How To Measure Anything

The Principles of Applied information Economics

Module 3

Hubbard Decision Research
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Glen Ellyn, Illinois 60137
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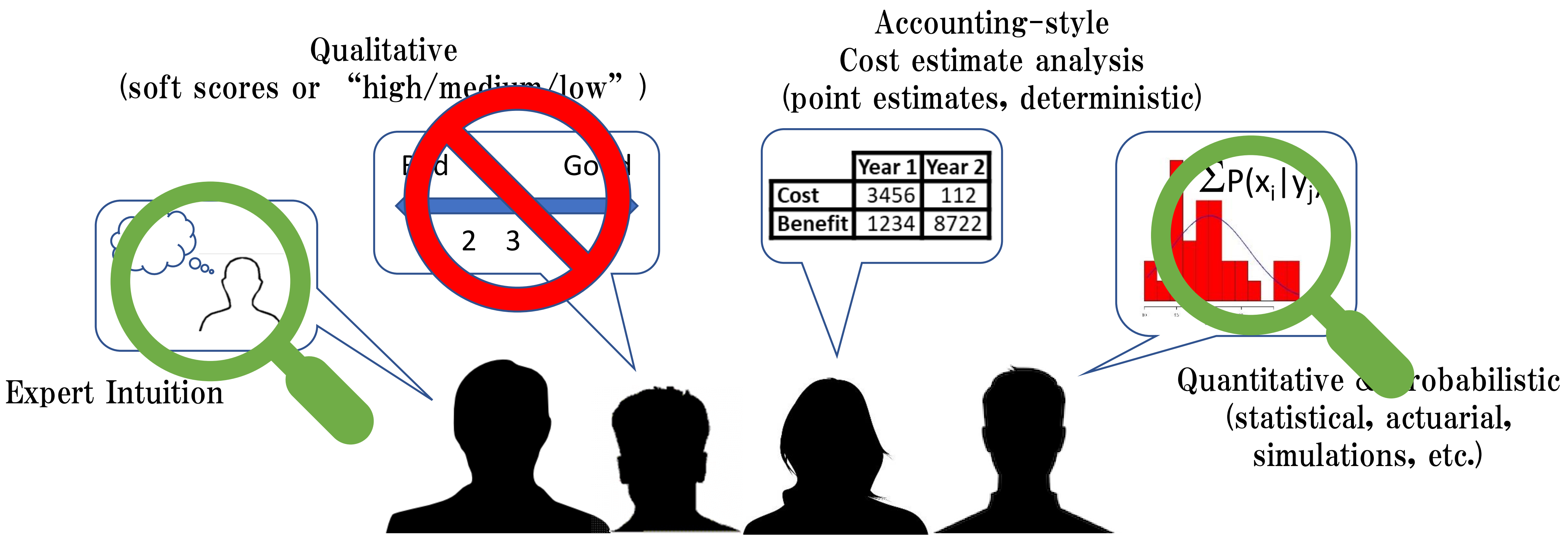
- **Deciding How to Decide**
  The Meta-Decision
- **How to Measure Anything**
  Overcoming the Illusion of Intangibles
- **Applied Information Economics**
  Putting What Works Together

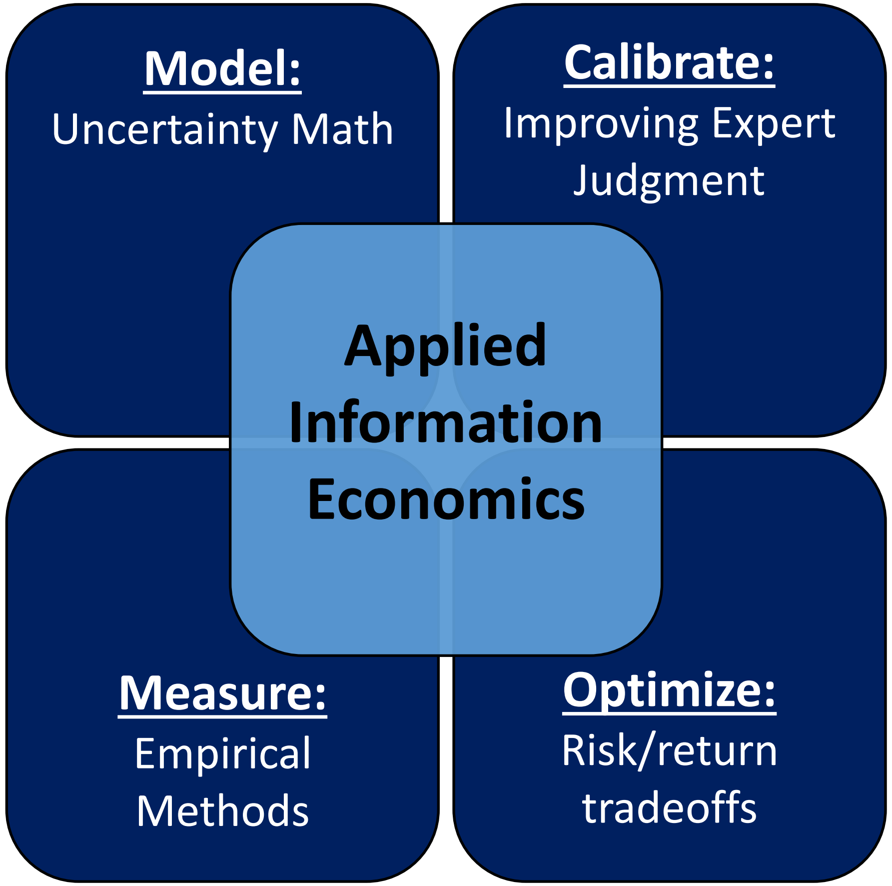
How to Measure Anything

Reviewing Where We Are



The Components of AIE

Decision Making Based Only On Methods That Work



Model: Doing Math with Uncertainty

- Probabilities and Monte Carlo simulations
- Computing risk and the value of information

Calibrate: Improving Expert Judgement

- Calibration training of individual experts
- Weighting experts by tracking performance
- Controlling for inconsistency

