Applied Information Economics
An Executive Overview

A Proven Method for Measuring Intangibles, Optimizing Decisions & Avoiding Catastrophe

Hubbard Decision Research

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Objectives

- Discuss key concepts behind Applied Information Economics (AIE) including:
  - How AIE uses uncertainty, risk and measurement more like a statistician or actuary
  - How AIE is different from other methods
  - How AIE approaches an investment decision
- Discuss surprising findings from the combined results of 60 major AIE analysis projects and some powerful examples of measurements made with this method

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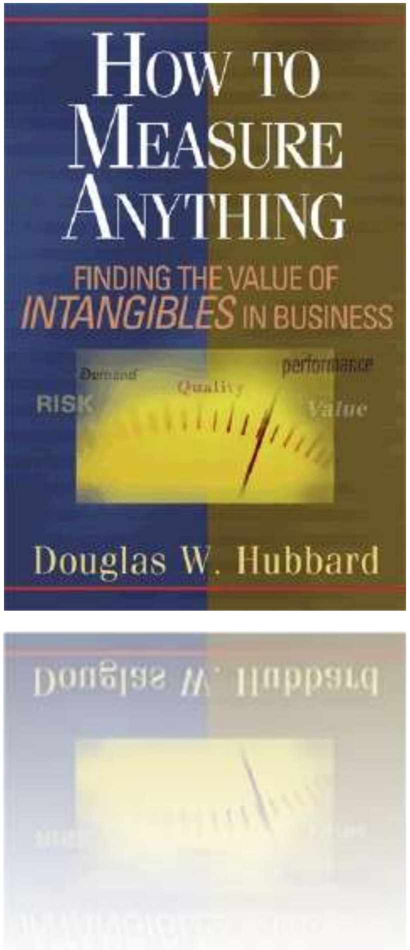
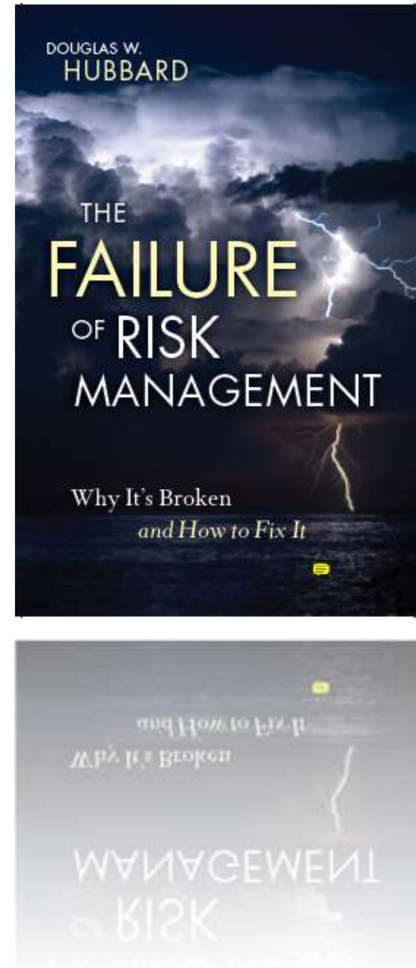
Background



- In the past 14 years, I conducted 60 major risk/return analysis projects so far
- I noticed that what were thought of as “impossible” measurements could actually be measured
- I also noticed that risk management and much decision analysis in business was mostly unscientific and did not reflect the latest research
- I wrote these two books published by John Wiley & Sons



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What is AIE?

Applied Information Economics (AIE) is:

1. The practical application of scientific and mathematical methods to quantify the value of management choices - regardless of how difficult the measurement challenge appears to be.
2. The optimization of the decision by optimizing the information gathering process itself – the highest payoff measurements are identified by computing the economic value of information.
3. The emphasis on using forecasting methods that have been scientifically tested to measurably reduce error of expert estimates

- "Quantifying the risk and comparing its risk/return with other investments sets AIE apart from other methodologies. It can substantially assist in financially justifying a project -- especially projects that promise significant intangible benefits." *The Gartner Group*
- "AIE represents a rigorous, quantitative approach to improving IT investment decision making…..this investment will return multiples by enabling much better decision making. Giga recommends that IT executives learn more about AIE and begin to adopt its tools and methodologies, especially for large IT projects." *Giga Information Group*

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A Few Examples

AIE was applied initially to IT business cases. But over the last 14 years it 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
  - The value of better information
  - The value of better security
  - The Risk of obsolescence and optimal technology upgrades
  - Vendor selection
  - The value of infrastructure
  - Performance metrics for the business value of applications
- Engineering
  - The risks of major engineering projects
- Business
  - Market forecasts
  - The risk/return of expanding operations
  - Business valuations for venture capital
- Military
  - Forecasting fuel for Marines in the battlefield
  - Measuring the effectiveness of combat training to reduce roadside bomb/IED casualties
  - R&D portfolios

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Assessing Assessment Methods

