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Climate Risk Management Analysis with MERGE

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Snowmass, CO

Building out impacts in MERGE

- Major model development effort underway
  - Steve Rose, Rich Richels at EPRI
  - Delavane Turner at Stanford
  - Rob Mendelsohn at Yale
  - Tom Rutherford at UW
- In this talk:
  - What question(s) are we trying to answer\illuminate?
  - What features does our model need to provide insights?

Research question

- What is the optimal extent of mitigation in the near-term?
- (or at least, what does it depend on?)
- Can we use synthesized information about impacts to articulate why and how we evaluate the trade-off with mitigation?

- Moving beyond cost-effectiveness analysis
- Risk management analysis vs. Cost-benefit analysis
  - Decision-making under uncertainty plays central role
  - Optimal hedging path over next two decades is the key outcome

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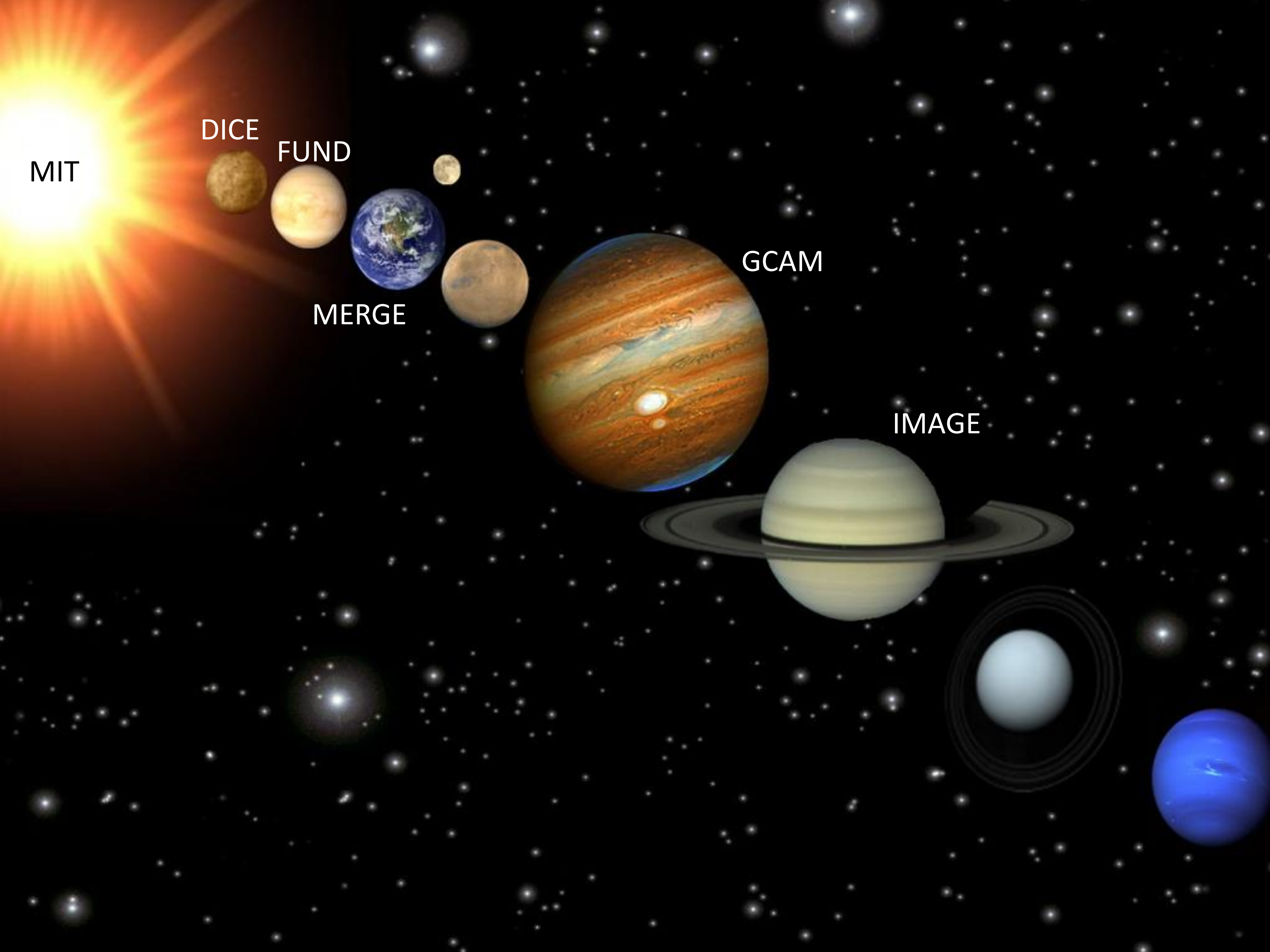
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DICE
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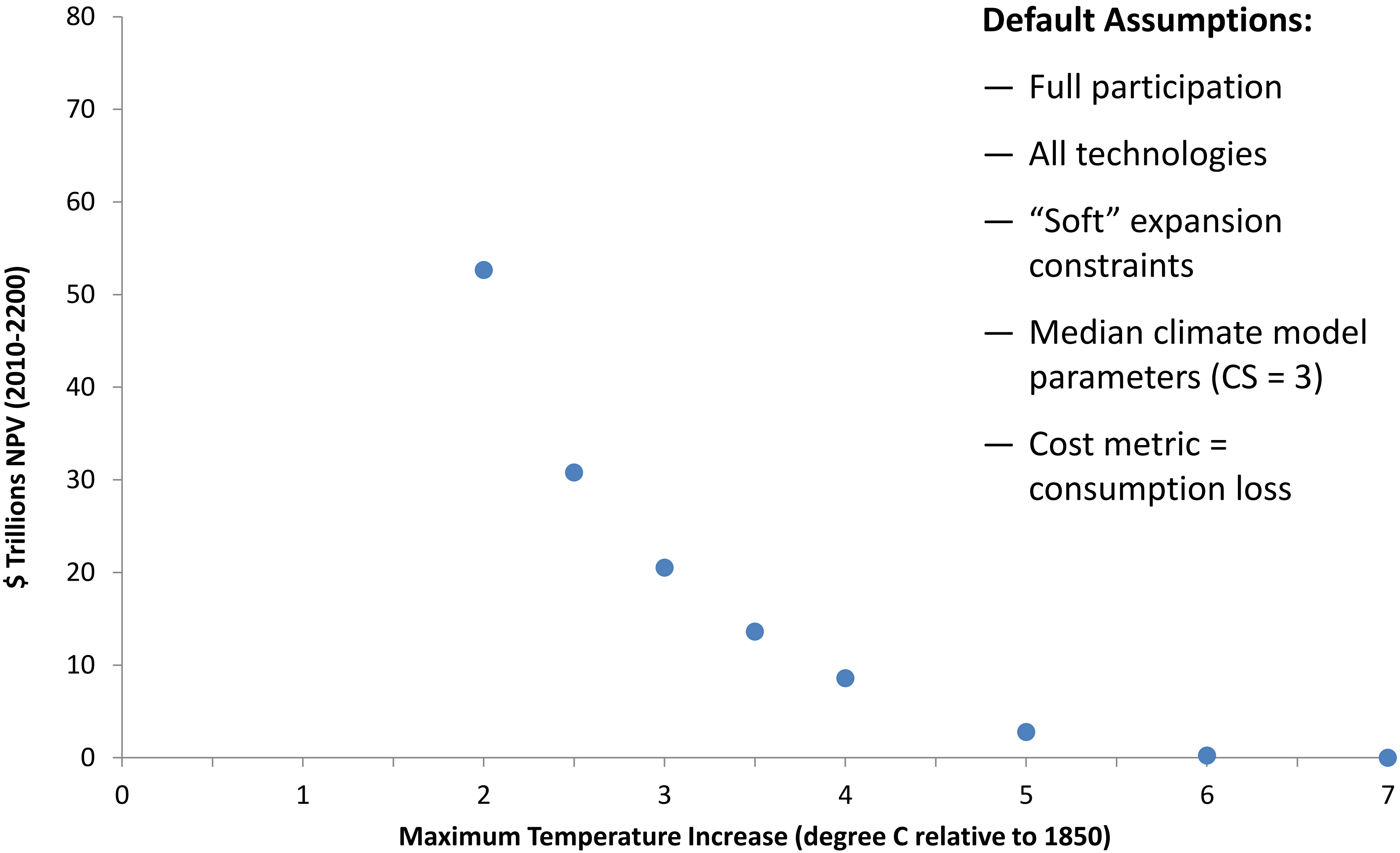
MERGE
GCAM
IMAGE

