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**Prediction Markets as an Information Aggregation Tool for Effective
Project Management in Defense Acquisition Projects**

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Prepared for the Naval Postgraduate School, Monterey, California 93943

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| 14. ABSTRACT A central challenge in defense acquisition is the development of accurate cost and schedule estimates. The lack of discipline in estimating and unrealistic expectations in the early phases of programs have been often cited as common causes for poor performance of large programs (GAO, 2004, 2006). Initial estimates provided by contractors are known to 'anchor' expectations (Aranda & Easterbrook, 2005), even when changes in personnel, technology, or budgetary priorities can affect the performance of a program. We examine the use of prediction markets as a tool for generating schedule estimates as a supplement to existing estimation methodologies. | | | |
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Preface & Acknowledgements

During his internship with the Graduate School of Business & Public Policy in June 2010, U.S. Air Force Academy Cadet Chase Lane surveyed the activities of the Naval Postgraduate School's Acquisition Research Program in its first seven years. The sheer volume of research products—almost 600 published papers (e.g., technical reports, journal articles, theses)—indicates the extent to which the depth and breadth of acquisition research has increased during these years. Over 300 authors contributed to these works, which means that the pool of those who have had significant intellectual engagement with acquisition issues has increased substantially. The broad range of research topics includes acquisition reform, defense industry, fielding, contracting, interoperability, organizational behavior, risk management, cost estimating, and many others. Approaches range from conceptual and exploratory studies to develop propositions about various aspects of acquisition, to applied and statistical analyses to test specific hypotheses. Methodologies include case studies, modeling, surveys, and experiments. On the whole, such findings make us both grateful for the ARP's progress to date, and hopeful that this progress in research will lead to substantive improvements in the DoD's acquisition outcomes.

As pragmatists, we of course recognize that such change can only occur to the extent that the potential knowledge wrapped up in these products is put to use and tested to determine its value. We take seriously the pernicious effects of the so-called “theory–practice” gap, which would separate the acquisition scholar from the acquisition practitioner, and relegate the scholar's work to mere academic “shelfware.” Some design features of our program that we believe help avoid these effects include the following: connecting researchers with practitioners on specific projects; requiring researchers to brief sponsors on project findings as a condition of funding award; “pushing” potentially high-impact research reports (e.g., via overnight shipping) to selected practitioners and policy-makers; and most notably, sponsoring this symposium, which we craft intentionally as an opportunity for fruitful, lasting connections between scholars and practitioners.

A former Defense Acquisition Executive, responding to a comment that academic research was not generally useful in acquisition practice, opined, “That's not their [the academics'] problem—it's ours [the practitioners']. They can only perform research; it's up to us to use it.” While we certainly agree with this sentiment, we also recognize that any research, however theoretical, must point to some termination in action; academics have a responsibility to make their work intelligible to practitioners. Thus we continue to seek projects that both comport with solid standards of scholarship, and address relevant acquisition issues. These years of experience have shown us the difficulty in attempting to balance these two objectives, but we are convinced that the attempt is absolutely essential if any real improvement is to be realized.

We gratefully acknowledge the ongoing support and leadership of our sponsors, whose foresight and vision have assured the continuing success of the Acquisition Research Program:

- Office of the Under Secretary of Defense (Acquisition, Technology & Logistics)
- Program Executive Officer SHIPS
- Commander, Naval Sea Systems Command
- Army Contracting Command, U.S. Army Materiel Command
- Program Manager, Airborne, Maritime and Fixed Station Joint Tactical Radio System



- Program Executive Officer Integrated Warfare Systems
- Office of the Assistant Secretary of the Air Force (Acquisition)
- Office of the Assistant Secretary of the Army (Acquisition, Logistics, & Technology)
- Deputy Assistant Secretary of the Navy (Acquisition & Logistics Management)
- Director, Strategic Systems Programs Office
- Deputy Director, Acquisition Career Management, US Army
- Defense Business Systems Acquisition Executive, Business Transformation Agency
- Office of Procurement and Assistance Management Headquarters, Department of Energy

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James B. Greene, Jr.
Rear Admiral, U.S. Navy (Ret.)

Keith F. Snider, PhD
Associate Professor



Panel 21 – Innovative Mechanisms for Improved Acquisition

| Thursday, May 12, 2011 | |
|------------------------------|---|
| 1:45 p.m. – 3:15 p.m. | <p>Chair: Dr. Fred Thompson, Professor, Atkinson Graduate School of Management, Willamette University</p> <p><i>Optimal Cost Avoidance Investment and Pricing Strategies for Performance-Based Post-Production Service Contracts</i></p> <p style="padding-left: 40px;">David Nowicki, Jose Ramirez-Marquez, and Ilona Murynets, Stevens Institute of Technology, and Wesley Randall, University of North Texas</p> <p><i>Prediction Markets as an Information Aggregation Tool for Effective Project Management in Defense Acquisition Projects</i></p> <p style="padding-left: 40px;">Ricardo Valerdi, Massachusetts Institute of Technology, and Matthew Potoski, Iowa State University</p> <p><i>Game Theoretic Real Option Approach of the Procurement of Department of Defense: Competition or Collaboration</i></p> <p style="padding-left: 40px;">Marc Rabaey, Belgian MoD, University of Hasselt</p> |

Fred Thompson—Grace and Elmer Goudy Professor of Public Management and Policy Analysis at the Atkinson Graduate School of Management, Willamette University. Dr. Thompson is a specialist in the field of tax policy and regulation.