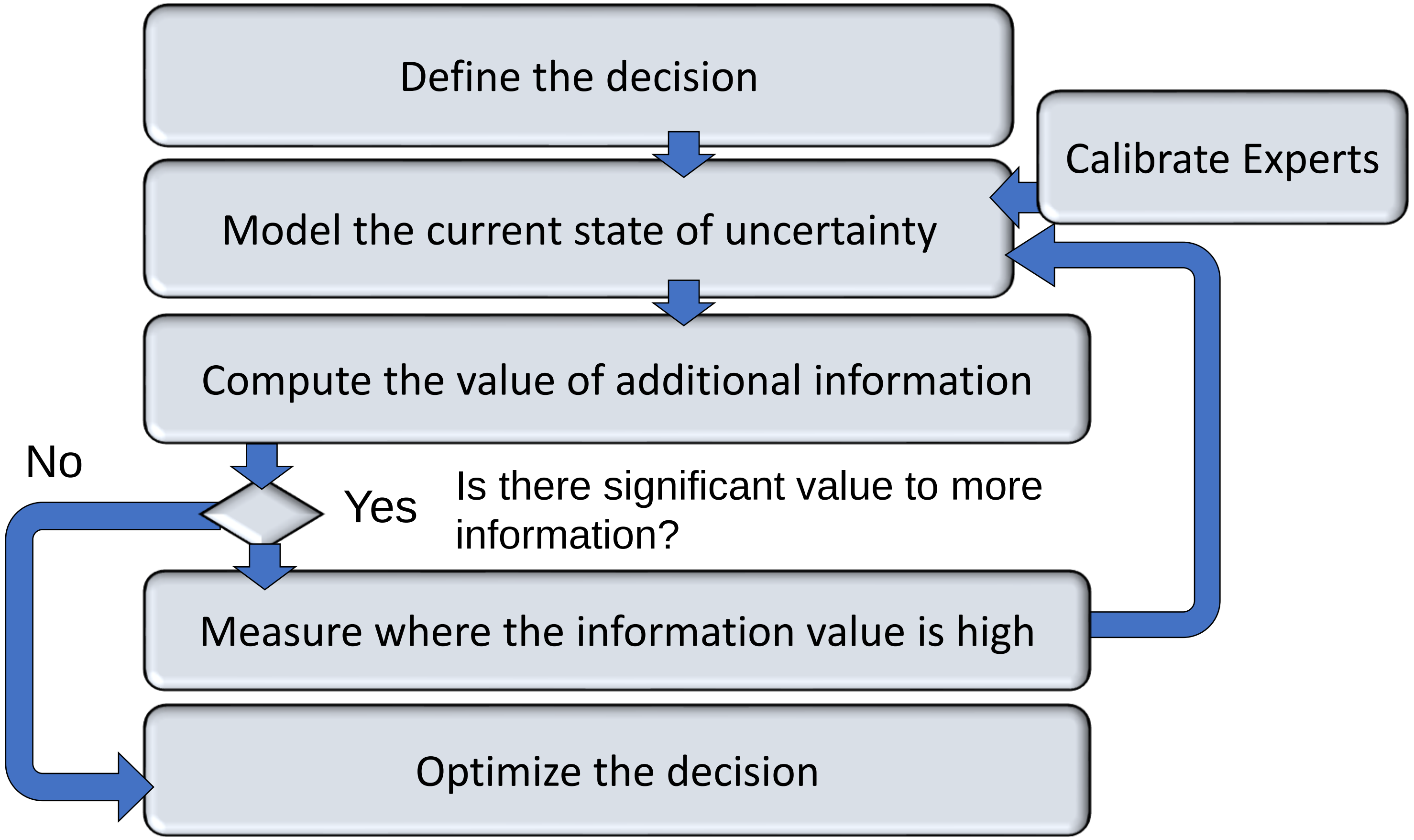
Measure: Empirical Methods

- Conventional statistical methods
- Bayesian methods

Optimize: Risk/Return tradeoffs

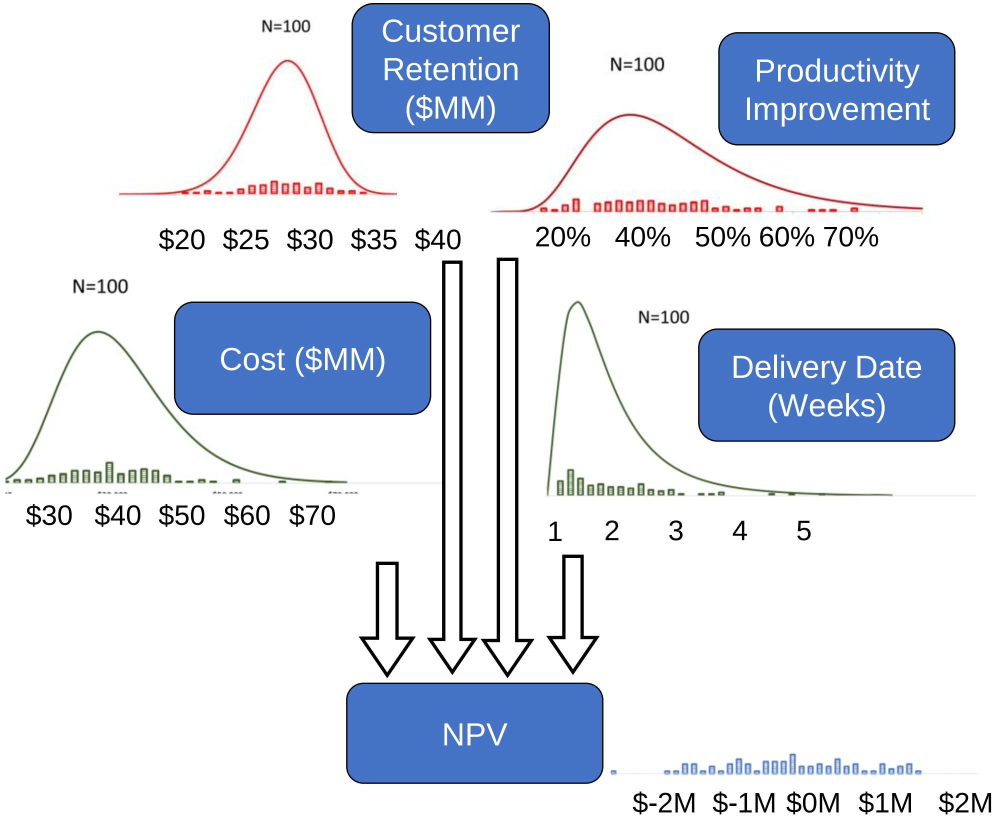
- Evaluating individual investment/project decisions
- Project/Portfolio optimization