- Only empirical evidence that forecasts and decisions are actually improved can separate real benefits from a "placebo effect"
- Effective methods for evaluating IT investments should have a lot in common with well-known methods in other fields (actuarial science, portfolio optimization, etc.)
- What doesn't count as evidence that a method works:
  - Testimonials from users or any perception of a benefit
  - Wide use or acceptance as an official "standard" or "best practice"
  - Being "structured" or "formal"
  - The expertise of the developers

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Key Comparisons

Applied Information Economics	Traditional Methods
Uncertainty and risk are modeled like a statistician or an actuary would model it – even (and especially) when there is limited data	The chance of failure, negative returns or disaster is not quantified and it is unlikely key risks will even be identified
All components of AIE have been proven in controlled experiments to improve on unaided human judgment	There is no evidence (other than anecdotal cases in uncontrolled situations) that the decision is any better – Often, unproven "scoring" methods are employed
Any "intangible" is defined in terms of its practical consequences and is modeled economically	"Intangibles" are excluded or will be assessed with arbitrary, unproven scoring methods
The value of additional information is computed for each measurement – this results in many revelations about measurements are critical	The value of information is not computed and there is no way to know that the right measurements are taken
The level of risk aversion or risk tolerance is quantified as in Modern Portfolio Theory (Nobel Prize 1990)	Risk tolerance is never quantified in any sound, mathematical way

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Six Key Concepts

1. Any “intangible” can be defined in terms of its practical business consequences
2. We must look at uncertainty, risk and measurement like a statistician
3. There are proven methods that improve on human judgment
4. We can learn how to put odds on unknowns
5. We can compute the value of additional information to direct empirical measurements
6. We can quantify the level of risk aversion or risk tolerance and “optimize” the investment

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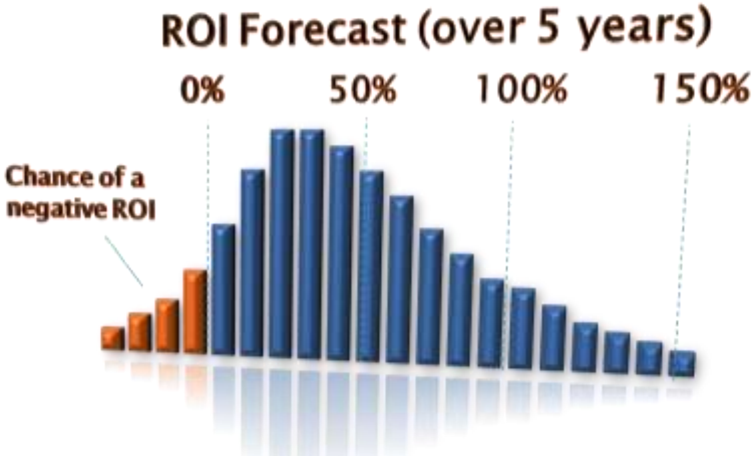
Uncertainty, Risk & Measurement

Measuring Uncertainty, Risk and the Value of Information are closely related concepts, important measurements themselves, and precursors to most other measurements

- The "Measurement Theory" definition of measurement: ***"A measurement is an observation that results in information (reduction of uncertainty) about a quantity."***
- An Actuary's approach to Risk Measurement***: "To quantify probability and loss of an undesirable possibility"***
- The value of a Measurement: "The monetized reduction in risk from making decisions under less uncertainty"
- We model uncertainty statistically – with Monte Carlo simulations



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An Approach That Works

1. Define the decision
2. Quantify the current uncertainty (model what you know now)
3. Compute the value of additional information
4. Measure where the information value is high
5. Optimize the decision