Cost-Effectiveness analysis has been… effective

- Models have extensively characterized mitigation costs
  - Technological uncertainty
  - Baseline uncertainty
  - Participation and delay
- Costs for alternative forcing targets are reported by EMF, IPCC
- Climate outcomes/uncertainty have been dealt with ex post

- We propose as a starting point a re-calibrated cost analysis that explicitly makes temperature change the argument

Total Cost of Achieving Temperature Goals



Default Assumptions:

— Full participation

— All technologies

— "Soft" expansion constraints

— Median climate model parameters (CS = 3)

— Cost metric = consumption loss

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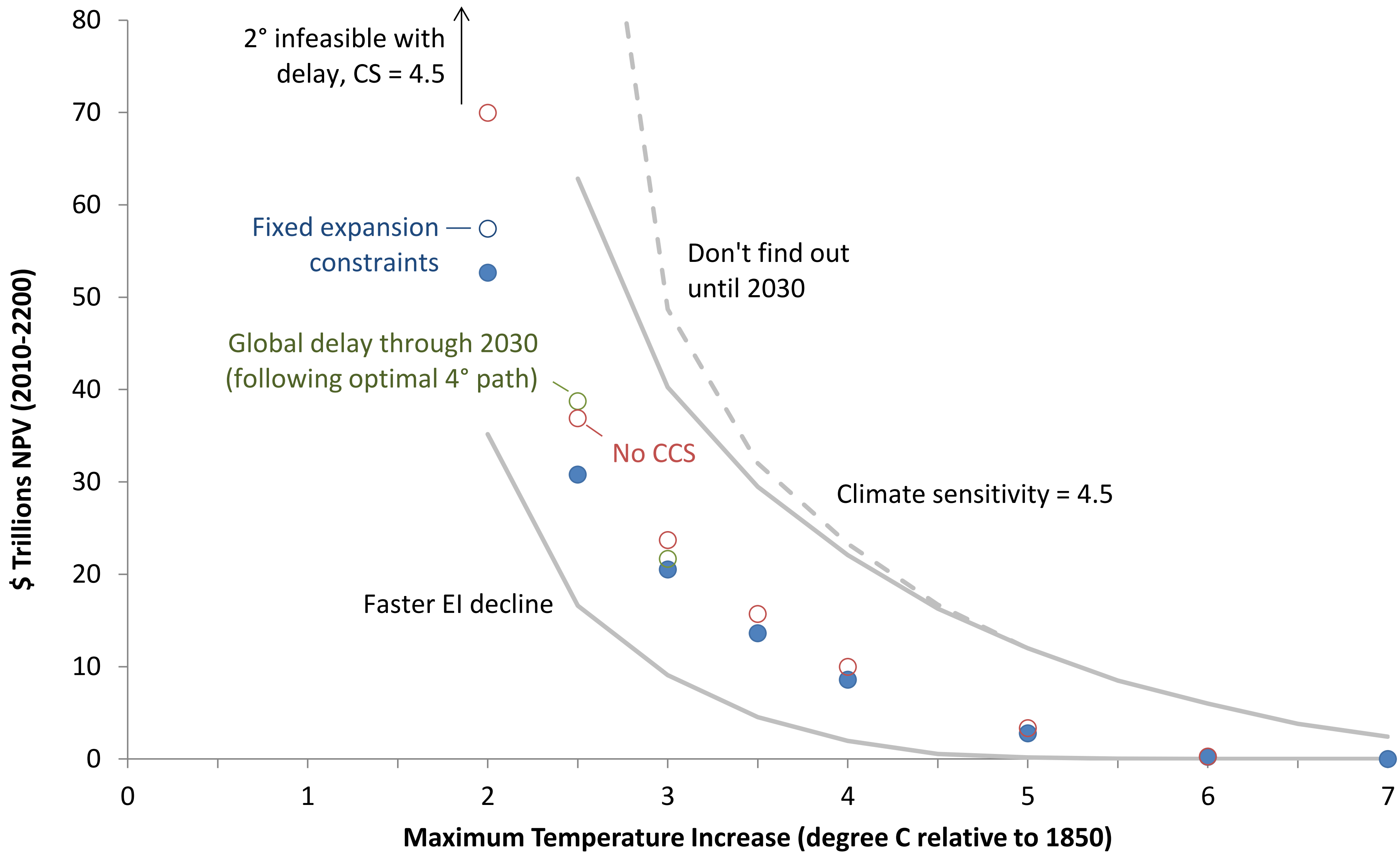
Sensitivity of Costs to Assumptions