Dr. Thompson is co-editor of the *Handbook of Public Finance*. He was the founding editor of the *International Public Management Journal* and is currently associate editor of the *Journal of Comparative Policy Analysis*. He has been published in numerous scholarly journals, including the *American Political Science Review*, *Public Administration Review*, *Public Choice*, and *Journal of Economic Behavior and Organization*.

In 2000, Dr. Thompson received the Distinguished Research Award of the National Association of Schools of Public Affairs and Administration and the American Society for Public Administration. In 2005 he received the Aaron B. Wildavsky Award for Outstanding Lifetime Scholarly Achievement in the field of public budgeting and financial management of the Association for Budgeting and Financial Management. In 2006 he served on the United Nations Development Program’s Blue Ribbon Commission on Macedonia.

Dr. Thompson earned his Bachelor of Arts in Economics and History from Pomona College and his PhD from the Center for Politics and Economics, Claremont Graduate University.



Prediction Markets as an Information Aggregation Tool for Effective Project Management in Defense Acquisition Projects

Ricardo Valerdi—Research Associate, Lean Advancement Initiative, Engineering Systems Division, MIT. He is a Visiting Associate in the Center for Systems and Software Engineering at USC. Dr. Valerdi is a two-time recipient of the Best Thesis Advisor Award in the MIT Technology & Policy Program, the Best Article of the Year Award in the *Systems Engineering Journal*, and Best Paper Awards at the Conference on Systems Engineering Research and International Society of Parametric Analysts. He teaches a course on cost estimation and performance measurement at MIT and is actively engaged in executive education. His research focuses on systems engineering metrics, cost estimation, test and evaluation, human systems integration, enterprise transformation, and performance measurement. His research has been funded by Army Test & Evaluation, Navy Acquisition Research Program, Air Force Office of the Surgeon General, Air Force Acquisition Chief Process Office, BAE Systems, and the IBM Center for the Business of Government. Dr. Valerdi is the co-editor-in-chief of the *Journal of Enterprise Transformation*, served on the Board of Directors of the International Council on Systems Engineering, and is a Senior Member of the IEEE. He received his BS/BA in electrical engineering from the University of San Diego in 1999, and his MS and PhD degrees in systems architecting and engineering from the University of Southern California in 2002 and 2005. Between 1999 and 2002, he worked as a systems engineer at Motorola and has been affiliated with the Aerospace Corporation's Economic and Market Analysis Center. His contributions to the field include the Constructive Systems Engineering Cost Model (COSYSMO), a model for estimating systems engineering effort, which has been calibrated with data provided by BAE Systems, Boeing, General Dynamics, L-3 Communications, Lockheed Martin, Northrop Grumman, Raytheon, and SAIC. He is the author of over 100 technical publications that have appeared in IEEE, AIAA, and INCOSE conferences. His research has appeared in several journals, including the *Journal of Systems Engineering*, *Journal of Systems and Software*, *IEEE Software*, *IEEE Systems Journal*, *Information, Knowledge and Systems Management*, and *CrossTalk—The Journal of Defense Software Engineering*. He served as Program Chair of the 20th and 24th Forum on COCOMO and Software Cost Modeling. [rvalerdi@mit.edu]

Matthew Potoski—Professor, Department of Political Science, Iowa State University. Dr. Potoski teaches public administration, policy, and politics. His research focuses on how people can solve problems in developing, implementing, and managing public policies. He studies voluntary regulations, contract management, and other topics. Dr. Potoski is the co-editor of the *Journal of Policy Analysis and Management* and the *International Public Management Journal*. In 2007–2008 he was a Distinguished Visiting Scholar at the Bren School of Environmental Management, University of California-Santa Barbara. He is the recipient of the ISU LAS Mid Career and Early Career Awards for Achievement in Research. Dr. Potoski received his PhD from Indiana University in December 1998. He also received an undergraduate degree from Franklin and Marshall College in Lancaster, PA, and a master's degree from the University of Vermont. [potoski@iastate.edu]

Abstract

A central challenge in defense acquisition is the development of accurate cost and schedule estimates. The lack of discipline in estimating and unrealistic expectations in the early phases of programs have been often cited as common causes for poor performance of large programs (GAO, 2004, 2006). Initial estimates provided by contractors are known to “anchor” expectations (Aranda & Easterbrook, 2005), even when changes in personnel, technology, or budgetary priorities can affect the performance of a program. We examine the use of prediction markets as a tool for generating schedule estimates as a supplement to existing estimation methodologies.



Report Summary

A central challenge in defense acquisition is the development of accurate cost and schedule estimates. The lack of discipline in estimating and unrealistic expectations in the early phases of programs have been often cited as common causes for poor performance of large programs (GAO, 2004, 2006). Initial estimates provided by contractors are known to “anchor” expectations (Aranda & Easterbrook, 2005), even when changes in personnel, technology, or budgetary priorities can affect the performance of a program. We examine the use of prediction markets as a tool for generating schedule estimates as a supplement to existing estimation methodologies. A prediction market provides an environment for traders to buy and sell contracts whose value is tied to an uncertain future event, such as the duration of a weapons system acquisition. Most notably used today for predicting election outcomes, prediction markets are used to forecast product sales, movie box office returns, terrorist attacks, and sporting events (Wolfers & Zitzewitz, 2004).