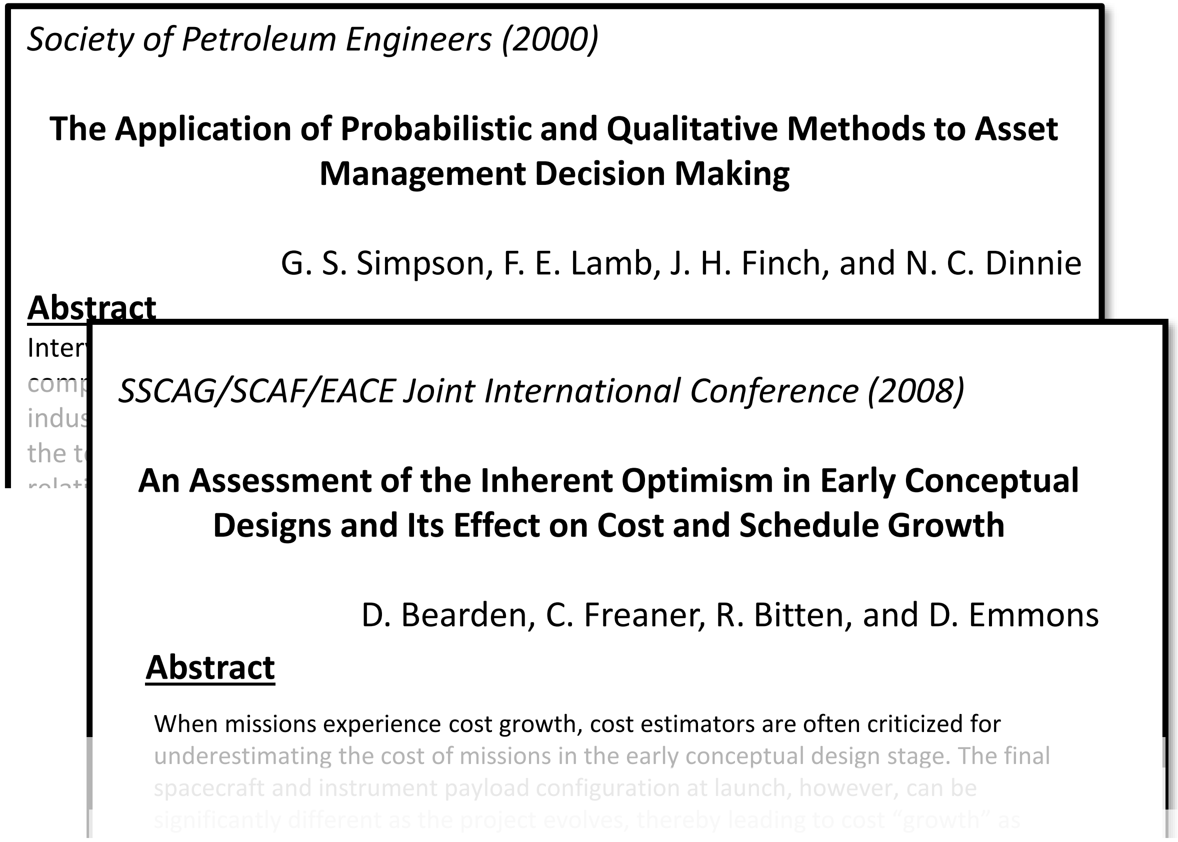
AIE can quantify *anything* and then optimizes decisions by focusing measurements where they matter most.



Evaluating the Meta-Decision Options

The Monte Carlo Simulation





Society of Petroleum Engineers (2000)

The Application of Probabilistic and Qualitative Methods to Asset Management Decision Making

G. S. Simpson, F. E. Lamb, J. H. Finch, and N. C. Dinnie

Abstract

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SSCAG/SCAF/EACE Joint International Conference (2008)

An Assessment of the Inherent Optimism in Early Conceptual Designs and Its Effect on Cost and Schedule Growth

D. Bearden, C. Freaner, R. Bitten, and D. Emmons

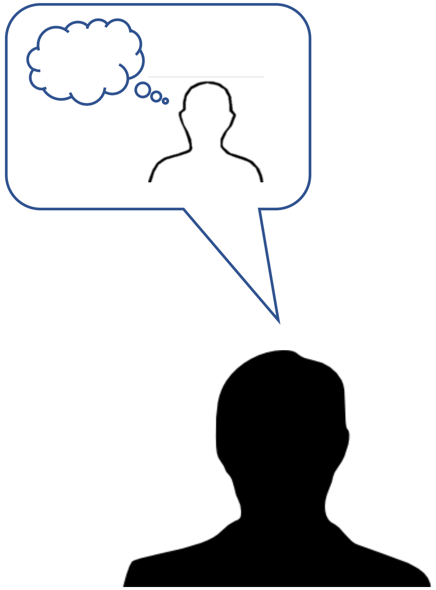
Abstract

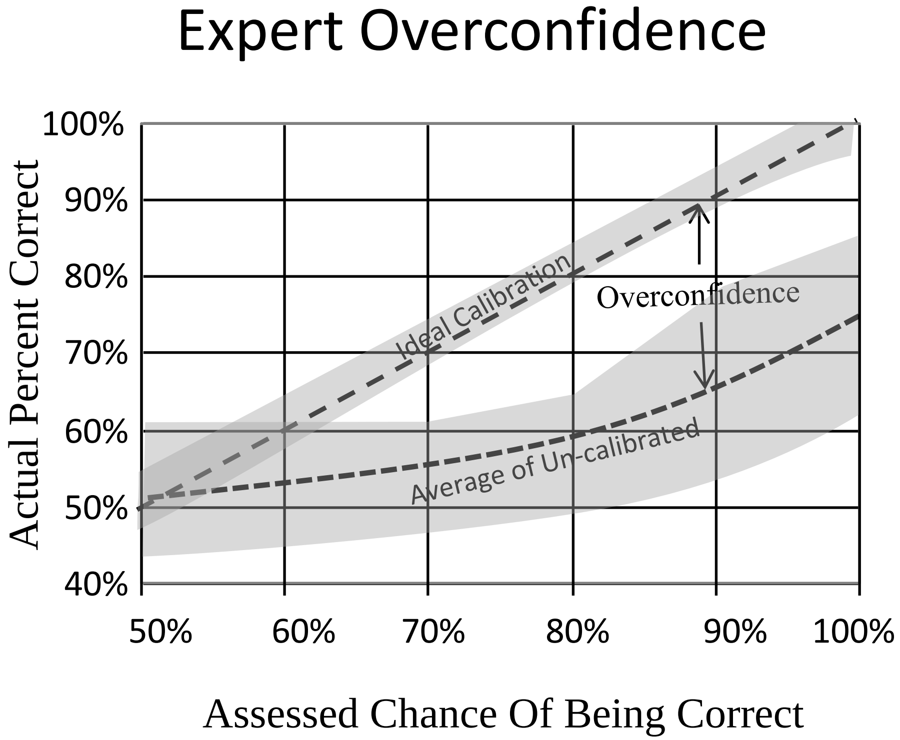
When missions experience cost growth, cost estimators are often criticized for underestimating the cost of missions in the early conceptual design stage. The final spacecraft and instrument payload configuration at launch, however, can be significantly different as the project evolves, thereby leading to cost "growth" as

