The Innovation Dilemma
Uncertainty and the Paradox of Universalism

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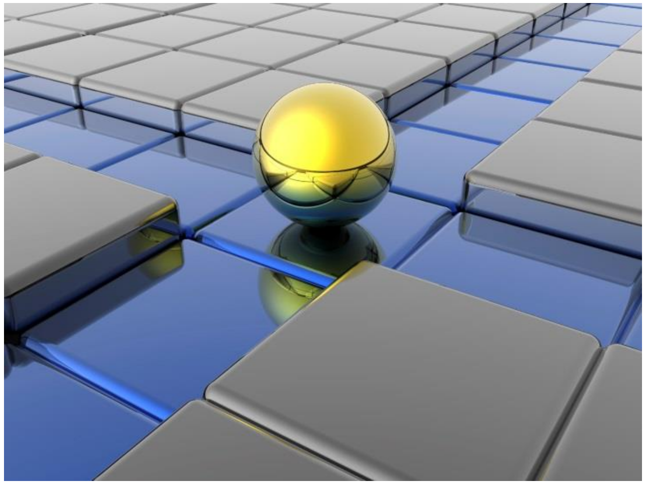

Outline

Paradox of universalism: Definition and examples.

Severe uncertainty:

- Shackle-Popper indeterminism.
- The idea of an info-gap.

Innovation dilemma: Definition and examples.

Info-gap robust satisficing:

Resolving the dilemma and paradox.

Example: The innovation dilemma of rural poverty.

Universalism

Universalism

- A precept or law is **universal** if it applies everywhere at all times.
- No exceptions or violations are tolerable or possible.

Paradigmatic universalism: laws of physics

- Stable and universal.
- Violation is physically impossible.
- Contradiction to theory falsifies the theory.

Weaker (semi) universalisms in human affairs.

Paradox of Universalism

Paradox of universalism:

- Unknown future contingencies may force operational violation of the principle.
- Principle vs pragmatism.
- Knowledge vs ignorance. Uncertainty.

Example: Paradox of Universalism

Imperative for survival.

Bio-organisms, corporations, states **insist on survival.**

Principle: "conservative dynamism" (Donald Schon).

Paradox due to uncertainty:

- Change is needed for survival.
- Future challenges are unknown.
- Radical changes may be needed that undermine conservative survival.

Example: Paradox of Universalism

UN Universal Declaration of Human Rights (1948).

"Everyone has the right to freedom of opinion and expression ... without interference and to seek, receive and impart information and ideas through any media and regardless of frontiers." (Article 19)

Paradox: Tolerates incitement against toleration.

Principle: limit abhorrent or dangerous speech.

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- Future disputes about what is abhorrent.
- Future effectiveness of speech (e.g. social media).

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Risk and Uncertainty

Probabilistic risk

or

Knightian "true uncertainty"

Probabilistic Risk

Consequence	Probability
Drought	Stochastic process
Industrial accident	Actuarial tables
Tsunami	Historical data
Faulty air filters	Quality control data
Deception, scam	Sociological data

Risk is:

- Structured: known event space
- Modeled with probability
- Manageable (but still risky)

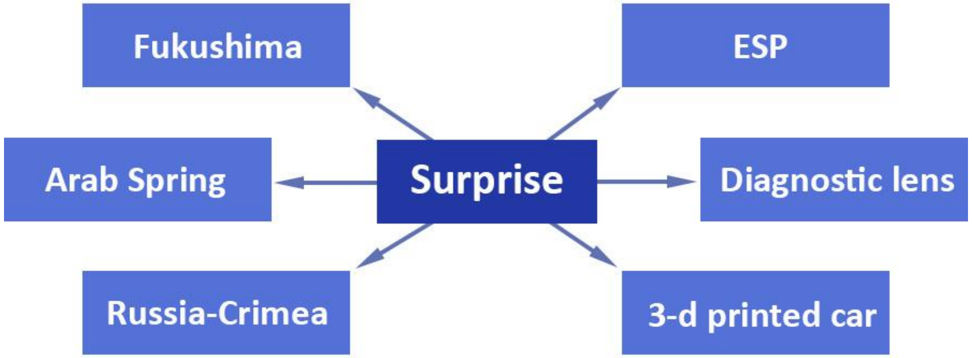
Frank Knight's "true uncertainty"

"The uncertainties which persist … are **uninsurable**

because there is

no objective measure

of the probability".



