Robust Strategies: Creating Conversation Between Modelers and Managers

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Climate Scenarios and Projections: the Known, the Unknown, and the Unknowable applied to California

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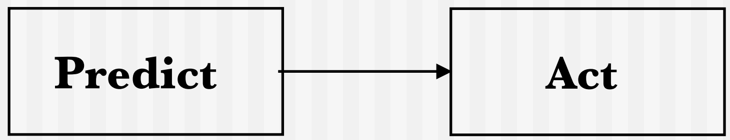
"Predict-then-Act" Methods Can Complicate Conversations about Deep Uncertainty

Traditional analytic methods characterize uncertainties as a prelude to assessing alternative decisions



Climate change confronts decisionmakers with deep uncertainty, where

- They do not know, and/or key parties to the decision do not agree on, the system model, prior probabilities, and/or "cost" function

Decisions can go awry if decisionmakers assume risks are well-characterized when they are not

- Uncertainties are underestimated
- Competing analyses can contribute to gridlock
- Misplaced concreteness can blind decision-makers to surprise

Robust Decisionmaking Characterizes Vulnerabilities of Strategies

Under conditions of deep uncertainty decisionmakers often

- Use choice of strategy, not additional information, to reduce uncertainty

Robust strategies

- Perform reasonably well compared to the alternatives across a wide range of plausible futures

Robust decisionmaking is an iterative, analytic process for

- Identifying robust strategies, which are insensitive to most uncertainties
- Characterizing the small number of uncertainties to which the strategies remain vulnerable

Four Key Elements of Robust Decision Making

- Consider large ensembles (hundreds to millions) of scenarios
- Seek robust, not optimal strategies
- Achieve robustness with adaptivity
- Design analysis for interactive exploration of a multiplicity of plausible futures

Conversation #1: Your Assumptions Are Wrong

Scene: Sacramento, 1990s

Cast: Analysts briefing chancellors and state-wide elected officials

Problem: Potential state budget constraints cause access deficits in state universities

