Towards a Holistic Integration of Energy Justice and Energy System Engineering

Preliminary Exam

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ILLINOIS

Outline

Presentation Goals

I have the following goals for this presentation:

1. **Motivate** why social science and quantitative modeling *must* be more strongly integrated (based on the relations among three types of uncertainty).
2. **Demonstrate** how `Osier` currently accomplishes this goal.
3. **Propose** future work to enhance `Osier`'s capabilities and validate its usage.

Proposal Overview

I propose to:

1. **Deepen** the theoretical foundations of this work.
2. **Develop** an optimization tool (`Osier`) that
   - addresses three related uncertainties,
   - closes the gap between technical expertise and public preferences,
   - enhances justice outcomes related to energy planning.
3. **Validate** this tool by conducting a case study of energy planning processes in the Champaign-Urbana region.

Outline

Anthropogenic Climate Change

- Climate change is happening!

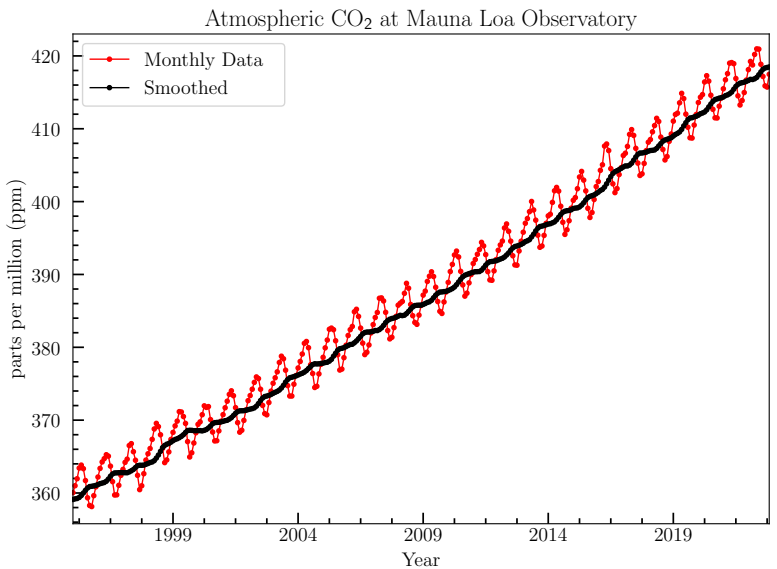


Figure 1: Observed increase in CO_2 levels at Mauna Loa Observatory [6].

Anthropogenic Climate Change Exists

- Climate change is happening!