A prediction market is a means of forecasting some unknown future condition of the world. In a prediction market, buyers and sellers trade contracts and money for contracts whose payoff depends on the future state (Wolfers & Zitzewitz, 2004). If the market is well functioning, contract prices reflect the collective wisdom of the market participants. There are three primary types of prediction markets.¹ Much of the enthusiasm for prediction markets derives from the efficient markets hypothesis. In a truly efficient prediction market, the market price of a prediction market contract will best summarize traders’ beliefs about the probability of the event’s occurrence. Efficient prediction markets should outperform available polls and other forecasting mechanisms.

We anticipate prediction markets to outperform existing defense acquisition estimation techniques (i.e., parametric, analogy, activity-based) for cases in which there is ample “soft,” relative to “hard,” information, and information is broadly and unevenly held by diverse actors. Examples of such circumstances include one-of-a-kind acquisitions in which limited historical information exists, and acquisitions that are prone to performance impacts to external events. Modifications to the design, shifts in program personnel, or changes in the political landscape may have significant impacts on the cost and duration of a program. Existing cost-estimation techniques are not sensitive to these types of changes because (1) most Cost Estimating Relationships (CERs) are based on technical factors, rather than programmatic “soft” factors; (2) cost estimates are not dynamically updated as a program evolves, making the original estimate outdated as soon as the climate changes; and (3) cost estimates are a manifestation of a few decision makers, often under tremendous time pressure, working with limited and, perhaps biased, information.

By shifting the paradigm from estimating by individuals to estimating by groups, we can harness the wisdom of crowds by capturing their collective intelligence. A prediction market facilitates the aggregation of data from diverse and independent sources, yielding more accurate forecasts. The prediction markets’ value is grounded in several factors. First, they provide a way to leverage the wisdom of crowds by aggregating information from diverse sources. Studies have shown that under the right circumstances, prediction markets are quite accurate, and often more so than even the most accurate individual forecasters (Surowiecki, 2005; Griffiths & Tenenbaum, 2006). Second, they mitigate decision biases stemming from pressures to “price to win” and hide information. Third, they enable frequent sampling of information, which makes them more responsive to environmental changes. Finally, prediction markets provide incentives for traders to seek out additional information.

¹ The following discussion of prediction market types comes from Wolfers and Zitzewitz (2004).



As with any markets, prediction markets may fail—and produce inaccurate forecasts—if not properly designed and executed. Like markets generally, effective prediction markets require a sufficient number of buyers and sellers, well informed about each other and their resources, and a mechanism through which they can exchange resources under fully specified, clear, and enforceable contracts. We briefly discuss some potential challenges in prediction market design before discussing more specific prediction market design principles and the conditions for making them successful.



How Weapon Systems Are Like Jelly Beans

Prediction Markets as Information Aggregation Tool for Effective Project Management in Defense Acquisition Projects