Chancellor: There is no problem

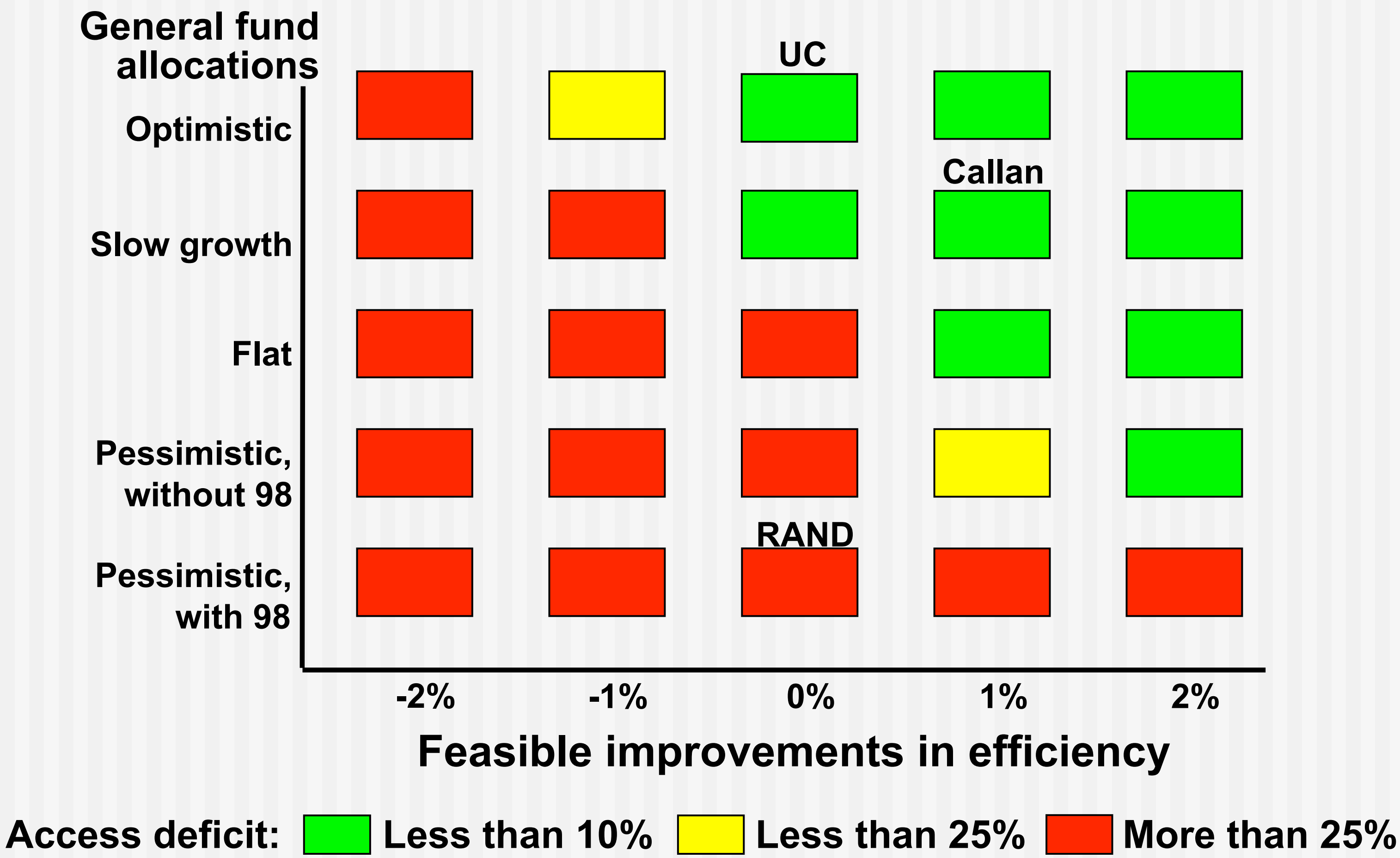
Analyst: Our analysis suggests future pressure on state budget may cause a problem

Chancellor: My staff reviewed your work. Your elasticities are wrong and your enrollment forecasts outdated

Analyst: Even using different elasticities and enrollments, our analysis would show your plans are vulnerable to budget shortfalls

Chancellor: The governor gave me his word that we'll have the funds we need

Landscapes of Plausible Futures Can Help Decisionmakers Consider Assumptions They Reject



Conversation #2: Your Model Is Wrong

Scene: Pentagon, after first Gulf War

Cast: Analysts briefing US Air Force General and his staff

Problem: Which new weapons systems to procure

Analyst: Our sophisticated combat simulation model, using the best available data, suggests weapons mix X1 > X2 > X3.

Colonel (opposed to weapons system X1): What reliability did you assume for weapons system X1?