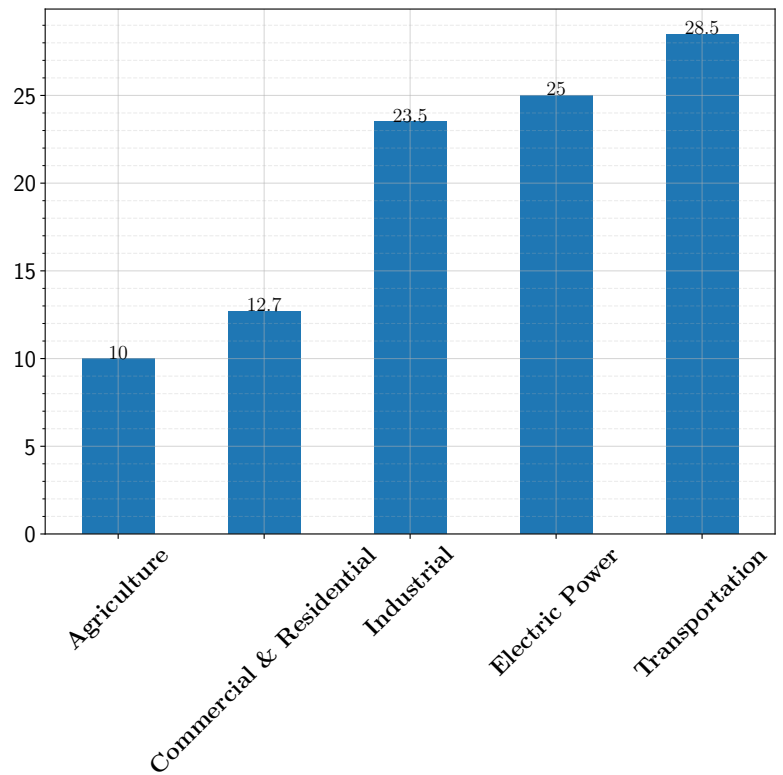


Figure 2: Carbon emissions by economic sector

Outline

Triarchic Theory of Model Development

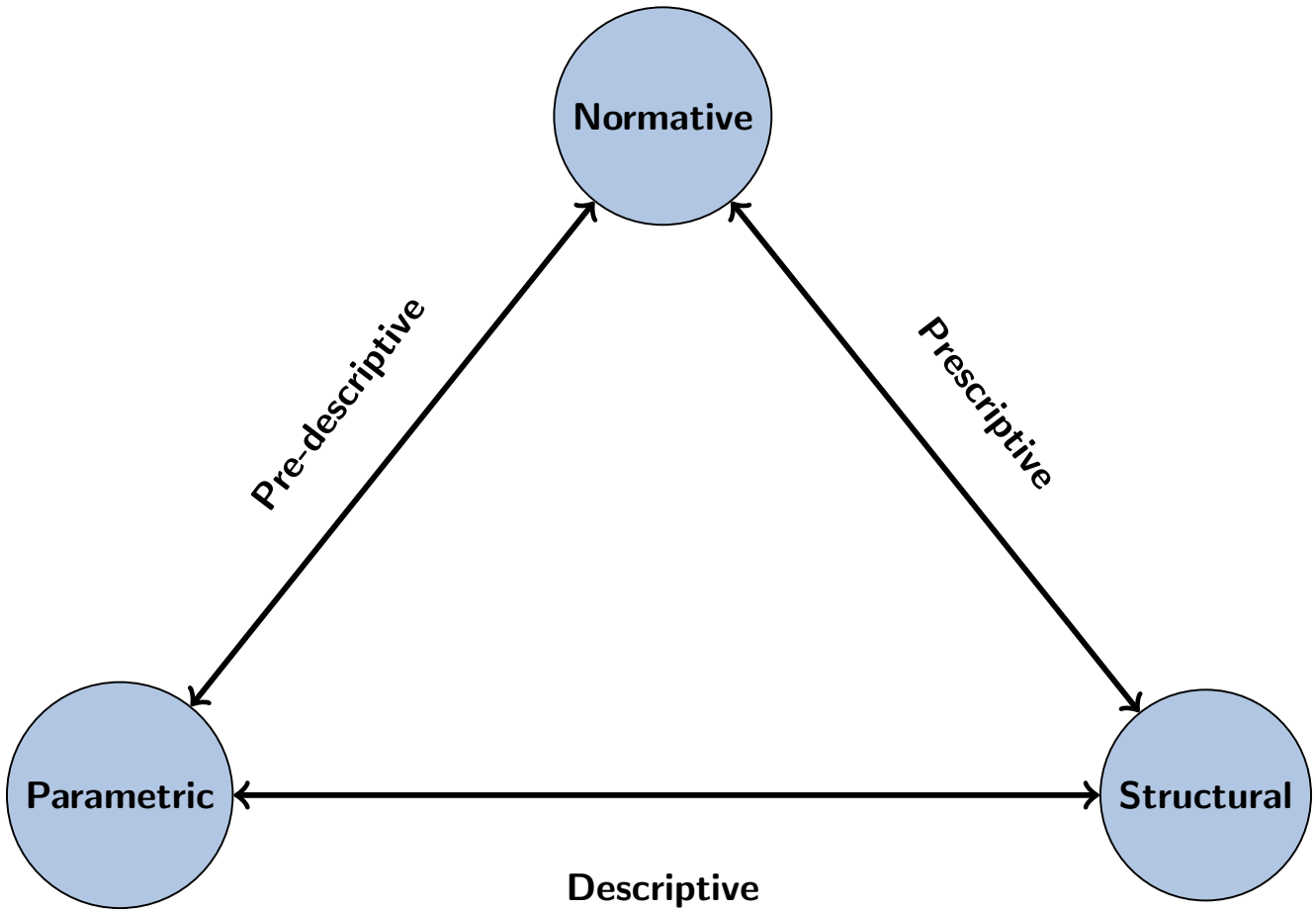
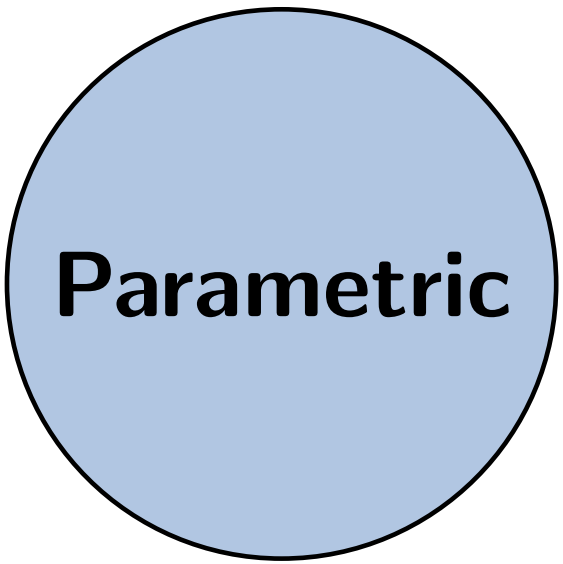


