15.023J / 12.848J / ESD.128J Global Climate Change: Economics, Science, and Policy
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Effect of Uncertainty and Learning on Decisions

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Course so far…

- Projecting climate impacts
- Costs of GHG emissions reductions
- Analysis under certainty
- Descriptions of uncertainty
  - Probability distributions

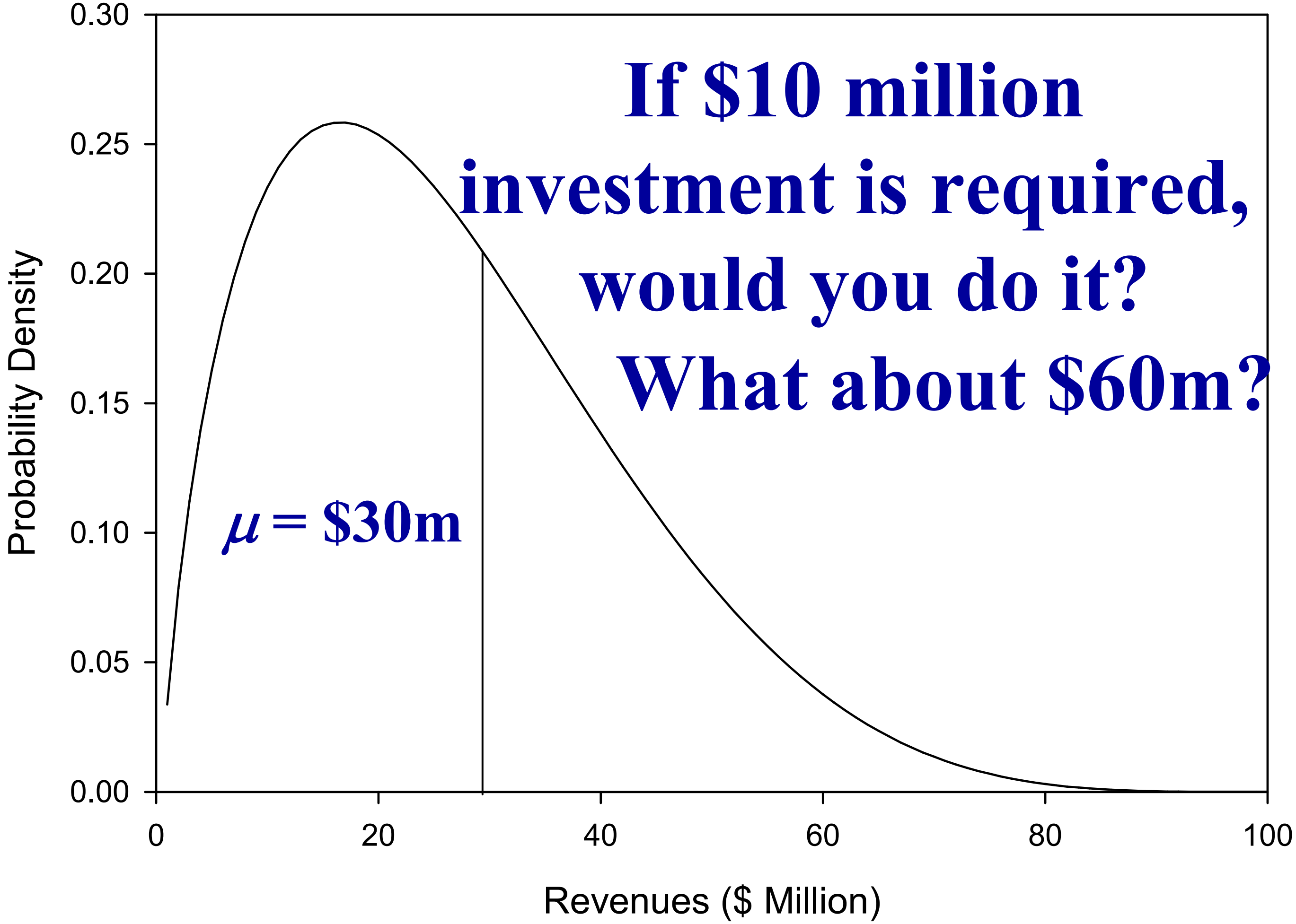
Outline

- Motivation: Why uncertainty matters
- Effect of learning on decisions
- Application of decision analysis to climate policy

Motivation I
The "Question"

Since climate change is so uncertain, shouldn't we just *wait* until we know more?

Why Does Uncertainty Matter?



Why Does Uncertainty Matter?

- If no learning is possible and no risk aversion
  - Make decision based on expected value
- If you can learn and revise along the way
  - May want to do more or less at first (hedging)
- If you are risk-averse
  - You care about more than mean outcomes

What is “Risk-Aversion”?

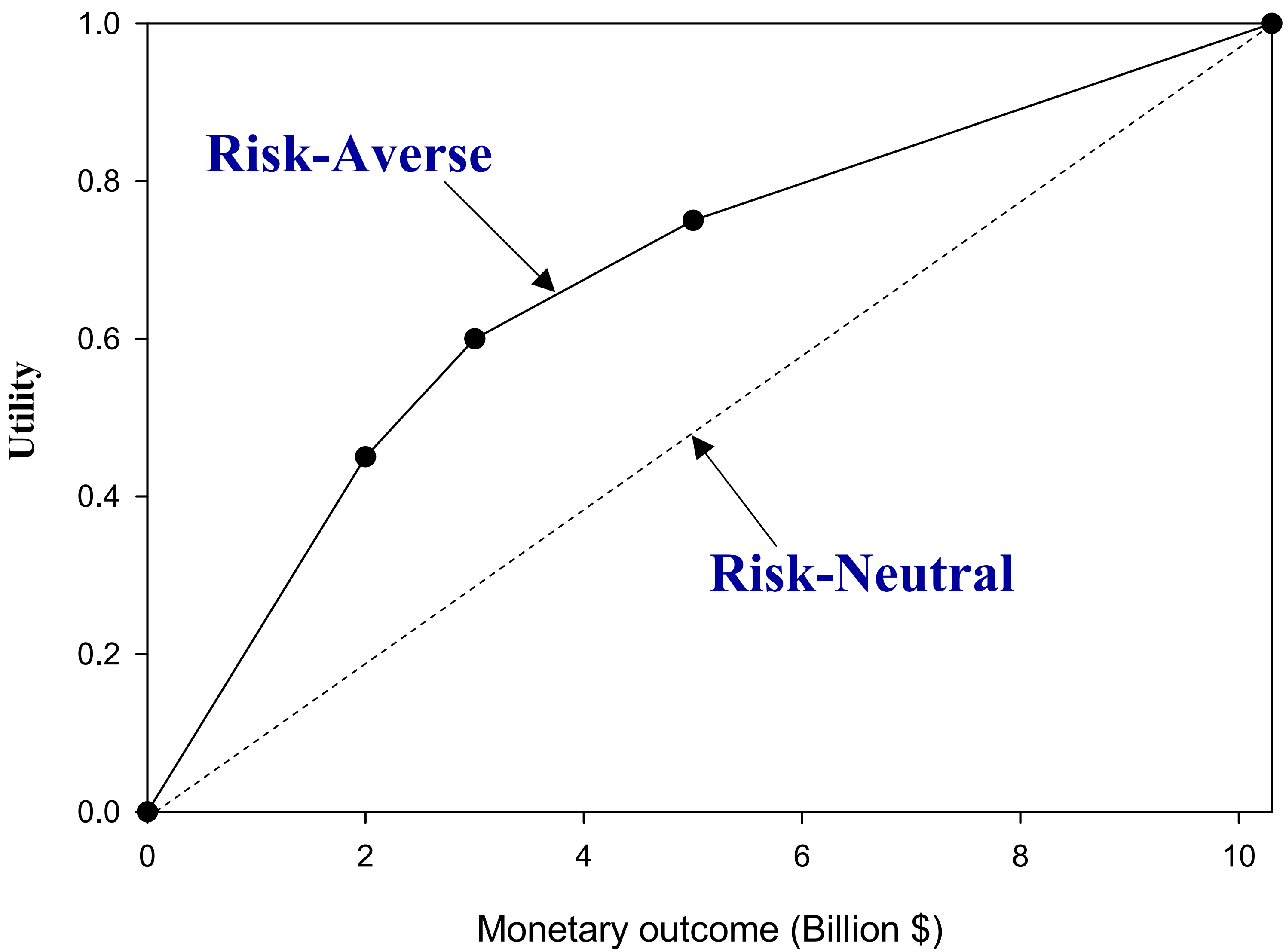
Choose:

A) A gamble with 50% chance of paying \$100 and 50% chance of paying \$0

or

B) Pay \$49 for sure

Risk-Averse Utility Function



Why Does Learning Matter?

- ***Why*** would you do something different today if you can learn tomorrow?

- Answer: if the outcome is irreversible

Arrow-Fisher Irreversibility

- Problem:
  - Two time periods t=1, 2
  - Total forest area = 100
  - Cost of cutting forest $C(x)$
  - Benefits of cutting forest $B(x)$ - UNCERTAIN
  - Choose x_1, x_2 to Max (B-C).
- What is x_1 if you can't learn?
- What is x_1 if you can learn between t_1 and t_2?