Analyst: 85%

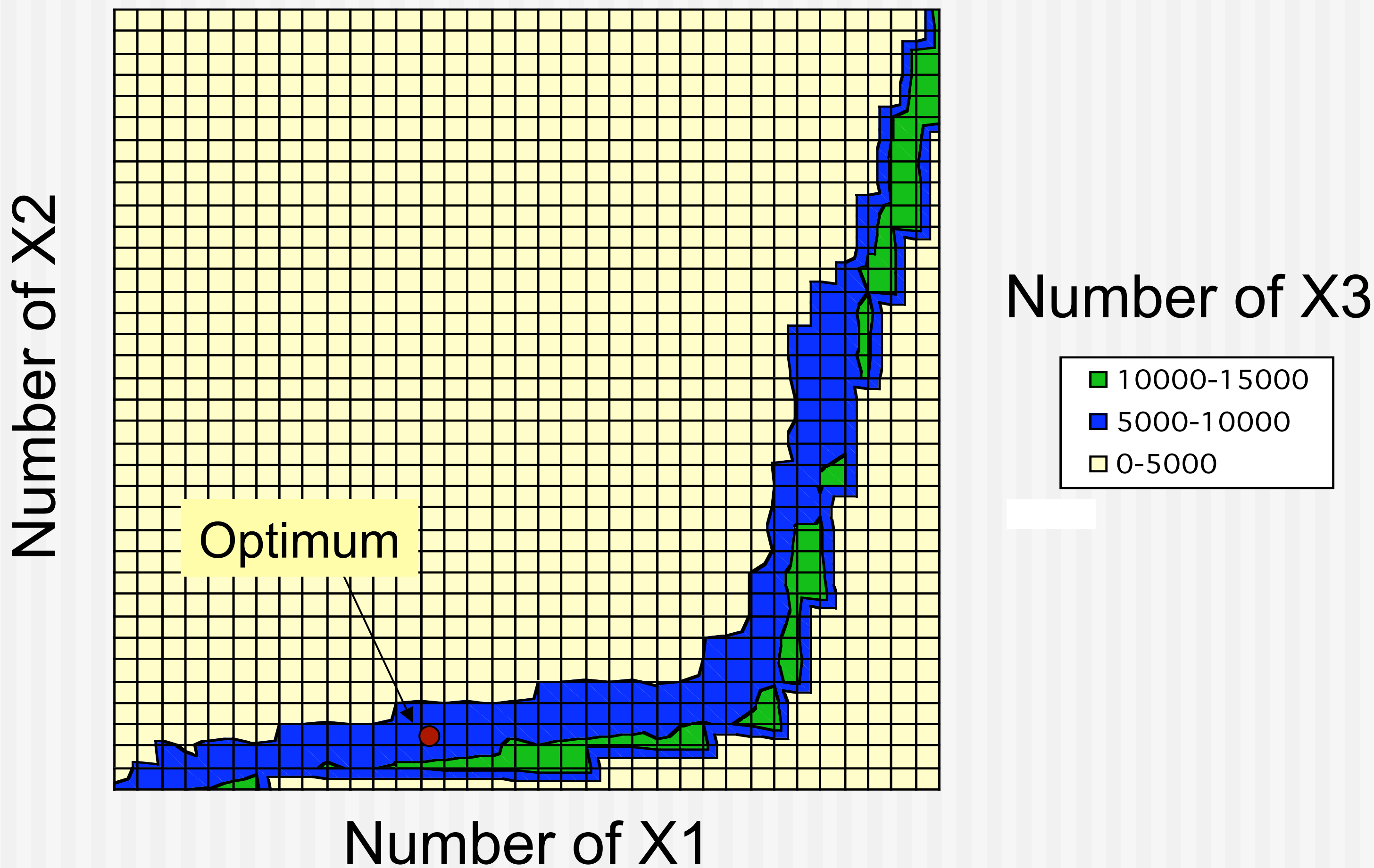
Colonel: What results do you get when you assume 90% and 80%?

Analyst: X2 > X1 > X3 for 90% and X3 > X1 > X2 for 80%

General: You're telling me that if its reliability goes up or down you buy less of weapon X1? How much did you spend developing this model?

"Level Sets" of Solutions Can Help Focus Horse Trading on Most Reasonable Solutions

Set of solutions with objective function within 5% of optimum



Conversation #3: Surprise!

Scene: Vincennes, Spring 1940

Cast: French General Staff

Problem: How to deploy French Army to counter Nazi threat

Staff General: Forward units report vehicle sounds east of Ardennes

Gen. Gamelin: We captured the German High Command's secret documents last November. I know those commanders. They plan to come from the North.

General: Just in case, we could put de Gaulle behind the seam of the 1st and 2nd armies. The only units there now are untrained reservists.

