

Cost-benefit analysis of Urban ADF

		5%	10%	30%
Quantified impacts in million €				
Safety	Accidents	4,251	8,507	25,517
Efficiency	Travel time	n.a	n.a	n.a
	Accident-induced congestion	81	162	485
Environment	CO_2 emissions	n.a	n.a	n.a
	Fuel costs	n.a	n.a	n.a
∑ Net quantified benefits		**4,332**	**8,669**	**26,002**
Cost of Motorway, million €		**2,567**	**5,135**	**15,405**
NET BENEFIT/COST-RATIO		**1.69**	**1.69**	**1.69**
Qualitatively evaluated impacts				
Safety	Impacts outside ODD	0/+	+	++
	Perceived risk of accidents	0/+	0/+	0/+
Efficiency	Travel time cost savings	0/+	+	++

Cost-benefit analysis of ADF package

- Quantified impacts are sum of Motorway and Urban ADF

		5%	10%	30%
Quantified impacts in million €				
Safety	Accidents	4,750	9,585	28,803
Efficiency	Travel time	-93	-295	-416
	Accident-induced congestion	90	181	542
Environment	CO_2 emissions	-11	-45	21
	Fuel costs	-15	-73	35
∑ Net quantified benefits		**4,721**	**9,353**	**28,895**
Cost of Motorway, million €		**2,917**	**5,834**	**17,503**
NET BENEFIT/COST-RATIO		**1.62**	**1.60**	**1.65**

- Safety impacts of Parking ADF have not been estimated

Supplementary analyses

- Indicate the monetary value of qualitatively evaluated impacts for:
  - Safety impacts outside ADF's ODD, i.e. on other roads
  - Travel time cost savings
- Indicate the monetary value of Parking ADF

Indicated monetary values of qualitatively evaluated impacts
1) Impacts outside ADF's ODD

- Impacts of ADFs outside their ODD are not investigated in impact assessments
- However, ADF's built-in sensors' set up (ADAS) potentially enables use of additional safety systems also on other roads

- Monetary values are indicated based on the following assumptions:
  - ADAS targeted accidents make up 60% of all types of accidents (Fahrenkrog et al., 2017: 75%)
  - ADAS sensors are capable of preventing 25% of these accidents (Drees & Bahout, 2019, Lubbe et al., 2018: 29%)
  - Effects are the same for all types of accidents on all types of roads
  - Effects increase proportionally with penetration rates

Indicated monetary values of safety impacts outside Motorway and Urban's ODD

Social value of accident prevention outside ADFs' ODD

	5%	10%	30%
Motorway ADF, million €	2,412	4,423	14,470
Urban ADF, million €	1,731	3,462	10,386
Motorway and Urban ADFs, million €	1,638	3,275	9,826

Indicated monetary values of qualitatively evaluated impacts 2) Travel time cost savings

- Mobility impact assessment survey results show that:
  - L3 cars lead to 12-25% reduction in travel time costs

Social value of travel time cost savings, 12%-25%

	5%	10%	30%
Motorway ADF, million €	496–1,034	993–2,068	2,978–6,205
Urban ADF, million €	1,383–2,880	2,765–5,760	8,295–17,281
Package: sum of Motorway and Urban, million €	1,879-3,914	3,758-7,828	11,273-23,486

