

Effects of climate change and adverse weather conditions on transport

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Background

Project is part of the BSIK programme 'Climate Change Spatial Planning' (www.klimaatvoorruimte.nl)

General research strategy

Analyse impact of weather on transport sector



KNMI 2006 scenarios show impact of climate change on weather conditions in 2050



Assess impact of climate change on transport sector

Climate change: KNMI 2006 scenarios for 2050

Two crucial parameters

- 1°C or 2°C increase in global temperature in 2050 relative to 1990
- Weak or strong changes in wind circulation in Europe

Four KNMI 2006 scenarios

M	1°C increase in temperature, weak changes in wind circulation;
M+	1°C increase in temperature, strong changes in wind circulation;
W	2°C increase in temperature, weak changes in wind circulation;
W+	2°C increase in temperature, strong changes in wind circulation.

Main consequences for weather patterns in the Netherlands

- Increase in temperature
- Large variation in precipitation patterns between scenarios

Climate change

Wind speed and direction

- Uncertain and large spatial variation
- General tendency is a small increase in maximum wind speeds

Sea level rise

- Around 10 cm for 2050
- Around 25 - 30 cm for 2100

Three main lines of research

A. General literature survey

B. Climate change and road transport

- Mode choice and traffic speed

C. Climate change and inland navigation

- Economic loss due to changes in water levels

A. Literature survey

Road transport: Weather and safety

- Precipitation (rain and snow) is by far the most relevant weather variable
- Precipitation increases accident *frequency*
- Mixed evidence on impact of precipitation on accident *severity*

Climate change consequences

- Decrease in number of wet days decreases accident frequency, increase in rainfall at wet days and extreme rainfall increases accident frequency
- Ambiguity with respect to accident severity as well
- Increase in frequency and duration of dry spells decreases road safety when it starts raining

Road transport: Weather and congestion

- Reduction of traffic flow and traffic speed due to precipitation
- AVV (2005): 1/3 of increase in (severity of) traffic jams in 2004 vis-à-vis 2003 can be explained by an increase in precipitation
- Surprisingly few other empirical studies on the impact of precipitation on frequency and severity of traffic jams

Consequences of climate change

- Increase in number of wet days and rainfall at wet days in winter increases congestion
- Decrease in number of wet days in summer decreases congestion
- Increase in rainfall at wet days in summer increases congestion

Consequences: Rail, air and water

Rail transport: Infrastructure failures

- Higher temperatures reduce failures due to icing but increase failures due to high temperatures
- Changes in maximum wind speed are small
- Relative number of failures and accidents due to adverse weather seems to be limited, however

Air transport: Delay and accidents

- Relatively small impact as far as increases in maximum wind speed appear to be generally small
- Highly uncertain because it also depends on issues not in KNMI scenarios (e.g., visibility)
- Appears to depend to a great extent on changes in wind direction, which are uncertain and region specific

Consequences: Rail, air and water

Inland shipping: Economic loss due to low water levels

- Increase in frequency and duration of dry spells, implying higher prices and welfare losses
- Higher costs due to larger variation in water levels (increase in uncertainty)
- Canada: Cost increases of 18% to 42%, depending on the sector chosen; weighted average is around 30%
- Sharp increase in frequency of extreme costs

B. Climate change and road transport:

Mode choice and traffic speed

Central questions

- How does weather influence mode choice decisions by individuals?
- How does weather influence traffic speed?

Data sources

Data: OVG 1996 (AVV)

- More than 500,000 useable observations
- Contain 77 variables on personal characteristics and trip characteristics
- Survey covers the entire Netherlands

Data: Weather Report 1996 (KNMI)

- Hourly weather data for every day in 1996
- Recorded by 39 stations, covering all 458 municipalities of the Netherlands
- Contains information on temperature, wind, precipitation and sunlight

Main results

Mode choice

- Switch from bicycle to car under cold and extremely cold circumstances (4% to 8%)
- Switch from car to bicycle as temperatures increase above 10 °C (2% to 5%)
- The effects of wind are small; the use of the bicycle decreases sharply at wind speeds higher than 6 Bft (around 4%)
- As precipitation increases, people reduce bicycle use and increase use of car and public transportation (around 3%)

Traffic speed

- Small reduction in overall traffic speed and in traffic speed during the morning and evening peak
- Substantial reduction of traffic speed during morning peak (7%) and evening peak (10%) at congested routes

C. Climate change and inland navigation:

Economic loss due to changes in water levels

Outline

Analysis of economic loss in the inland navigation sector as a result of low water levels in the river Rhine

Research outline:

Climate change



Increase in frequency of low water levels in the river Rhine



Higher price per ton for transportation by barge



Costs for the economy

Data and model specification

Data

- Characteristics of inland navigation trips 1986-2004
- Water levels 1986-2004

Dependent variables

- Load factor
- Price per ton

Explanatory variables

- Time trend
- Trip distance in logarithm
- Ship size
- Cargo type
- Navigation direction & backhaul
- Monthly dummies
- Water level

Results

Water level	Load factor	Price per ton
> 261		
251-260	-0.040	0.040
241-250	-0.146	0.122
231-240	-0.153	0.089
221-230	-0.153	0.145
211-220	-0.268	0.209
201-210	-0.351	0.293
191-200	-0.416	0.337
181-190	-0.467	0.316
= 181	-0.541	0.505

- Average annual welfare loss period 1986-2004: € 28 million
- Welfare loss 2003: € 91 million

Model simulations

To what extent will the competitive position (in terms of tons) of inland waterway transport in the Kaub related Rhine market deteriorate as a result of climate change?

Model

- NODUS: A GIS based software model which provides a tool for detailed analysis of freight transportation over extensive multimodal networks
- Reference situation is a year that has no restrictions due to low water levels
- Simulate difference between base scenario and W+ scenario

Simulation results

Substitution from inland navigation to road and rail transport in W+ scenario

NSTR group	% change	Proportion rail	Proportion road
0	-4.6%	0.63	0.37
1	-1.9%	0.09	0.91
2	-0.9%	0.57	0.43
3	-0.9%	0.27	0.73
4	-2.0%	0.66	0.34
5	-3.3%	0.25	0.75
6	-1.7%	0.05	0.95
7	-2.2%	0.96	0.04
8	-1.9%	0.32	0.68
9	-3.7%	0.87	0.13
Total (0-9)	-1.7%	0.42	0.58

Conclusions

Literature survey

- Empirical findings often difficult to compare in a quantitative way
- Effects of weather (and climate change) are often ambiguous in sign
- Blind spots in knowledge, existing knowledge lacks robustness

Mode Choice

- Most important pattern is substitution between car and bicycle due to changes in temperature, rain and wind
- Order of magnitude is between 2% and 10%, depending on the magnitude of the change in weather

Conclusions

Inland waterway transport

- Average annual economic loss due to low water levels in 1986-2004 period of € 21 million
- Substitution of freight of around 2% from inland waterways to road (share = 0.60) and rail (share = 0.40) transport

Background documents

- Koetse, Rietveld, 2007, Climate change, adverse weather conditions, and transport: A literature survey.
- Sabir, Koetse, Rietveld, 2007, The impact of weather conditions on mode choice decisions: Empirical evidence for the Netherlands.
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