Gamelin: de Gaulle is a trouble maker. I don't want him that far from headquarters. The likelihood that the Germans can get their artillery through the Ardennes is nil. They will come from the North.

RDM Identifies Robust Strategies and Key Uncertainties with Iterative Process

Suggest candidate robust strategy

- Initial choice is contingent on probability weighting across futures

Characterize breaking scenarios

- i.e., clusters of futures where strategy performs poorly independent of assumed weightings

Identify strategies that hedge against these vulnerabilities and the tradeoffs among them

Example Application of Robust Decisionmaking

Example: What near-term actions will help ensure strong economic growth and a healthy environment over the course of the 21st century?

Used "Toy" systems-dynamics model with

- 41 input parameters representing uncertainties about
  - future economic, demographic, and environmental trends
  - values and capabilities of future decisionmakers
- Four value functions based loosely on UN Human Development Index, which reflects interests of a range of stakeholders
- Near-term strategies affect "decoupling" rate

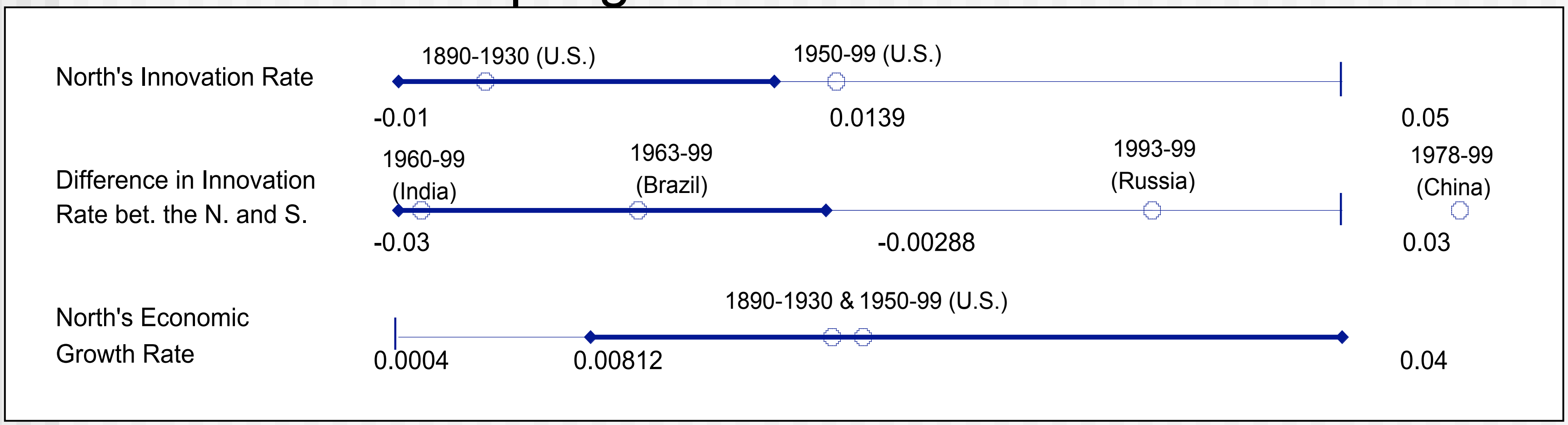
Initial scan suggests most robust strategy is "Safety Valve" with

- **Stringent near-term emissions intensity milestones**
- **Stringent cost thresholds**

Where Does this Candidate Robust Strategy Fail?