Wheeler’s Island

“We live on an island of knowledge
surrounded by a sea of ignorance.
As our island of knowledge grows,
so does the shore of our ignorance.”

John A. Wheeler

Non-probabilistic true uncertainty

D Discovery

- America
- Nuclear fission
- Martians (not yet?)

Non-probabilistic true uncertainty

D Discovery

I Invention/Innovation

- Printing press: material invention.
- Ecological responsibility: conceptual innovation.
- French revolution: social innovation.

Non-probabilistic true uncertainty

D Discovery

I Invention/Innovation

S Surprise (Asymmetric uncertainty)

- Ambush
- Competitor’s innovation
- Natural catastrophe

Non-probabilistic true uncertainty

D Discovery

I Invention/Innovation

S Surprise (Asymmetric uncertainty)

What's the next D I or S ???

Knightian uncertainty:

- Unstructured: unknown event space.
- Indeterminate: no laws.
- Barely manageable.

Info-gap uncertainty: examples

- Transcendental probability.
- Policy for climate change.
- (Many more…)

Carroll's Transcendental Probability

Riddle from *Pillow Problems*:

“A bag contains 2 counters, as to which nothing is known except that each is either black or white. Ascertain their colours without taking them out of the bag.”

Answer: “One is black, and the other white.”

Charles Dodgson

Alice

Policy for climate change

Sustained rise in green house gases causes:

- Temperature rise.
- Economic loss.

Models:

- Temperature change: $\Delta CO2 \Rightarrow \Delta T$.
- Economic impact: $\Delta T \Rightarrow \Delta GDP$.

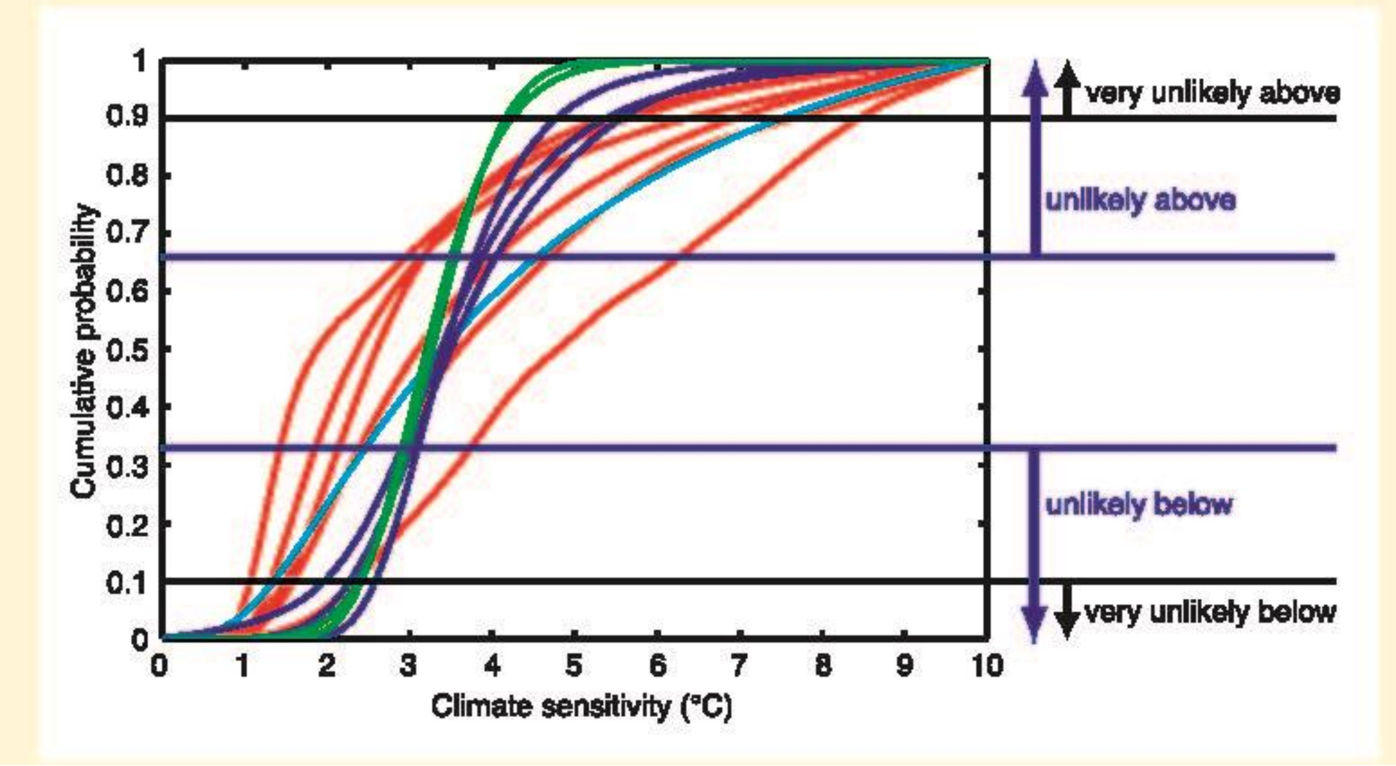
The problems:

- Models highly uncertain.
- Data controversial.

Policy for climate change

E.g., IPCC model for equilibrium clim. sensitivity, S.

- Likely range: 1.5C to 4.5C.
- Extreme values highly uncertain.
- 10 models for *p(S)*:



What is an info-gap?

Info-gap:

Disparity between what one

does know

and what one

needs to know

in order to make a

responsible decision.

Two elements: **uncertainty** and **consequence**.

Distinct from probability.

What is an info-gap?

Role a fair dice:

- Equal probabilities of 1 , . . . , 6.
- Known event space; known likelihoods.

Iraqi WMD in 2002: What is the event space?

- 2 events: Either they do or they don’t have WMD.
- 8 events: Small or big am’ts, making more y/n, will use y/n.
- More possibilities.
- Rolling an N-sided dice, but:
  Unknown event space; unknown likelihoods.

What is an info-gap?

Probabilistic thinking sometimes useful:

- Soviet 1941 estimate: German invasion very likely. Captured documents, reconnaissance, etc.
- Hence “No invasion” very unlikely.

Binary logic:

- Proposition either true or false.
- Excluded middle: proposition can’t be both T and F.

Probability applies excluded middle to uncertainty:

Proposition can’t be ‘very likely’ and ‘very unlikely’.

What is an info-gap?

In strategic affairs: can’t always exclude the middle.

Example: UK nuclear assessment in WW II.

- Germany building atom bomb? **Very likely.**
  Otto Hahn visited Fermi in 1930s;
  won Nobel Prize for nuclear fission (1944/45).
- Germany building atom bomb? **Very unlikely.**
  Nazi Germany abjured ‘Jewish physics’.

The assessment faced an info-gap.

What is an info-gap?

Ignorance or ambiguity or potential for surprise.

Two elements: **uncertainty** and **consequence**.

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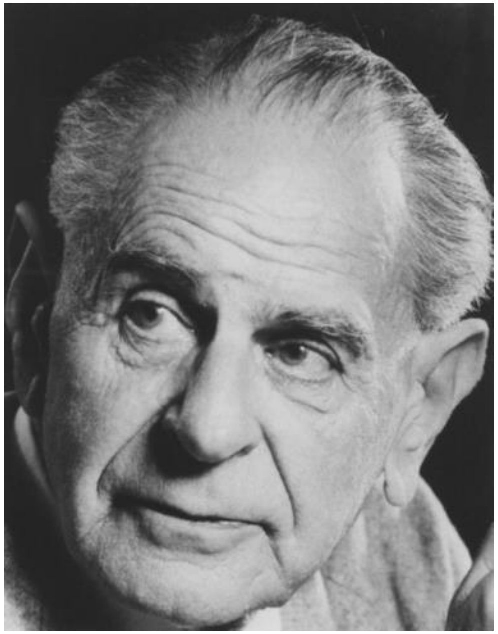
In human affairs, info-gaps result from **Shackle-Popper indeterminism**.

Shackle-Popper indeterminism

GLS Shackle, 1903-1992



Karl Popper, 1902-1994

Shackle-Popper Indeterminism

Intelligence:

What people **know**, influences how they **behave**.

Discovery:

What will be **discovered tomorrow** can't be **known today**.

Implies

Indeterminism:

Tomorrow's behavior can't be fully modelled today.

- Info-gaps, indeterminism: **unpredictable.**
- **Ignorance is not probabilistic.**

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Innovation dilemma: Definition and examples.

Info-gap robust satisficing:

Resolving the dilemma and paradox.

Example: The innovation dilemma of rural poverty.

Innovation dilemma: The Idea

Choose between 2 options:

Option 1:

- New and innovative (paradigm: new technology).
- Very promising.
- Higher uncertainty.

