Why Risk Analysis is Difficult

and

Some Thoughts on How to Proceed

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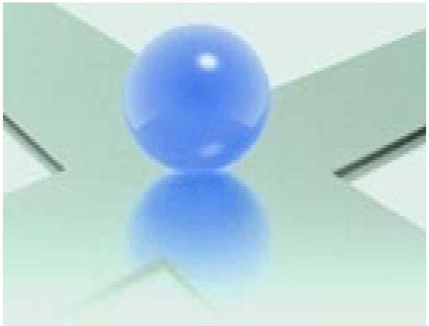

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Contents

1 *Highlights*

§ What is

Risk Analysis?

§ Article titles from *Risk Analysis:*

- **Pesticides and Methylmercury in the United Arab Emirates.**
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§ Goals of risk analysis:

- **Improve safety.**
- **Identify causes of injury.**
- **Support decision making.**

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§ **Why is risk analysis hard?**

- **Complex variable processes.**
- **Conflicting requirements.**
- **Lots of uncertainty.**

§ **Other difficulties:**

- **Psychology.**
- **Social and cultural issues.**
- **Institutions.**

Part I

Why Risk Analysis is Difficult

2 *A Bit of History*

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§ History of human thought:

- **Cerebral cortex: many 10,000s of years.**
- **Agriculture and settlement: 7-8,000 years.**
- **Writing: 5,000 years.**
- **Science:**
  - **Ancient Greeks had some: 2,000 years.**
  - **Mostly modern Europe: 500 years.**

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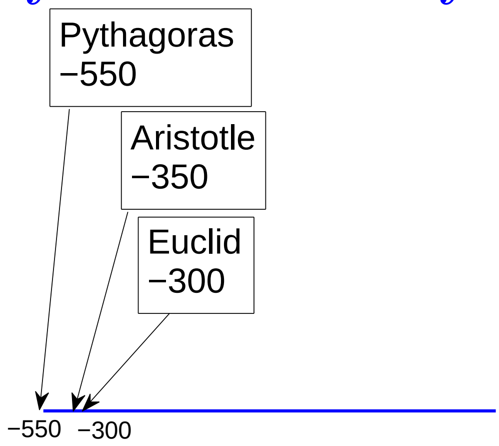

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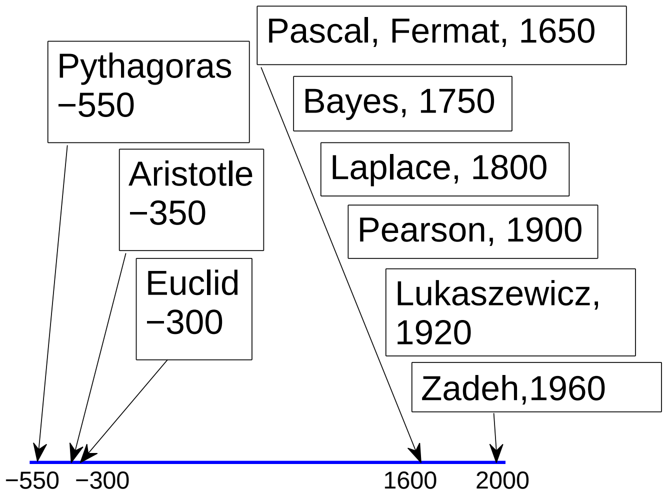

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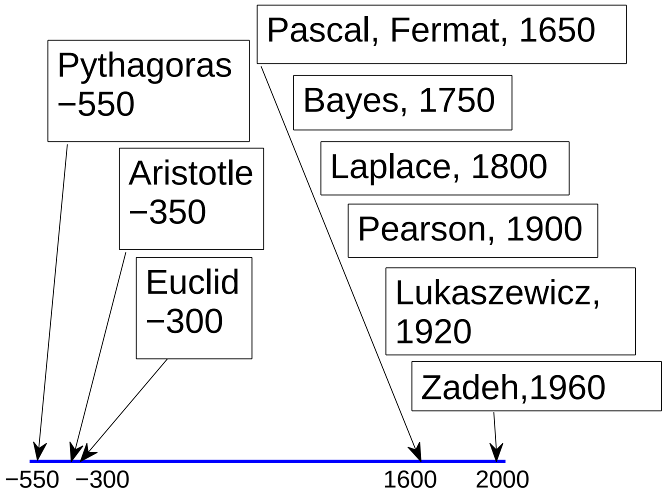