Figure 3: A summary of three uncertainties and their interactions.

Parametric Uncertainty



Definition (Parametric Uncertainty)

Related to uncertainty in model inputs (empirical values). The most commonly addressed type of uncertainty in science and engineering [13, 2, 10].

May be classified as either **aleatory** or **epistemic** [11, 8].

Examples of Parametric Uncertainty

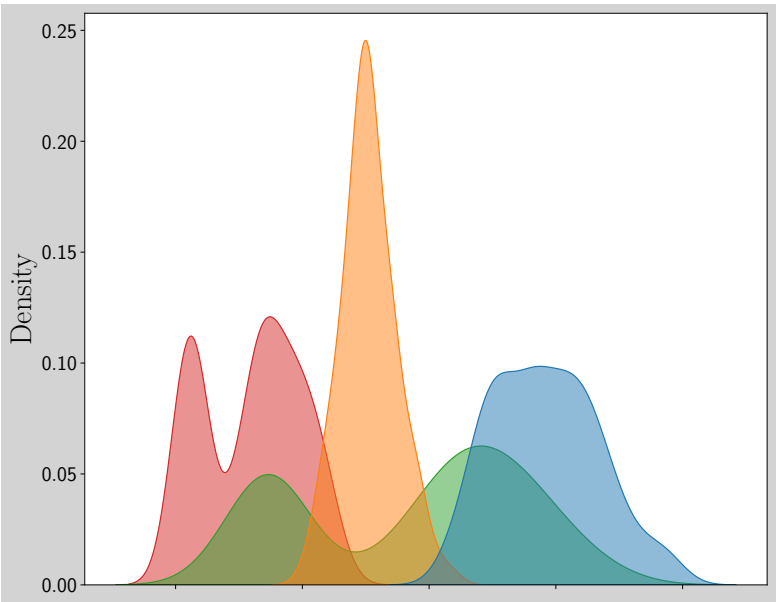


Figure 4: Possible distributions of several parameters.