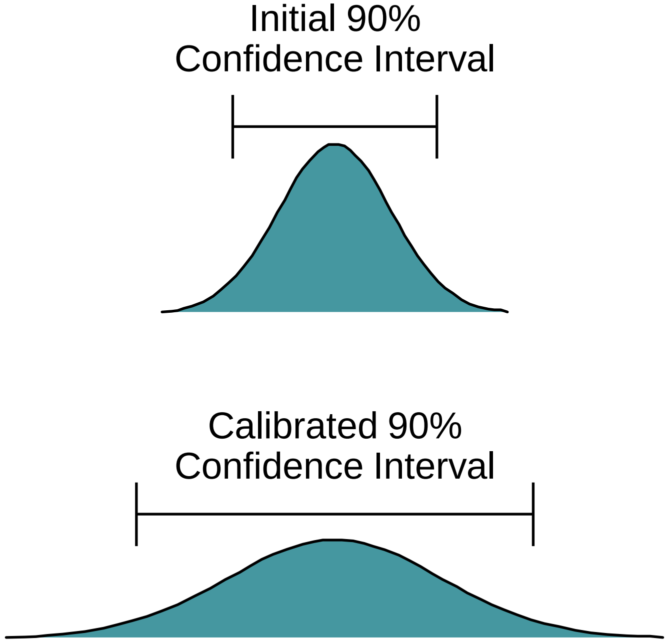
Expert Calibration: Overconfidence

Training Subject Matter Experts to Be More Realistic When Assessing Uncertainty

When expert performance is tracked, they have a much lower chance of being right than they expect



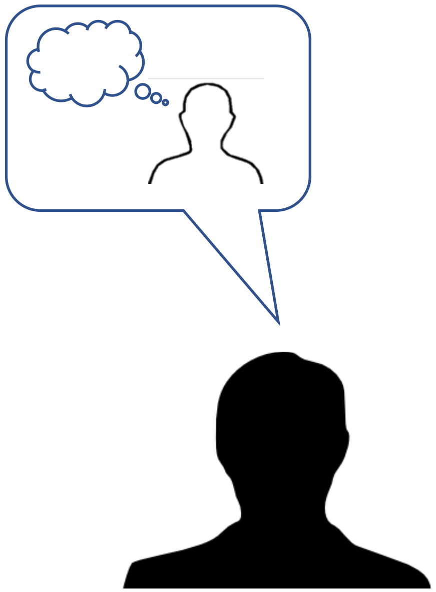




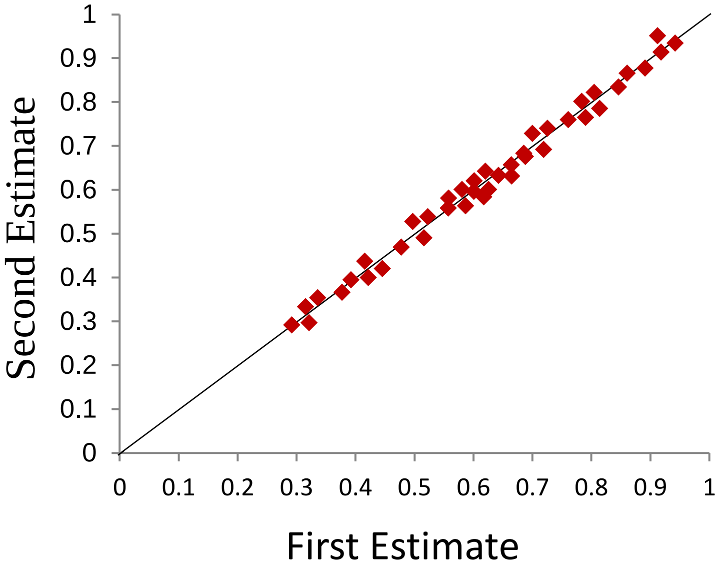
Expert Calibration: Consistency

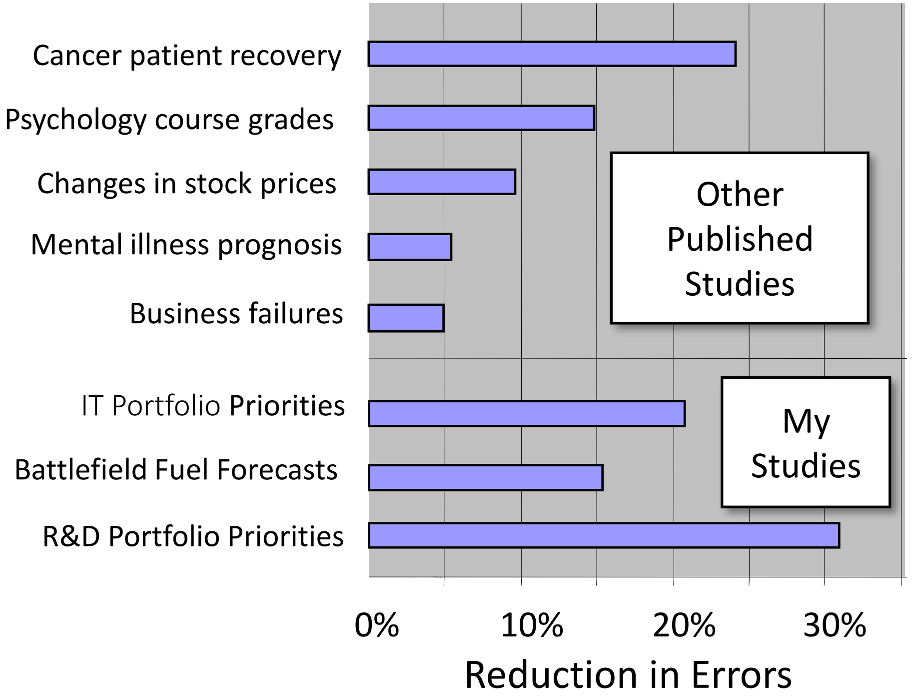
Measuring and Reducing the Inconsistency of Experts

Methods that statistically "smooth" estimates of experts show reduced error in several studies for many different kinds of problems.



Subject Matter Expert (SME) Inconsistency





Expert Calibration: Comparing Experts

Measuring and Improving Expert Estimation and Forecasting Performance

Tetlock also looked at what improved *forecasting.*

He tracked 743 individuals who made at least 30 forecasts each over a 2-year period.

He determined factors that made the biggest difference in the performance of forecasting.