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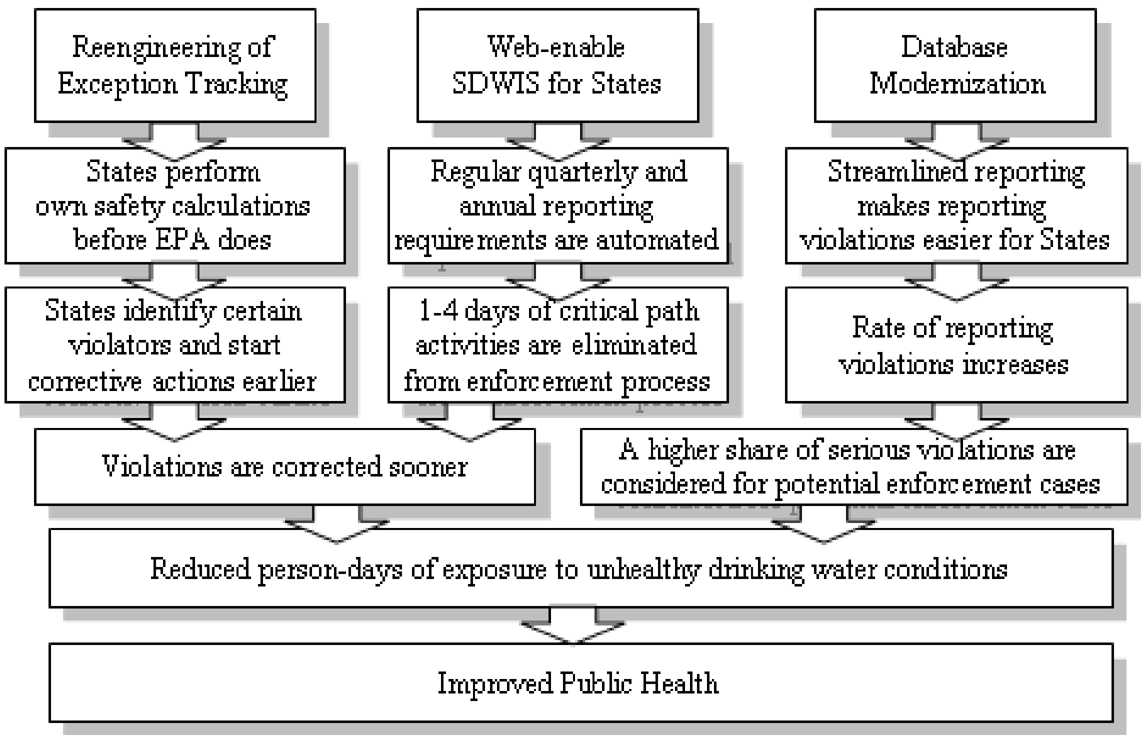
Defining the Decision

- The EPA needed to compute the ROI of the Safe Drinking Water Information System (SDWIS)
- As with any AIE project, we built a spreadsheet model that connected the expected effects of the system to relevant impacts – in this case public health and its economic value



Model What You Know

- Decades of studies show that most managers are statistically "overconfident" when assessing their own uncertainty
  - Studies showed that bookies were great at assessing odds subjectively, while doctors were terrible
- Studies also show that measuring *your own* uncertainty about a quantity is a general skill that can be taught with a ***measurable*** improvement
- Training can "calibrate" people so that of all the times they say they are 90% confident, they will be right 90% of the time

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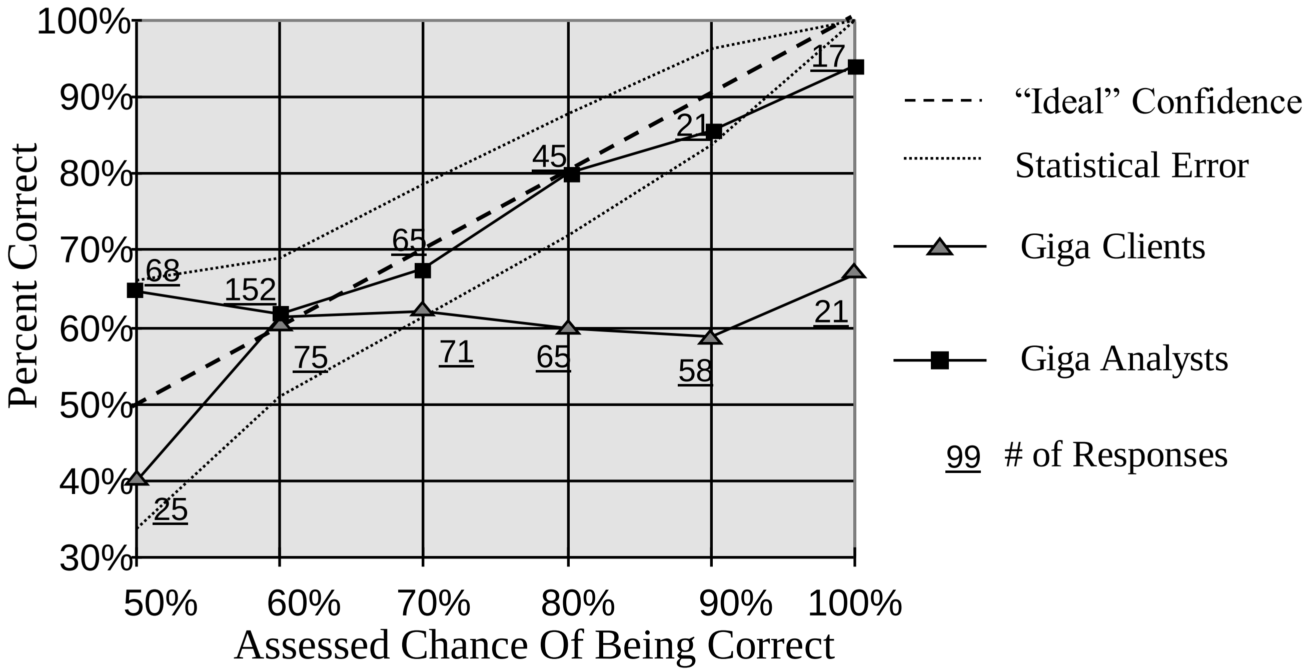
Calibrated Probabilities

- 1997: An experiment Hubbard conducted with Giga Information Group proves people can be trained to assess probabilities of uncertain forecasts
- Hubbard has calibrated hundreds of people since then
- Calibrated probabilities are the basis for modeling the current state of uncertainty



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The Value of Information

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

The formula for the value of information has been around for almost 60 years. It is widely used in many parts of industry and government as part of the “decision analysis” methods – but still mostly unheard of in the parts of business where it might do the most good.