Indicated monetary value of Parking ADF

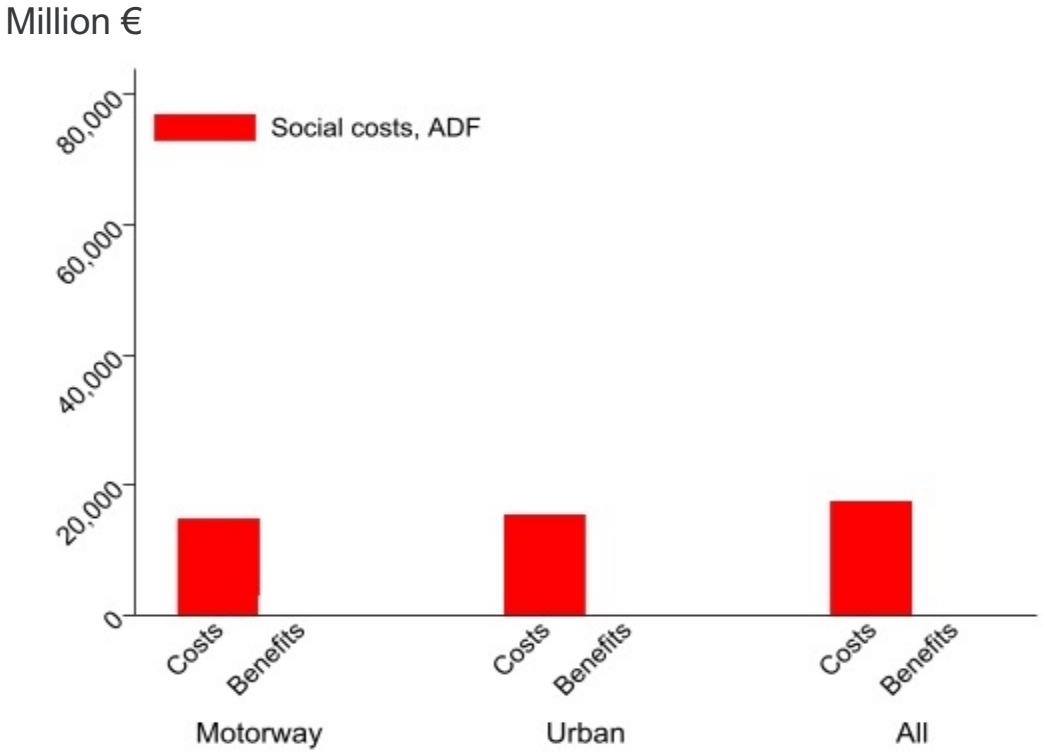
- Estimates based on insurance data from Germany
  - 23.2% of all insurance claims are parking related
  - One accident may have more than one insurance claim
    - Number of accidents is between 2,7 million € and 4,2 million €
  - Expected prevention of parking related accidents: 75% to 100%
  - Average cost per parking related accident estimated to 2,334 €

3) Parking ADF, cont'd

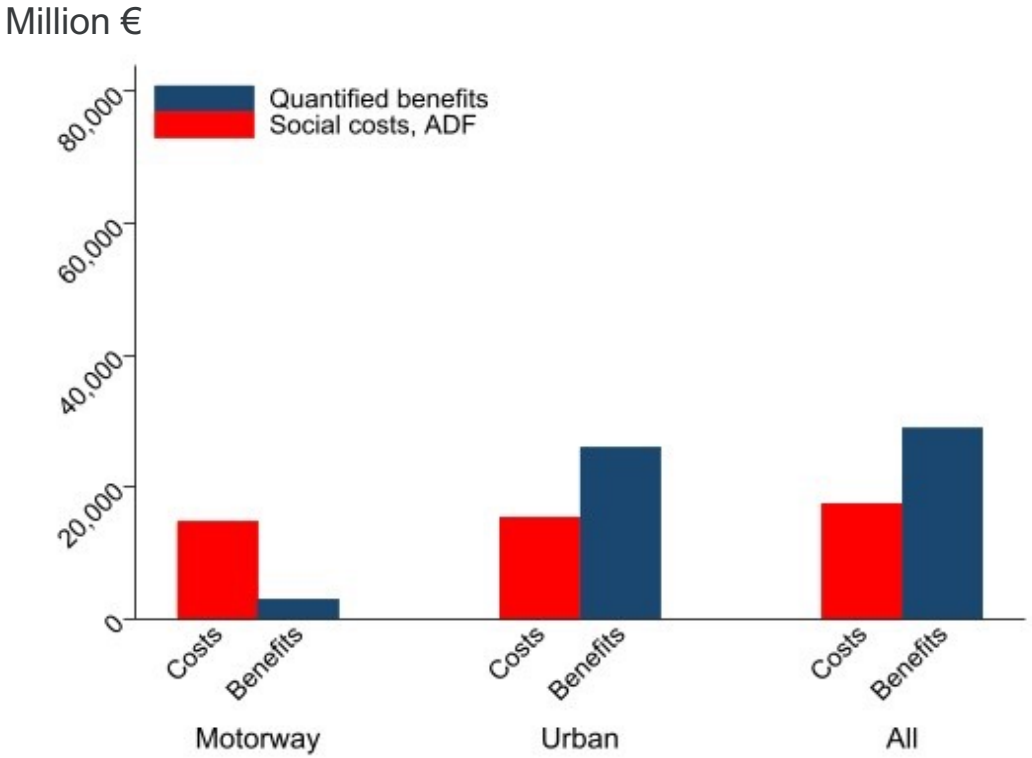
- Assumptions for indicating monetary value of Parking ADF
  - Number of German accidents is the average of the minimum and maximum numbers
    - The share of parking related accidents relative to the stock of passenger cars is the same as in Germany for EU27+3
  - Effectiveness: Parking ADF prevents 80% of parking related accidents

