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Weather service chain analysis WSCA

An approach for appraisal of the social-economic benefits of improvements in weather services

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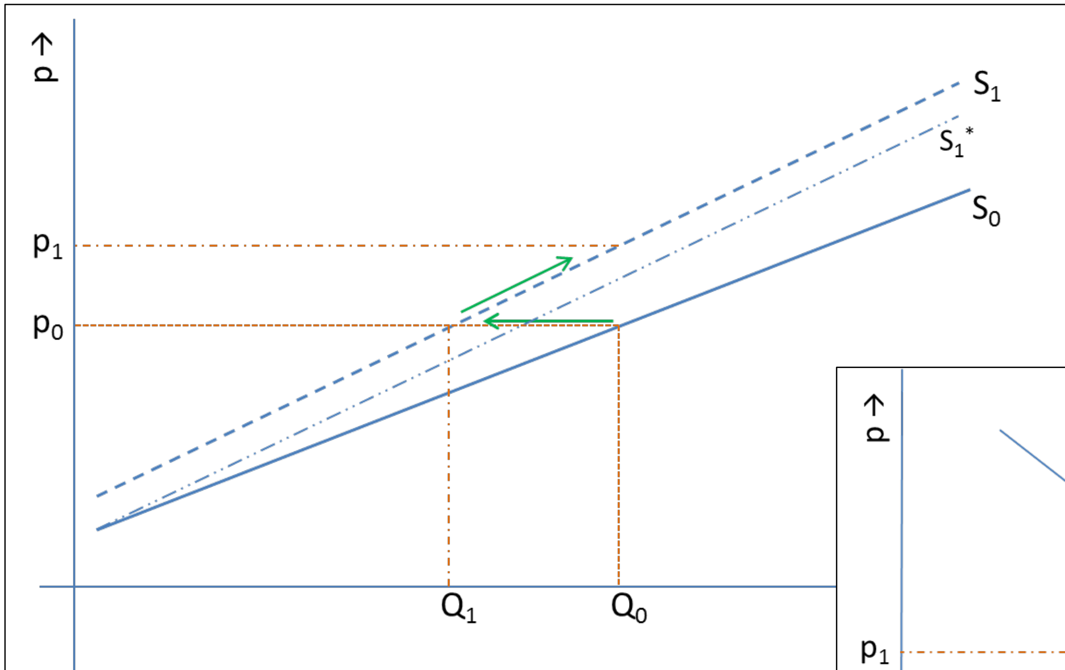
Structure

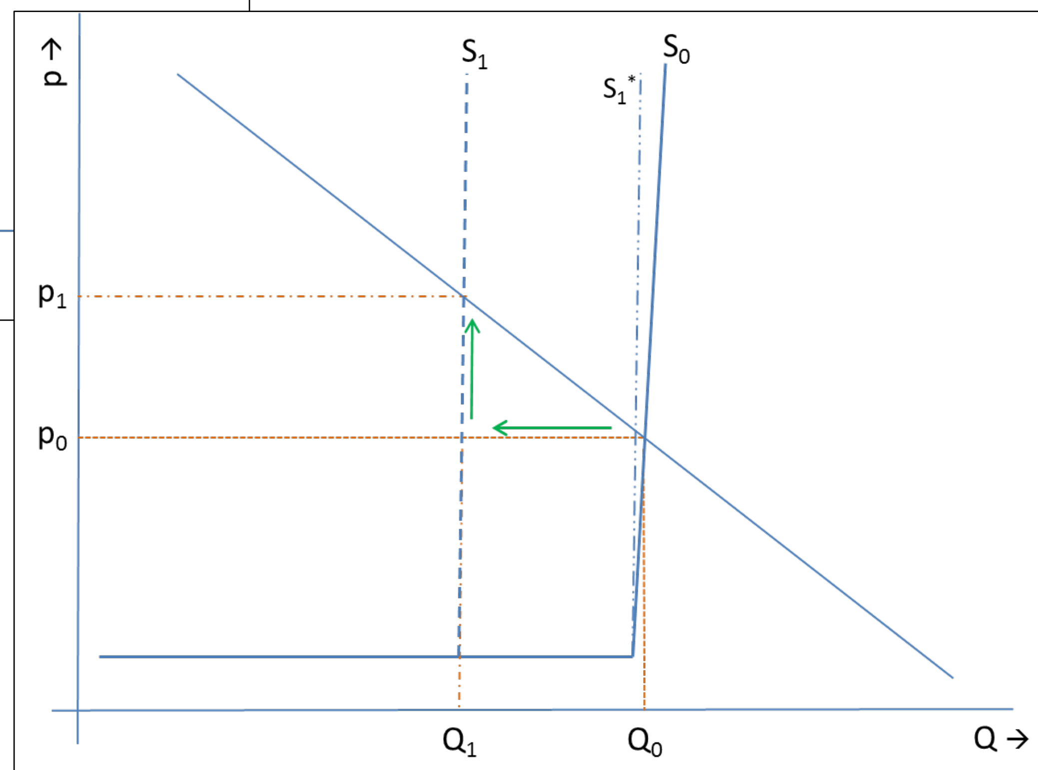
- Effects of weather vs. those of weather information
  - Transport tends to have a large coping range
  - Response time and rigidities
- Traditional cost-loss model
- WSCA approach
- WSCA application example
- conclusions