- Rates (e.g., interest, learning, growth),
- costs (e.g., fuel, capital, O&M),
- aggregated energy demand,
- spent fuel burnup [4],
- nuclear cross-section data [3, 12],
- likelihood and magnitude of consequences (i.e., probabilistic risk assessment).

Addressing parametric uncertainty

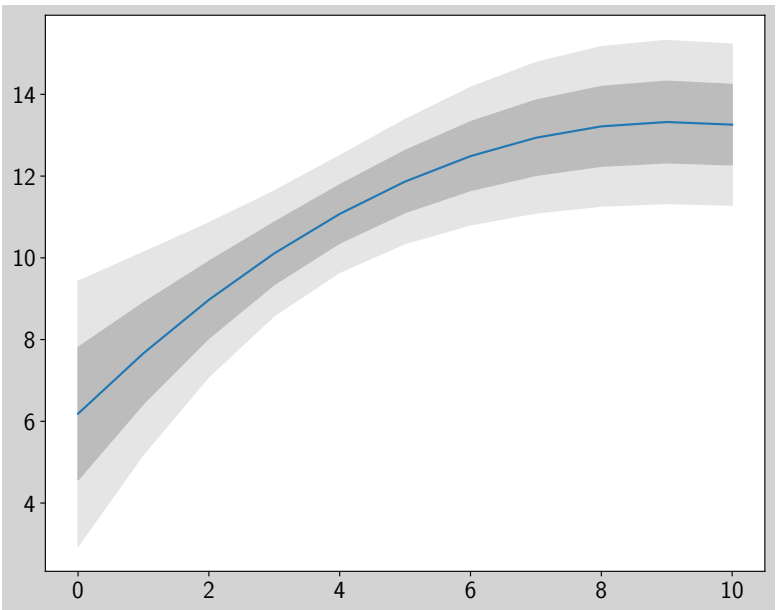


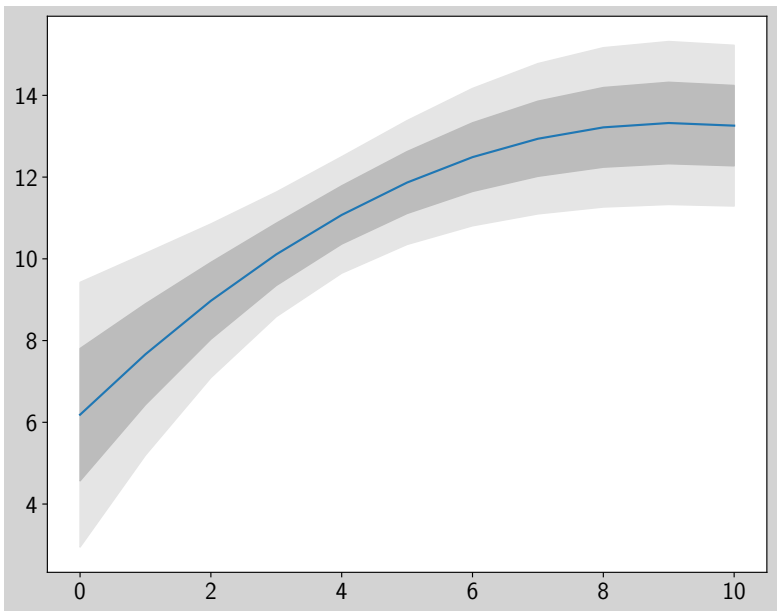
Figure 5: Addressing parametric uncertainty produces confidence intervals.

Idea: Rerun a simulation until you reach a large enough sample size to do statistics.