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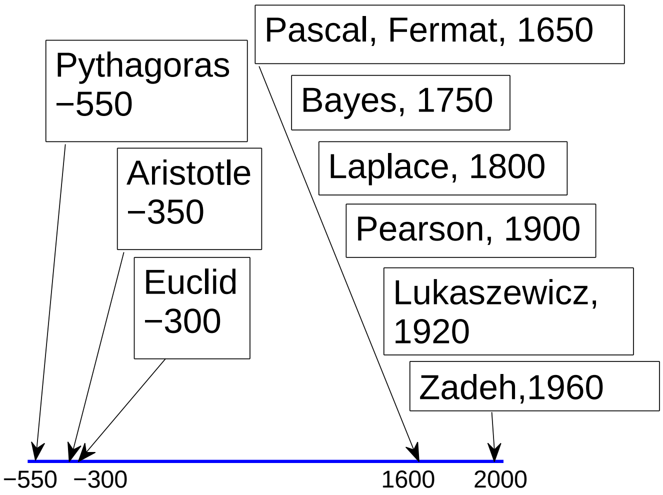

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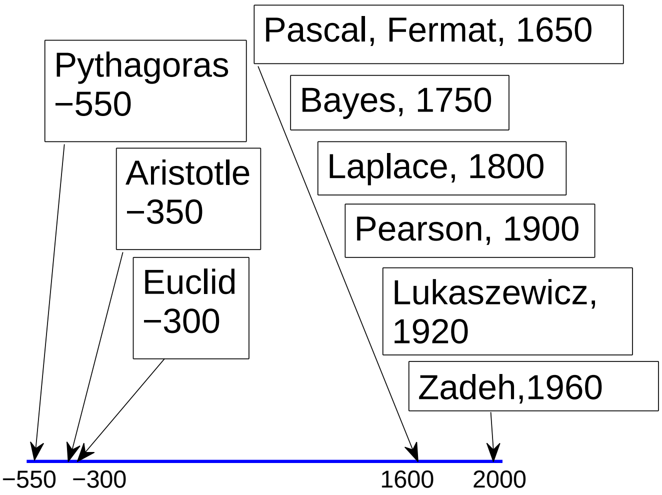

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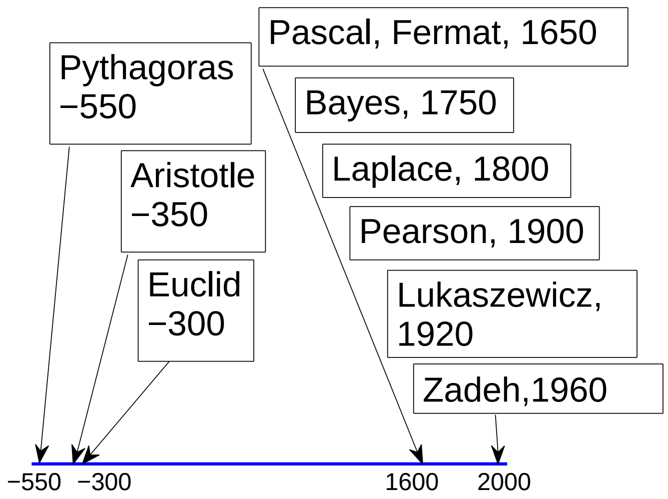

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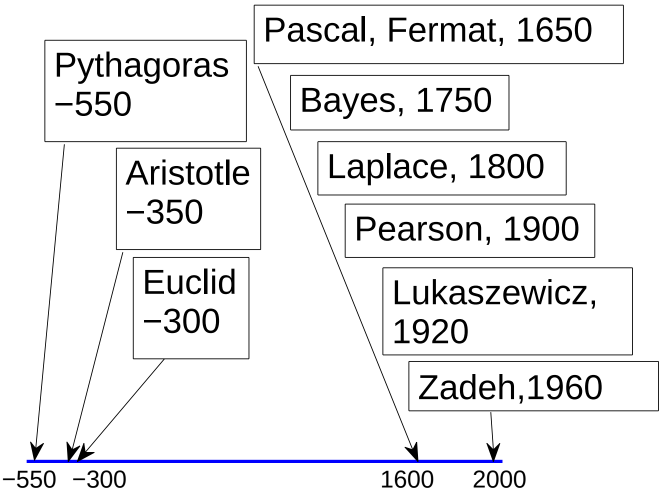