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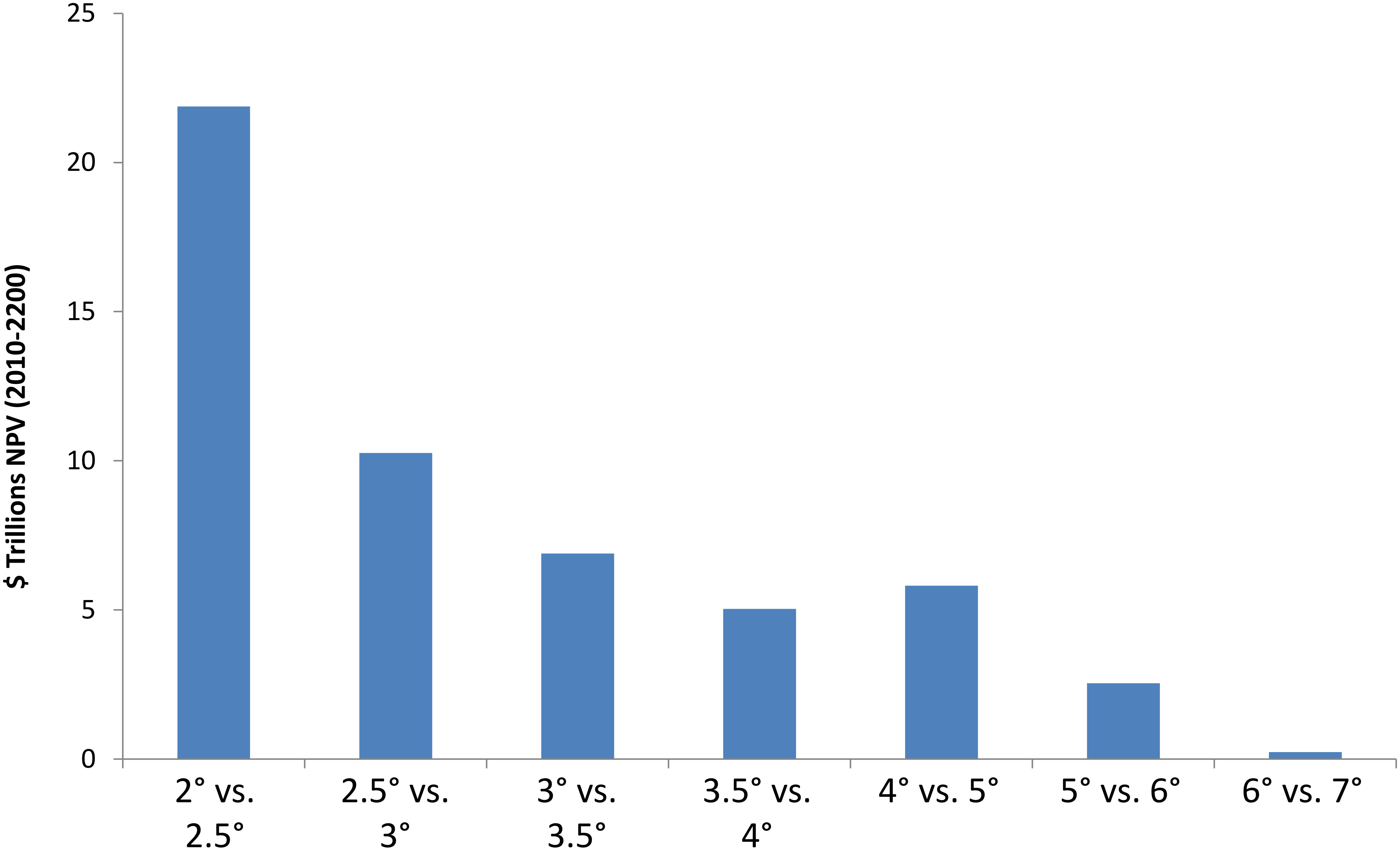
Incremental Costs of Temperature Goals