Irreversibilities in Climate Change

- GHG Concentrations
  - Temperature Change
  - Climate Damages

- Capital Stock / Economic Investments

DICE
Model of Climate and Economy

- Simple Model of Economy:
  - Capital and Labor Make GDP
  - GDP split between Savings and Consumption
  - CO_2 Emissions from Production
- Simple Climate Model
  - Carbon Cycle – Emissions to Concentrations
  - Radiative Forcing
  - Energy Balance

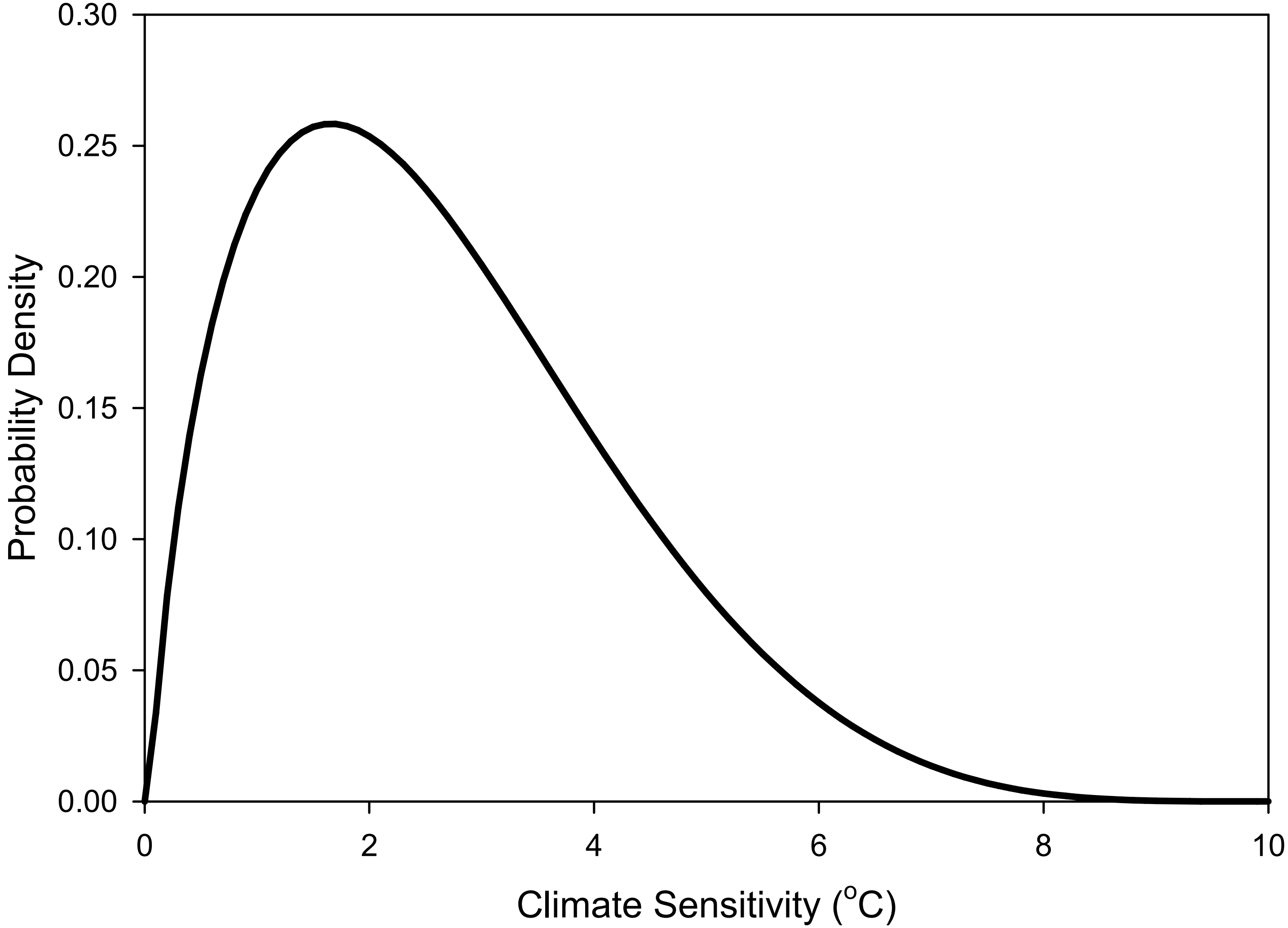
DICE (Continued)

- Policy Variable:
  - Reduce Emissions by Fraction (μ)
  - Abatement Costs $C = f(\mu)$
  - Damage Costs $D = f(\Delta T)$
- Maximize Discounted Utility (Consumption)
- Two Types of Analysis
  - Cost-Benefit (balance abatement costs with damage costs)
  - Cost-Effectiveness (set absolute constraint)

Focus of this Study: Climate Sensitivity

- One of the critical uncertainties
- Defn:
  - Amount of global mean temperature change from a doubling of CO_2 at equilibrium.
- Meaning:
  - Represents net effect of feedbacks in the atmosphere.

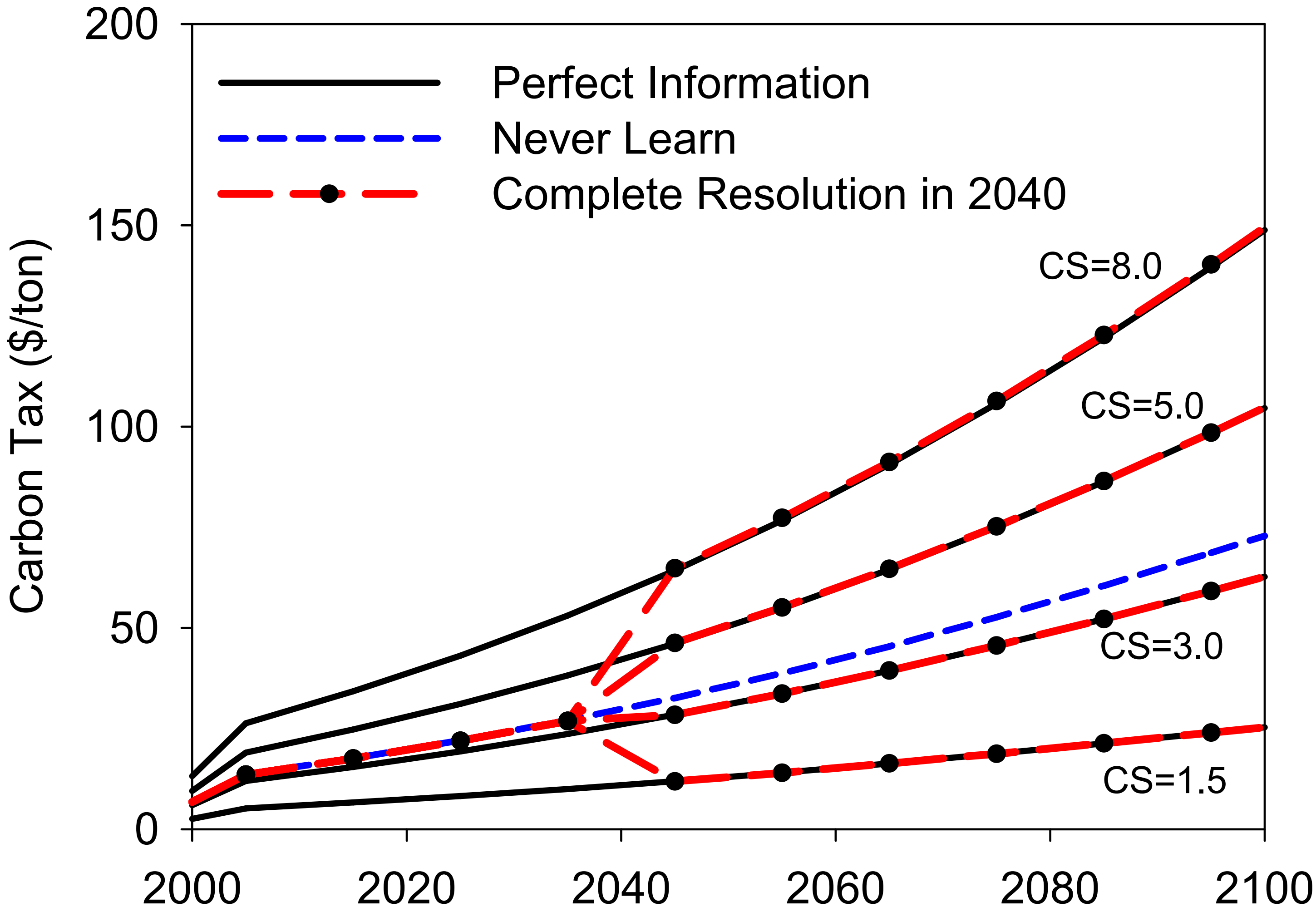
Current Uncertainty in Climate Sensitivity