Formal methods to address parametric uncertainty*:

- "Monte Carlo" (i.e., statistical sampling)

Addressing parametric uncertainty



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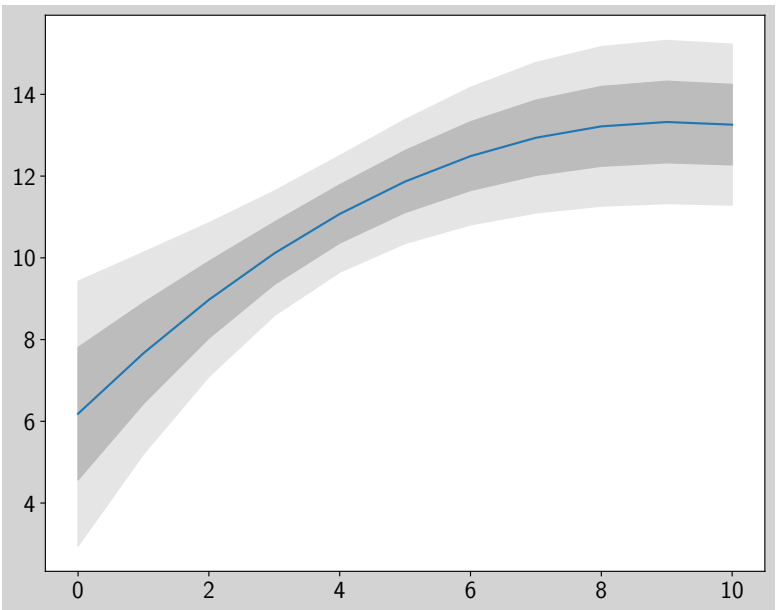
Addressing parametric uncertainty



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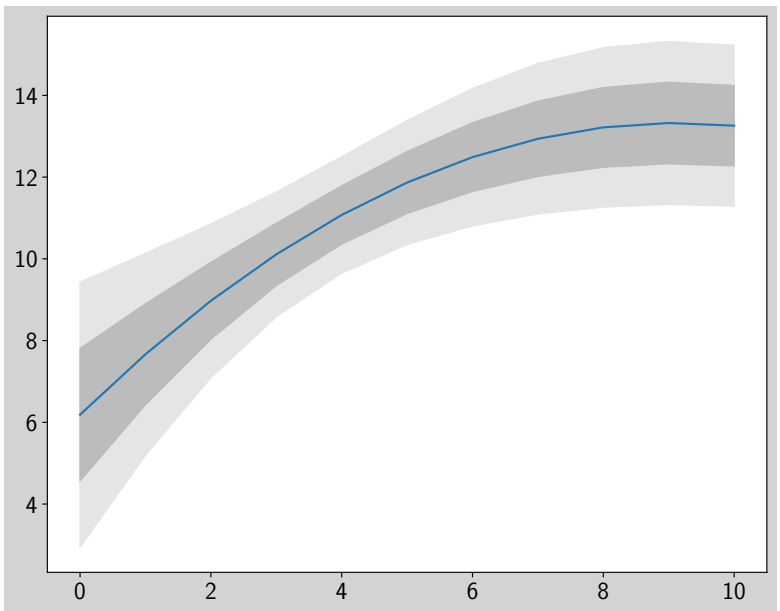

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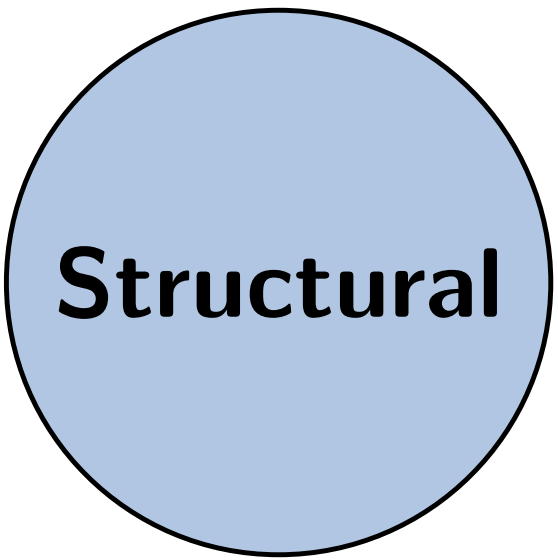
- Stochastic optimization

*These methods are appropriate for **aleatory** uncertainties.