Model Features for Risk Management Analysis

1. Characterization of sectoral impacts
2. Characterization of physical processes
3. Stochastic control formulation
4. Expanded representation of preferences

1. Characterization of sectoral impacts

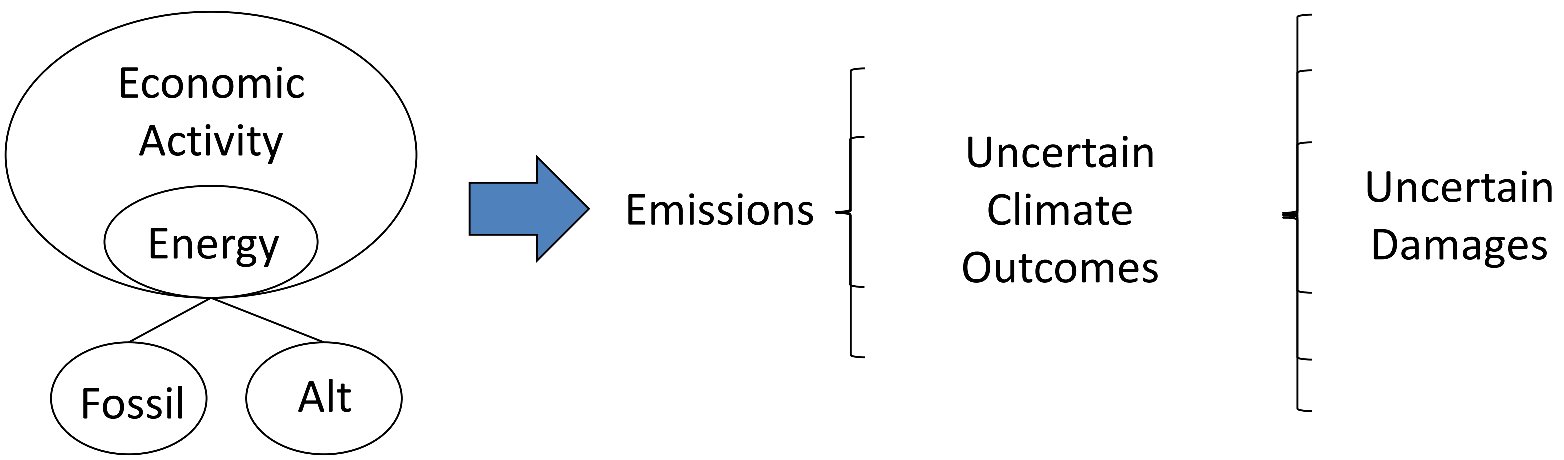
- Impacts as a function of temperature or other climate outcome
- Reduced-form emulation of bottom-up results
- Metric could be sector-dependent
- Include adaptation
- Be as comprehensive as possible
- Retain as much distributional information as possible
  - Geographic/demographic
  - Uncertainty
  - Some aggregation is inevitable

2. Characterization of physical processes

- Methane outgassing (intermediate climate outcome)
- Ice sheet dynamics (intermediate impacts outcome)
  - For example, can we develop a reduced-form model for (uncertain) rate of ice melt from WAIS / Greenland as a function of temperature to drive coastal impacts model?
  - This would drive investments in both mitigation and adaptation
- Other tipping points?