What it means:

1. Information reduces uncertainty
2. Reduced uncertainty improves decisions
3. Improved decisions have observable consequences with measurable value

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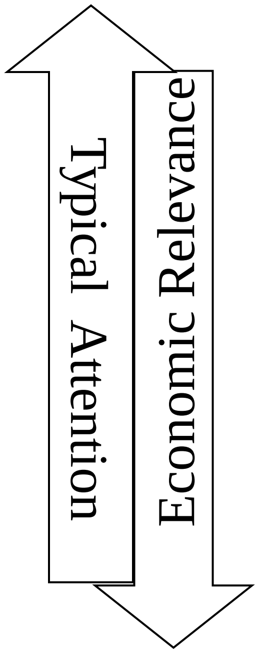
The Measurement Inversion

- After the information values for over 4,000 variables was computed, a pattern emerged.
- The highest value measurements were almost never measured while most measurement effort was spent on less relevant factors
  - Costs were measured more than the more uncertain benefits
  - Small "hard" benefits would be measured more than large "soft" benefits
- Also, we found that, if anything, *fewer* measurements were required after the information values were known.

Measurement Attention vs. Relevance



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Next Step: Observations

- Once we’ve determined what to measure, we can think of observations that would reduce uncertainty
- The value of the information limits what methods we should use, but we have a variety of methods available
- Take the “Nike Method”: Just Do It – don’t let imagined difficulties get in the way of starting observations

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Practical Assumptions

- **Its been measured before**
- **You have more data than you think**
- **You need less data than you think**
- **Its more economical than you think**
- **Your subjective estimate of possible measurement errors is exaggerated**

"It's amazing what you can see when you look"
Yogi Berra

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Statistics and Measurement

- Several clever sampling methods exist that can measure more with less data than you might think
- Examples:
  - estimating the population of fish in the ocean is like measuring the mistakes/intrusions you didn't detect
  - Measuring the effect of a drug is like measuring the effect of project on the performance of a complex organization
  - Statistical methods used by most scientists apply to estimating the size or rate of change of virtually anything

Statistical Estimates of German Tank Production in WWII

Month of Production	Intelligence estimate	Statistical estimate	Actual (Based on captured documents after the war)
June 1940	1000	169	122
June 1941	1550	244	271
August 1942	1550	327	342

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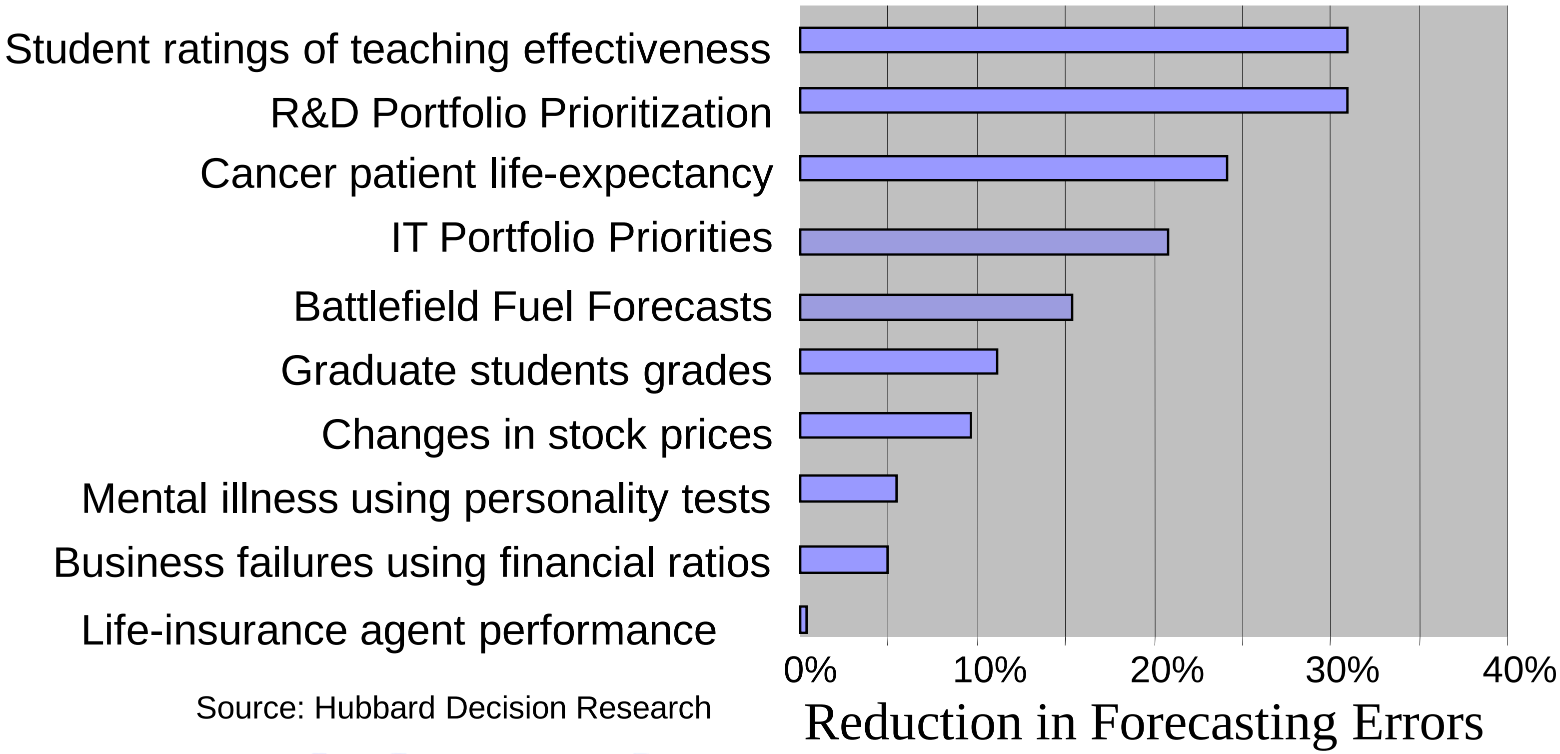
Reducing Inconsistency