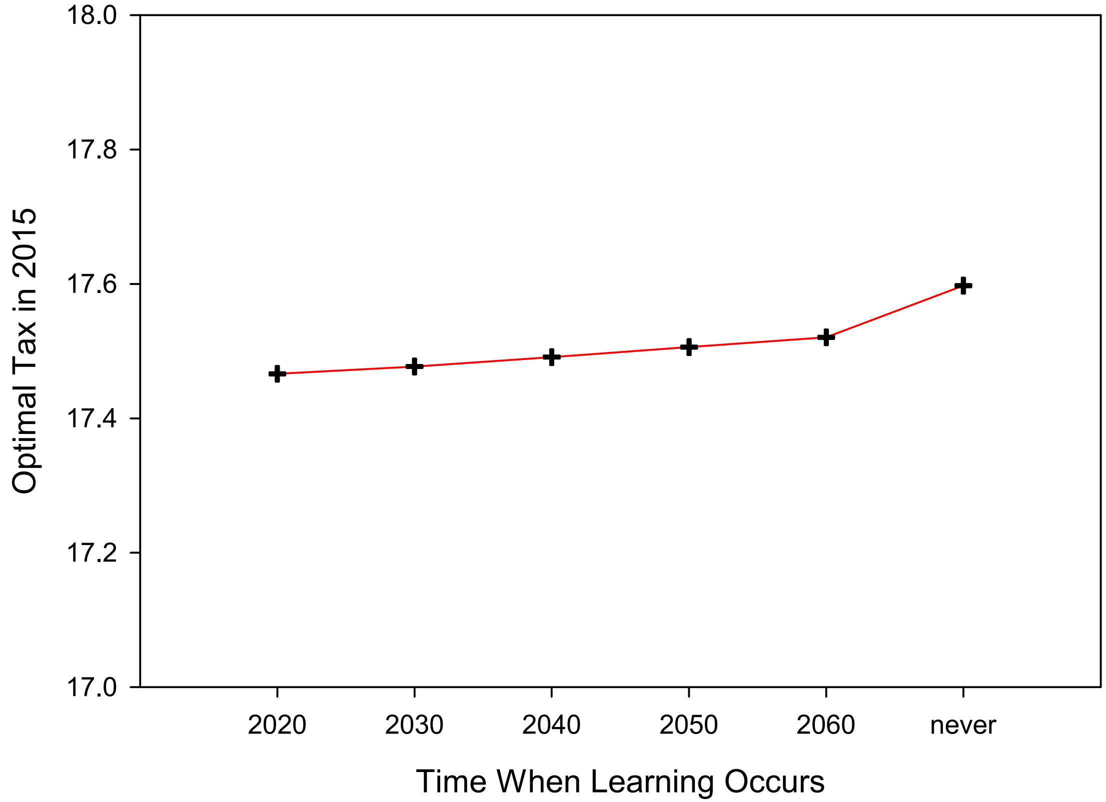
Alternative Analysis Frameworks

- Cost-Benefit
  - Use damage function to monetize climate impacts
  - Find economically efficient path of abatement
- Cost-Effectiveness
  - Pick some target (e.g., concentration or temperature stabilization)
  - Find least cost way to meet target

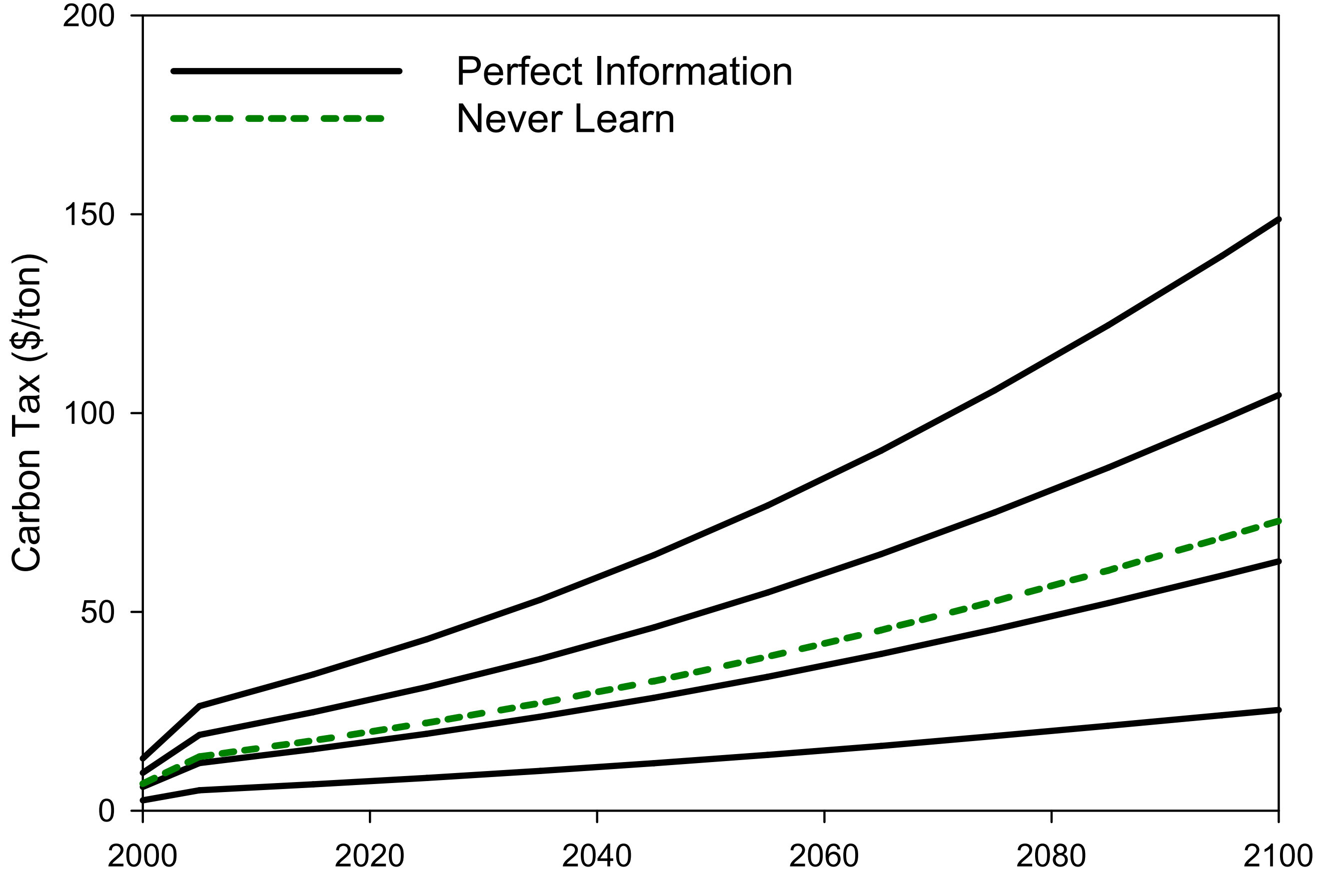
Effect of Learning on Efficient Policy



Effect of Learning under Cost-Benefit

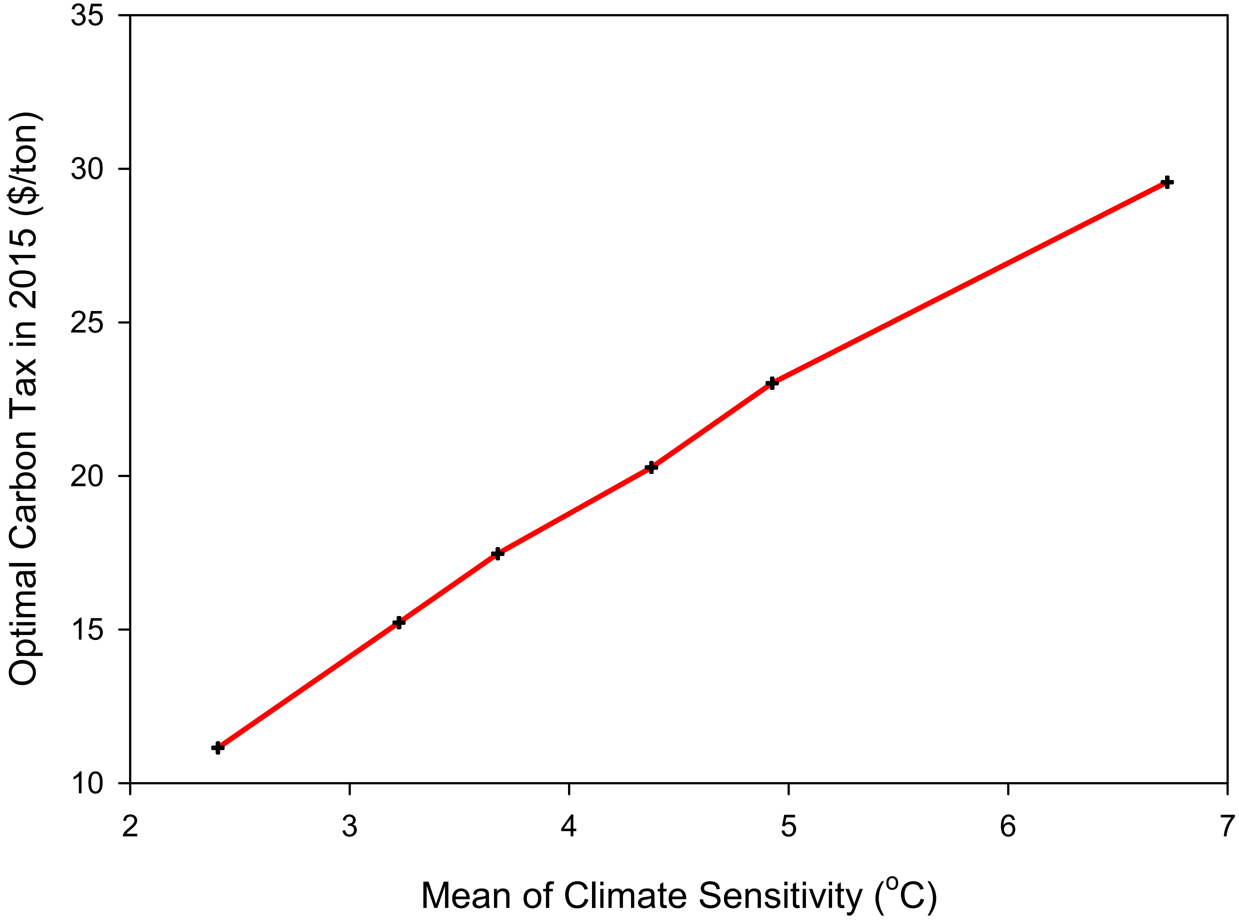


Hedging Policy Under Uncertainty Cost-Benefit Case



What Determines the Optimal Hedge?