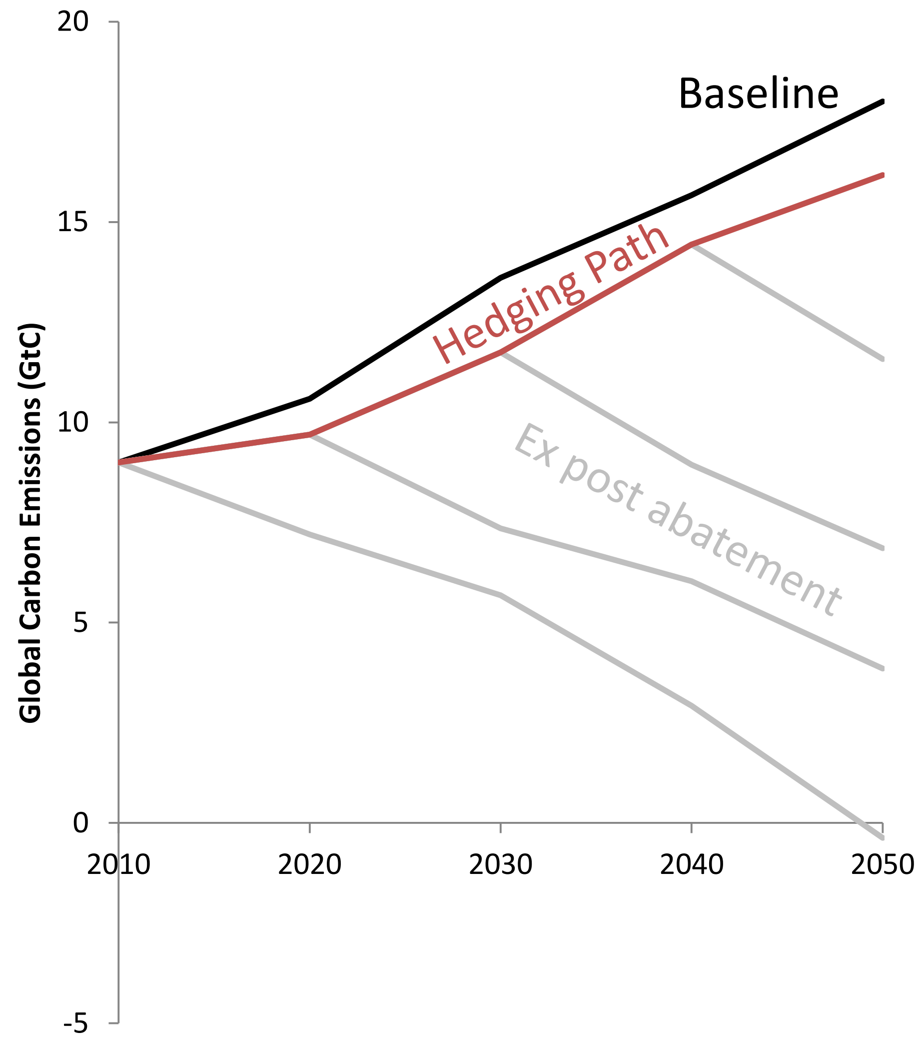
3. Stochastic control formulation

- State probability is endogenous
- For example, hazard rate for a discrete "catastrophic" event
- Implemented in MERGE – dimensionality is a big challenge