- The "Lens Model" is another method used to improve on expert intuition
- The chart shows the reduction in error from this method on intuitive estimates
- In every case, this method equaled or bettered the judgment of experts – this is the valid evidence for the effectiveness of an estimation or decision making method



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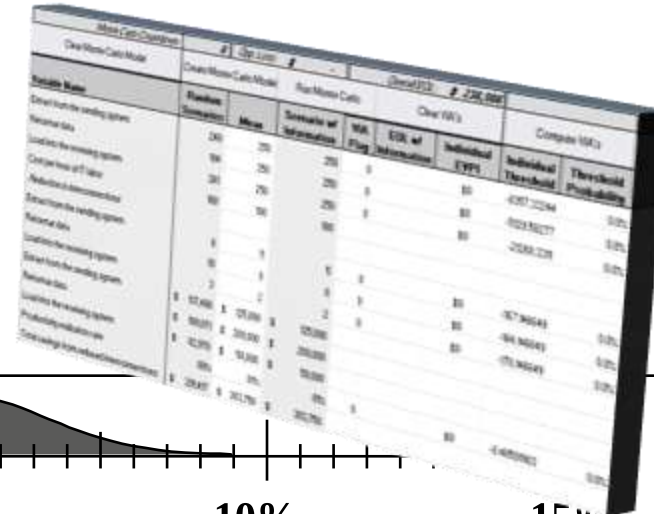
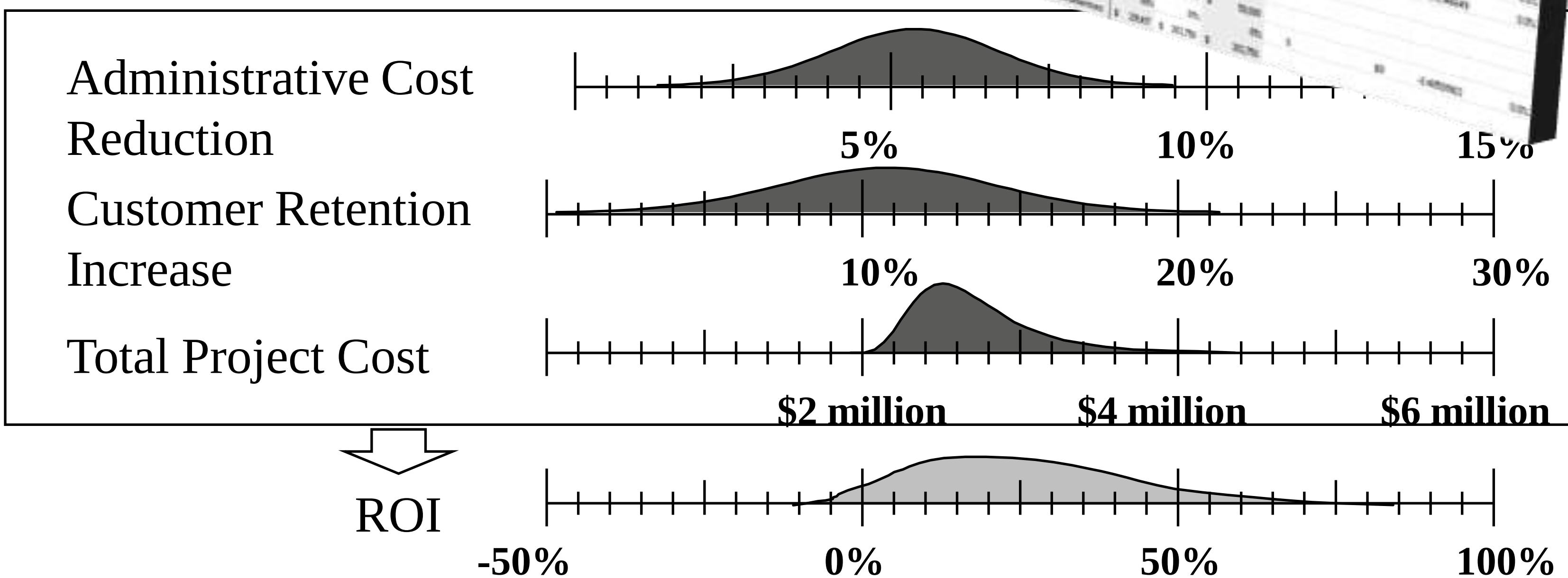
Risk/ROI w/ "Monte Carlo"

