Aalto University

# Mitigation strategy under uncertainty on climate sensitivity and damages

*IEW 2018*
*Tommi Ekholm*
*June 19th 2018*

*Paper:*
*Tommi Ekholm, Climatic cost-benefit analysis under uncertainty and learning on climate sensitivity and damages, Under review (3rd round) for Ecological Economics*

# Climatic cost-benefit analysis

**Optimal strategy for reducing greenhouse gas emissions ($r$):**

How much does mitigation cost?

How sensitive climate is to emissions?

$$\min_r \sum_t \beta^t \left( C_t(r_t) + D_t\left(\Delta \mathrm{T_t}(r_0, \ldots, r_t)\right)\right)$$

How should future values be discounted?

What impacts climate change might have?

How these impacts should be valued?

# Climatic CBA – some critique

- Martin Weitzman (Rev.Econ.Stat, 2009):

  the artificial crispness conveyed by conventional IAM-based CBAs here is especially and unusually misleading compared with more ordinary non-climate-change CBA situations

- Robert Pindyck (JEL, 2013):

  *These models have crucial flaws that make them close to useless as tools for policy analysis*

- van den Bergh & Botzen (Ecol. Econ., 2015):

  In view of the many uncertainties and omissions in conventional cost–benefit analyses of climate impacts and the SCC, alternative approaches to decision-making should be considered for climate policy.

# Approach and objectives

- Portray the main uncertainties inside the CBA
→ find optimal strategies to hedge against them

- Assume learning to take place for the uncertain factors
→ portray how strategies need revisions to reflect new information

- Analyze the sensitivity to different, plausible assumptions
→ portray the imprecision of policy guidance from CBA

# Dealing with the problematic factors

| Climate sensitivity | Climate damages | Mitigation costs | Discount rate |
|---|---|---|---|
| uncertain value, estimates from literature | uncertain impacts; DICE damages, uncertain exponent | uncertain, but depend on human action | normative choice |
| 2 probability distributions | 2 probability distributions | 2 separate cases: Low / High costs | 3 separate cases: 1% / 3% / 5% |

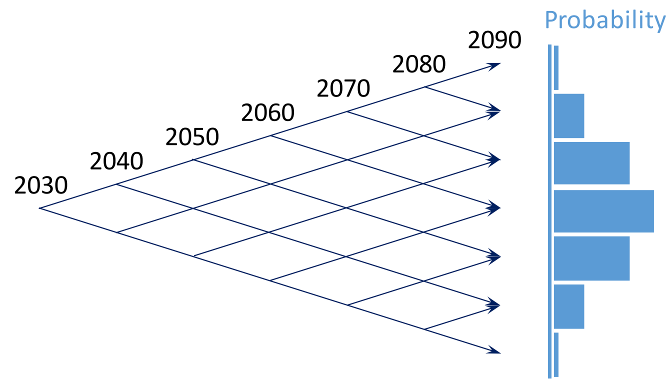
→ 24 stochastic long-term scenarios with the SCORE model

+ 2 deterministic cases with 1.5ºC and 2ºC limits

# Uncertainties and learning

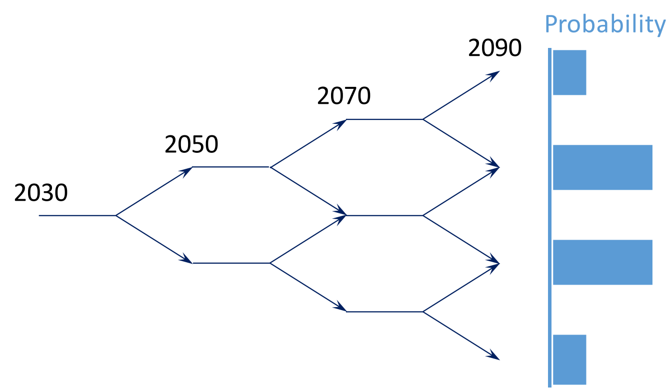
- Binomial lattices for climate sensitivity and the damage exponent
- Exogenous assumptions
- Two parameter sets for the distributions' locations
- Considered through sequential decision-making in SCORE