Structural Uncertainty



Definition (Structural Uncertainty)

[R]efers to the imperfect and incomplete nature of the equations describing the system [2].

This type of uncertainty will *always* persist.

Examples of Structural Uncertainty

- Objective functions (most typical)

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- Spatiotemporal resolution

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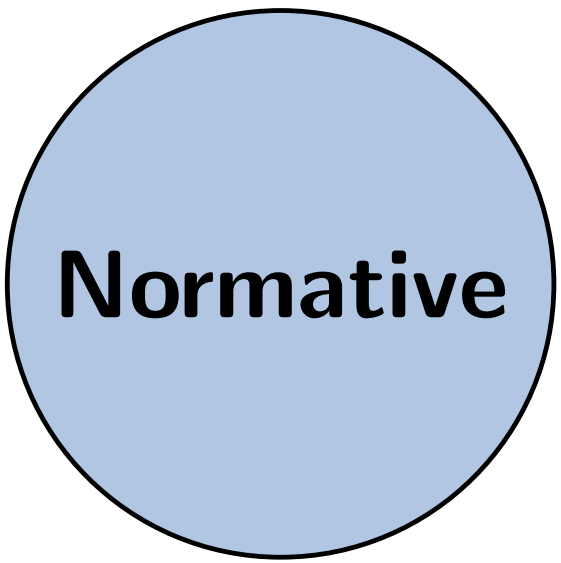
Examples of Structural Uncertainty

- Objective functions (most typical)
- Spatiotemporal resolution
- Physics fidelity
- Solution method

Addressing Structural Uncertainty

Normative Uncertainty

Stating your assumptions is a necessary but insufficient condition for addressing normative uncertainty.

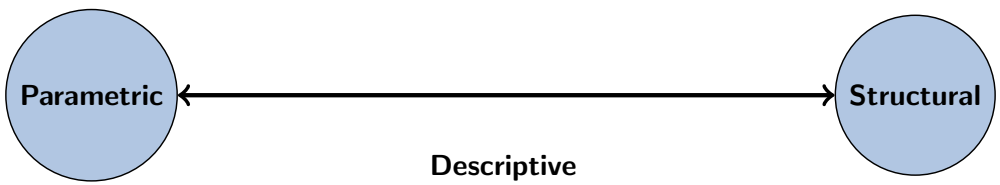


Answers the question "what is acceptable and why?"

- Climate change is happening!

Descriptive: Parametric-Structural

- Climate change is happening!



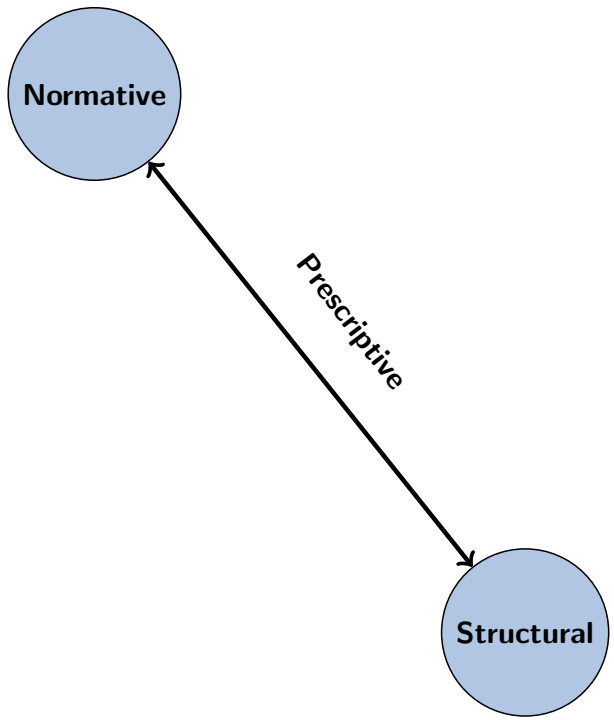
Prescriptive: Structural-Normative

Generating prescriptive conclusions is the primary reason to model energy systems.