Answer: The Shape of the Probability Distribution

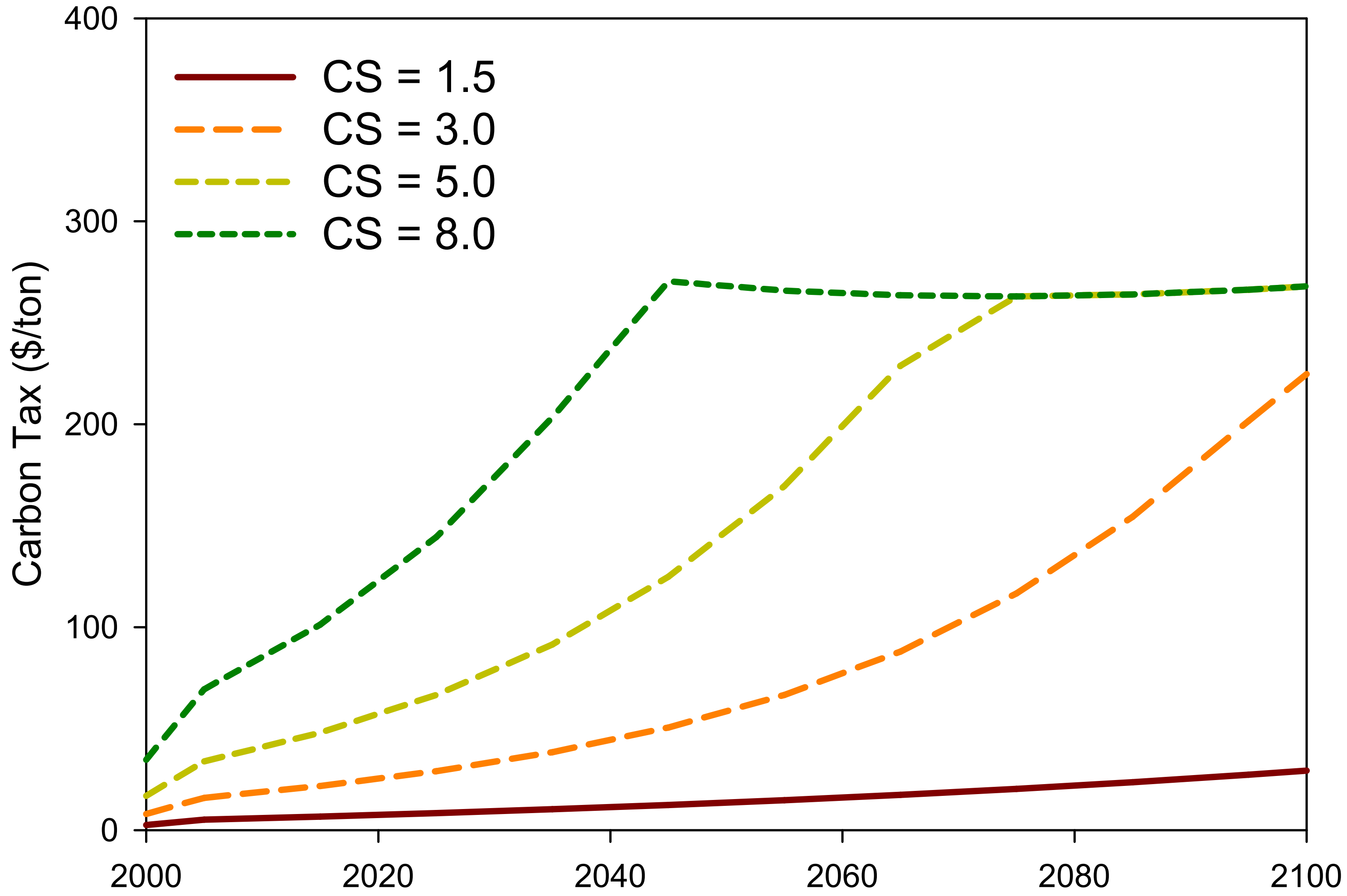


Decision-Making under Uncertainty

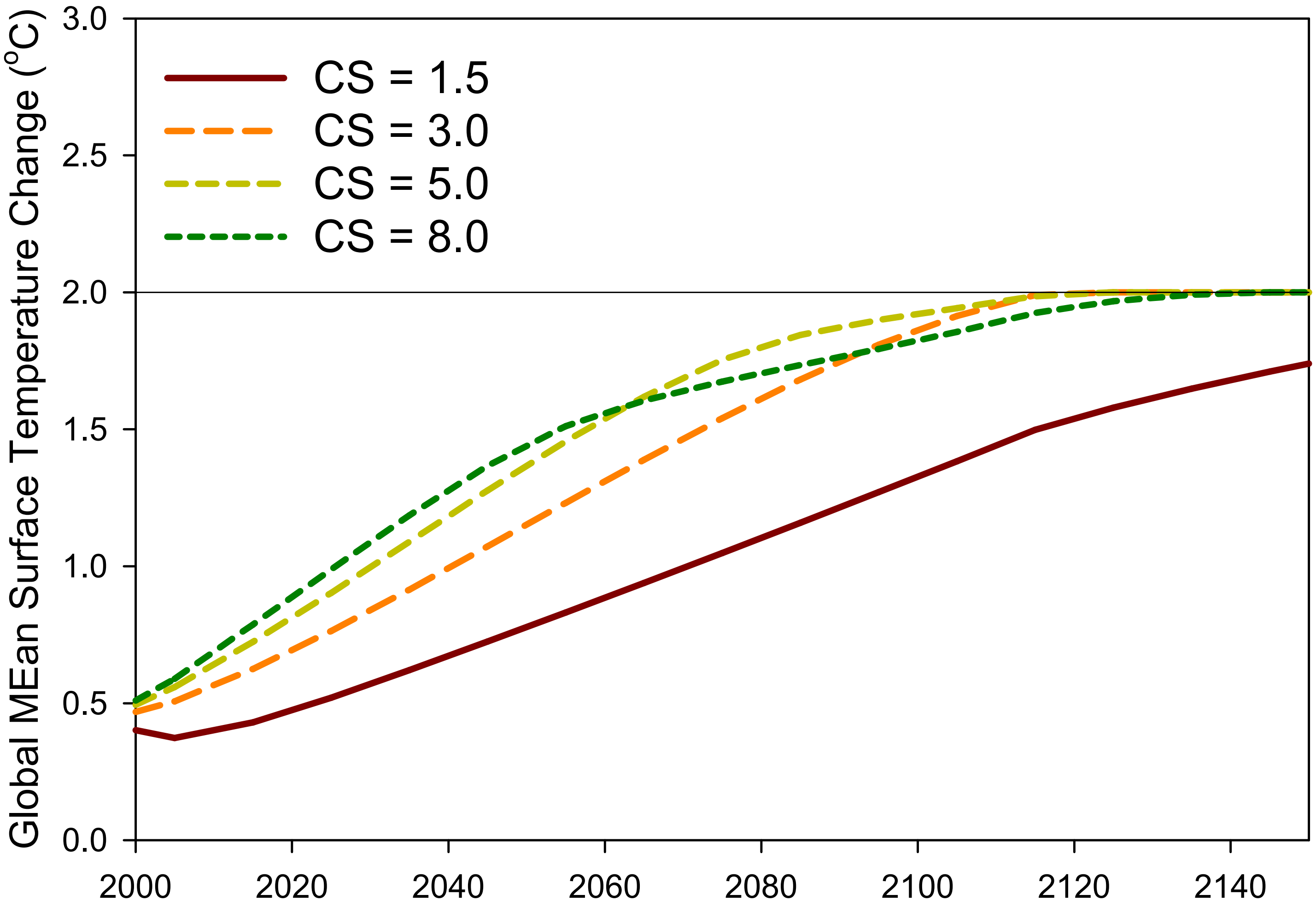
Some Simple Starting Points:

1) What should you do if you KNOW?
2) What should you do if you will NEVER LEARN?
3) What should you do if you don't know, but WILL LEARN at time T?
4) What should you do if you don't know and will reduce your uncertainty at time T?