Climate sensitivity (°C)




| Normal | Lognormal |
|---|---|
| 1.2 | 1.0 |
| 1.7 | 1.4 |
| 2.3 | 1.9 |
| 2.9 | 2.9 |
| 3.6 | 3.9 |
| 4.5 | 5.8 |
| 5.5 | 7.5 |

Damage function exponent

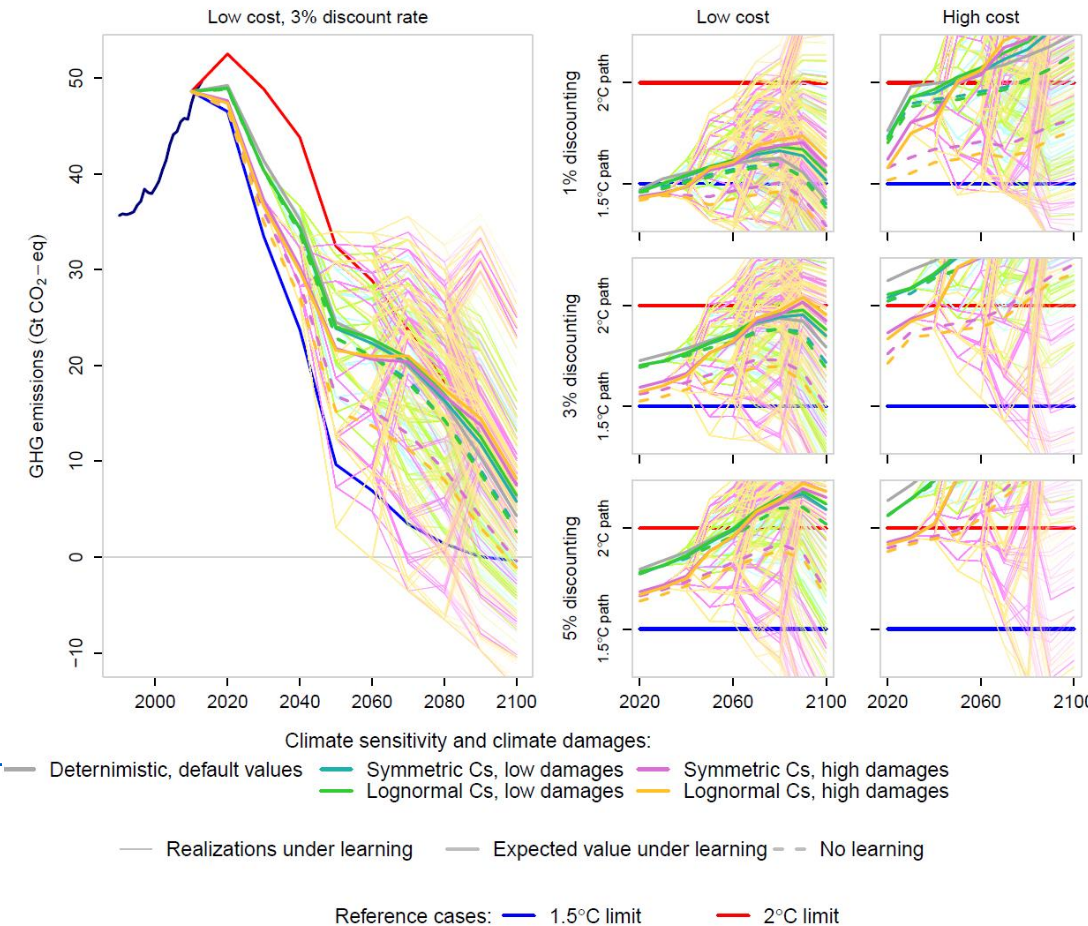



| Low | High |
|---|---|
| 1 | 0.5 |
| 1.5 | 1.5 |
| 2.5 | 2 |
| 3 | 5 |