If the solution to structural uncertainty was identifying alternative, "sub-optimal" solutions, then the prescriptive stage means deciding among these diverse alternatives.

Theorem (Arrow's Impossibility Theorem)

It is impossible to construct a utility function that maps individual preferences onto a global preference order without imposition or dictating [7, 5, 1].



How are representative probability distributions chosen?

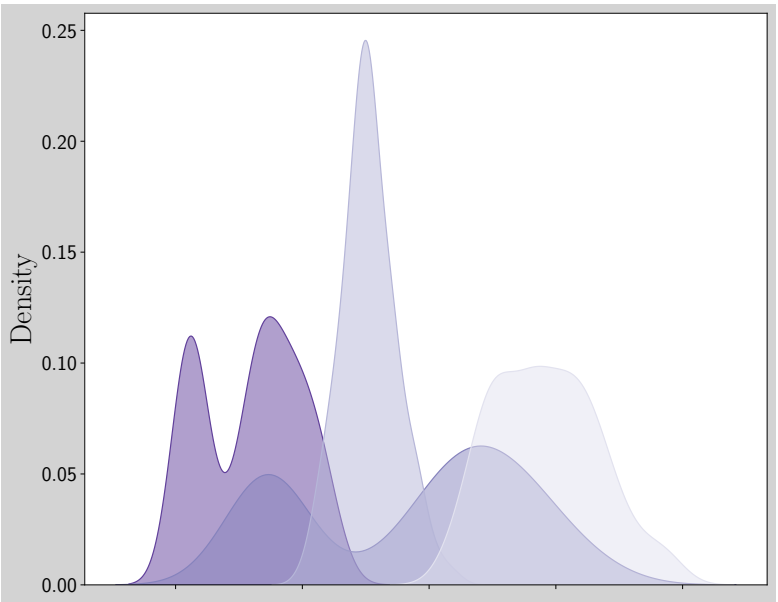


Figure 6: Possible distributions for a single parameter. Which is best?

The probability distributions are usually obtained through modelers' judgement or expert elicitations [13].

- A

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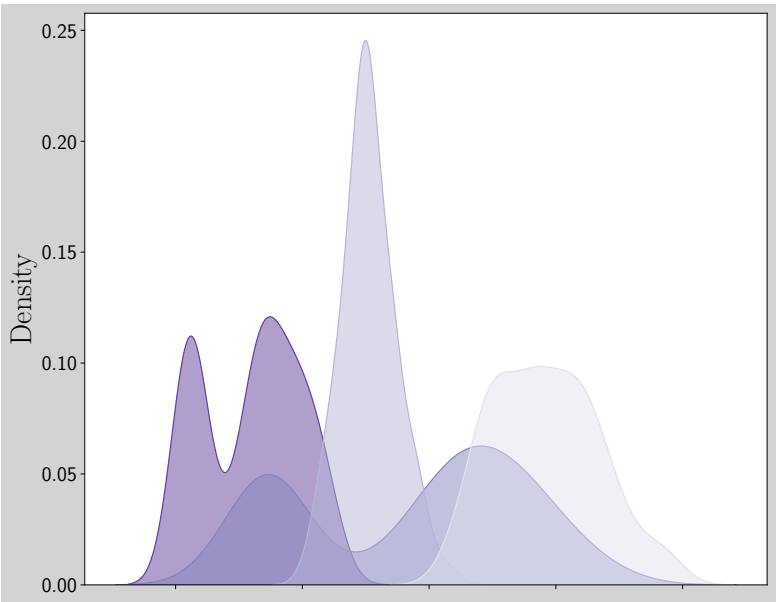

Figure 6: Possible distributions for a single parameter. Which is best?

The probability distributions are usually obtained through modelers' judgement or expert elicitations [13].