Illustration: Optimal Carbon Tax for Temperature Target of 2°C



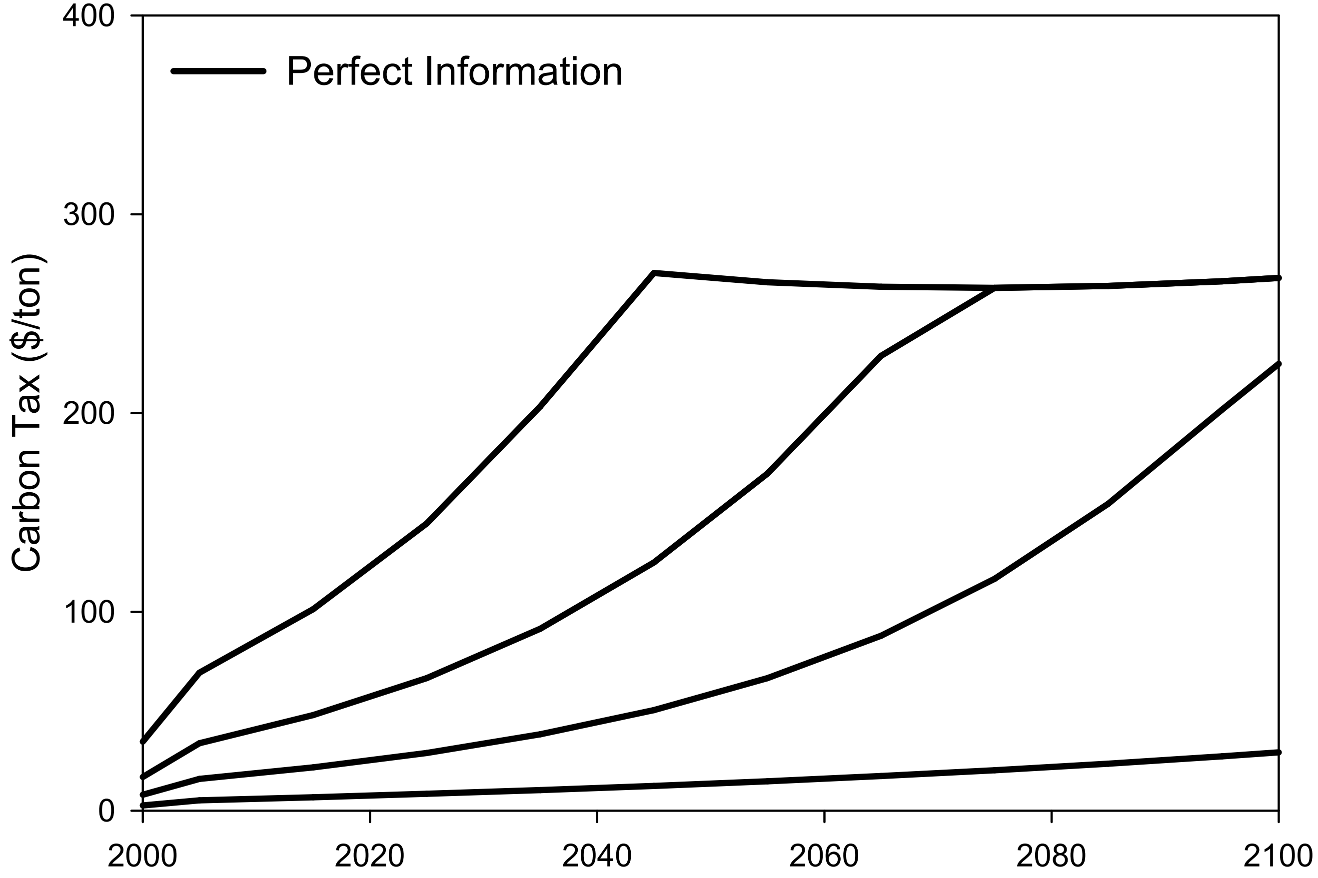
Realized Temperature Change for 2 Degree Target



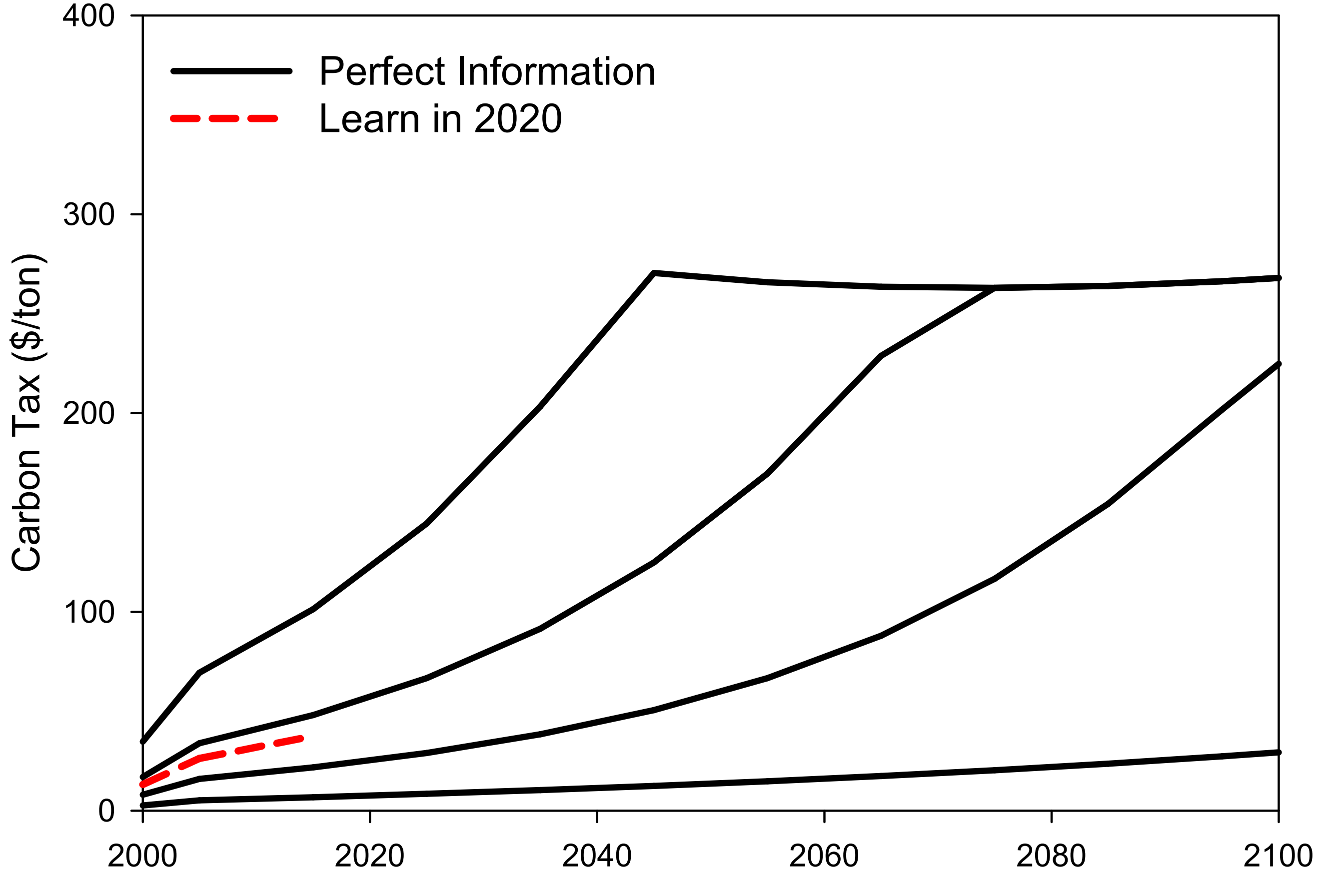
QUESTION: What should we do now if we are uncertain?

- Wait (do nothing until we know more)?
- Implement Highest Tax (worst case)?
- Implement Lowest Tax (best case)?
- Something in the Middle?
  - Where in the middle?