# Results

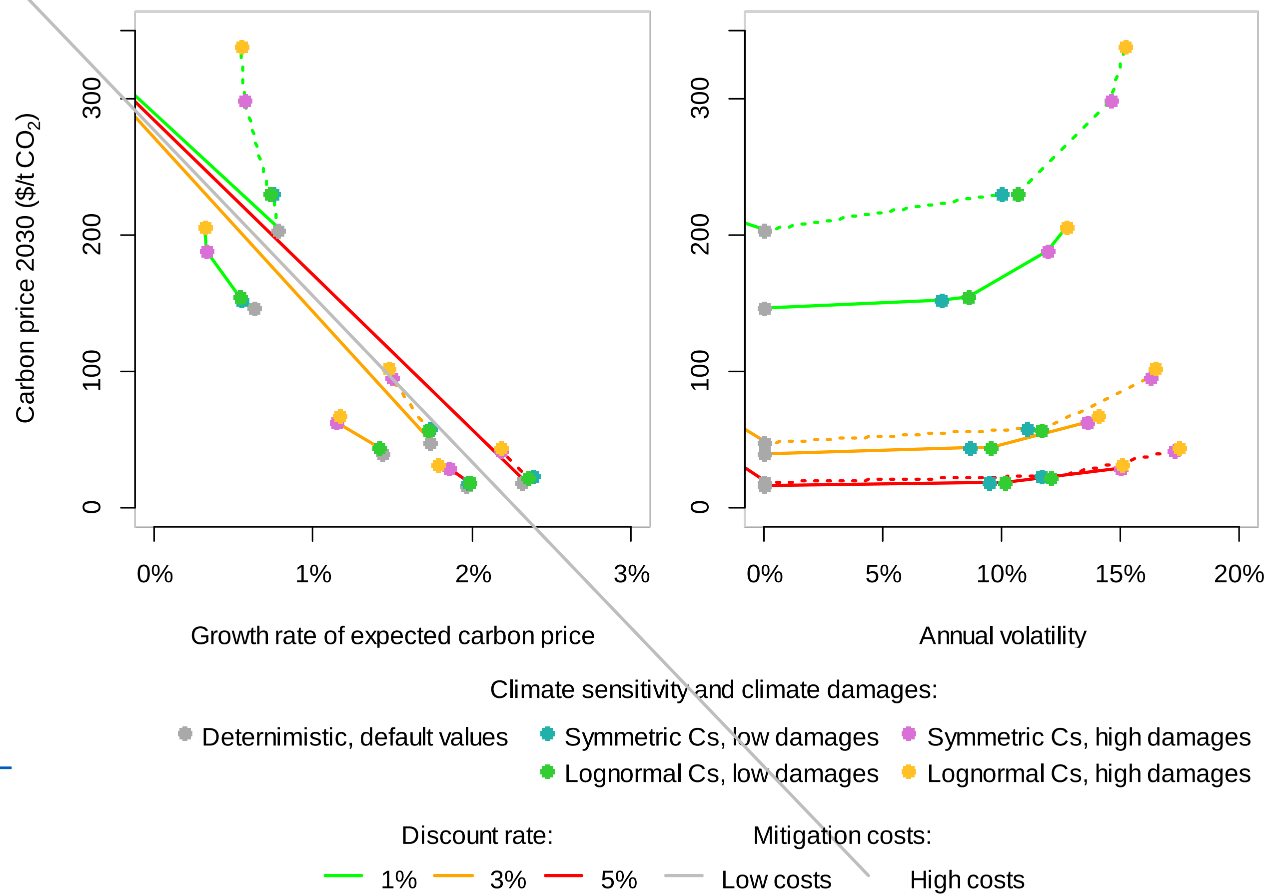
# Optimal emission pathways

- Mostly between 1.5°C and 2°C pathways up to 2050
- Strong divergence over time due to assumed learning
- Higher uncertainties make stronger mitigation optimal
- No learning leads to even stronger near-term mitigation