Journal of Experimental Psychology: Applied
2015, Vol. 21, No. 1, 1–14

1076-898X/15/$12.00 http://dx.doi.org/10.1037/xap0000040

The Psychology of Intelligence Analysis: Drivers of Prediction Accuracy in World Politics

Barbara Mellers, Eric Stone, Pavel Atanasov, Nick Rohrbaugh, S. Emlen Metz, Lyle Ungar, Michael M. Bishop, and Michael Horowitz
University of Pennsylvania

Ed Merkle
University of Missouri

Philip Tetlock
University of Pennsylvania

This article extends psychological methods and concepts into a domain that is as profoundly consequential as it is poorly understood: intelligence analysis. We report findings from a geopolitical forecasting tournament that assessed the accuracy of more than 150,000 forecasts of 743 participants on 199 events occurring over 2 years. Participants were above average in intelligence and political knowledge relative to the general population. Individual differences in performance emerged, and forecasting skills were

Probabilistic Training

- Subjects were trained in basic inference methods, using reference classes, and avoiding common errors and biases.

Teams and Belief Updating

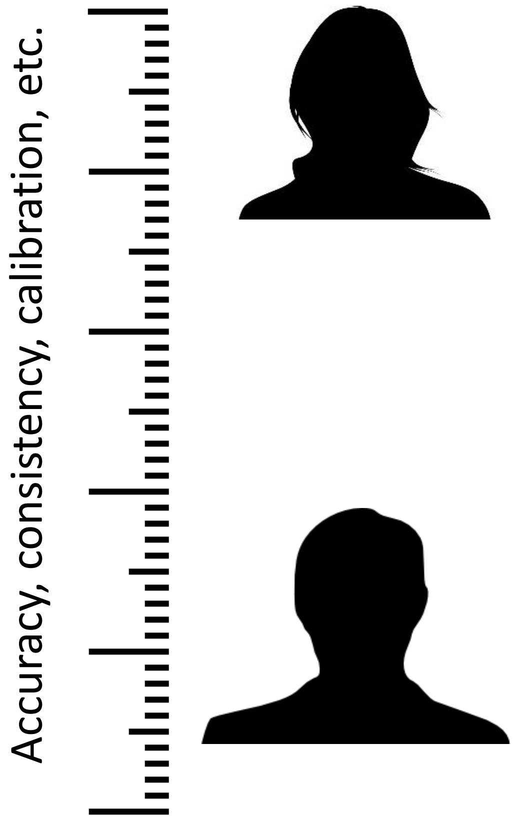
- Teams deliberated more and individuals were willing to update beliefs based on new information.

Selecting the Best

- Brains matter. Both topic expertise and overall IQ were the best predictors of performance.

Expert Calibration: Comparing Experts

How to Aggregate Experts



Expert Elicitation: Using the Classical Model to Validate Experts' Judgments

Abigail R. Colson* and Roger M. Cooke†

...ers with all of the information
...ptimal management choices.
...mation with the judgment of
...l science and statistics cannot
...is, decision makers have few
...s a way to quantify the uncer-
...ude methods as disparate as
...ying colleagues, or following
...ing probabilistic judgments.

Automatica, Vol. 24, No. 1, pp. 87–94, 1988
Printed in Great Britain.
0005–1098/88 $3.00 + 0.00
Pergamon Journals Ltd.

Brief Paper

Calibration and Information in Expert Resolution; a Classical Approach*

ROGER COOKE†, MAX MENDEL‡ and WIM THIJS§

Key Words—Expert resolution; expert opinion; subjective probability; calibration.

Abstract—A classical approach to expert resolution is presented using the concepts of calibration and information. Methodological problems with calibration measurements are brought to light and solutions are proposed. An experiment is described in which this approach is shown to have descriptive value.

Introduction

INTEREST in expert resolution is motivated by the increasing use of subjective probabilities in scientific studies, particularly in quantitative risk assessment. The principles of expert resolution are also applicable in situations where probabilistic diagnostic systems must be evaluated as well as in training and selection programs for personnel who may be called upon to give expert probability assessment (Mendel ...

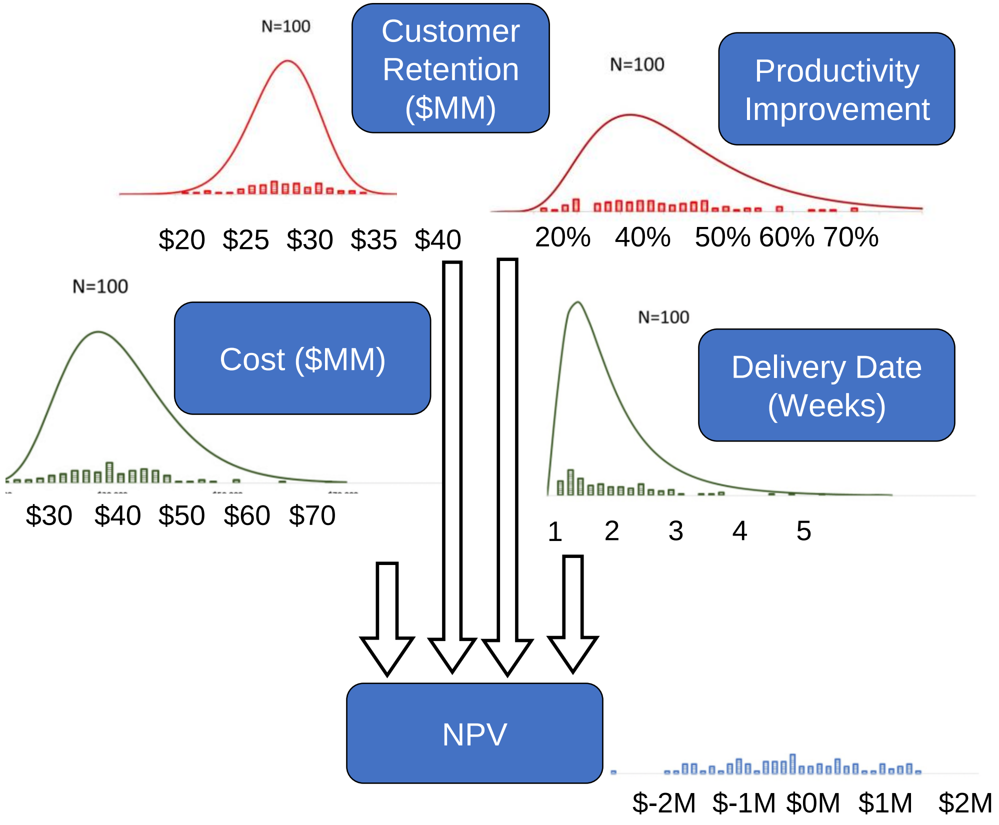
bias. As pointed out in Agnew (1985) and Genest and Schervish (1985), these assessment tasks are rather forbidding. Kempthorne and Mendel (1987) draw attention to other problems in Morris' theory. On the other hand, the Bayesian approach enables the decision maker to calculate the precise value of an expert for a particular decision problem in terms of increased expected value.