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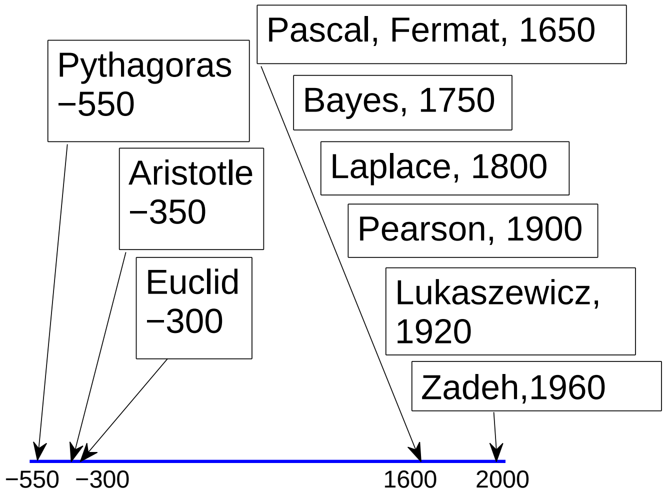

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§ **We're just beginning to understand uncertainty.**

3 *Shackle-Popper Indeterminism*

3.1 *Shackle-Popper Indeterminism*

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§ **Intelligence:**

What people know,

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Tomorrow's behavior cannot be

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§ **Information-gaps, indeterminisms,**

sometimes

cannot be modelled probabilistically.

§ **Ignorance is not probabilistic.**

§ Two types of discoveries:

- **Discover what does exist (recovery).**
  - **America.**
  - **HIV virus.**
  - **House keys.**
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4 *Hume and the Problem of Induction*

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§ **Induction:**

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§ Hume's problem (prelim smry):

- Induction cannot prove validity of induction.
- Knowledge, including science, based on induction.
- How to justify knowledge?

§ Hume:

- **“[W]e cannot give a satisfactory reason why we believe, after a thousand experiments, that a stone will fall or fire burn”.**[1]
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[1] Hume, D. *An Inquiry Concerning Human Understanding,* 1748, edited by Antony Flew. Collier Books, 1962, p.160.

§ Hume:

- **"[W]e cannot give a satisfactory reason why we believe, after a thousand experiments, that a stone will fall or fire burn".[2]**

- **"For all inferences from experience suppose, as their foundation, that the future will resemble the past and that similar powers will be conjoined with similar sensible qualities. . . .**

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§ **Hume's justification of induction: habit.**

Today we'd say: psychology.

[7]Hume, D. *An Inquiry Concerning Human Understanding,* 1748, edited by Antony Flew. Collier Books, 1962, p.160.

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§ **One can never test the future:**

- **All tests occur now.**
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- **Rug metaphor:**

The future can never be tested,
just as one can never step on
the rolled up part of an endless rug
unfurling always in front of you.[9]

[9] Yakov Ben-Haim, 2011, The end of science?
http://decisions-and-info-gaps.blogspot.com/2011/10/end-of-science.html

§ Goodman's green and grue example.

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§ **No help. Make grue-like hypotheses consistent with current knowledge.**

- **Past does not constrain the future.**
- **Hume: "Whatever *is* may *not be*."[10]**

[10]Hume, D. *An Inquiry Concerning Human Understanding,* 1748, p.161.

§ Why are Hume's problems important:

- **for risk analysis?**
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§ Induction is important:

- Learn from experience by induction.
- Base decisions on knowledge.

§ We need to know:

- What inferences are valid? (green or grue)
- What knowledge is warranted.
- What learning algorithms are valid?

Part II

Some Thoughts on How to Proceed

5 *Epistemic Paralysis*

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§ Epistemic paralysis (Locke's wingless man):

"If we will disbelieve everything,
because we cannot certainly know all things;
we shall do muchwhat as wisely as he,
who would not use his legs,
but sit still and perish,
because he had no wings to fly".[11]

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- **Belief and action justified despite uncertainty.**

§ Practical implications:

- **Acquire best available "models:" data, knowledge, understanding, ...**
- **Acknowledge: better models in future.**
- **Balance between skepticism and action. Tools needed for this balancing.**

[15] Locke, John, *An Essay Concerning Human Understanding,* 5th edition, 1706. Roger Woolhouse, editor. Penquin Books, 1997, I.i.5.