May 12, 2011

NPS

Monterey, CA

Prof. Matt Potoski

Iowa State University

Dr. Ricardo Valerdi

MIT

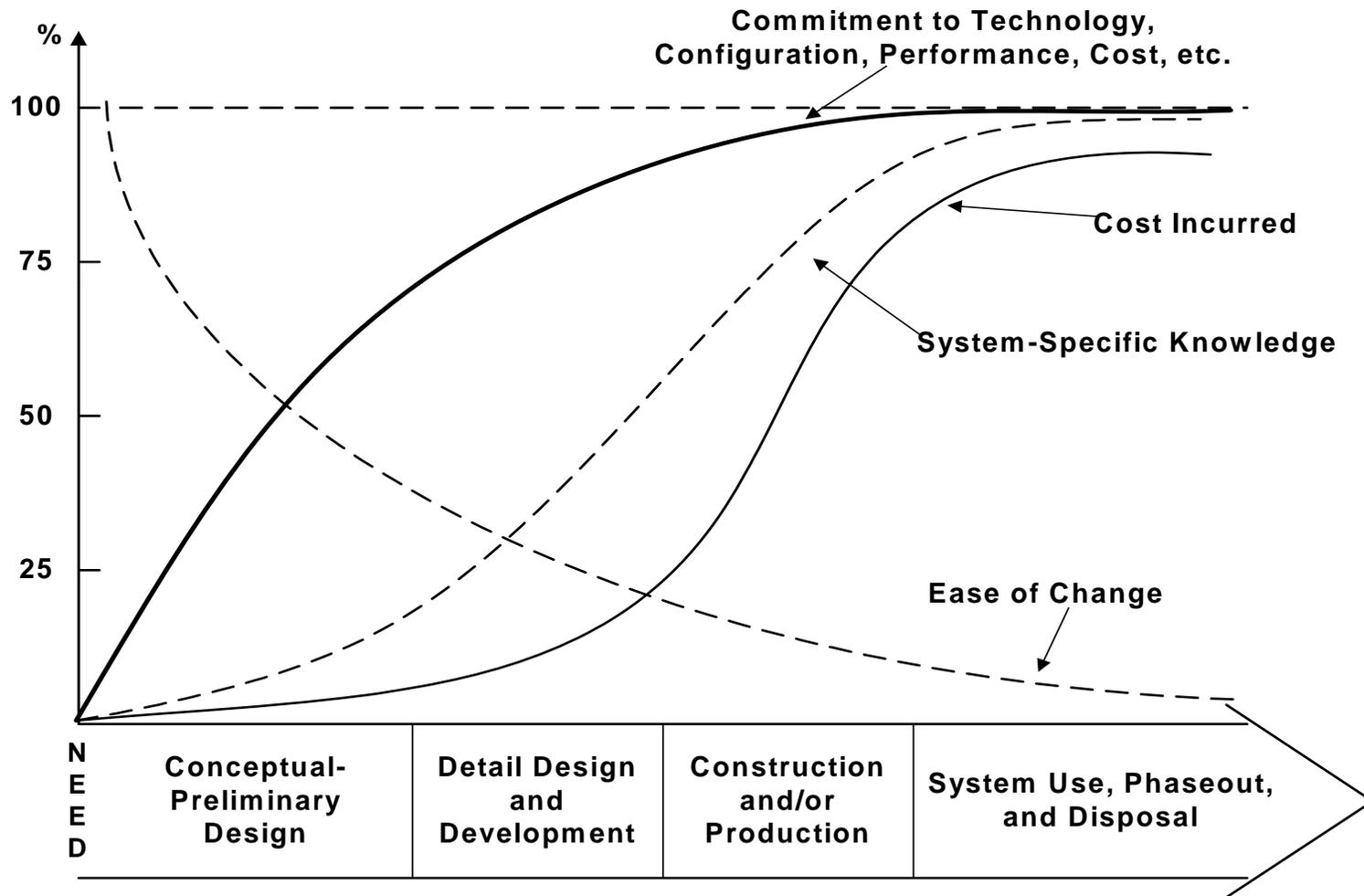
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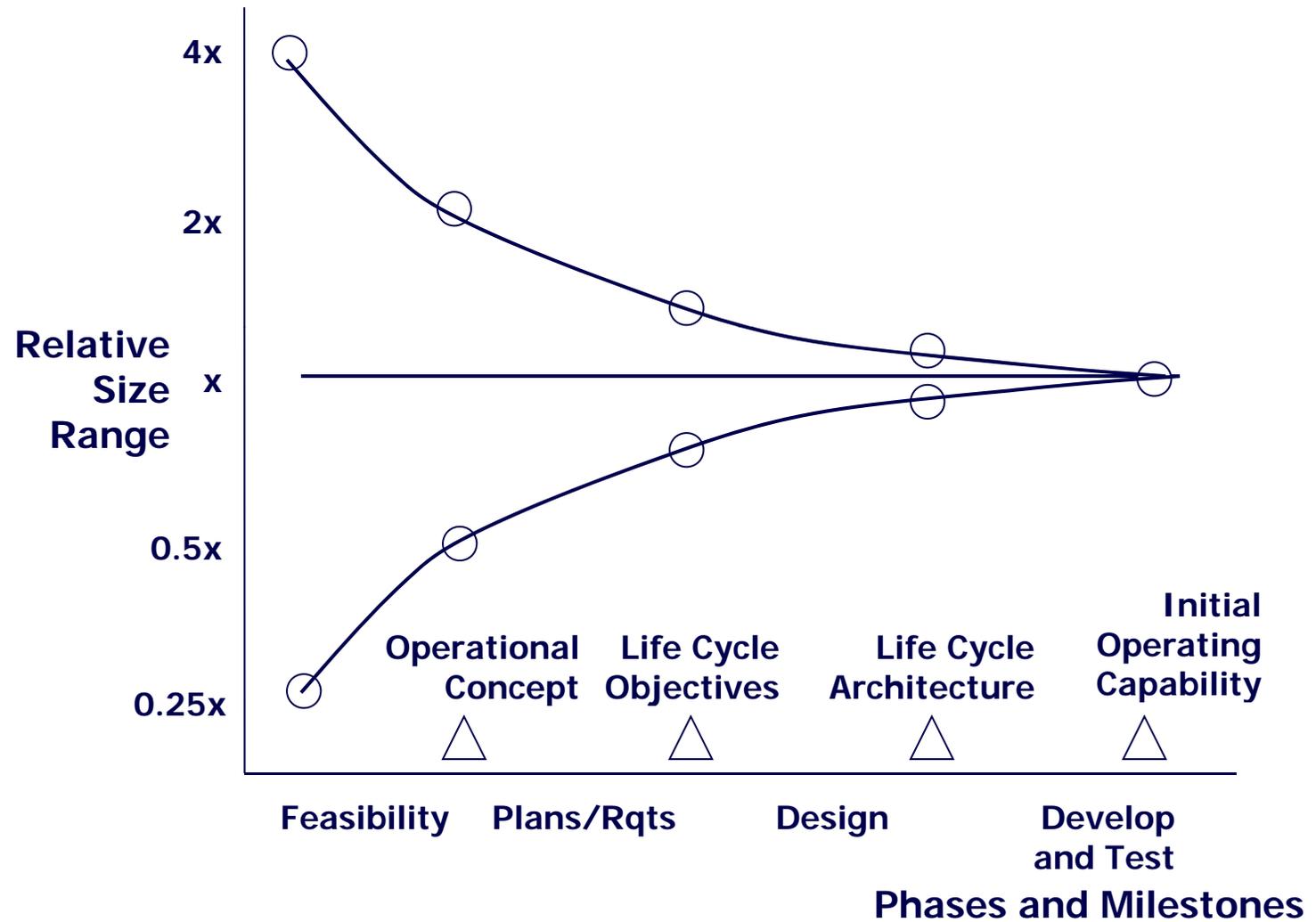
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- Special thanks to MITRE for extending their support and time, and for providing some useful information on prediction markets.
- We wish to thank Adam Siegel of Inkling Markets for his suggestions on prediction market design.

