Acquisition Research Program:
Creating Synergy for Informed Change

Prediction Markets for Defense Acquisition: The Devil is in the Details

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Navy Student Theses

- ## Lt. Josh Dishmon
  - ### Review acquisition-relevant applications of prediction markets

- ## Lt. Michael A. Chinn & Lt. Leslie A. Huffman:
  - ### Prediction Markets for Navy Manpower Outcomes
  - ### Did a pilot set of prediction markets for manpower outcomes (and fun topics)

Promise and Pitfalls of Prediction Markets

- Potentially VERY powerful tool

BUT …

- The "devil is in the details"
  - Small changes in market design can have big impacts
  - #1 rule of carpentry: "Measure twice, cut once"
- A little econ knowledge can be a dangerous thing
  - A basic understanding of the principles is <u>not</u> sufficient to design and implement an effective market
  - Within DoD, several examples where a good economic idea has been implemented in a sub-optimal fashion
  - Pattern: From "too slow" to "too fast" with good ideas

Popular (but Applicable?) Prediction Markets

Market	Focus
Iowa Electronic Markets <www.biz.iowa.edu/iem> Run by University of Iowa	Small-scale election markets.
Centrebet <www.centrebet.com> For profit company	Northern Territory bookmaker, offering odds on election outcomes, current events, sports, and entertainment.
intrade <www.intrade.com/> For profit company	Trades in political futures, financial contracts, current events, entertainment, etc.
Economic Derivatives <www.economicderivatives.com> Run by Goldman Sachs and Deutsche Bank	Large-scale financial market trading in the likely outcome of future economic data releases.
Newsfutures <www.newsfutures.com> For profit company	Political, finance, current events and sports markets. Also technology and pharmaceutical futures for specific clients.
Foresight Exchange <www.ideosphere.com> Non-profit research group	Political, finance, current events, science and technology events suggested by clients.
Hollywood Stock Exchange <www.hsx.com> Owned by Cantor Fitzgerald	Success of movies, movie stars, and awards. Data used for market research.

Applications Relevant for Acquisition

Application	Firm	Description
Sales Forecasting	Hewlett-Packard	Hewlett-Packard used an internal market system to forecast printer sales. HP's official forecast erred by 13%, while the market erred by 6%; the market performance exceeded the accuracy of official forecasts 75% of the time.
Product Development	Eli Lilly	Eli Lilly applied internal markets to predict which of six potential new drugs would have the greatest success in passing product development hurdles.
General Forecasting	Google	Google uses internal markets to forecast new product launch dates and new office openings, predicting the likelihood that an event will occur and on a specific date.
Product Development	Siemans	An internal market predicts whether the firm will deliver software projects on time
Product Development	Microsoft	Uses internal markets to predict whether projects will meet milestones articulated in their project plans

Sources: **Chen and Plott (2002), Corporate Executive Board 2006), Kiviat(2004), Malone (2004), Ortner (1998)**

Asset Value & Market Prices as Predictors

- Two dimensions of value for any asset/contract :
  - **Arbitrage value:** Potential financial benefit from reselling asset/contract at a higher price at a later date
  - **Intrinsic value:** Expected financial benefit of holding the asset/contract indefinitely (or until market closes)

- Many people think about the value of stocks in the stock market only in terms of the *arbitrage value*

- Prediction markets provide reasonable predictions only when prices reflect estimate of *intrinsic value*

- Thus, assets and markets must be designed to direct focus toward intrinsic value

Measuring Prediction Market Performance

- Prediction markets make predictions by aggregating knowledge among traders
- Thus, prediction market performance can only be measured by degree of information aggregation
- Prediction market performance can <u>not</u> best be measured by prediction accuracy
  - Predicting a coin flip
  - Better weatherman: Las Vegas or Seattle?
- At best, prediction market performance can be measured by <u>relative</u> accuract
  - But alternative predictions often don't exist

Measuring Prediction Market Performance

- "There's a common 'weatherman' misunderstanding about prediction markets, especially in the press. Perhaps counterintuitively, a weatherman is not wrong if the sun comes out after a 90 percent forecast for rain because there was still a 10 percent chance of sunshine. Instead, the weatherman is a good predictor if it rains 90 percent of the time when he gives a 90 percent chance of rain—any more or less would be poor predictions. Prediction markets work the same way."