- A Monte Carlo simulation generates thousands of random scenarios using the defined probabilities and ranges
- The result is a range ROI not a point ROI





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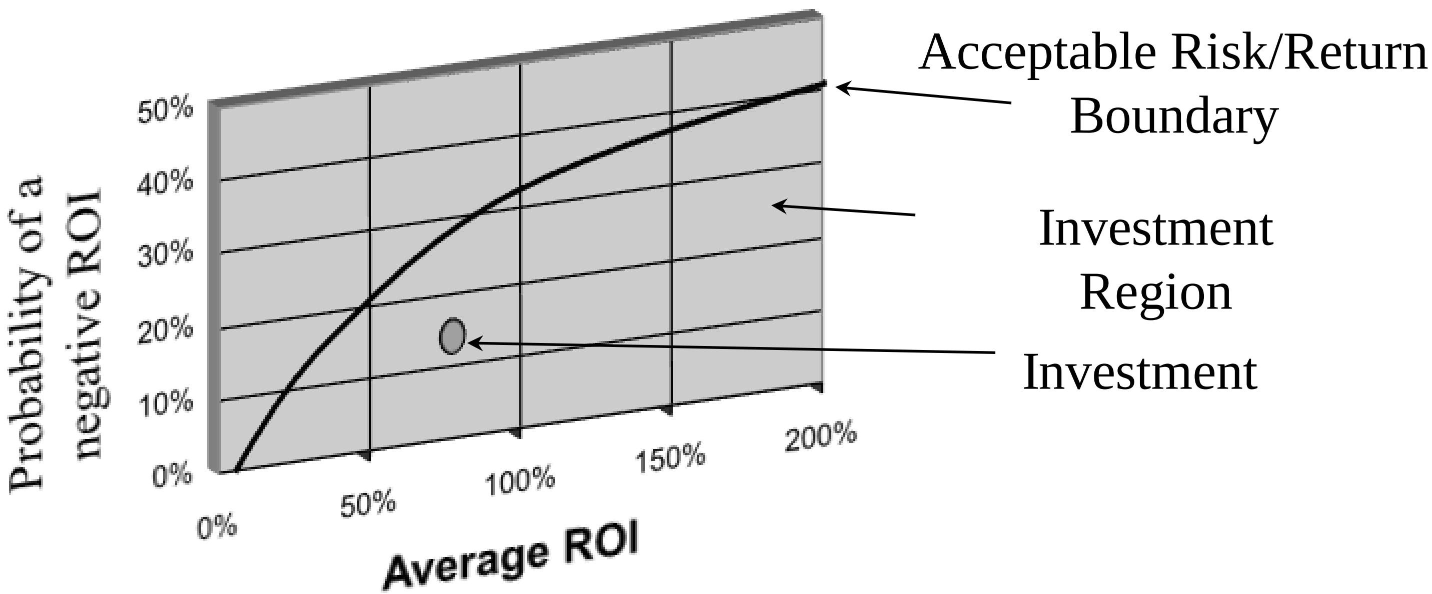
Quantifying Risk Aversion

- The simplest element of Harry Markowitz's Nobel Prize-winning method "Modern Portfolio Theory" is documenting how much risk an investor accepts for a given return.
- The "Investment Boundary" states how much risk an investor is willing to accept for a given return.
- For our purposes, we modified Markowitz's approach a bit.