Cost Commitment on Projects



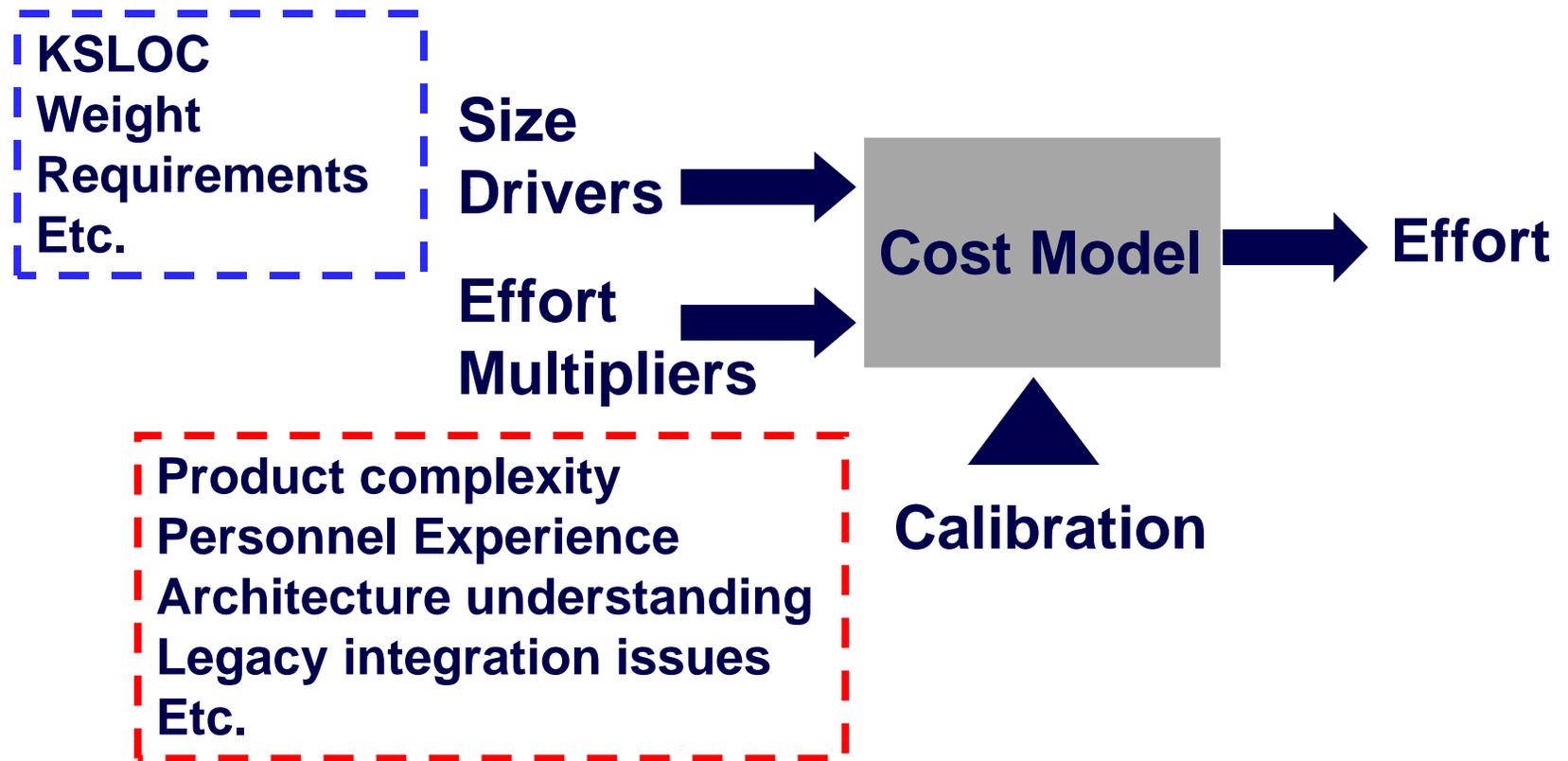
Blanchard, B., Fabrycky, W., *Systems Engineering & Analysis*, Prentice Hall, 1998.

