Risk, Ambiguity, and Misspecification:

Implications for Climate Change Policy

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Uncertainty, Climate Change and Policy Challenges

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A Challenge

> *"The economic consequences of many of the complex risks associated with climate change cannot, however, currently be quantified. ... these unquantified, poorly understood and often deeply uncertain risks can and should be included in economic evaluations and decision-making processes."*

Rising, Tedesco, Piontek, Stainforth, 2022

Haunted by Hayek's forewarning

"Even if true scientists should recognize the limits of studying human behaviour, as long as the public has expectations, there will be people who pretend or believe that they can do more to meet popular demand than what is really in their power."

From Hayek's Nobel address (1974)

Uncertainty tradeoffs

- How much weight do we assign to:
  - best guesses
  - potentially bad outcomes

  when making decisions?
- Should our decision responses be more proactive or more passive?
- Do we act now, or do we wait until we learn more?

Decision theory

Provides:

- axiomatic formulations of "rationality" in the presence of uncertainty, broadly conceived
- tractable ways to capture alternative uncertainty components in dynamic environments
- a framework for confronting deep uncertainties

Statisticians' wisdom

"Since all models are wrong, the scientist must be alert to what is importantly wrong. It is inappropriate to be concerned about mice when there are tigers abroad." Box (1976).

"The very word "model" implies simplification and idealization. The idea that complex physical, biological or sociological systems can be exactly described by a few formulae is patently absurd. The construction of idealized representations that capture important stable aspects of such systems is, however, a vital part of general scientific analysis and statistical models, especially substantive ones ... " Cox (1995).

Three recent decision theory contributions

- "Structured ambiguity and model misspecification" with Sargent (*Journal of Economic Theory*, 2022)
- "Risk, ambiguity, and misspecification: Decision theory, robust control, and statistics" with Sargent (Invited Lecture: *Journal of Applied Econometrics*, 2023)
- "Making decisions under model misspecification" with Cerreia-Viglio, Maccheroni, and Marinacci (2024)

The basic ideas emerged in earlier work.

Formalizing uncertainties

- allow for a broad perspective on uncertainty
  - risk - unknown outcomes with known probabilities
  - ambiguity - unknown weights to assign to alternative probability models
  - misspecification - unknown ways in which a model might give flawed probabilistic predictions
- include formulations that are dynamic and recursive
- confront "deep uncertainties"

Approach

- draw on and develop modifications of Savage-style axiomatic formulations from decision theory to extend notions of uncertainty beyond risk in ways that make contact with applied challenges in economics and other disciplines
- distinguish concerns about misspecification of likelihoods from concerns about the misspecification of priors
- computationally tractable methods of implementation that include an adversarial second decision maker that explores systematically the consequences of changing the probabilistic inputs relative to a baseline specification

This opens the door to better ways for conducting uncertainty quantification for dynamic, stochastic models used for private sector planning and governmental policy assessment.

Goals and inputs

Goals:

- ▷ assess the impact of uncertainty on prudent decision or policy outcomes
- ▷ isolate the forms of uncertainty that are most consequential for these outcomes.

Inputs:

- ▷ tools from probability and statistics to limit the type and amount of uncertainty that is entertained
- ▷ aversion to or dislike of uncertainty about probabilities over future events

Refined uncertainty quantification

Three questions:

- How much uncertainty aversion should we impose?
  - trace through sensitivity to the choice of penalty parameters or constraints to determine the implications
- What are the probabilistic adjustments induced by this aversion?
  - inspect the impact on the implied worst-case distributions from the implied min-max problem
- Which channels of uncertainty matter the most?
  - activate the robustness concerns one channel at a time
  - compare the decision outcomes to those from a decision problem with all concerns activated simultaneously

Two applications of "quantitative storytelling"

- Dynamic climate policy under uncertainty
- Prudent land allocation in the Brazilian rainforest

Dynamic climate policy under uncertainty

- There are many calls for immediate climate policy implementation.
- Existing limits to our understanding of the timing and magnitude of climate change impacts have led to apprehension by some.
- We study how a prudent decision-maker confronts uncertainty in a setting where:
  - there will be future information about damage severity
  - but the value of further empiricism in the near term is limited
  - research and development investment hastens the uncertain discovery of a green technology

Joint research with Barnett, Brock and Zhang: "How Should Climate Change Uncertainty Impact Social Valuation and Policy?"

What is the challenge?

Four sources of uncertainty:

- ▷ productivity: capital investment today alters future output
- ▷ geosciences: CO_2 emissions today impact the future climate
- ▷ economics: climate change in the future alters economic opportunities and social well-being
- ▷ technology: research and development investment today may eventually lead to the discovery of economically viable technologies

Research question: Which of the four sources is of most concern for designing policy?

Findings

Our initial research shows that:

- the unknown timing of the success of the R&D investment is the most potent contributor to uncertainty for climate-economics policy;
- this source of uncertainty leads to doing more green R&D investment;
- need to reduce emissions in the short term to allow for R&D to have a chance to be successful, even though this response is less sensitive to uncertainty.

Land allocation in the Brazilian rainforest

- land can be used to plant trees and absorb carbon or it can be used for agriculture, including grazing cattle
- uncertainty about land use productivities that is very high dimensional

We build a spatial-dynamic model of prudent land use choice under uncertainty to measure the social cost and benefit of preserving the Amazon rain forest. We document which sources of uncertainty should be of most concern for alternative specifications of the social costs of carbon emissions.

Joint with Assuncao, Munson, and Scheinkman: "Carbon prices and forest preservation over space and time in the Brazilian Amazon"

Concluding remarks

- Uncertainty matters for policy tools like the social cost of global warming and social investment in green research and development
- Understanding the sources of uncertainty, broadly conceived, used by the private sector and by governments will make economic policy more effective.