Don’t blur weather and weather information effects

- Damage in transport due to extreme weather can be substantial, e.g. via
  - Infrastructure, vehicles, fatalities, cargo, delays, loss of confidence and subsequent demand loss/mode switch
- Yet, the question is *what difference* weather information can make as compared to an uninformed system / users
  - Traffic volume reduction largest factor in accident reduction when adverse weather is expected (Cools et al 2010) – including a selectivity bias towards less skilled drivers
  - In Finland – the hotter the summer seems to boost road casualty numbers more than the colder the winter

Capacity rigidity affects weather service benefit





Traditional approach – cost/loss model

Action	Adverse weather	Not adverse weather
Protection	**C**	**C**
No protection	**L**	**0**

$$q = \frac{p_1 - p}{1 - p}$$

$$q^* \geq \frac{\frac{C}{L} - p}{1 - p}$$

where $\boldsymbol{q}$ denotes the forecast quality ($0 < q < p_1$),

$\boldsymbol{p_1}$ is the conditional probability of adverse weather (given that adverse weather was forecast),

$\boldsymbol{q^*}$ is the critical value where weather service starts to produce benefits

Cost/Loss model – limiting assumptions

- Weather information acquisition cost are zero
- All users of weather information are – otherwise – all perfectly informed
- Prevention cost are zero
- Uncertainty range around the forecast is constant over time and not extremely large
- Information level of other market parties does not affect decision

These assumptions imply that the Cost/Loss model (incl. uncertainty extensions) is only straightaway applicable in aviation and maritime navigation

Weather service chain analysis 1

- Information decay and ability to exploit information varies, therefore we have to consider the **weather service information chain** (**WSCA**) in detail
- From forecast generation to eventual societal benefit 6 (or even 7) steps can be distinguished
- Approach can be formalized by means of survival analysis
  - product sum of consecutive fractions
  - fractions can change over time

Weather service chain analysis 2

example of explorative application to road traffic

→ step-up to quantitative analysis

	Information filtering steps	Present qualities and room for improvement
1	weather forecast accuracy	Accuracy levels good, 92% or 19 out of 21 bad weather days were predicted (Sihvola et al. 2008, in Finland)
2	information/message customer orientation	Road weather warnings are well understood by drivers – about 90% of people understand what is meant by "normal" "poor" or "very poor weather" (Quantis 2010), Sihvola et al.
3	access to weather information	high availability, user rates however only about 62 % (Sihvola et al. 2008, in Finland) messages needed about current road weather conditions including in-car systems and road sings (WIST 2002)
4	comprehension of the information	People mostly use personal observations over real weather information (Pisano and Nelson 1997), bad judgements about current conditions However weather information makes the judgement about current conditions more accurate (Sihvola and Rämä 2008) – 85%
5	ability to respond timely and effectively	the frequency of bad weather warnings sufficient for timely responds (Lazo 2002) but too high threshold for adjustments (Pisano & Nelson 1997), education needs about driving in bad weather conditions and the use of weather information – only 20% of all drivers change their decisions, however people with weather information make changes more often than other drivers, circa 40%. More study needed on this area.
6	actual effectiveness of responses	mostly right responses: (earlier departure from home, lower driving speeds, cancellations of trips and different routes used), however changes happen with too low magnitude: speed reductions too low, only 2% lower volume on road traffic when bad weather warning issued (Quantis in Finland) – we give numerical value of 80%
7	incidence of the costs and benefits of the response	awareness on who is eventually benefitting is important to understand; part of the benefits to vehicle drivers due to lower costs of driving, network analysis needed to estimate mode substitution