Cone of Uncertainty

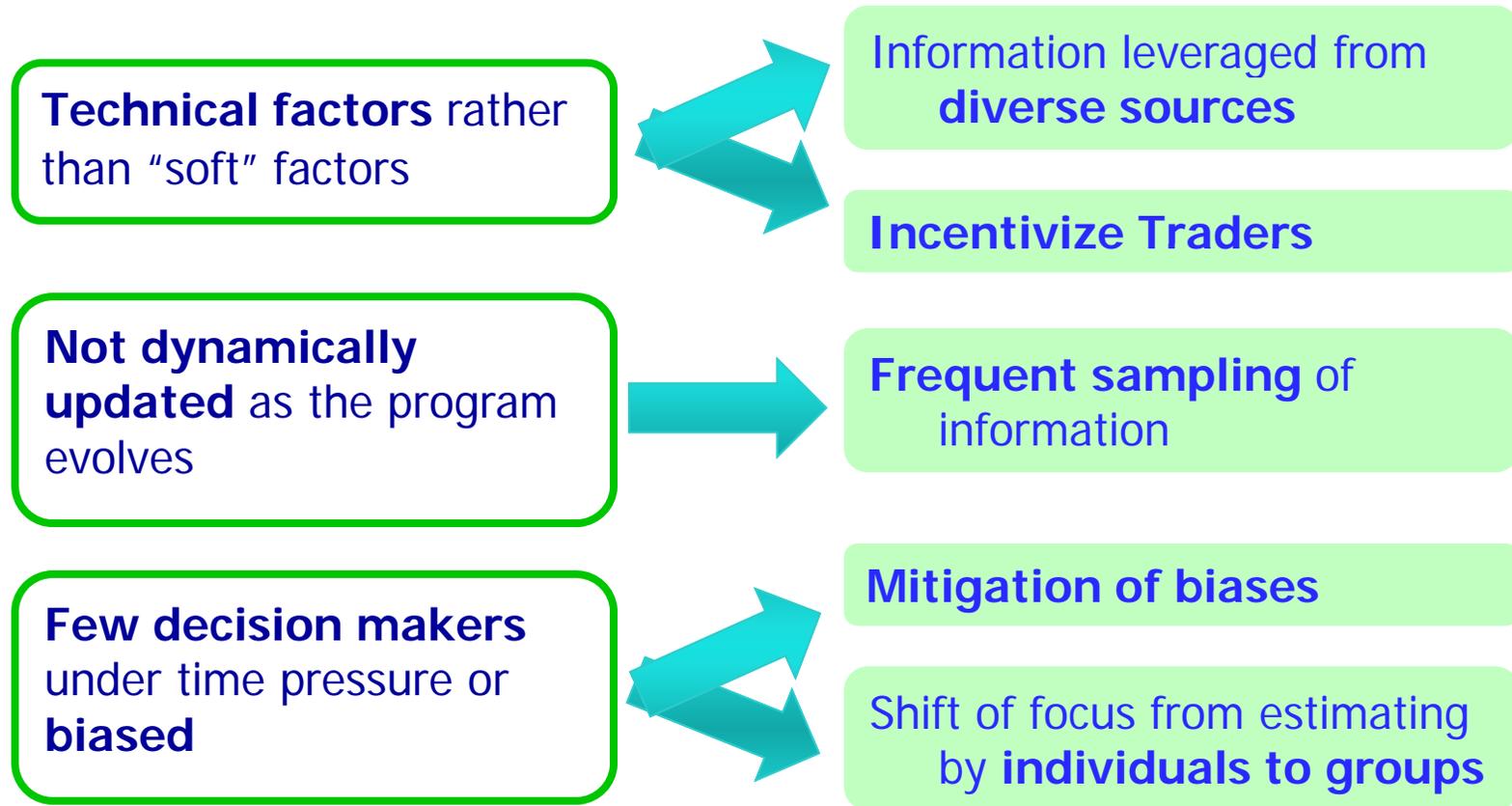


Source: Barry Boehm (USC)