Option 2:

- State of the art (paradigm: standard procedure).
- Less promising.
- Lower uncertainty.

Dilemma due to uncertainty.

Paradox of universalism

Universalism.

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P’dox of universalim as innov. dilemma

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Innovation dilemma:

Choose innovative or standard change for survival?

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Paradox due to uncertainty. We can't know:

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- Future effectiveness of speech (e.g. social media).

Innovation dilemma in formulating Article 19:

Choose **revolutionary vision** or **conventional wisdom**?

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Robust Satisficing

Two questions for decision makers:

1. What are our goals?
2. How much error/surprise can we tolerate?

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1. What are our goals?
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1. Satisficing: Achieving critical outcomes.

- Essential goals.
- Worst acceptable outcomes.
- Modest or ambitious.

Robust Satisficing

Two questions for decision makers:

1. What are our goals?
2. How much error/surprise can we tolerate?

1. Satisficing: Achieving critical outcomes.

2. Robustness:

- Immunity to ignorance.
- Greatest tolerable error or surprise.

Robust Satisficing

Two questions for decision makers:

1. What are our goals?
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1. Satisficing: Achieving critical outcomes.

2. Robustness: Greatest tolerable error.

Optimize robustness; satisfice goals:

Procedural (not substantive) **optimization.**

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Resolving the dilemma and paradox.

Example: The innovation dilemma of rural poverty.

Innovation dilemma of poverty

Rural poverty:

- Low agricultural productivity.
- High mortality/morbidity.
- Resentment and suspicion of government and NGOs.
- Local barons or warlords.

Innovative hi-tech proposal:

- New strains of plants.
- Better irrigation.
- Better fertilizers.
- Mechanization of field work.

Innovation dilemma of poverty

Potential gains from innovation:

- Higher agricultural productivity.
- Higher standard of living.
- Less arduous field work.

Potential losses from innovation:

- Failure of innovative crops, causing starvation.
- Social reorganization and upheaval.
- Rapid population growth, canceling gains (Malthus).

Dilemma: Innovation could be **much better**, or much worse.

How to choose?

Innovation dilemma of poverty

Basic questions:

- What are the **goals**?
- What is our **knowledge**?
- What are the **uncertainties**?

Robustness of an option:

Maximum tolerable uncertainty.

The knowledge-bifurcation. Is your knowledge:

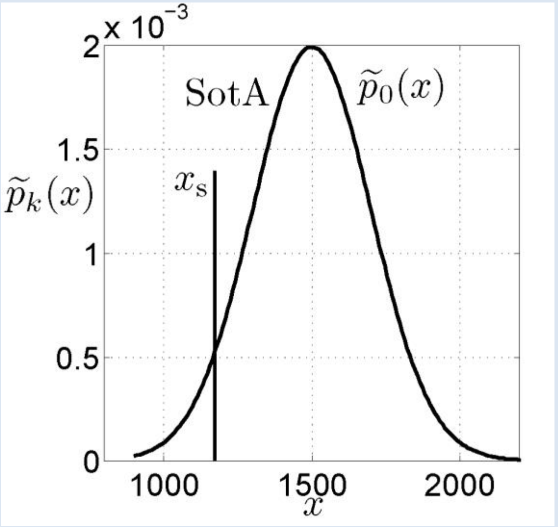
- **Quantitative:** data and equations?
- **Qualitative:** mainly insight and understanding,
  (perhaps with some numbers)?

We will consider both situations.

Poverty dilemma: quantitative

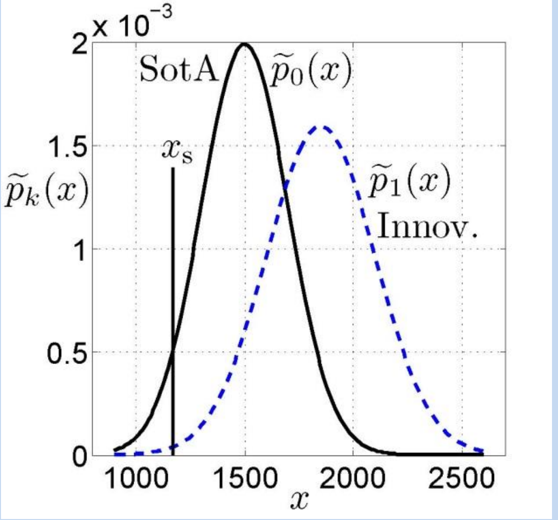
Field study of traditional State of the Art:

- Survival requirement: 1171 kg wheat/ha.
- Probability dist. of productivity **well known**.
- Survival probability: **0.95 (known).**
- Survival catastrophe return-time: **20 years (known).**



Knowledge about innovative option:

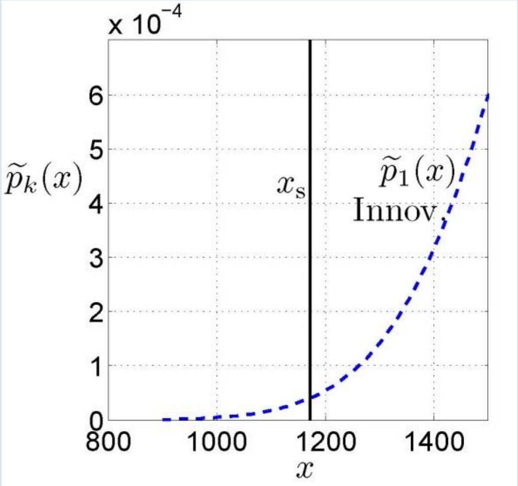
- Probability distribution of productivity **estimated, uncertain**.
- Survival probability: **0.9967 (estimate).**
- Survival catastrophe return-time: **303 years (estimate).**



The choice is clear?

Poverty dilemma: quantitative

Uncertainty of innovative option:



- Prob. distribution of productivity: estimated.
- True tail (rare but bad): highly uncertain.
- Survival probability & catastrophe return-time may be **much greater than for SotA**.

Robustness of an option: How much error can we tolerate?

Greatest **uncertainty** at which current **knowledge** satisfies the survival **requirement**.

Robust prioritization: Innovation or SotA?

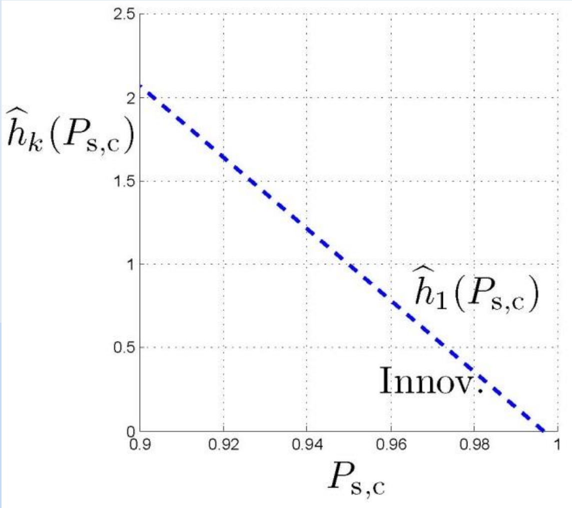
- Maximize robustness, satisfice outcome.
- Don't try to optimize the outcome.

Poverty dilemma: quantitative

Robustness of innovative option:

Pessimist's thm. Trade off:

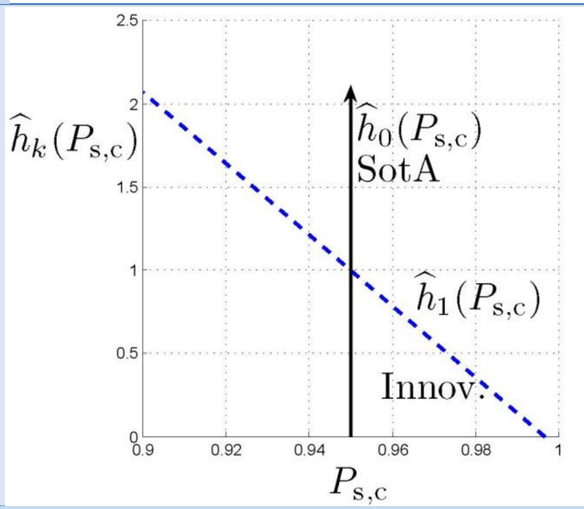
Higher survival prob ⟺ lower robustness



Zeroing: No robustness at estimated survival probability.

Robustness of SotA:

- **Unbounded** for survival probability up to 0.95.
- **Zero** for survival probability above 0.95.