- -Todd Proebsting, Microsoft

Prediction Markets as a Decision Tool

PROBLEM:
- Consider asset measuring project performance
- Market price drops (negative reflection on project)
  $\Rightarrow$ DoD or agency takes corrective action
  $\Rightarrow$ Market price goes up … or does it?
- Market price should already incorporate expectations about any corrective action
  $\Rightarrow$ Market price may not reflect what you think

SOLUTIONS:
- Measure variables unaffecting by DoD decisions
- Conditional assets/contracts: If ___, then ___

Using Conditional Assets/Contracts

DESCRIPTION:
- Conditional assets ask:
  - "If ____, then what is the probability that ___?"
  - "If ____, then what will be the measure of ___?"

PROBLEM:
- How do assets "payoff" if condition doesn't occur?
- If zero value, distorts price as a predictor

SOLUTION:
- Closing price termination rule
- If an asset is "delisted," each share of asset pays amount equal to average price over final X days
  - Delisting fear should <u>not</u> distort prediction value of price

Incentive Issues with "Play Money"

- Private corporations use real money
- Resistance to using real money in government
- With play money, traders go for the home runs:
  - Buy low-probability events
  - Avoid high-probability events
  - Leads to inaccurate probabilities of events
- Research suggests real money gives more accurate predictions

Incentive Issues with "Play Money"

- Competition and bragging rights as an incentive?
  - Requires degree of non-anonymity (not good)
  - How do traders know if they are "winning?"
  - Intrinsic values not realized until after close of market
- Portfolio value as measure of performance?
  - Does <u>not</u> recognize good predictors of outcomes
  - Rewards traders for being a good predictor of other trader's predictions (of other trader's predictions …)
- Beware of research suggesting play money works
  - Settings often involve intrinsic motivation

Market Maker Concerns

- Thin market $\Rightarrow$ asynchronous trades $\Rightarrow$ market maker
- BUT how is price adjusted in response to trades?
  - Critical for price to be a reasonable predictor
  - Without knowledge of underlying supply and demand, price adjustment is educated "guesswork"
- Current price may <u>not</u> reflect aggregate belief
  - Contributes to price volatility
- Alternative approach: Proxy bid/ask thresholds
  - If price rises above $___, then sell ___ units
  - If price falls below $___, then buy ___ units
  - PLUS: Gives off-equilibrium supply and demand info

Asset/Contract Types

- "Winner-take-all" assets/contracts
  - Pays fixed amount if outcome occurs, zero otherwise
  - Price reflects market expectation of probability of event
- "Index" assets/contracts
  - Pays variable amount tied to a specific future measure
  - Price reflects expectation of mean value of measure
- "Spread" assets/contracts
  - Pays fixed amount if & only if measure is above/below threshold (adjusted to balance two sides of market)
  - Price reflects expectation of median value of measure

Asset/Contract Types

- Winner-take-all markets are easiest to implement
  – Allow use of market-maker algorithm for thin market
  – Widely available mechanisms for doing so

BUT …

- Index markets may reveal more valuable info
  – Specific date on which an event is expected to occur
  – Specific degree of cost-growth that is expected to occur

Asset/Contract Design Issues

- To be valuable, a prediction market asset must measure something that is:
    - Valuable
    - Quantifiable
    - Clearly defined
    - Ex-post measurable
    - Exogenously determined

Thesis Student Pilot Study

- ## Participants:
  - N1 personnel
  - Recruiting command personnel
  - Researchers at NPS, CNA, other research org's

- ## Questions:
  - Manpower outcomes
  - Generally economic outcomes (unemployment, stock market)
  - Fun questions (NFL opener, Emmy's, MLB play-offs)

Thesis Student Pilot Study

- Participation was very low and tailed off, despite encouragement from N1
  - 11 of 35 non-NPS potentials made trades
- Adding "fun" questions didn't seem to increase participation in manpower outcomes
- Top reasons for lack of participation:
  - Lack of time
  - No incentive