De Groot and Fienberg (1986) and Winkler (1986) propose using proper scoring rules for evaluating probabilistic forecasters. Their approach is somewhat similar to the ideas presented here, though Cooke (1987) points out several significant differences.

In this article we approach the problem of expert resolution from a classical perspective. An expert probability assessment is treated as a statistical hypothesis in the sense of "objectivist" statistics, and we show how experts can be ...

Evaluating the Meta-Decision Options

The Monte Carlo Simulation



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The Value of Information

- The formula for the value of information has been around for many decades but still mostly unheard of in the parts of business where it might do the most good.
- AIE uses methods to systematically apply this even in decisions with many interacting variables.
- This has profound effects on what to measure and how.

IEEE Transactions on Systems Science and Cybernetics (1966)

Information Value Theory

Ron Howard

Abstract

The information theory developed by Shannon was designed to place a quantitative measure on the amount of information involved in any communication. The early developers stressed that the information measure was dependent only on the probabilistic structure of the communication process. For example, if losing all your assets in the stock

$$EVI = \sum_{i=1}^{k} p(r_i) \max\left[\sum_{j=1}^{z} V_{1,j}\, p(\Theta_j | r_i), \sum_{j=1}^{z} V_{2,j}\, p(\Theta_j | r_i), \ldots \sum_{j=1}^{z} V_{l,j}\, p(\Theta_j | r_i), \right] - EV\,*$$

OR, in its simplest form:

"The cost of being wrong times the chance of being wrong"

The Measurement Inversion

Why are Measurement Priorities Backwards?

In a business case, the economic value of measuring a variable is usually inversely proportional to the measurement attention it typically gets.

Lowest Information Value

Highest Information Value

A Common IT Project Example

- Initial cost
- Long-term costs
- Cost-saving benefit other than labor productivity
- Labor productivity
- Revenue enhancement
- Technology adoption rate
- Project completion

Most Measured

Least Measured

The Methods of Measurement

A Fundamental Equation for Measurement Methods

"Bayesian" methods in statistics use new information to update prior knowledge.

It can answer "What is the chance of X is true if I see Y?"

Bayes Theorem: $$P(X|Y) = \frac{P(X)P(Y|X)}{P(Y)} = \frac{P(X)P(Y|X)}{\sum_i P(Y|X_i)\,P(X_i)}$$

P(X) = the probability of X

P(X|Y) = the probability of X given the condition Y

$\Sigma\, P(Y \mid X_i)\, P(X_i)$ = the sum of the probability of Y under each possible condition

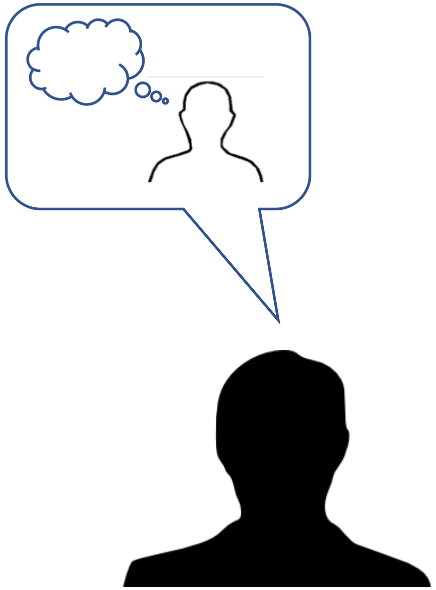
Quantifying Risk Aversion

What Risks Are We Willing to Accept?

The Psychology of Risk Aversion

Why Does Our Risk Tolerance Change?

Decision makers are also inconsistent regarding their own aversion to risk.



Neuron Vol. 47, (2005): 763–770

The Neural Basis of Financial Risk Taking

Camelia M. Kuhnen and Brian Knutson

Journal of Personality and Social Psychology
2001, Vol. 81, No. 1, 146–159

0022-3514/01/$5.00 DOI: 10.1037//0022-3514.81.1.146

Fear, Anger, and Risk

Jennifer S. Lerner
Carnegie Mellon University

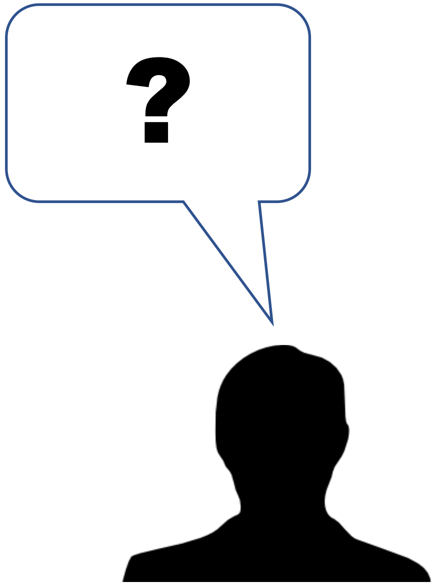
Dacher Keltner
University of California, Berkeley