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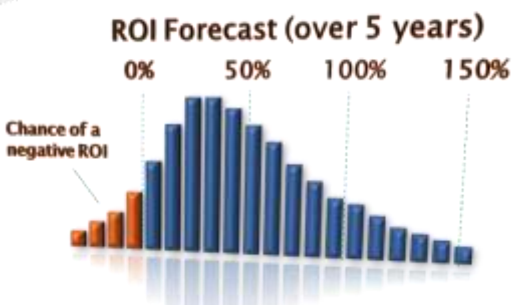
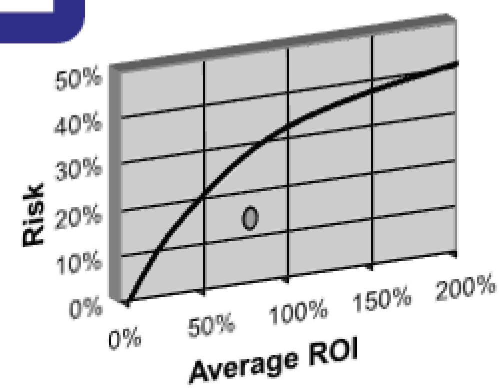
Review

1. Define Decision Model
2. Model w/Estimates & Measurements
3. Measure the value of additional Information
4. Measure where the information value is high
5. Optimize Decision

Calibrate Estimators

Modeling what you know now





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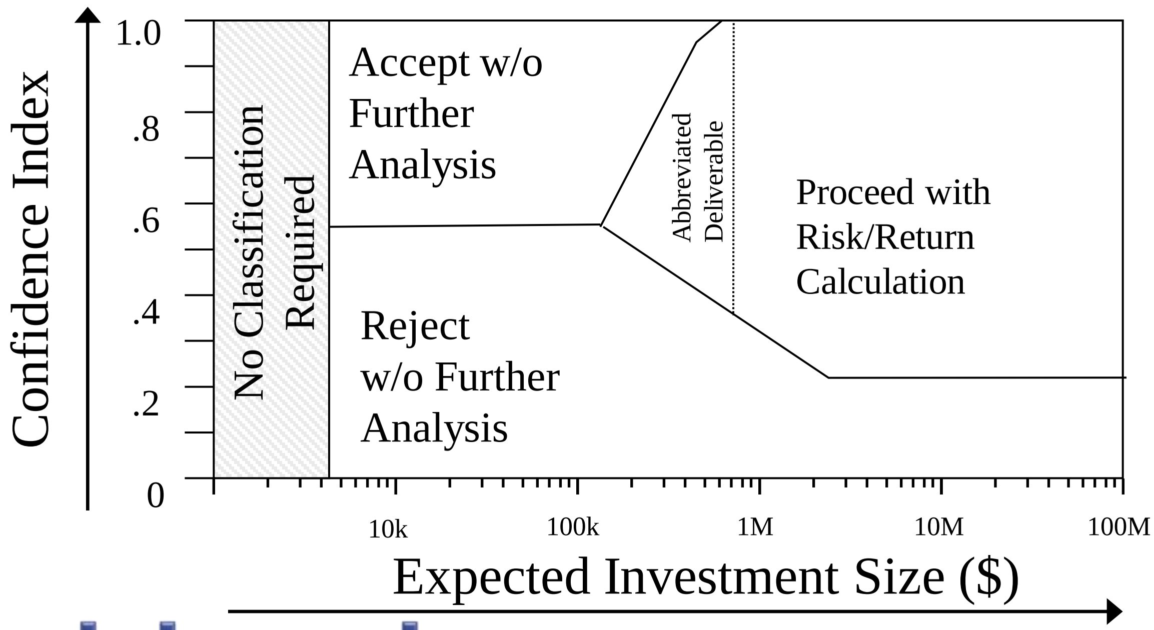
How Much Analysis?

- A statistical model of IT investments is created to assess their chance of success/failure
- Plotted against investment size, this tells us whether a project should be accepted, rejected, or go through a complete risk/return analysis
- The boundaries of the "classification chart" are unique to the organization, but must follow some constraints