Pilot Experiment

			Attribute 1	Attribute 2	Attribute 3
PROJECT					
Alpha –	Fail	.. ..	F	P	F
Beta –	Fail	.. ..	P	F	P
Gamma –	Pass	.. ..	P	P	P
Delta -	Fail	.. ..	F	P	P
Epsilon –	Pass	.. ..	P	P	P
Zeta -	Pass	.. ..	P	P	P

Pilot Experiment Results
Price Patterns & Performance Indicators

Pilot Experiment Results
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Pilot Experiment Results
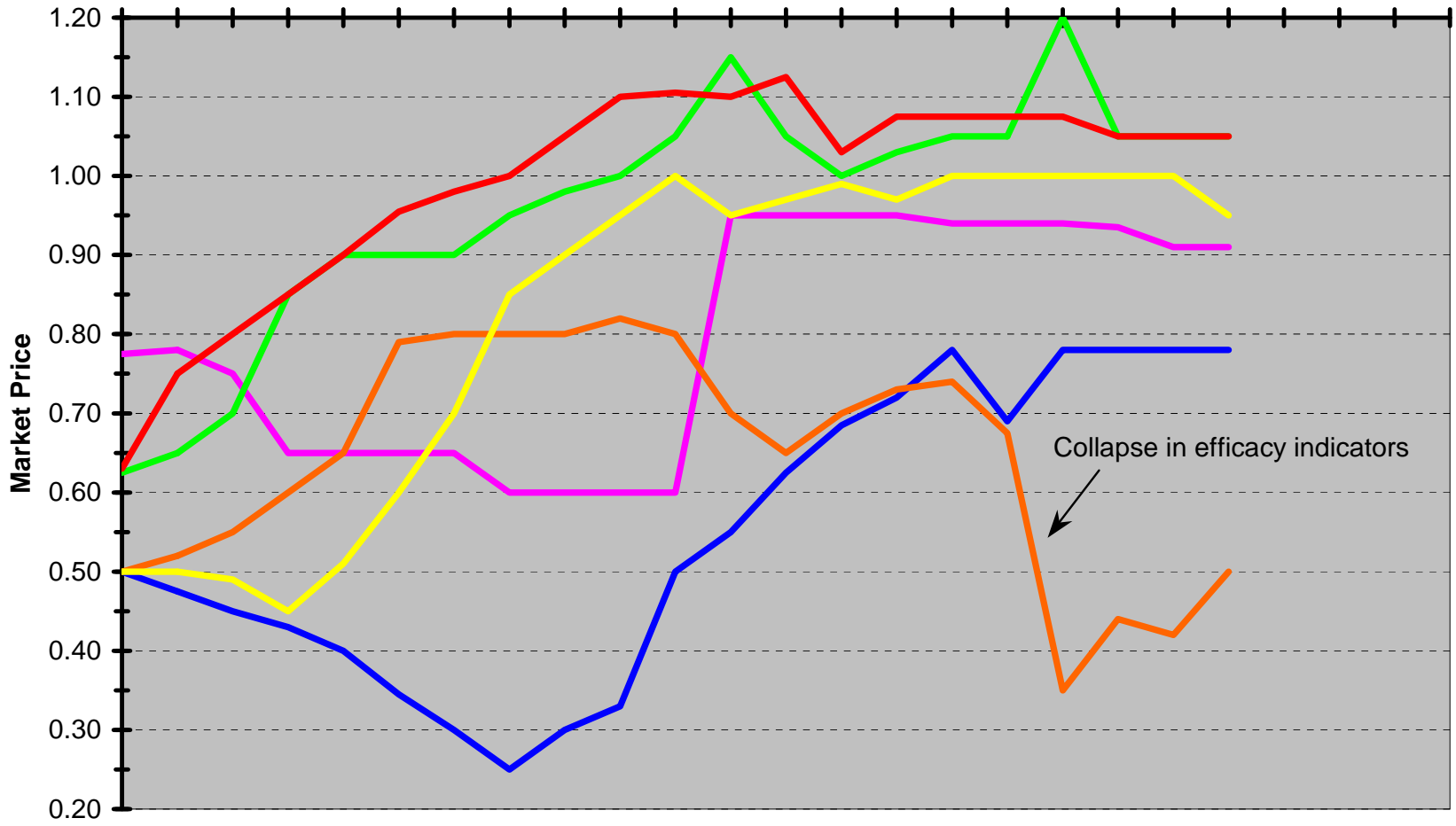## *Price Patterns & Performance Indicators*