6 Models and Robustness

[15] \lectures\talks\lib\models-rbs01.tex 8.4.2012

§ **Avoiding epistemic paralysis: many tools.**

We focus on concepts of robustness.

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§ Avoiding epistemic paralysis: many tools.

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§ 'Robust' means (OED):

- **'Strong and hardy; sturdy; healthy'.**
- **'Not easily damaged or broken, resilient'.**
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- **'Strong and hardy; sturdy; healthy'.**
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- **Robust statistical test yields approximately correct results despite falsity of assumptions or data.**
- **Robust decision:**
  - **Outcome is satisfactory despite error.**
  - **Resilient to surprise.**
  - **Immune to ignorance.**

§ Robustness operationalized in many ways:

- **Robust statistics.**[16]
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[16] Huber, Peter J., 1981, *Robust Statistics,* John Wiley, New York.

§ Robustness operationalized in many ways:

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[30] Hansen, Lars Peter and Thomas J. Sargent, 2008, *Robustness,* Princeton University Press, Princeton and Oxford.

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- **Examples (see earlier lecture[61]):**
  - **Animal foraging.**
  - **Financial markets.**
  - **Many engineering designs.**
  - **. . .**

[61] Paradox of Choice: Why More is less, \lectures\talks\lib\pdox-choice01.tex

§ Innovation dilemma:

- **2nd look. (See earlier lecture[62])**
- **Is robustness good response to innovation dilemma?**

[62] No-Failure Design and Disaster Recovery Lessons from Fukushima, \lectures\talks\lib\no-fail-disas-rec01.tex

7 Innovation Dilemma[62]

[62] \lectures\talks\lib\innov-dilem01.tex 8.5.2012

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  - **Lower uncertainty.**

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- **Automotive collision control:**
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- **Financial investment:**
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  - ◦ US Treasury bonds (SotA).
- **Risk taking or avoiding:**
  - ◦ Nothing ventured, nothing gained (innov).
  - ◦ Nothing ventured, nothing lost (SotA).

§ Decision strategies.

- **Outcome optimization:**
  - **Use models to predict outcomes.**
  - **Choose predicted best option.**
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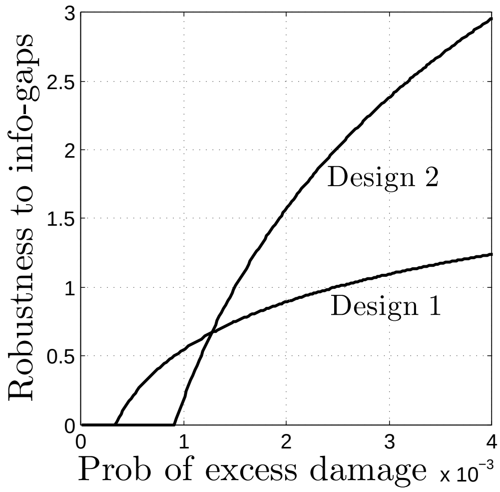
§ Question:

Which strategy suitable for innovation dilemma?

§ Optimize or robust-satisfice?



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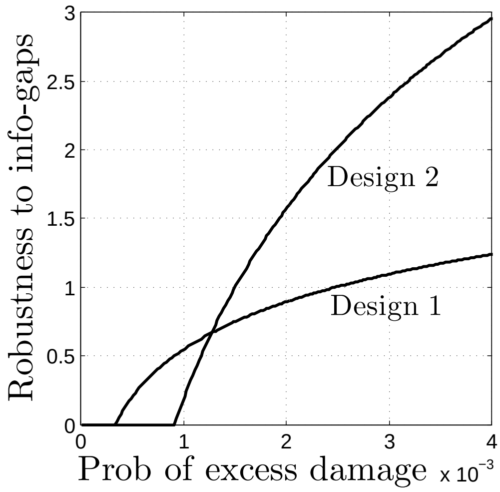

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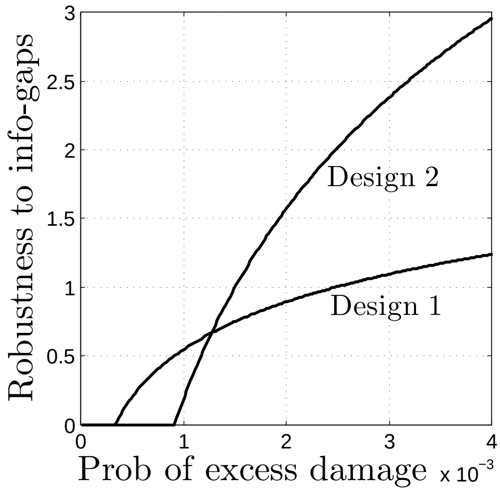

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§ Resolve innovation dilemma:

- **Value judgment on outcome requirement.**
- **Robustly satisfy requirement.**

§ Is robustness good response to innovation dilemma?