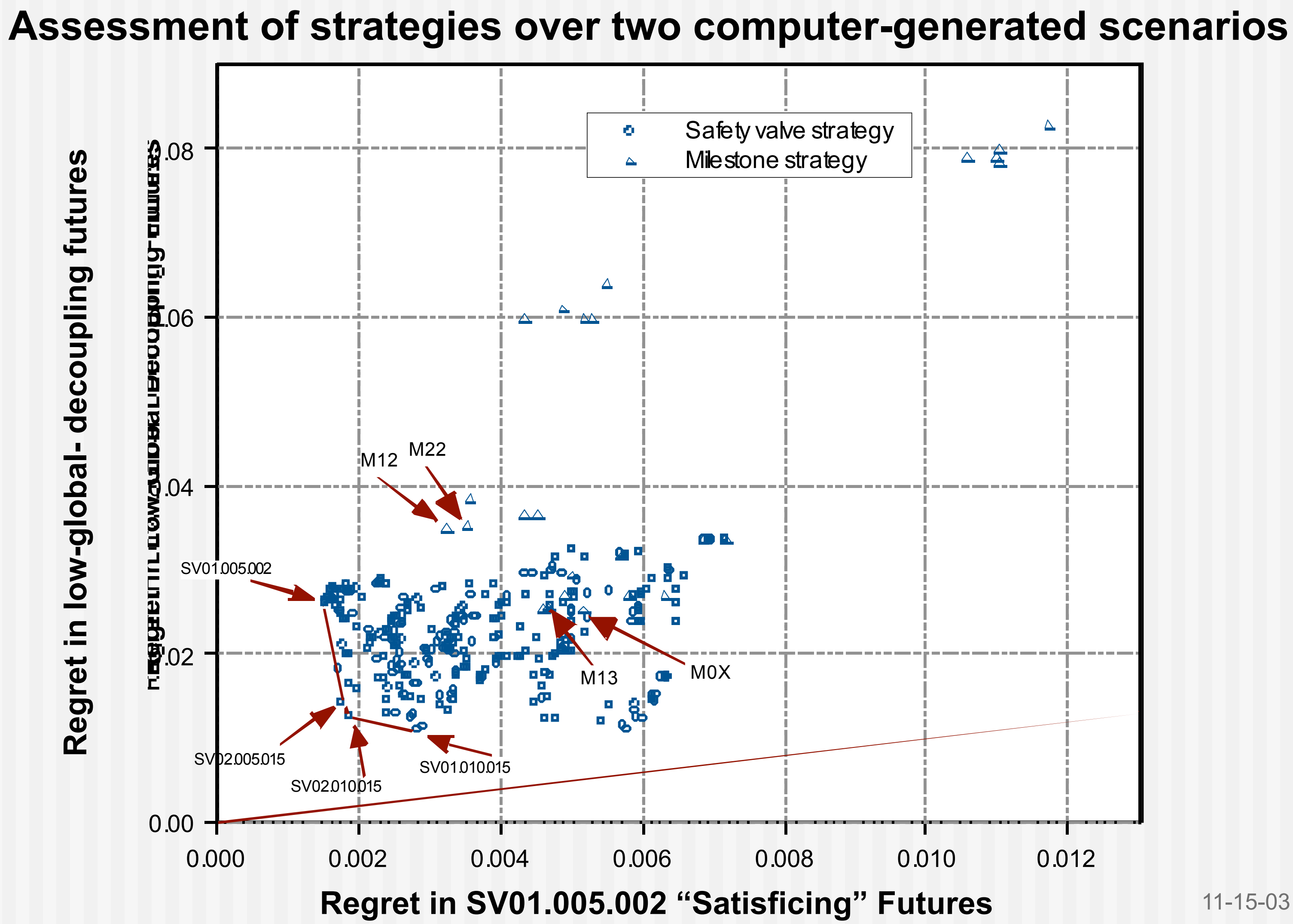
- “Data-mining” method identifies low-dimensional, easy-to-interpret region of input parameter space where strategy performs poorly