# Evolution of carbon prices

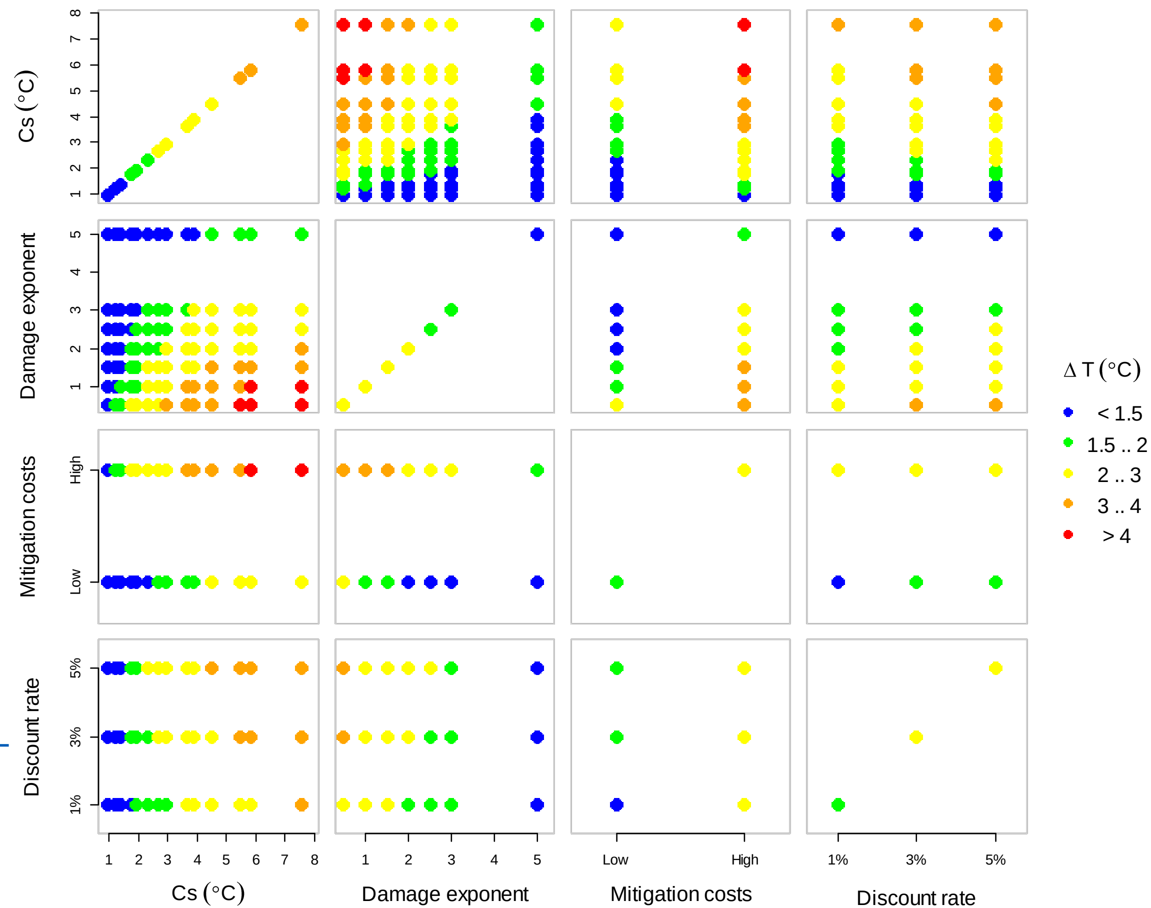
- Inverse relationship between 2030 carbon price and it’s growth, driven by discount rate and uncertainties
- Uncertainties, DR and costs affect 2030 carbon price strongly
- High volatility due to the assumed learning




Aalto University

# Stabilization level of temperature

- Considerable range on what level temperature is ultimately stabilized
- Depends especially on the realized climate sensitivity and damages
- Discounting has only a minor impact



# Conclusions

Methodological:

- Uncertainty can be considered, but assumptions are conjectural
- Allows to investigate novel aspects, e.g. carbon price volatility

Policy Guidance:

- Paris Agreement 1.5˚C to 2˚C targets good for medium-term
- Temperature targets might need adjustments in the long-term

Carbon pricing:

- No accurate guidance due to contestable assumptions
- Strong volatility due to the considered *scientific* uncertainties

Aalto University

# Thank you!

*Questions or comments: tommi.ekholm@aalto.fi*

*Paper:*
*Tommi Ekholm, Climatic cost-benefit analysis under uncertainty and learning on climate sensitivity and damages,*
*Under review (3rd round) for Ecological Economics*