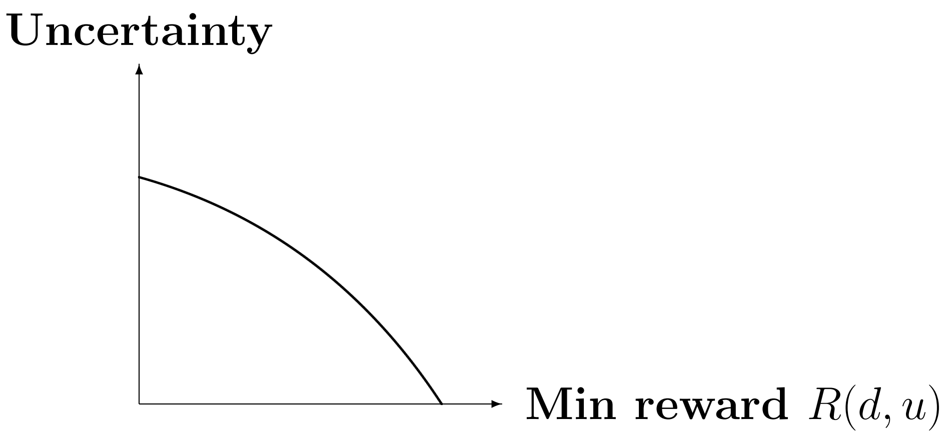
8 *Max-Min and Robust-Satisficing*

§ **Task: make a decision.**

- d = **decision.**
- u = **uncertain parameters, functs., sets.**
- $R(d, u)$ = **reward.**

[62] lectures\talks\lib\maxmin-rs03shrt.tex 5.4.2012

§ Trade-off: uncertainty vs. min reward.



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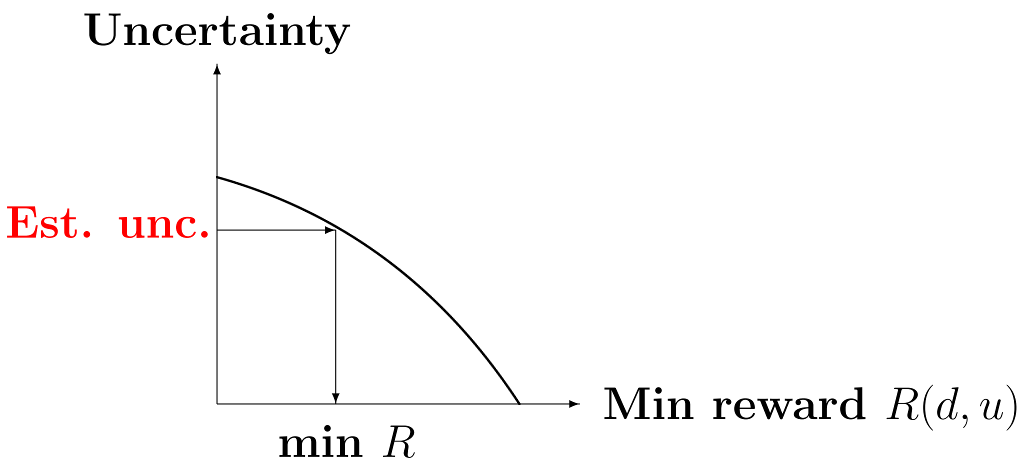