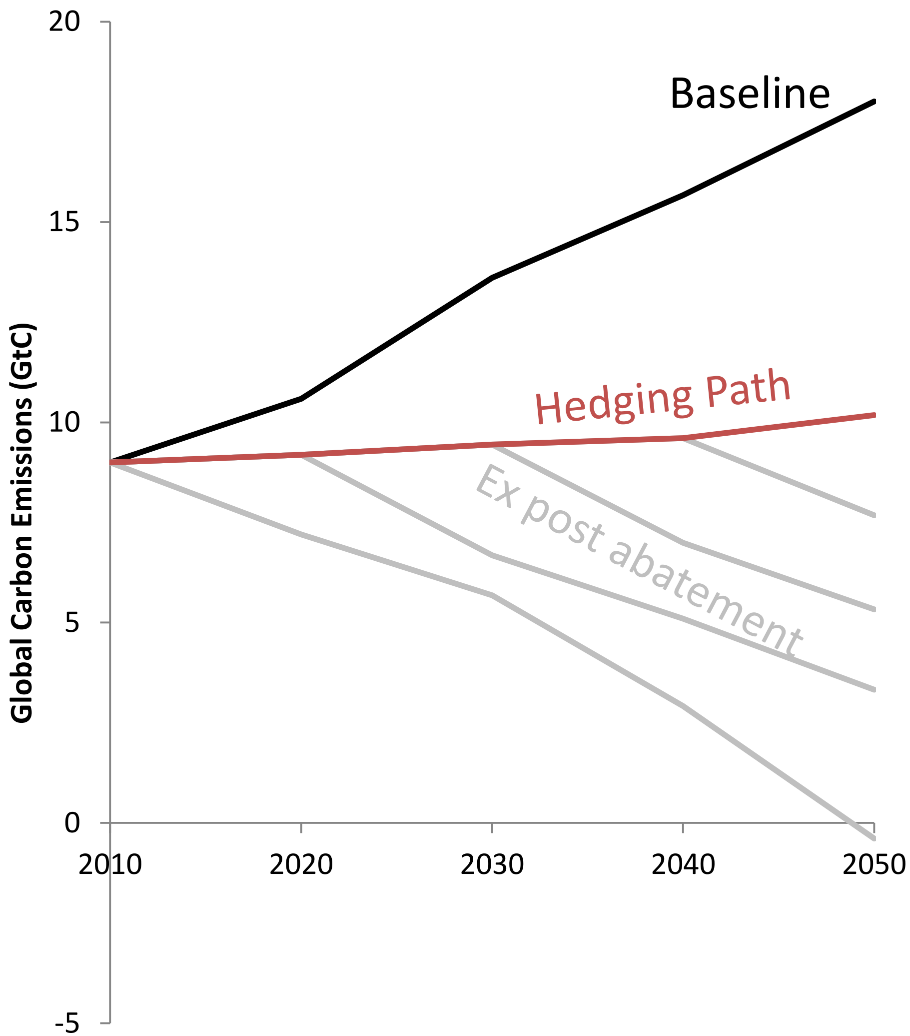
Example of hazard rate analysis

- Hazard rate is linear in temp increase up to 6°
- “Catastrophe” is described as
  - 1.3% GDP loss at trigger temperature
  - Cubic in temperature from that point
- No other damages



Example of hazard rate analysis

- Hazard rate is linear in temp increase up to 4°
- "Catastrophe" is described as
  - 1.3% GDP loss at trigger temperature
  - Cubic in temperature from that point
- No other damages