Weather service chain analysis 3

$$Q_{mt} = \prod_{s=1}^{7} \{P_{ms_t}\}$$

where $0 \leq P_{ms} = f_{ms}(x_{s_i}; \dots ; x_{s_{i+n}}) \leq 1$,
and therefore also $0 \leq Q_{mt} \leq 1$

$$B_{mt} = Q_{mt} . \gamma^{\alpha(1-Q_{mt})} . B_{m,t}^{max}$$

$$P_{ms} = \frac{\left[\sum_{j=1}^{M} \sum_{i=1}^{N} p_{j,i}\right]}{M.N}$$

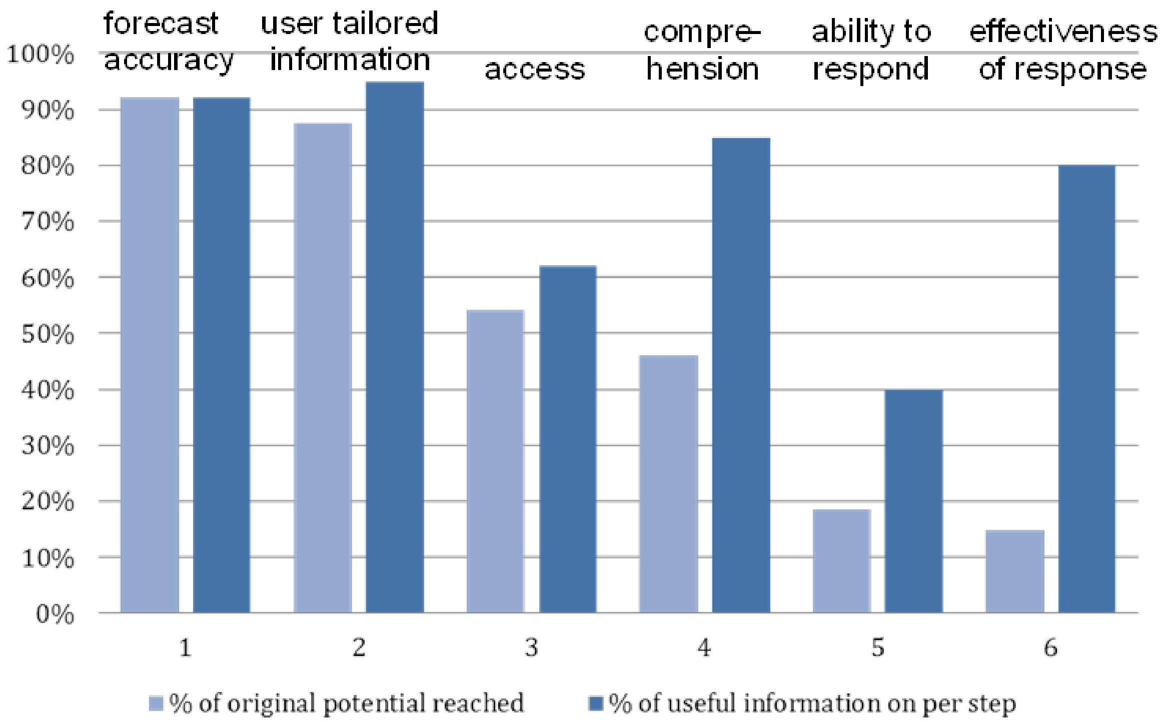
$$p_{j,i} = \frac{e^z}{1 + e^z}$$

$$z = \beta_0 + \sum_{i=1}^{n} \beta_i x_i$$

Photo by:Antonin Halas

Weather service chain analysis 4

- now only **14%** of theoretical potential realized
- this score equals to approx. 36 million €
- raising forecast accuracy *only* would generate 3 mln. € at most
- raising (also) access and ability boosts leverage of investment in forecast accuracy



NB! 7th step (redistribution effects) not considered

NB2! Interaction with weather service for road clearance planning to be reviewed

Conclusions

- Appraisal of net social-economic benefit of weather services requires identification of the end-user's **response** to the (incremental) information
- Only for highly professional users (aviation, marine navigation, electric power generation) the actual and theoretical benefit potential are quite near to each other, i.e. forecast accuracy the most decisive factor
- For most other user groups – e.g. road users – the **information's benefit decay** is substantial → this means that other features than forecast accuracy – e.g. *information access, information tailoring, cognitive capabilities, etc. deserve equal or more attention*
- The annual economic benefits of road weather information in Finland are preliminary estimated at € 36 mln. For the whole of Europe the corresponding figure amounts to € 3.4 bln. By addressing the *entire* WSC could be probably doubled.

Thank you

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