- A
- B

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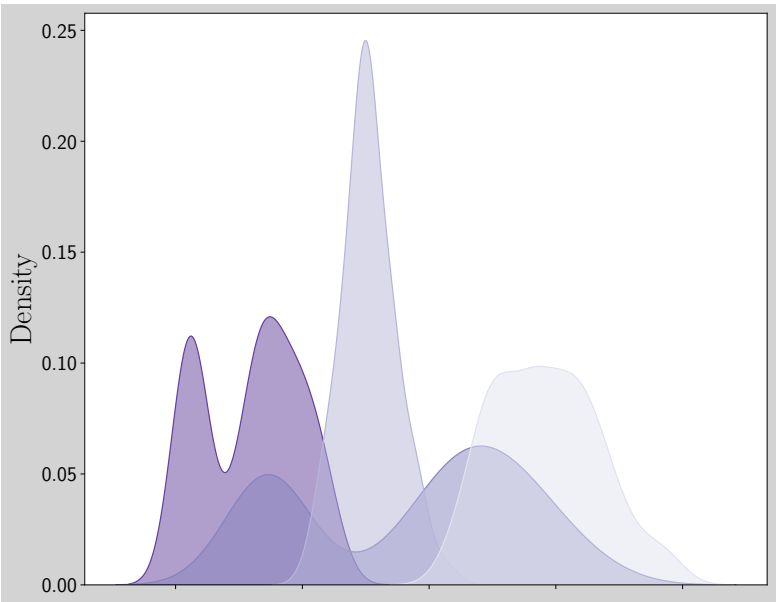
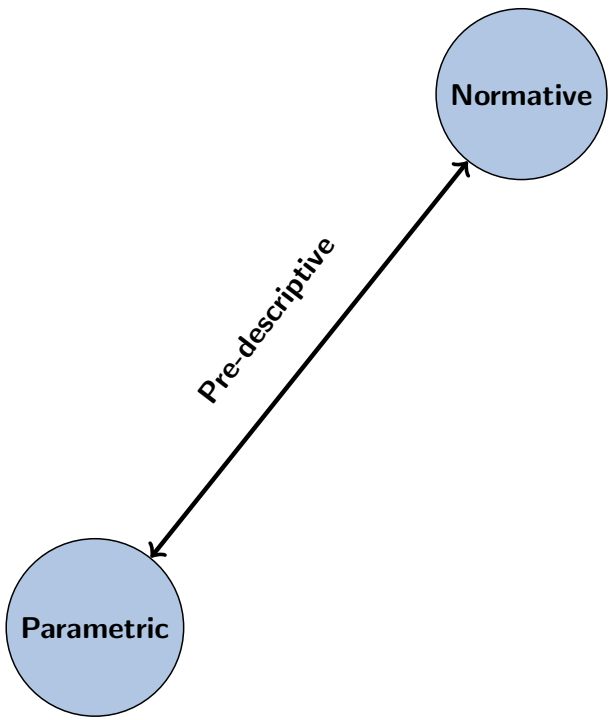


Figure 6: Possible distributions for a single parameter. Which is best?

The probability distributions are usually obtained through modelers' judgement or expert elicitations [13].

- A
- B
- C

How do modellers choose or create distributions?



Definition (Knightian/Deep/Epistemic Uncertainty)

Unknowable unknowns — uncertainties that cannot be quantified or measured due to a lack of knowledge or understanding.

Outline

Conclusion

We showed many things. This slide is an example of how you can animate bulleted lists, for more information about using beamer animations, checkout the overleaf article on overlay specifications in the group's guide.

- Cats are peculiar

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- Cats are peculiar
- Blue and Orange are fierce colors
- Math can be rendered nicely
- Cite your sources

We also tested citations [9]

Acknowledgement

Acknowledgements should include both people who helped and funding streams. If you are funded by an NEUP grant, that number usually goes here. .

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