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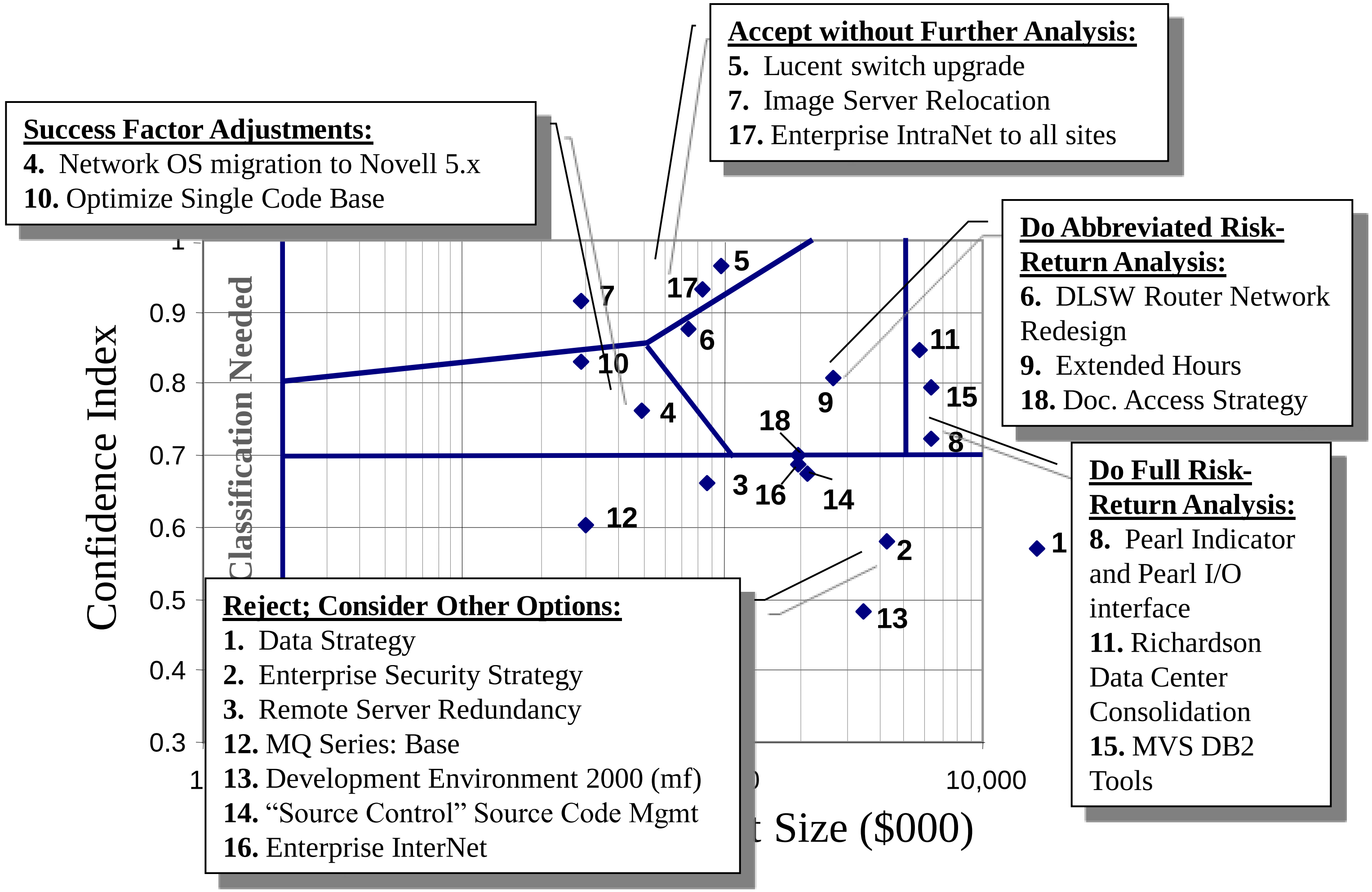
Example Classification



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Forecasting Fuel for Battle

Table 14.1 Summary of Average Effects of Changing Supply Route Variables	
Change	Change in gal/day*
Gravel vs. Paved	10,303
+5 mph average speed	4,685
+10 meter climb	6,422
+100 meter average altitude	751
+10 degree temp.	1,075
+10 miles of route	8,320
Additional stop on the route	1,980

- The US Marine Corps with the Office of Naval Research needed a better method for forecasting fuel for wartime operations
- The VIA showed that the big uncertainty was really supply route conditions, not whether they are engaging the enemy
- Consequently, we performed a series of experiments with supply trucks rigged with GPS and fuel-flow meters.

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Reactions: Fuel for the Marines

- “The biggest surprise was that we can save so much fuel. We freed up vehicles because we didn’t have to move as much fuel. For a logistics person that's critical. Now vehicles that moved fuel can move ammunition.“ ***Luis Torres, Fuel Study Manager, Office of Naval Research***
- “What surprised me was that [the model] showed most fuel was burned on logistics routes. The study even uncovered that tank operators would not turn tanks off if they didn’t think they could get replacement starters. That’s something that a logistician in a 100 years probably wouldn’t have thought of.” ***Chief Warrant Officer Terry Kunneman, Bulk Fuel Planning, HQ Marine Corps***

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Reactions: Safe Water

- “I didn’t think that just defining the problem quantitatively would result in something that eloquent. I wasn’t getting my point across and the AIE approach communicated the benefits much better.” ***Jeff Bryan, SDWIS Program Chief***
- “Until [AIE], nobody understood the concept of the value of the information and what to look for. They had to try to measure everything, couldn’t afford it, so opted for nothing. Translating software to environmental and health impacts was amazing. I think people were frankly stunned anyone could make that connection. The result I found striking was the level of agreement of people with disparate views of what should be done. From my view, where consensus is difficult to achieve, the agreement was striking” ***Mark Day, Deputy CIO and CTO for the Office of Environmental Information***

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Questions?

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