How Cost Modeling is Done Today



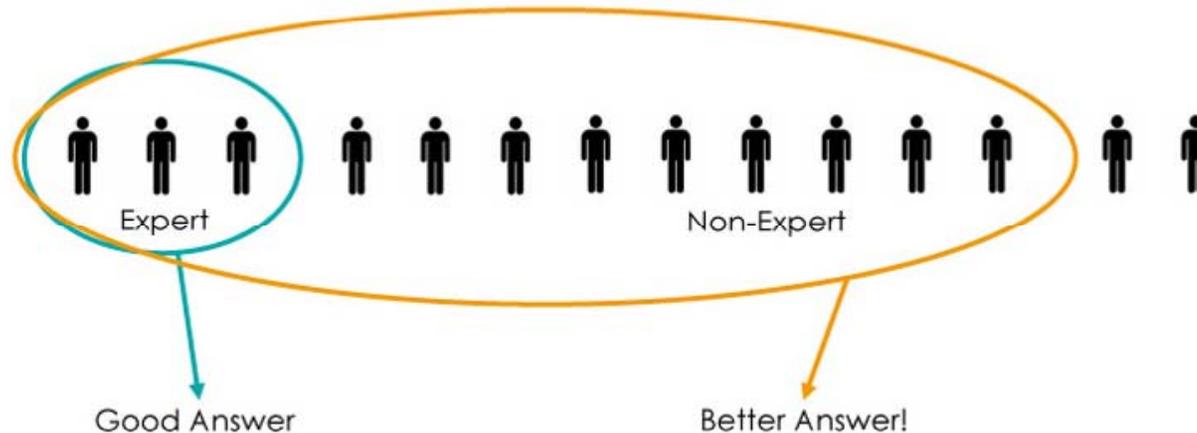
Prediction Markets: Value Proposition





Prediction Markets

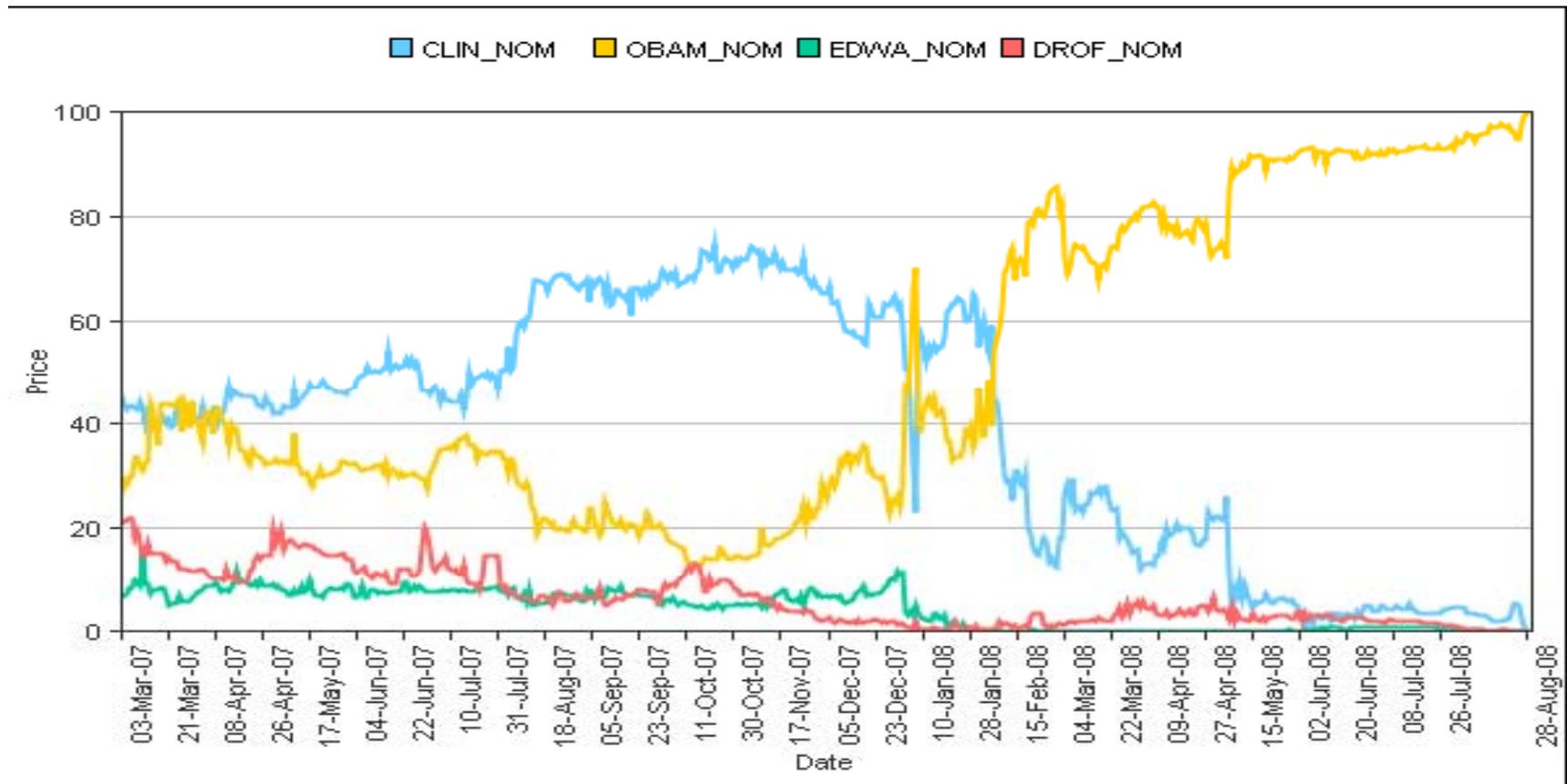
- A place where people can buy and sell contracts that pay the owner based on some future event



Example

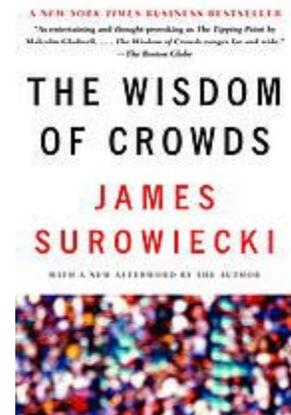
- Iowa Electronic Markets: 2008 Presidential Election
 - Buy and sell shares of candidate votes
 - Contract pays \$0.01 for each percentage point of Obama's vote
 - Contract pays \$1.00 if Obama wins