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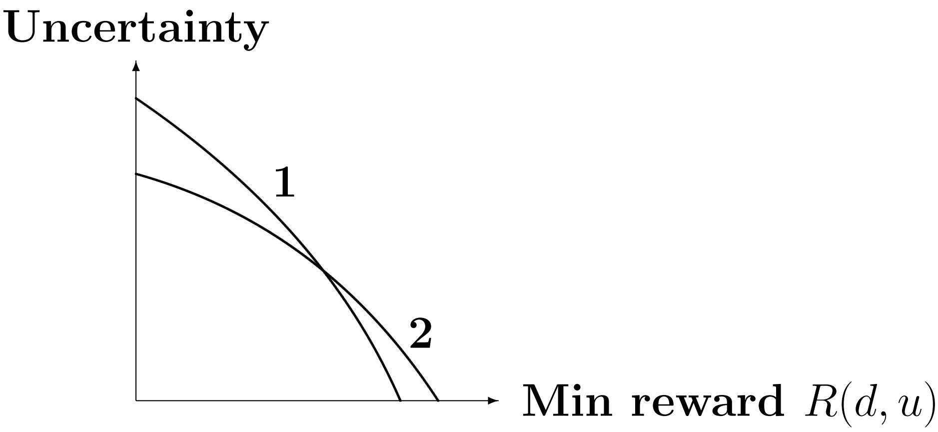

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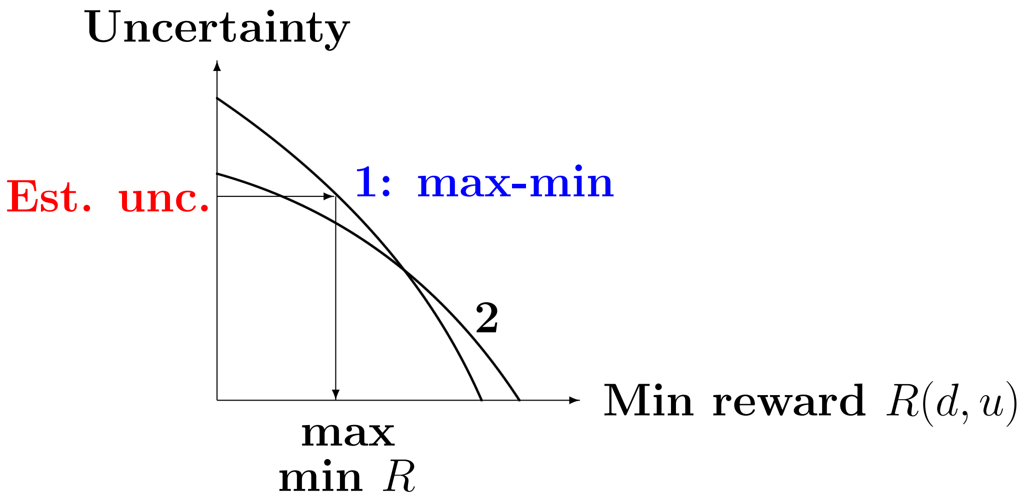

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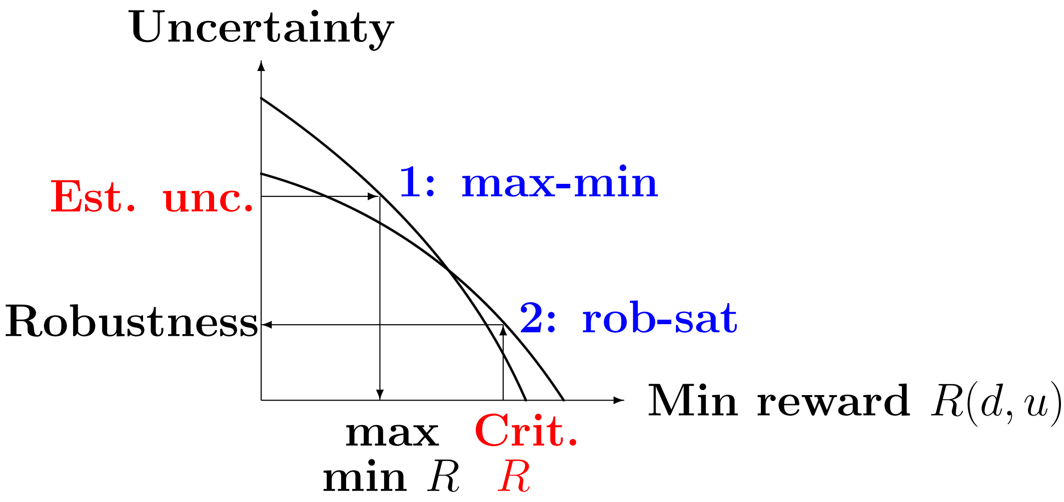