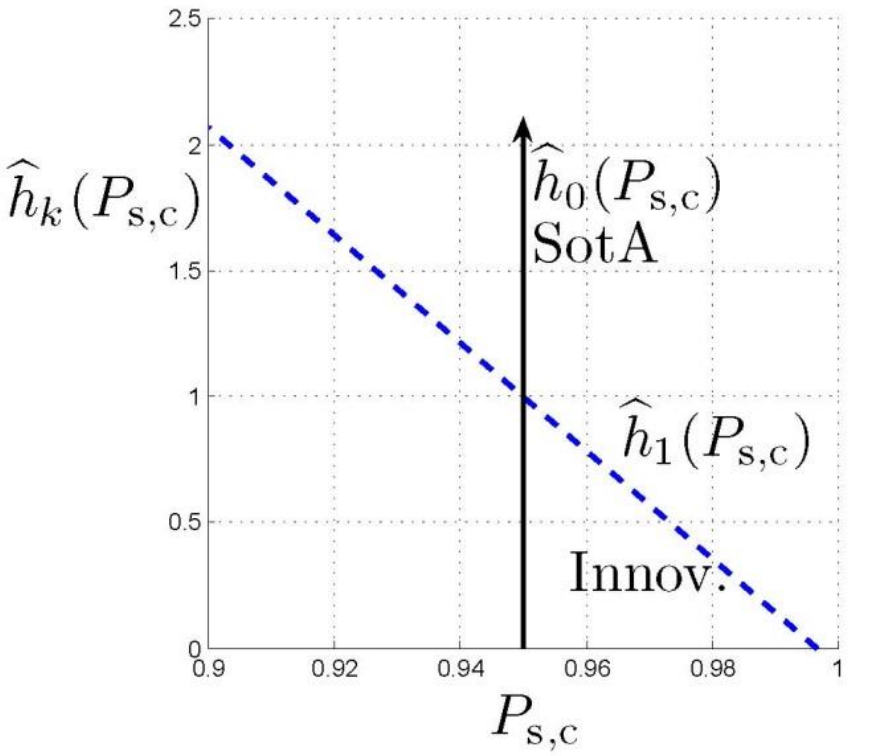


Decision: Choose by robustly satisfying the requirement.

Poverty dilemma: quantitative

Summary of quantitative analysis of innov. dilemma:

- **Zeroing:** no robustness at estimated survival prob.
- **Optimizer's fallacy:** Prioritize by estimates.
- **Trade off:** robustness vs survival probability.
- **Preference reversal:** Resolution of dilemma.



Poverty dilemma: qualitative

Now for the hard part:

Qualitative analysis of robustness.

Robustness:

- We can't evaluate it quantitatively.
- Assess it qualitatively with **proxies for robustness**:
  - **Resilience**: rapid recovery of critical functions.
  - **Redundancy**: multiple alternative solutions.
  - **Flexibility**: rapid modification of tools and methods.
  - **Adaptiveness**: adjust goals and methods online.
  - **Comprehensiveness**: interdisciplinary system-wide coherence.

Poverty dilemma: qualitative

Basic questions:

- What are the **goals**?
- What is our **knowledge**?
- What are the **uncertainties**?

Bernard Amadei: girl water carriers.

- **Goal**: more potable water.
- **Knowledge**: Abundant fuel. Pump tech. Local culture.
- **Uncertainties:**
  - Long-term maintenance? Catastrophe if not.
  - Stable fuel supply?
  - Social response: what happens to the girls?

Poverty dilemma: qualitative

Robust solution:

- **Satisfice** the goal. Don’t try to maximize. (Exploit trade off.)
- **Co-design**: local involvement in all stages (comprehensive).
- **Train** locals in pump maintenance (resilience, flexibility).
- **Transition period** of dual supply (redundancy).
- **Long-term contact** for emergency support (adaptiveness).
- **Education** for girls (and boys) (comprehensiveness).
- **Quantitative** analysis where possible.

Poverty dilemma: qualitative

Methodological re-cap:

- **Trade off:** higher ambition = lower robustness.

  Ambitions: Yes. Wishful thinking: No.
- **Zeroing:** Best-estimated outcomes have no robustness.

  Satisfice your goals. **Optimize** your robustness.

  Don’t try to maximize the outcome.
- **Preference reversal:** sub-optimal may be more robust.

  Wood burning steam pump more robust to uncertainty than solar electric technology.

Last words

Paradox of universalism: consequence of uncertainty.

Severe uncertainty:

- Shackle-Popper indeterminism.
- The idea of an info-gap.

Innovation dilemma: New is promising; more uncertain.

Info-gap robust satisficing:

Satisfice the goals, optimize the robustness.

Example: The innovation dilemma of rural poverty.

Questions?