“Low Global Decoupling” scenario

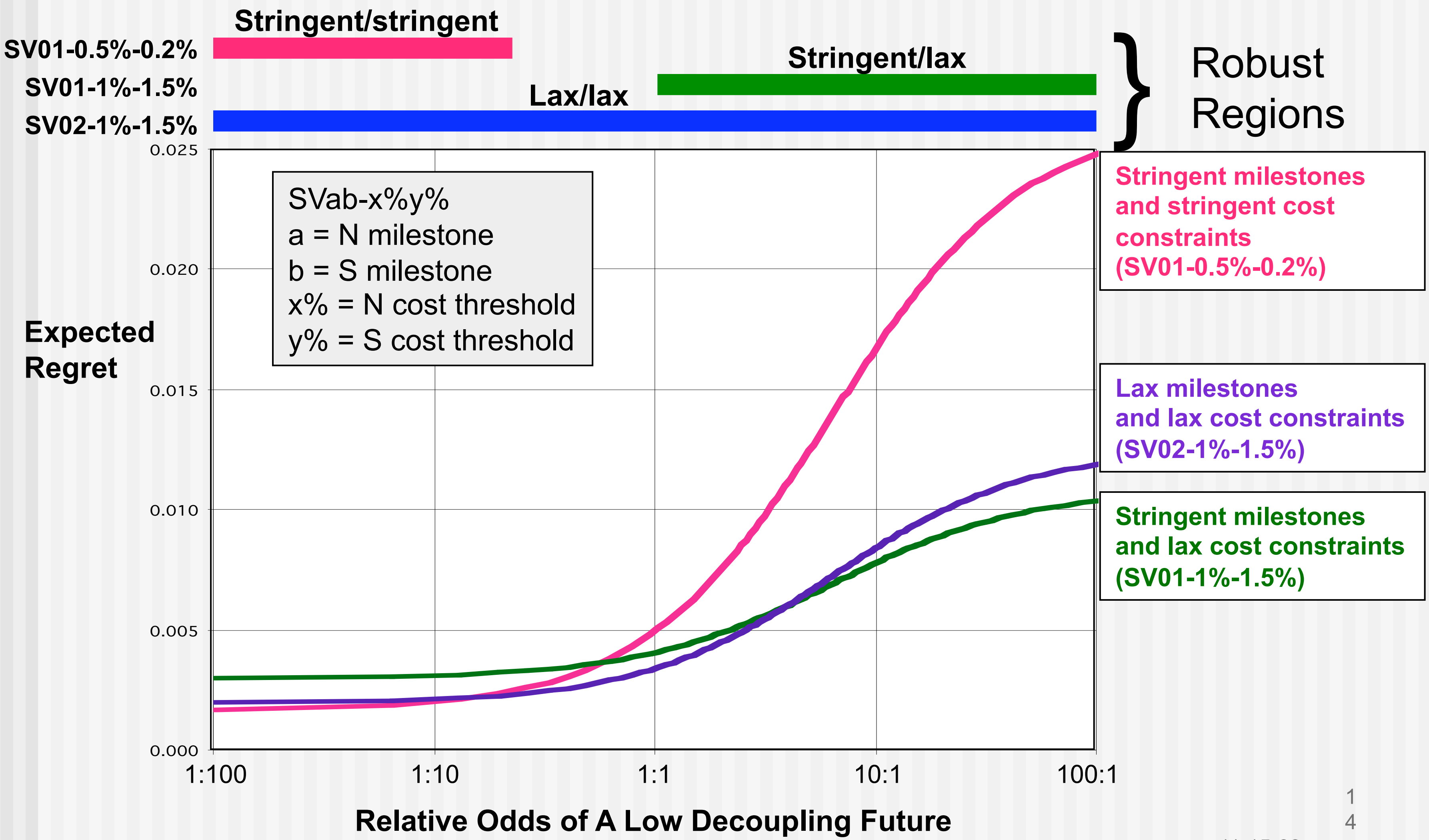


- Can interpret this region as a “scenario” of particular interest to decisionmakers

What are Best Strategies to Hedge Against These Vulnerabilities?



How Should Decisionmakers Choose Among These Alternative Strategies?



Research Is Needed to Define Circumstances Where Each Method Performs Best