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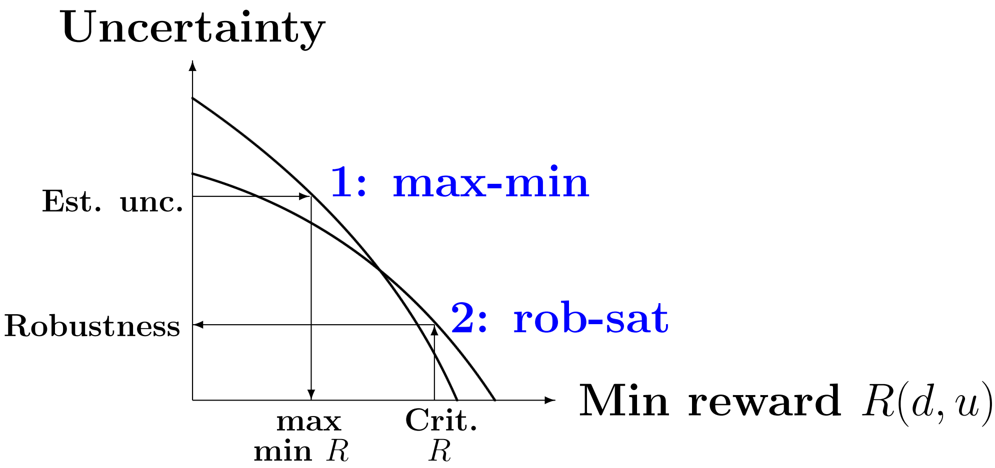

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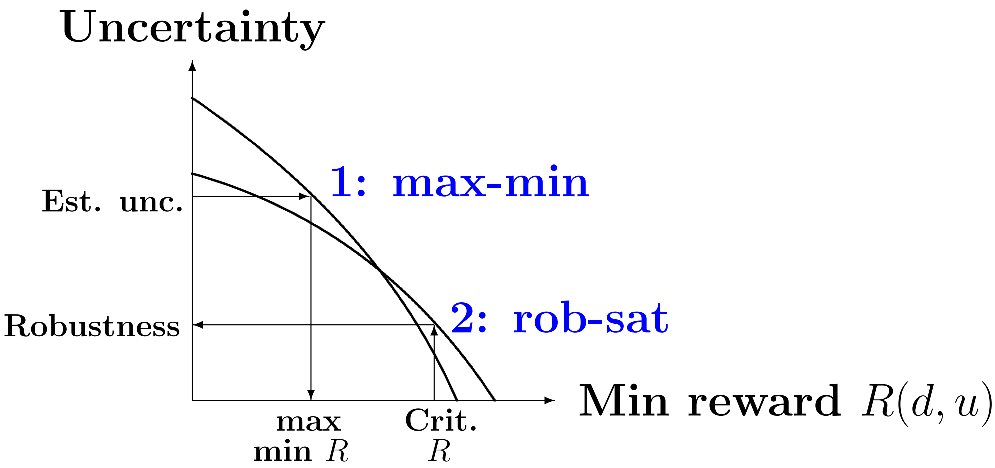

§ Modeller's equivalence: description.

- **Max-min can always describe rob-sat (by adjusting prior beliefs).**
- **Rob-sat can always describe max-min (by adjusting requirements).**

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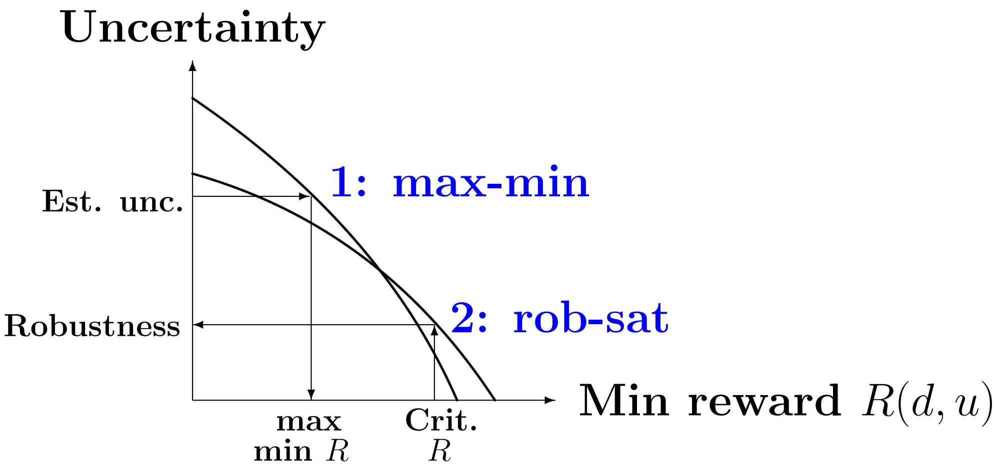