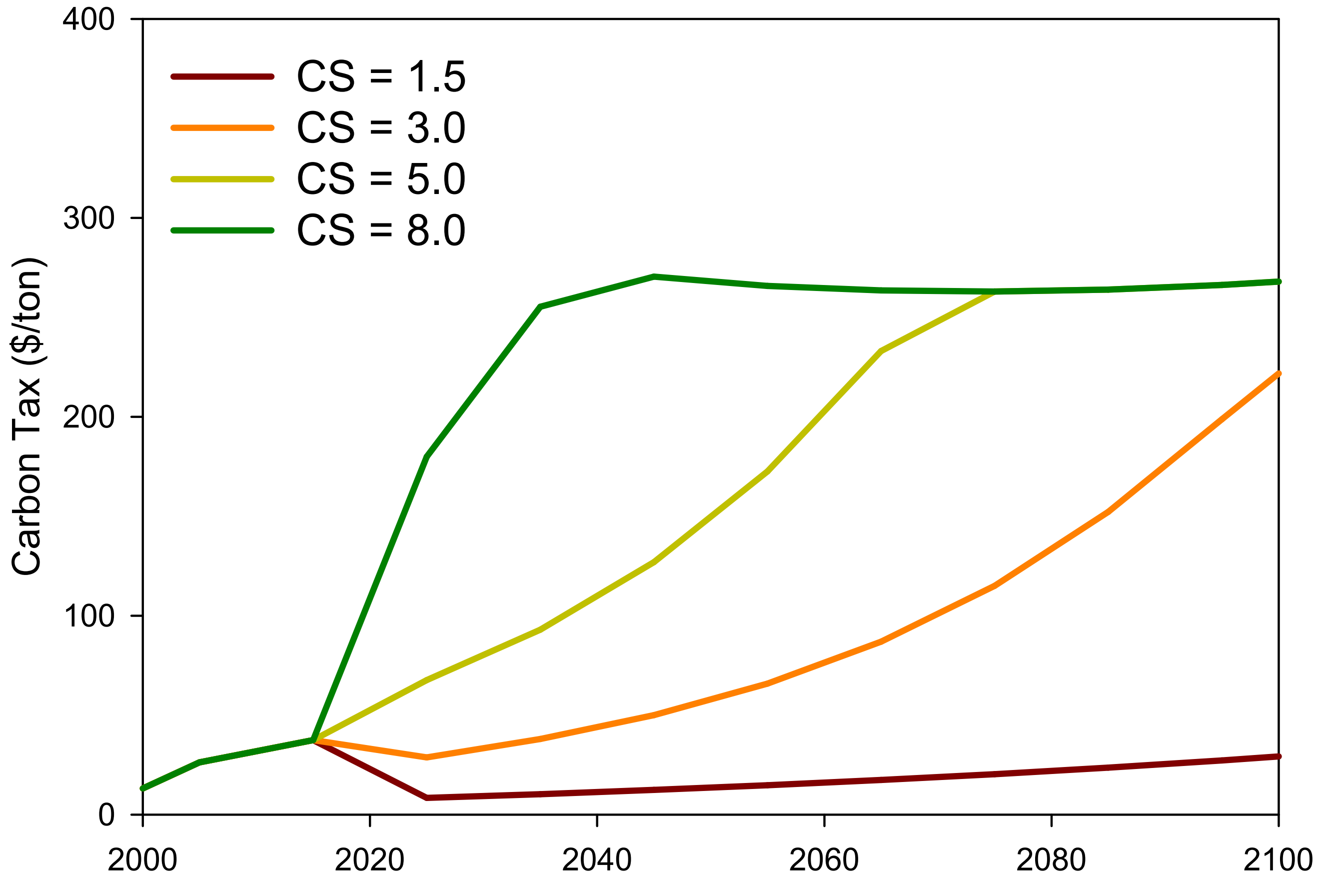
Relative to Best Policy in Each Case…



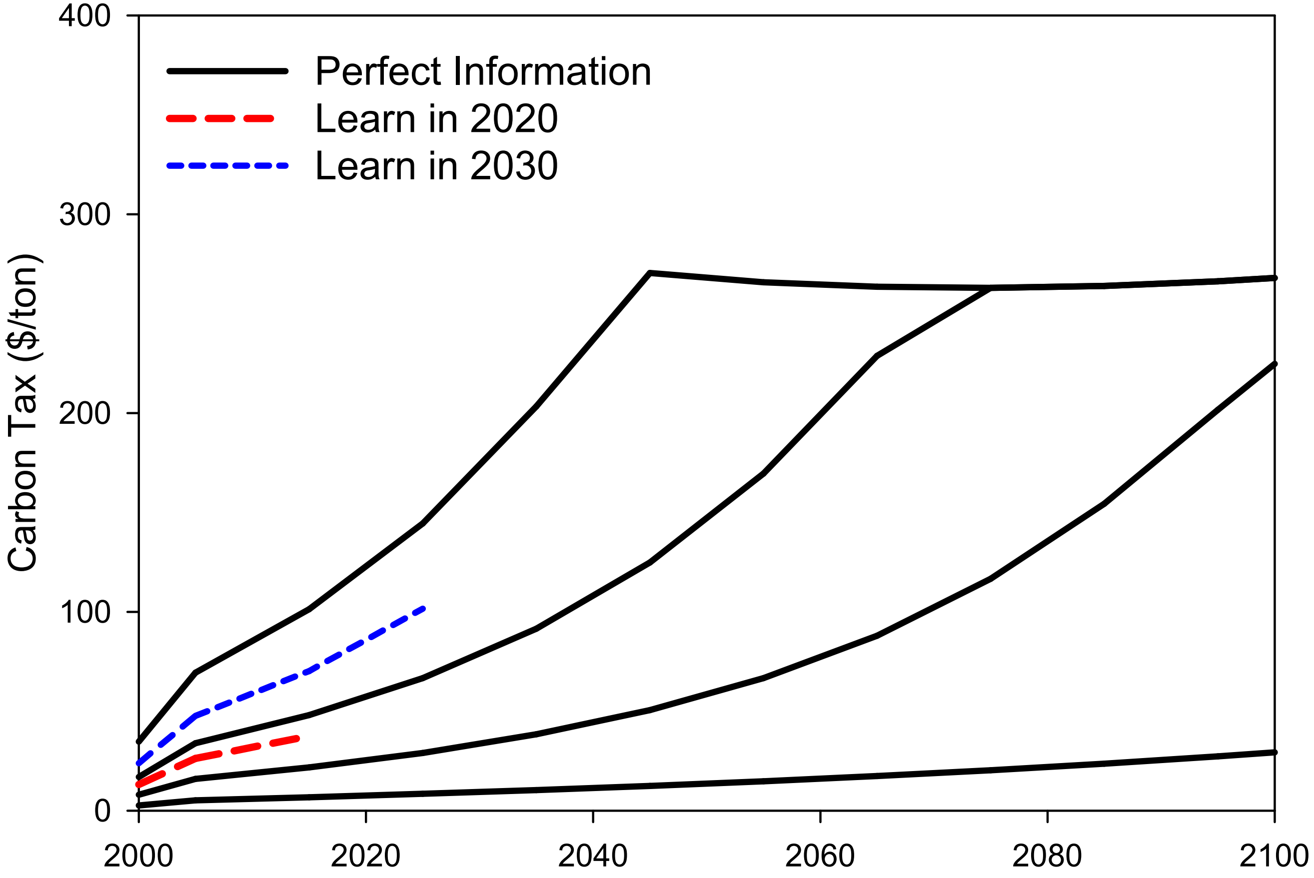
If We Learn in 2020



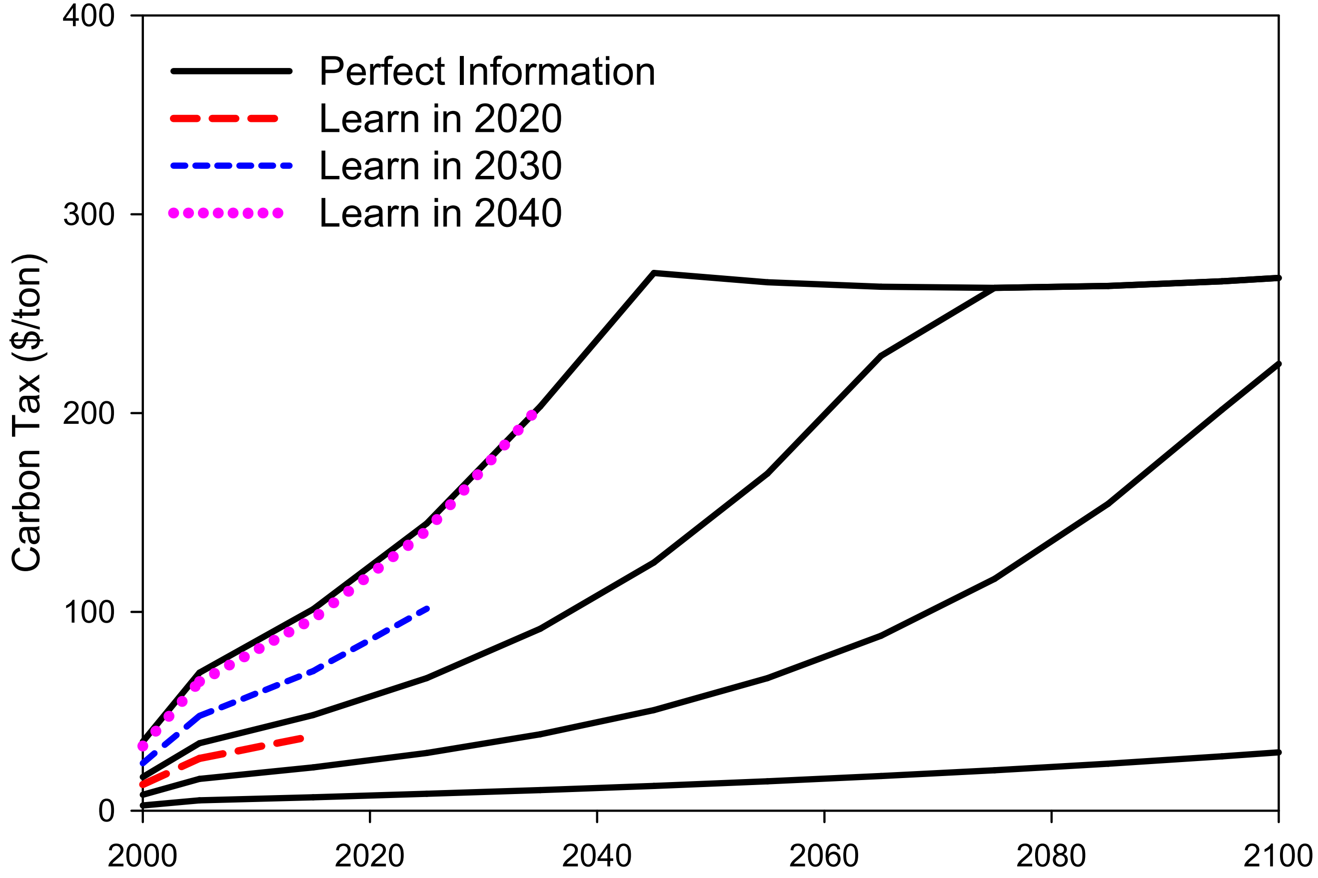
Simulating Learning: Stochastic Programming