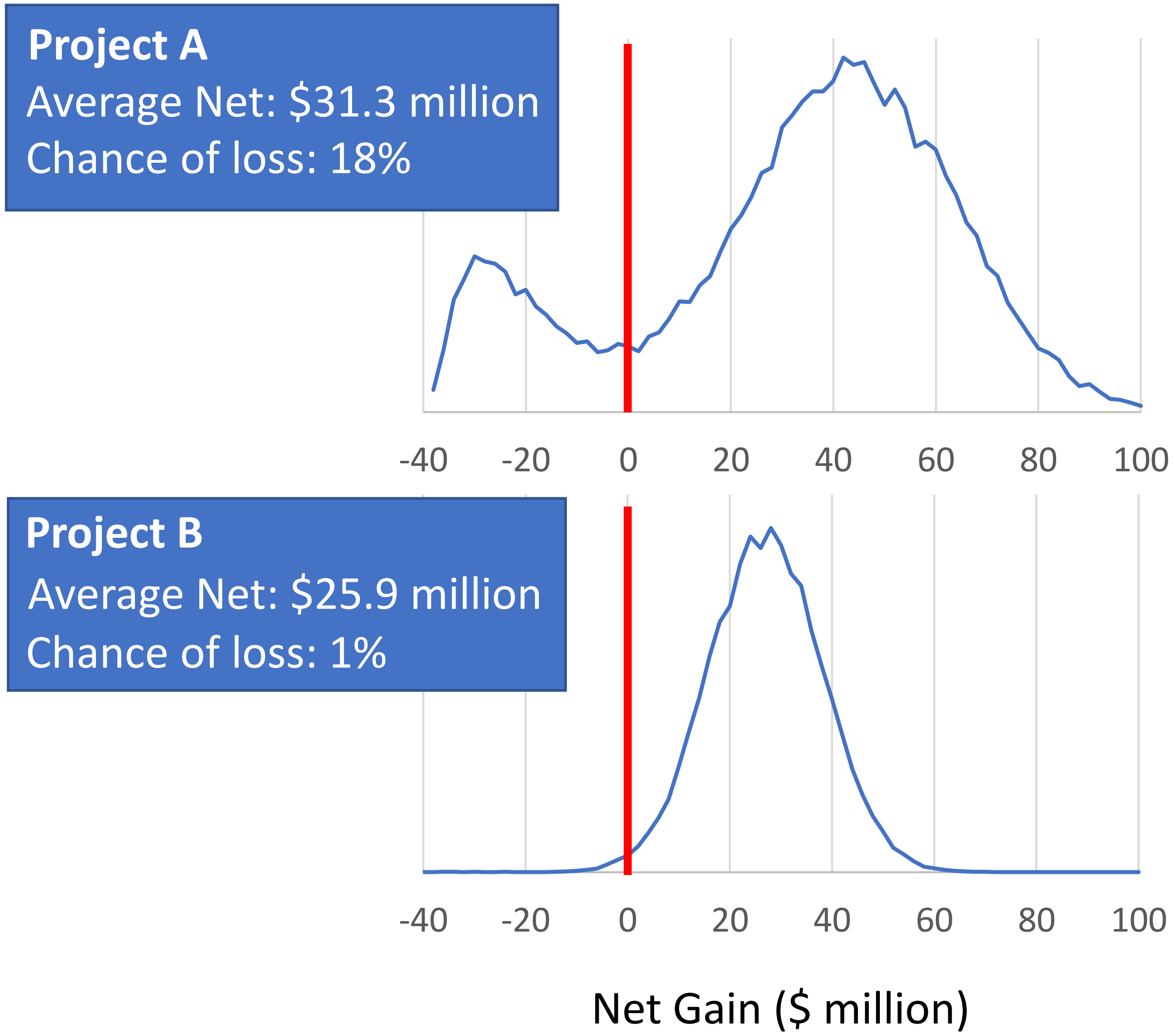
…er & D. Keltner, 2000), the authors predicted
…perception. Whereas fearful people expressed
…people expressed optimistic risk estimates and
…for naturally occurring and experimentally
…ople more closely resembled those of happy

Factor	Risk Aversion
Being around smiling people	↓
Recalling an event causing fear	↑
Recalling an event causing anger	↓
A recent win in an unrelated decision	↓
A recent loss in an unrelated decision	↑