- Indicated social benefit:
  - 5%: 436 million €
  - 10%: 873 million €
  - 30%: 2,619 million €

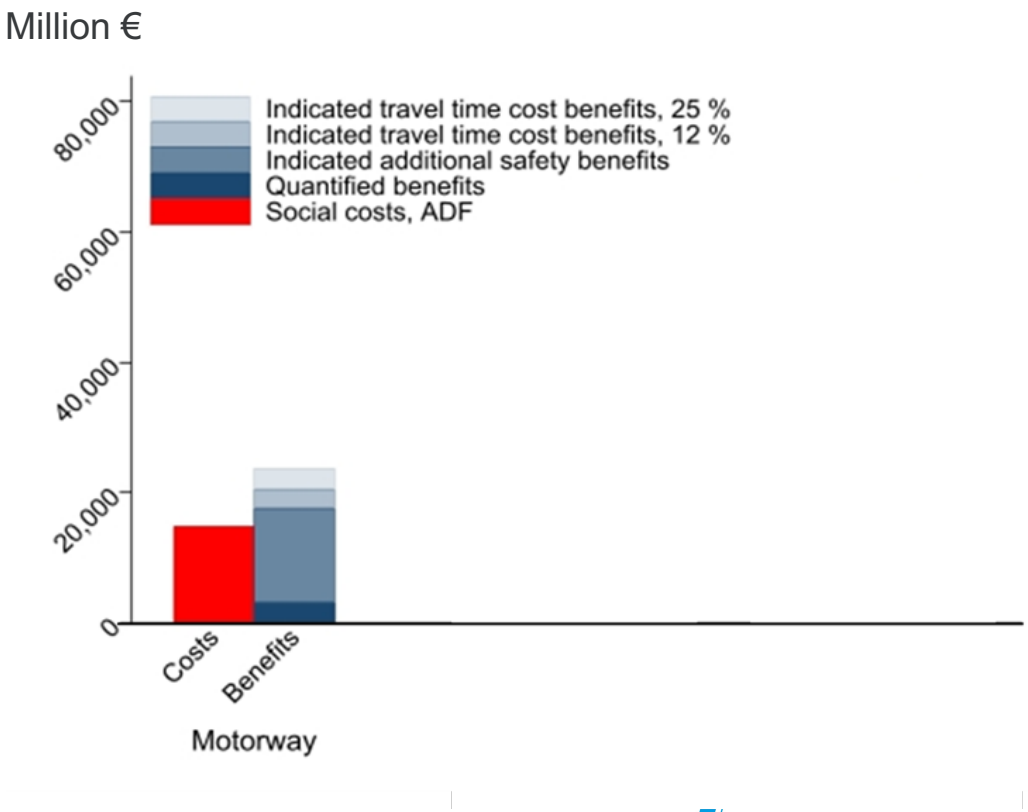
Summary of the main findings: 30% ADF penetration