2008 Democratic Nomination Race

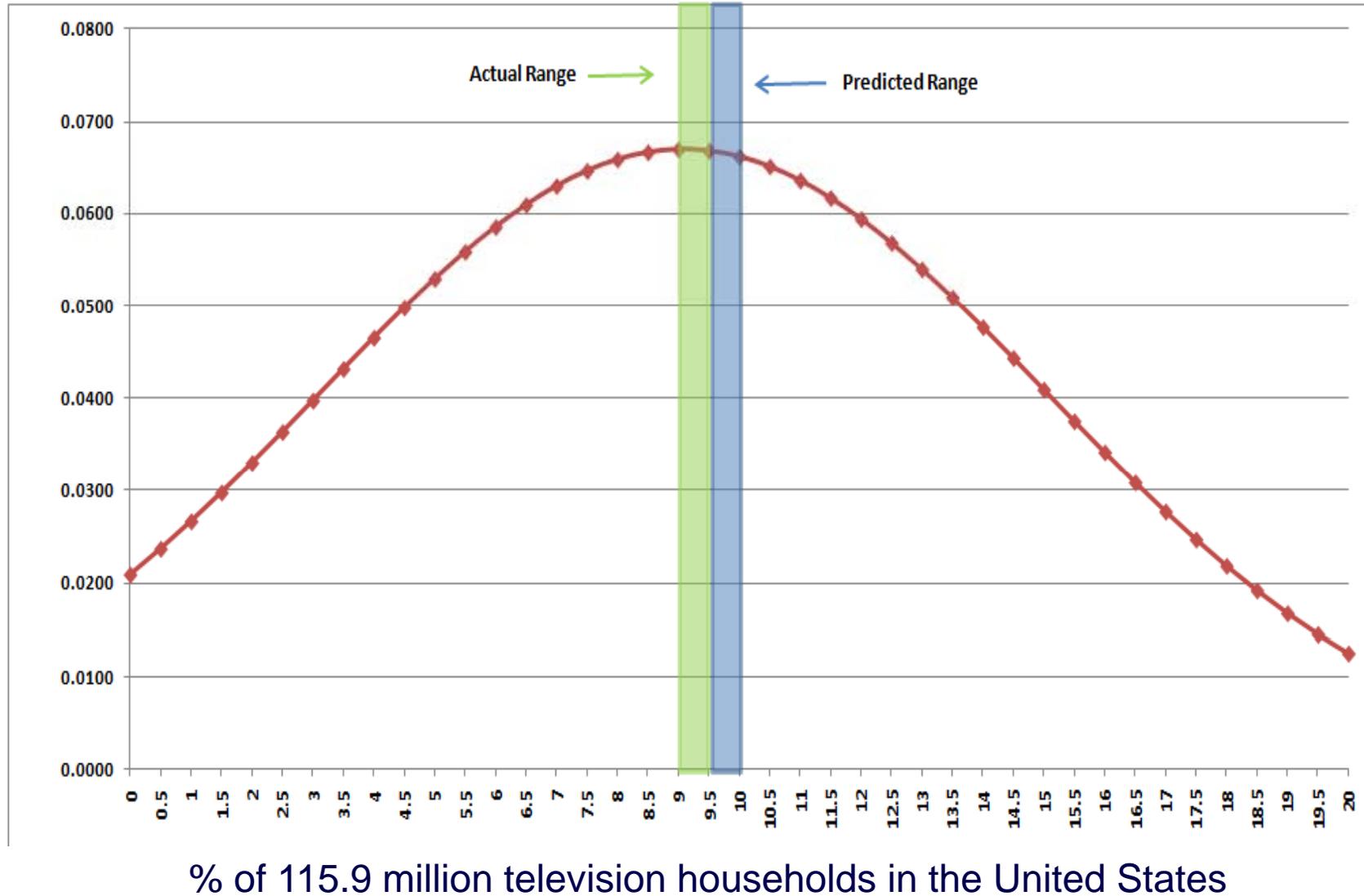


Hypothesis: prediction markets are “efficient markets”

- Market prediction summarizes traders’ beliefs about what will occur in future
 - Truthful revelation: biased trading gets counter traded (e.g., political trading markets)
 - Information discovery: informed trading is rewarded
- Crowds can be “wise”
 - Diversity, independence, decentralization, aggregation



Example: Nielsen ratings for Monday night football



The Case for Prediction Markets

- “First order effects”: information aggregation for accurate prediction
 - Mechanism for bringing together information
 - Incentives for searching out information
 - Incentives for revealing information

The Case for Prediction Markets

- “Second order effects”: organization culture and communication
 - Signal topics of interest
 - Promote interest and engagement in topics
 - “Flatten” hierarchy
 - Invigorate culture

Questions PM's can answer: practical guidelines

- “Contractible”: can write a contract about future events with unambiguous and verifiable outcomes
- Outcome categories are mutually exclusive and exhaustive

Types of Questions

- Bad: "Sales of Xbox consoles will exceed expectations by the end of the year."
- Good: "How many Xbox consoles will be sold between November 1 and December 31, 2010?"

Using Prediction Markets: Early Lessons

- Problem: “I don’t know how to run a prediction market; it seems hard”
- Remedy:
 - Use Inkling software:
www.inklingmarkets.com
 - Market makers are key

Using Prediction Markets: Early Lessons

- Problem: “Liquidity”: not enough trades and traders
- Remedies:
 - Incentives:
 - Prizes
 - Recognition
 - “Hard” and “Fun” questions
 - Newsletters
 - Senior management involvement

Using Prediction Markets: Early Lessons

- Problem: “Insider trading”
 - Some traders have/will have inside information
- Remedies:
 - Change questions
 - Change trading window
 - Restrict trading access to “insiders”

Osama Bin Laden to be captured/neutralized before midnight ET on 30 Jun 2011

OSAMA.CAPTURE.JUN11

Oct 08, 2010 - May 02, 2011



Source: www.intrade.com ©

Prediction Markets: Case Study - SWCS

Design Components to consider

Stocks

Marketplace

Traders



Shallow Water Combat Submersible

Implement prediction markets to surface potential program risks, and generate cost/schedule estimates as a supplement to existing estimation methodologies

Prediction Markets: Benefits to SWCS

Benefit from the prediction markets event forecasts.

Increased involvement of the participants in anticipating events.

Identifying informal information channels in their organization.

Continuous review of factors impacting cost and schedule

Agility

Efficiency

Transparency

Prediction Market Design

First Order Questions: Program of interest

- Will SWCS be certified by August 1, 2012?
- The cost of the first unit will be \$x.

Second Order Questions: Traders and the trading process

- Who has information about the program (who makes money in the market?)
- Where did they learn this information?
- What is your motivation for trading? (e.g. to win/to solve the problem/to validate my knowledge)

Third Order Questions: Behavior outside the markets

- Did prediction market participation increase team knowledge, collaboration and information sharing?
- Did it outperform a cost model in terms of agility, transparency, sensitivity to events?

Prediction Market Design Principles

Sufficiently broad following

Incentives based on constant participation and ability to predict accurate results

Ample historical data

Mix of hard and fun questions

Anonymity of participants, information security/confidentiality