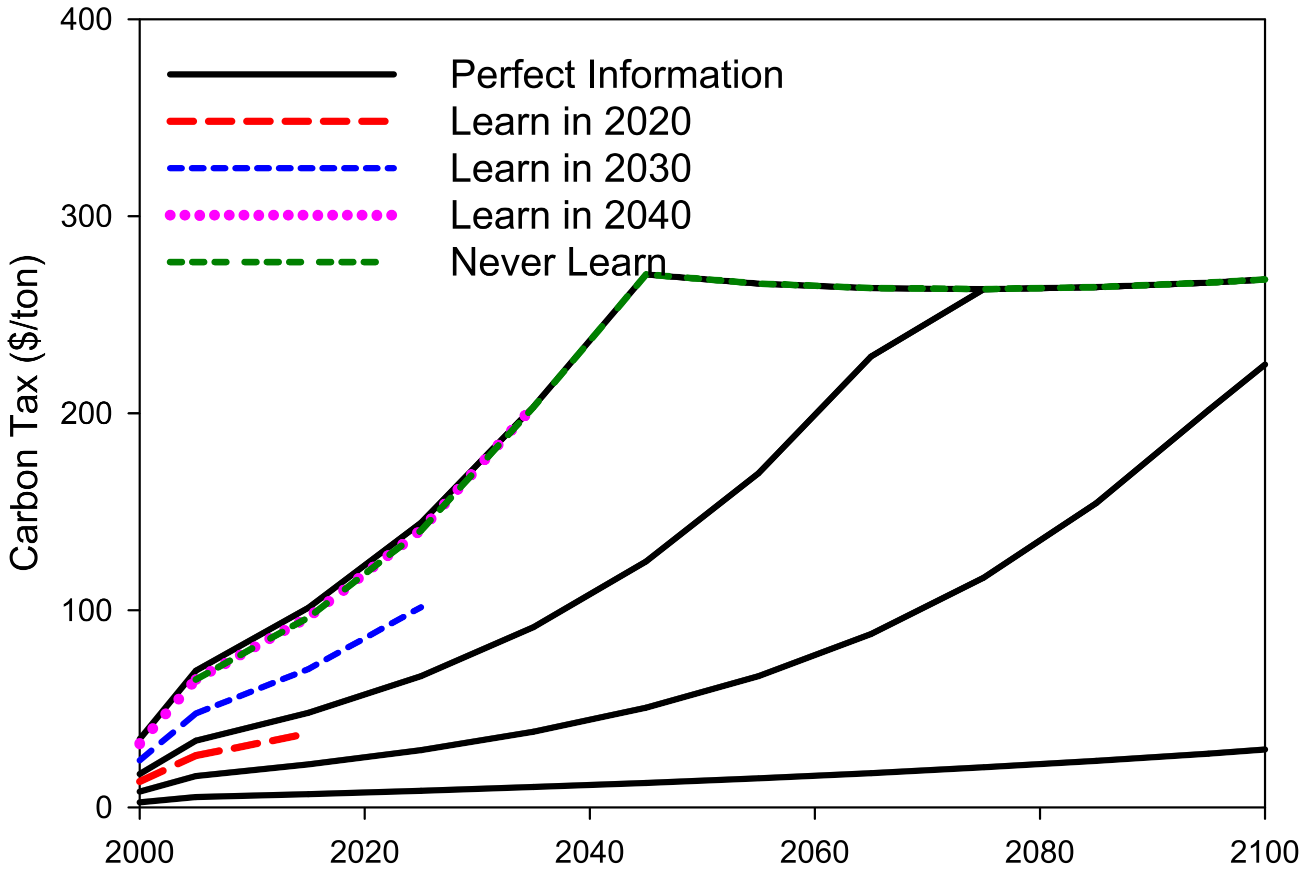
If We Learn in 2030



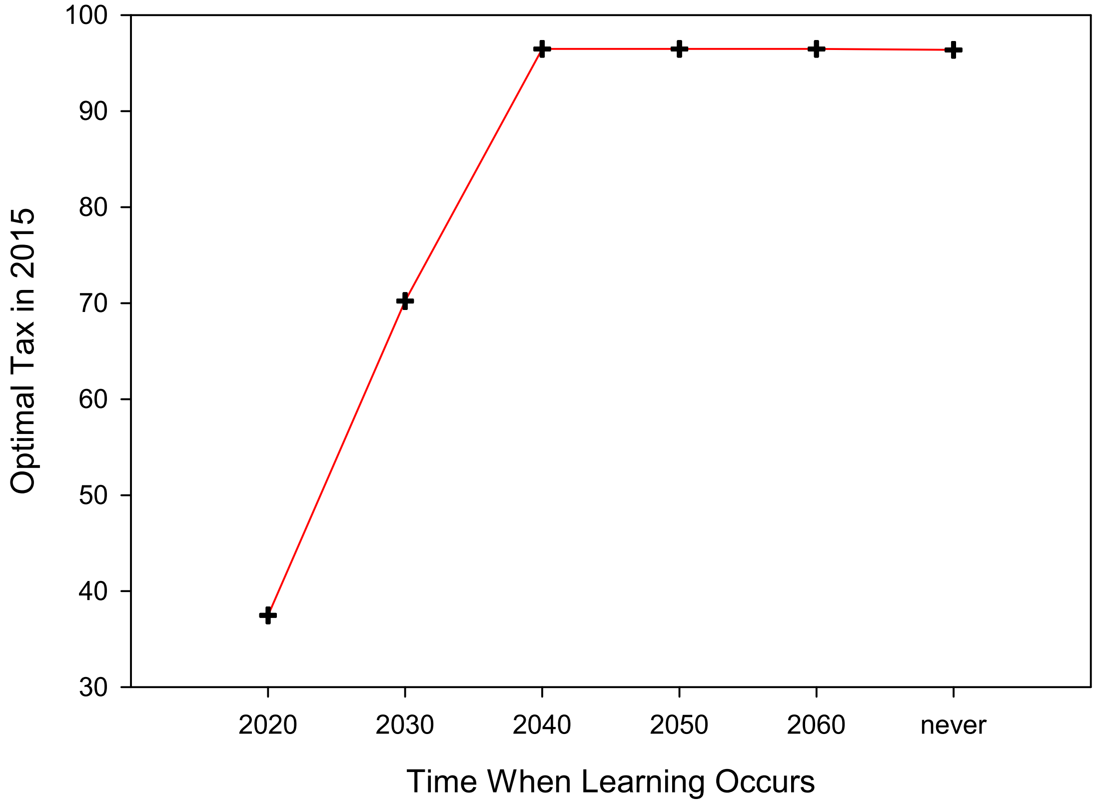
If We Learn in 2040



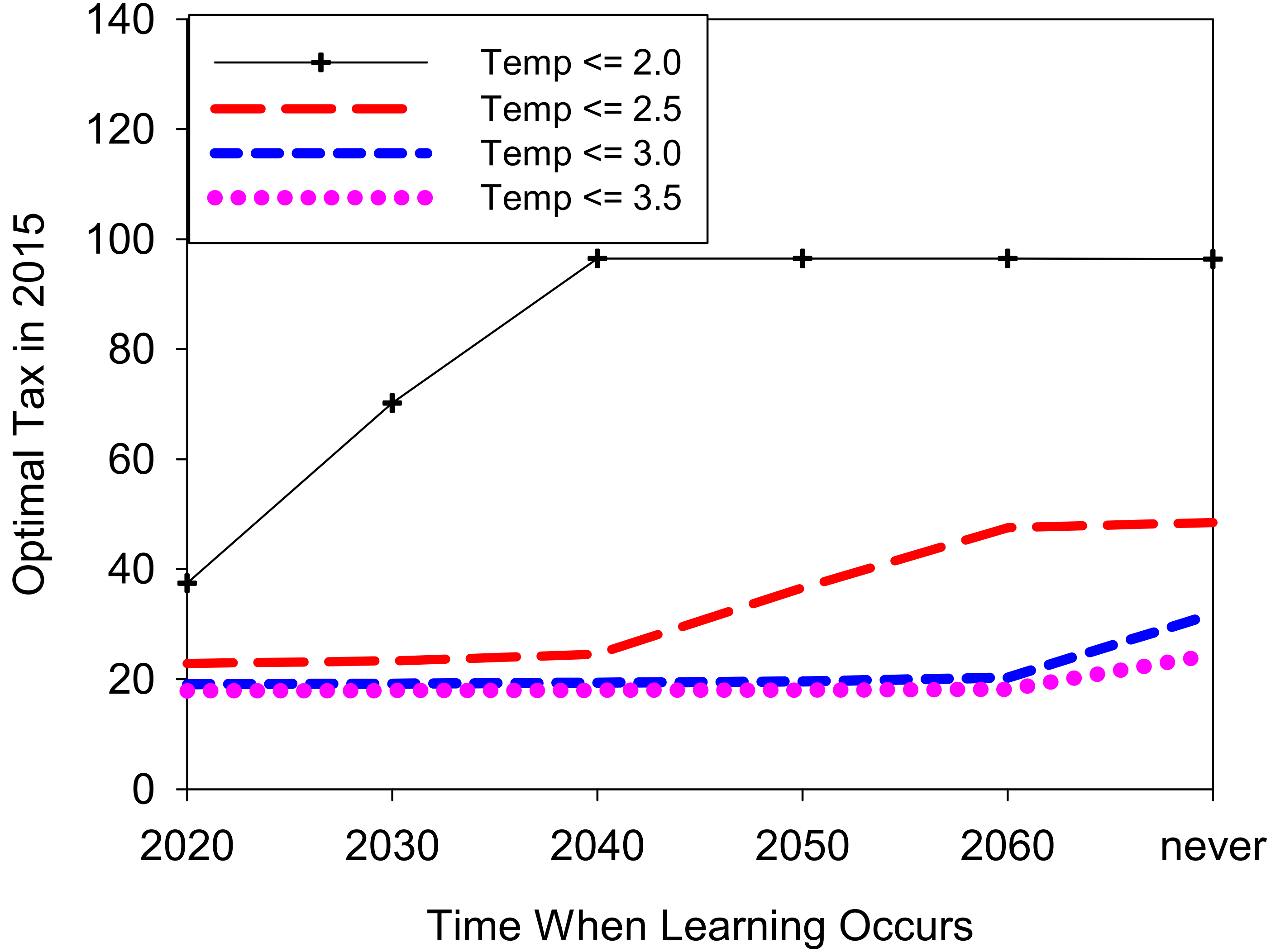
If We Never Learn



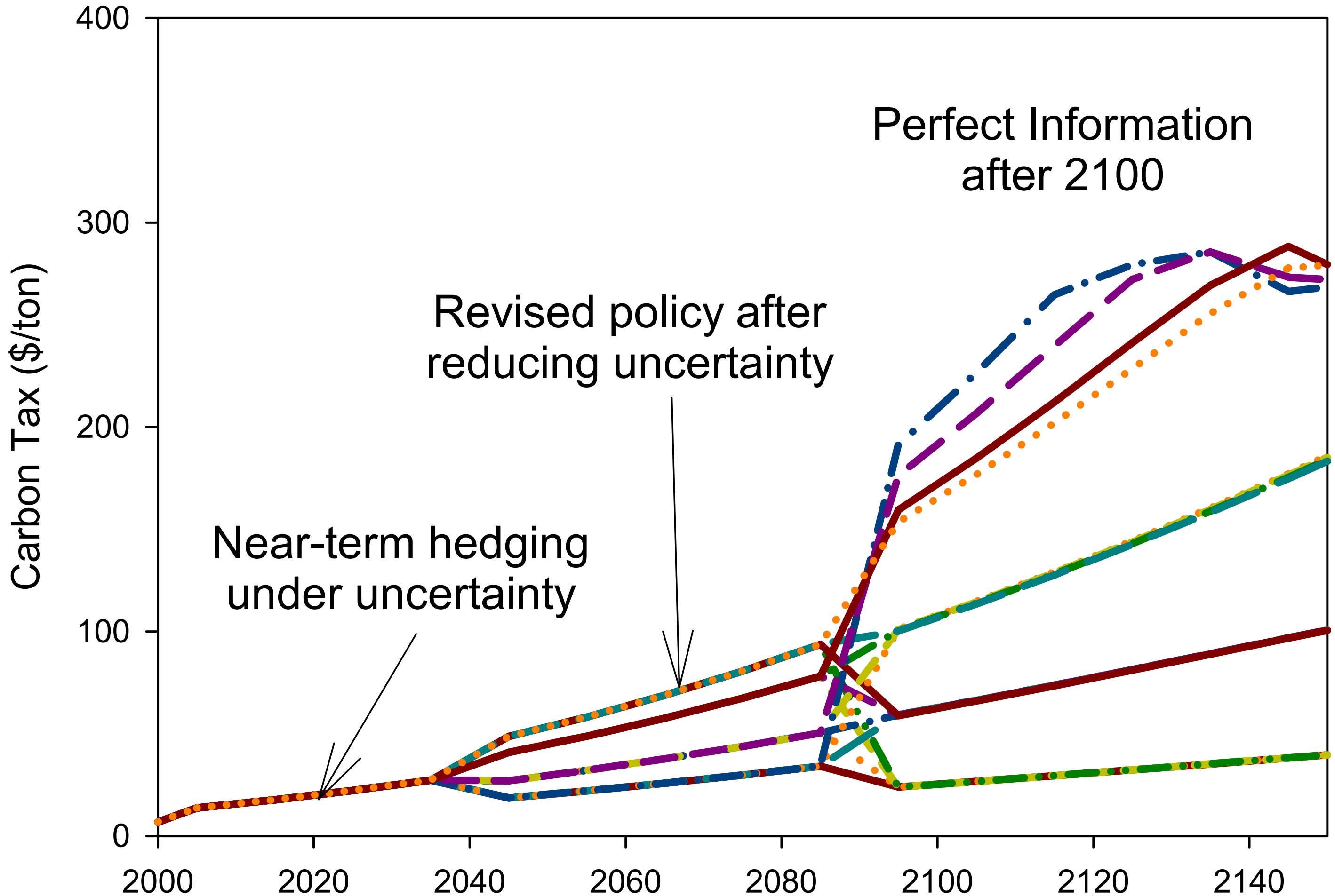
Summary – Effect of Learning Later with 2° target



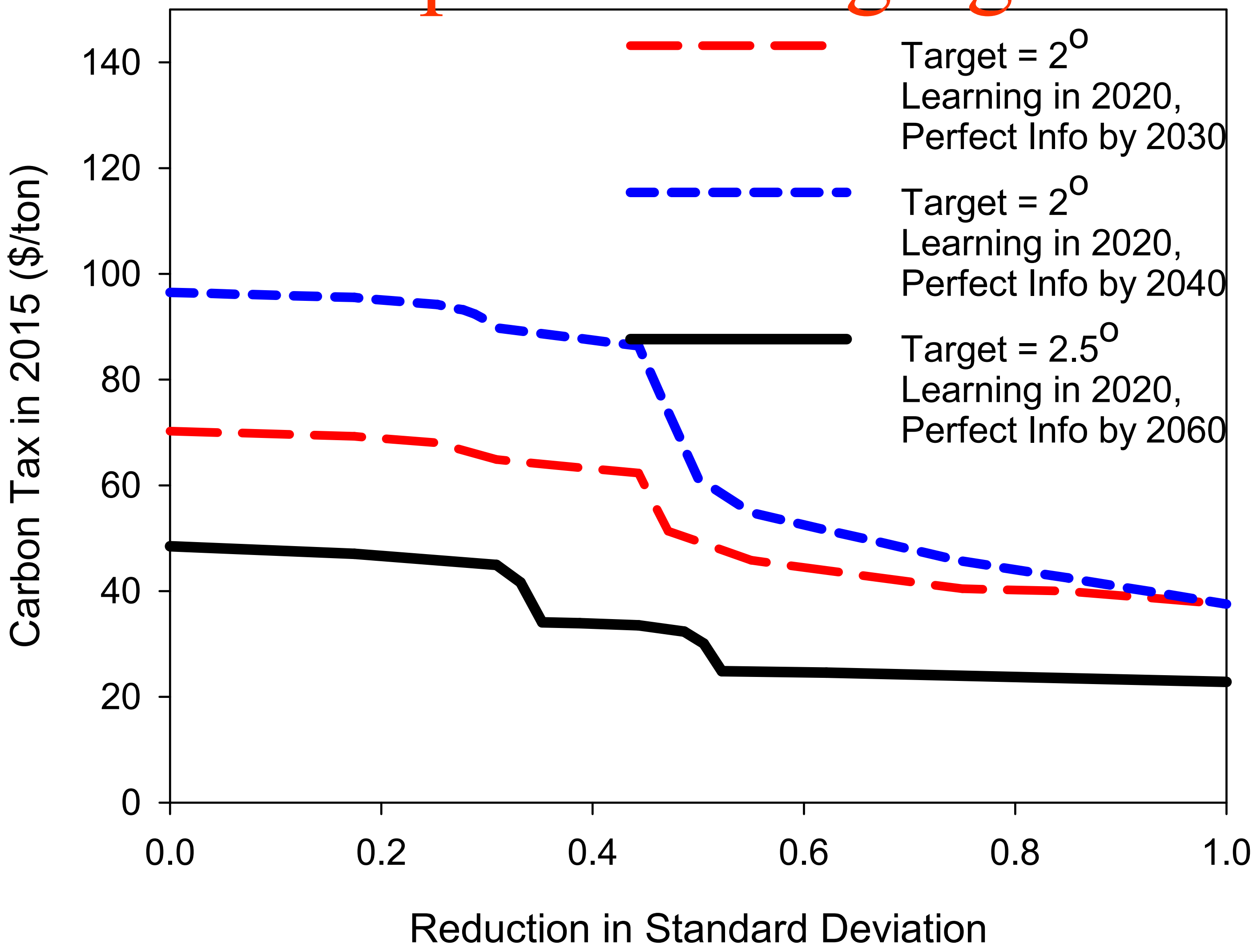
Effect of Learning for Several Temperature Targets



Decision under uncertainty with partial learning



Effect of Partial Learning on Optimal Hedging



Summary

- Wait to Learn?
  - No, start now, adjust later.
  - How much depends on your expectations.

- If I can learn
  - Do a little less now
  - Depends on when you will learn
  - Depends on your goal (stabilization vs balancing costs and benefits)