Summary of the main findings: 30% ADF penetration

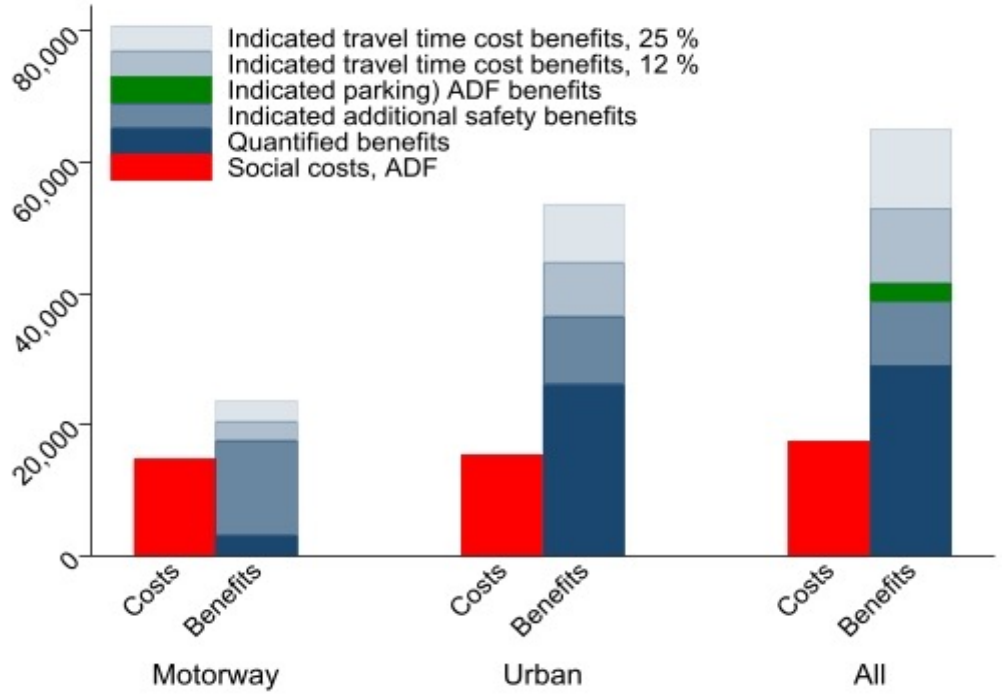


Summary of the main findings: 30% ADF penetration



Summary of the main findings: 30% ADF penetration

Million €



Individual car driver's perspective

- The individual car driver's perspective is different from society's perspective
  - ADF costs are higher (sales price is 3 times higher than producer costs)
  - Benefits are considered more narrow (What's in it for me?)
- Two ways of considering the value of ADF for individual car driver
  - Based on the overall socio-economic impact assessement results
  - Based on the stated willingness to pay from surveys
- Both the results of the socio-economic analysis and stated willingness to pay indicate that there is a potential market for L3 cars
  - However, the size of this ADF market is highly uncertain

Conclusion

- Motorway ADF:
  - Social benefits do not exceed the costs if only quantified impacts are considered
- Urban ADF:
  - Quantified social benefits are greater than the costs
- Combination of Motorway, Urban and Parking ADFs:
  - Quantified social benefits are greater than the costs
- Factors such as indirect safety effects (addressing accidents on other road types due to inbuilt ADF sensors) and increased travel quality by generating travel time cost savings would increase the social benefits, in particular for the Motorway ADF

Thank you for your kind attention.

Afsaneh.Bjorvatn@snf.no
Per.Heum@snf.no
Karl.Pedersen@nhh.no

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 723051.