Quantifying Risk Aversion

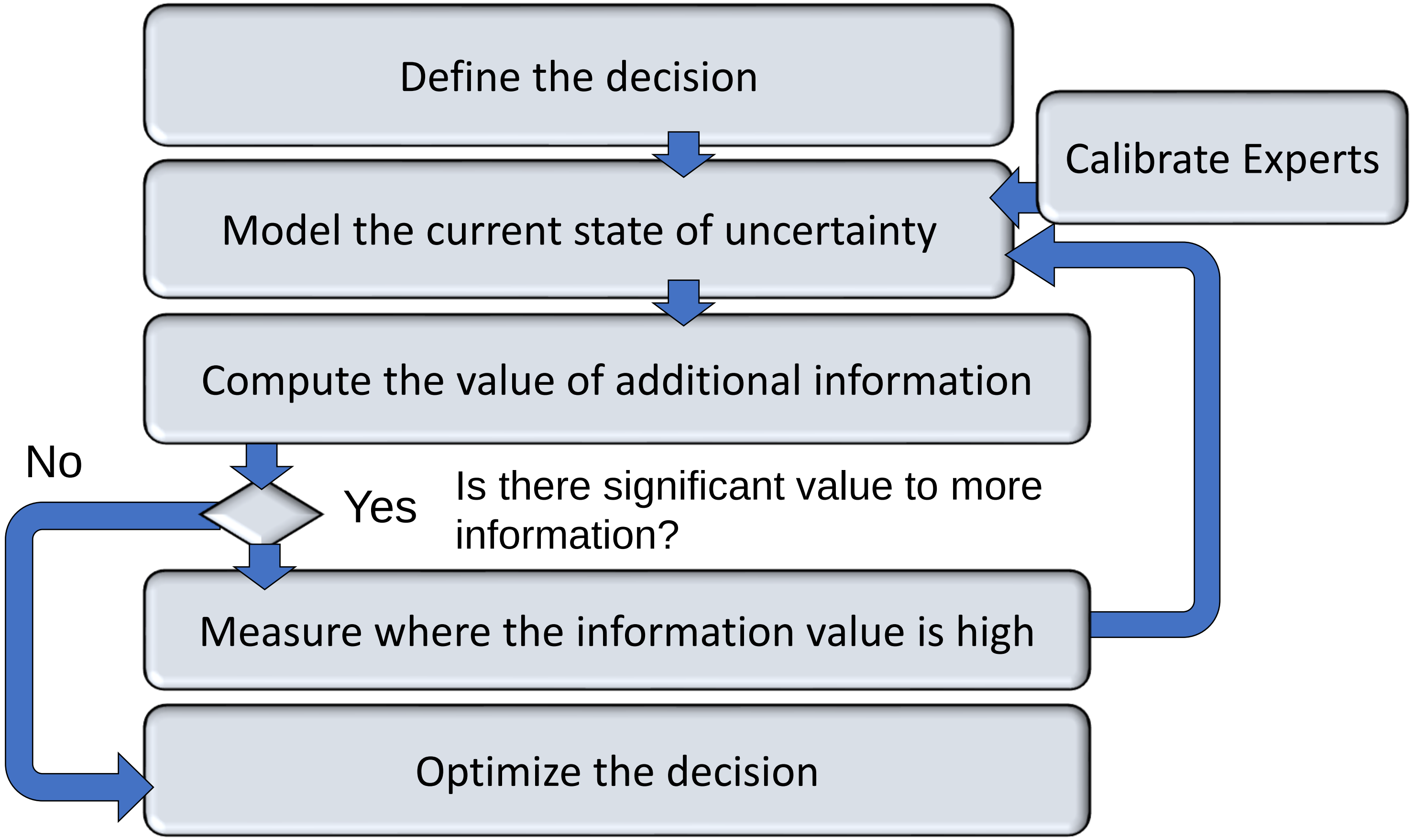
An Example of Risk-Return Dilemma





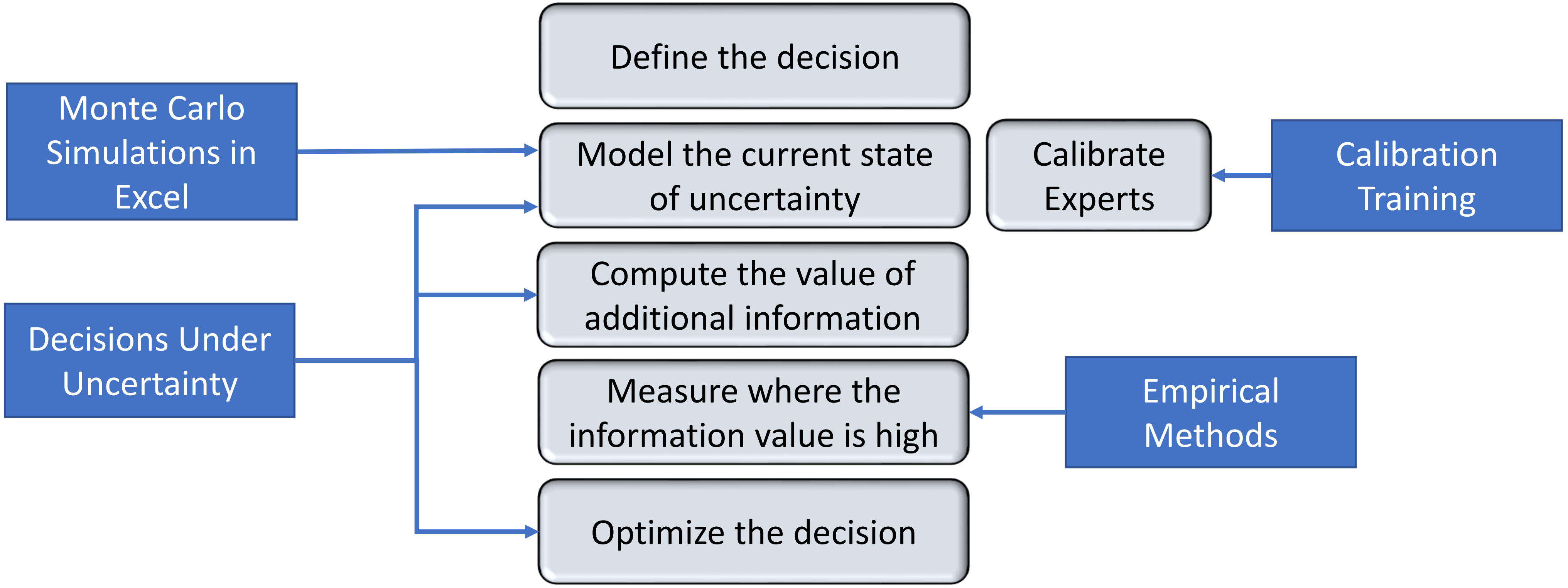
Review of The Process

Pulling It All Together



What Following Courses Will Cover

Connecting the Training and the AIE Method



Past Uses of Applied Information Economics

A Variety of Industries, Decision Problems and Scope of Effort

Over the last 20 years, AIE has also been applied to other decision analysis problems in all areas of Business Cases, Performance Metrics, Risk Analysis, and Portfolio Prioritization.

IT

- Prioritizing IT portfolios
- Risk of software development
- Value of better information
- Value of better security
- Risk of obsolescence and optimal technology upgrades
- Value of infrastructure
- Performance metrics for the business value of applications

Business

- Movie/film project selection
- New product development
- Pharmaceuticals
- Medical devices
- Publishing
- Real estate

Engineering

- Infrastructure upgrades
- Risk of mine flooding

Government & Non Profit

- Environmental policy
- Sustainable agriculture
- Procurement methods
- Grants management

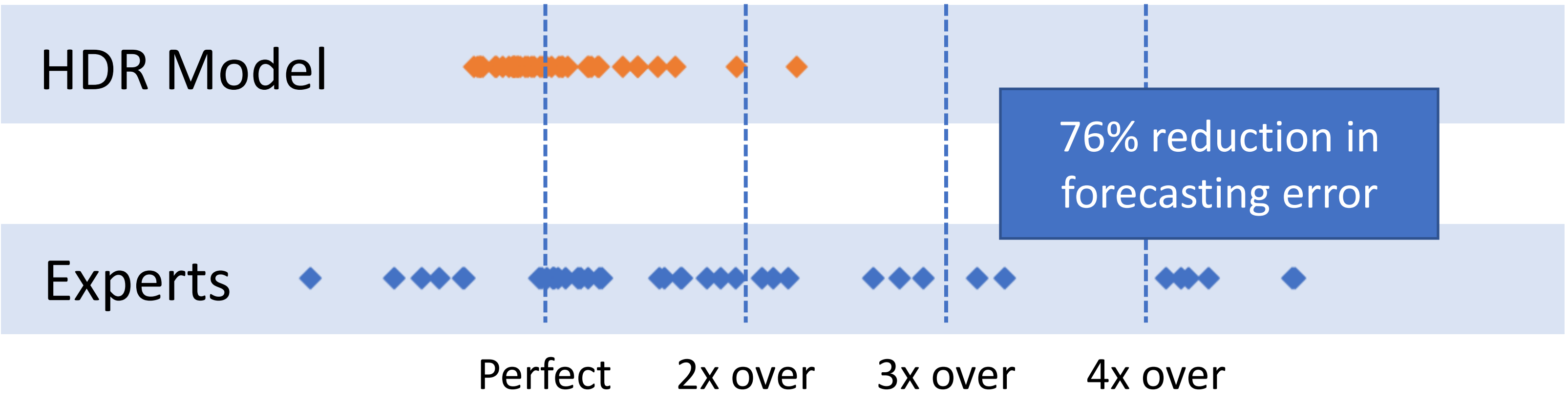
Military

- Forecasting battlefield fuel consumption
- Effectiveness of combat training to reduce roadside bomb/IED casualties
- R&D portfolios

Measuring the Performance of a Model

AIE vs. Previous Client Models

Life Technologies, Inc.
Forecasting first- and second-year revenue of new products in the biotech lab equipment industry.



US Marine Corps
Forecasting fuel for the battlefield

According to the USMC's own calculations: A 50% reduction in forecasting error resulting in $100 million annual savings in reduced fuel and operational costs.

Summary

Major Benefits of Applied Information Economics

Every component of AIE is based on methods that showed measurable improvements on expert intuition — over a large number of trials and reported in peer-reviewed journals.

AIE explicitly addresses the measurement inversion problem by computing the value of information as a basis for all measurements.

AIE quantifies uncertainty and risk in a manner that is mathematically meaningful (i.e. can be used in probabilistic models).

With well over 100 examples from a variety of industries, the method has become well-defined and repeatable.

Now, you can take your final review questions for the entire course.

This concludes the course How to Measure Anything: The Principles of Applied Information Economics