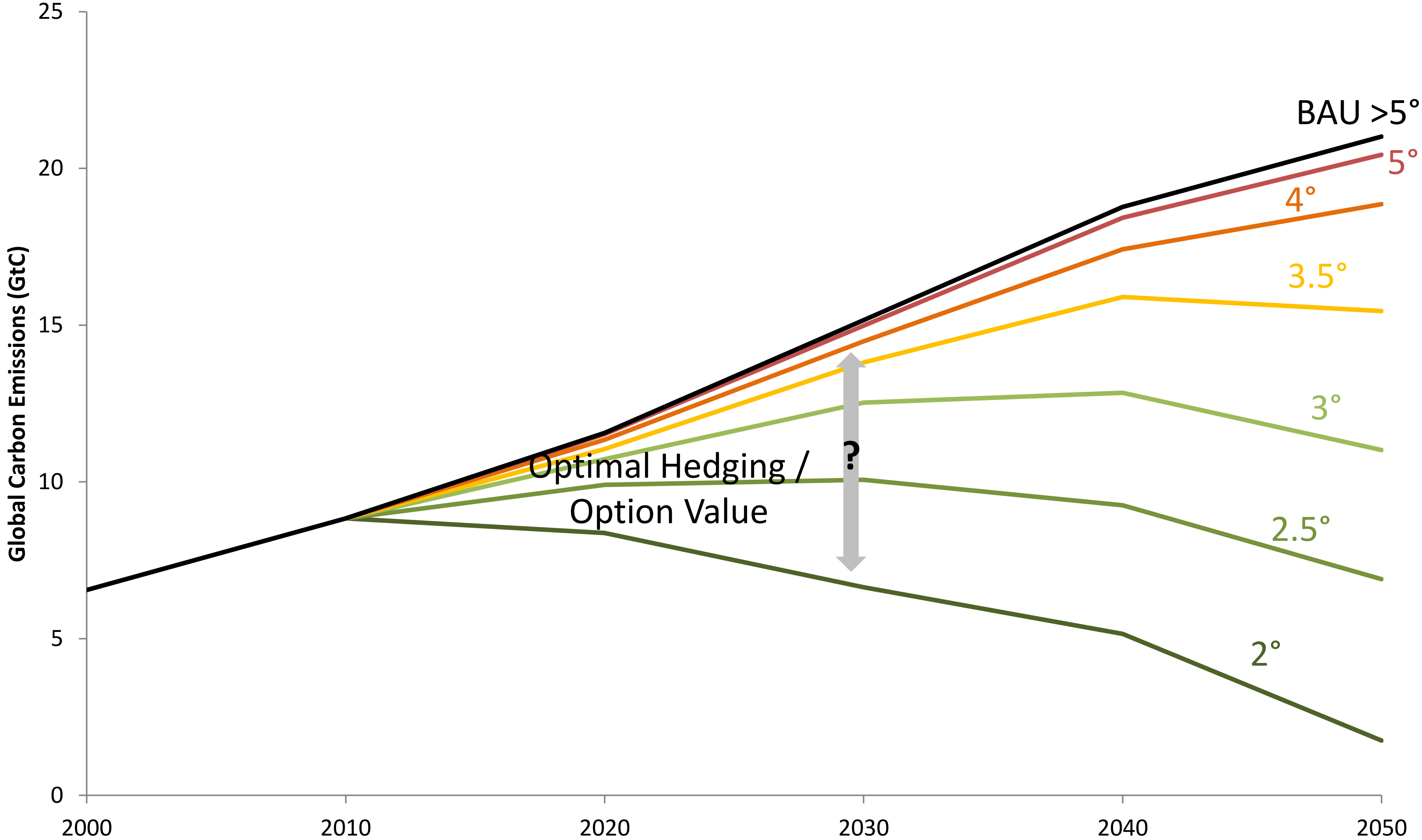
4. Expanded representation of preferences

- More flexibility with respect to intertemporal trade-offs
  - Market decisions may reflect one discount rate
  - But a social planner may choose policy based on another rate
- More heterogeneity with respect to agents
  - Income distribution and inequality aversion
  - Planner may consider marginal utility on a per capita basis
- Can implement a “bi-level” solution to reflect different views (e.g. planner vs. market) in an internally consistent way

Challenges and Opportunities

- To integrate information about impacts into a risk management analysis, the decision framework must adapt
  - Uncertainty
  - Distributional implications (distinct from equity per se)
  - Structural differences in how impacts are valued
- Optimization with stochastic control is computationally intensive (and not easy to parallelize off-the-shelf)
  - New solution algorithms
  - Reducing dimensionality elsewhere in the model

Can we inform these trade-offs? (Yes.)



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