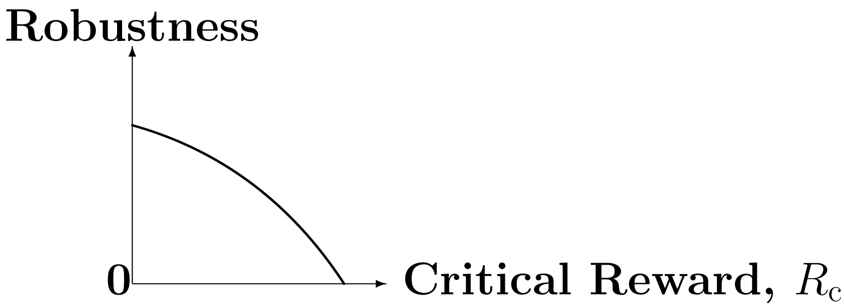
§ Modeller's equivalence: description.

§ Decision-maker's duality: prescription.

Max-min and rob-sat differ if:

- **Max-min gain too low, or,**
- **Worst case is uncertain.**

§ Optimizing vs Robustifying



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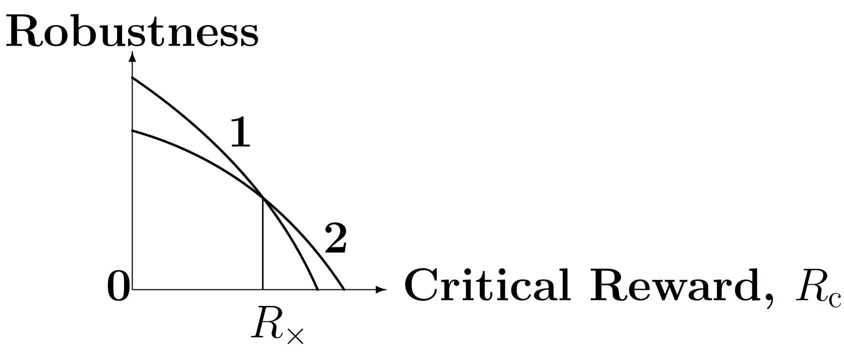

- **Trade off:** Robustness vs performance.
- **Zeroing:** No rbs of predicted reward.
- **Predicted optimum:** 2.
- **Robust-satisficing optimum:** 2 iff $R_c > R_\times$.

§ Info-gap robustness is non-probabilistic.

Is it a good bet?

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§ **Evolutionary advantage of robustness:**

- **Robustness may proxy for Probability of survival.**
- **Proxy theorems.**

9 *Opportuneness*

[62] \lectures\talks\lib\opportuneness01.tex 5.4.2012

§ **Risk analysts:**

- **Prevent high-consequence adverse events in critical technologies.**
- **Are risk averse.**

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§ **Robustness and opportuneness:**

- **Converses.**
- **Risk analysts mainly use robustness.**
- **Opportuneness has 3 supporting roles.**

§ Utility of opportuneness analysis:

- **Choose from 2 options w/ similar rbs.**
  Opportuneness can break the tie.
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- **Choose from 2 options w/ similar rbs.**
  Opportuneness can break the tie.
- **Robustness and opportuneness:**
  - **Not necessarily antagonistic.**
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- **If rbs and ops are antagonistic:**

Trade some robustness for opportuneness.

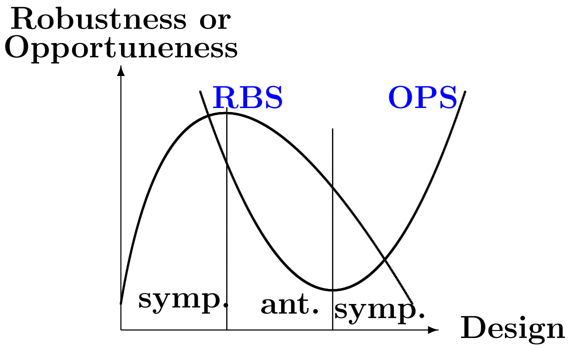

Figure 1: **Robustness and opportuneness curves.**

10 Conclusion

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- **Knowledge is limited.**
- **Uncertainty is unlimited.**
- **Other factors:**

resources, psychology, institutions, ...

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