Pilot Experiment Results
Price Patterns & Performance Indicators

Collapse in efficacy indicators
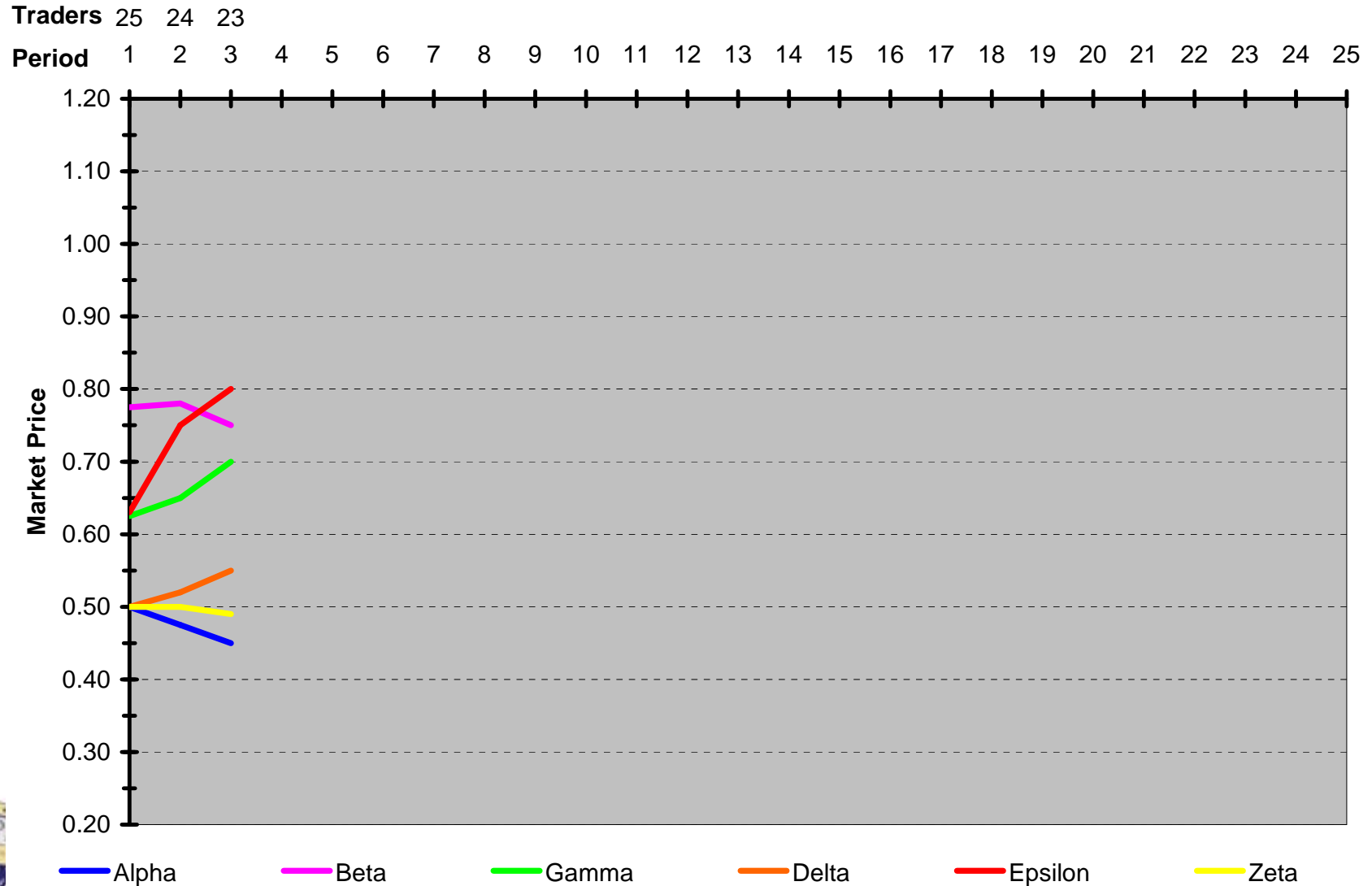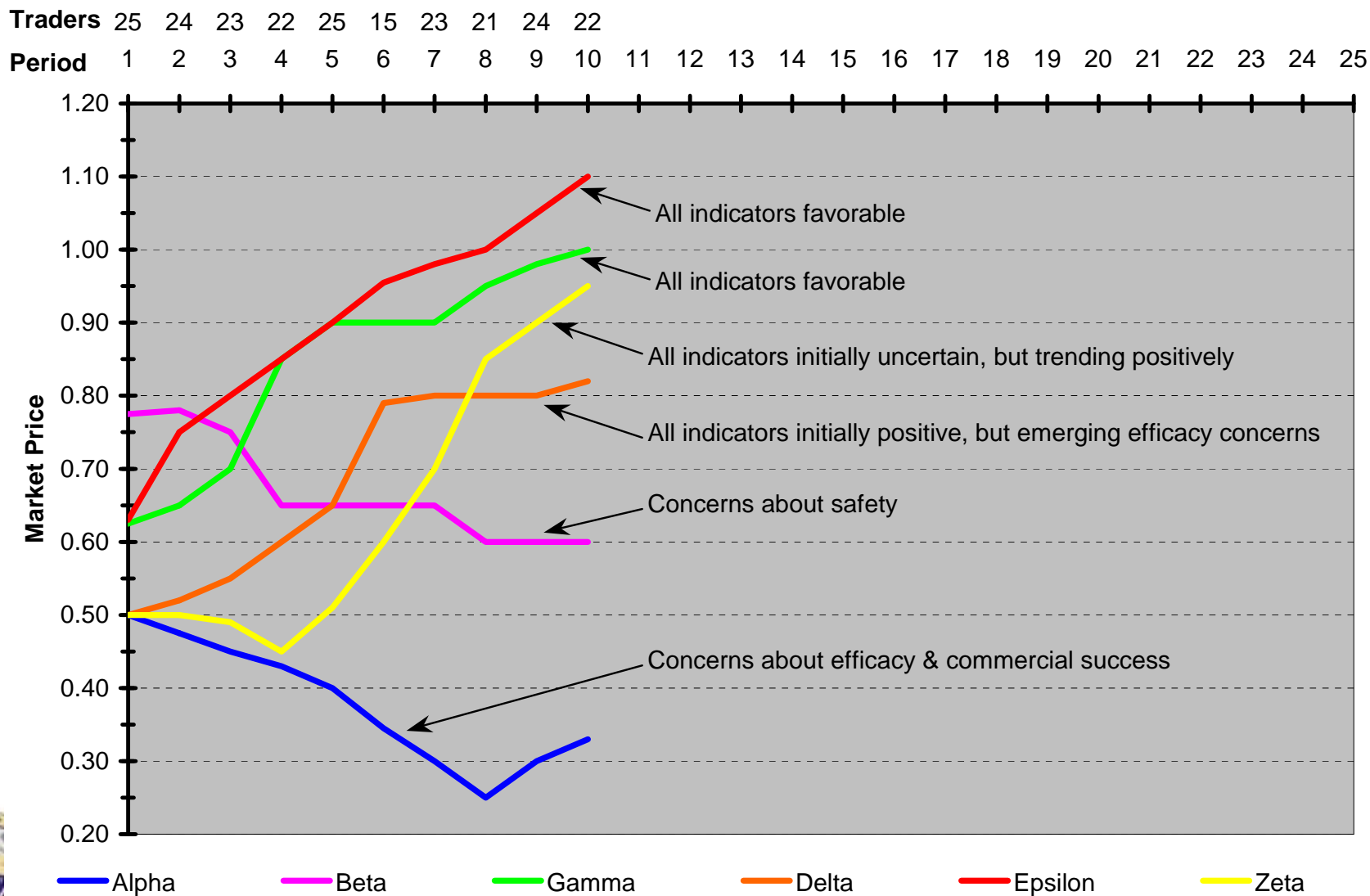
Pilot Experiment Results
Price Patterns & Performance Indicators

Traders	25	24	23	22	25	15	23	21	24	22	18	13	17	12	14	15	11	10	11	12	10	10	11	9	3
Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25

Collapse in safety indicators →

Legend: Alpha (blue), Beta (magenta), Gamma (green), Delta (orange), Epsilon (red), Zeta (yellow)
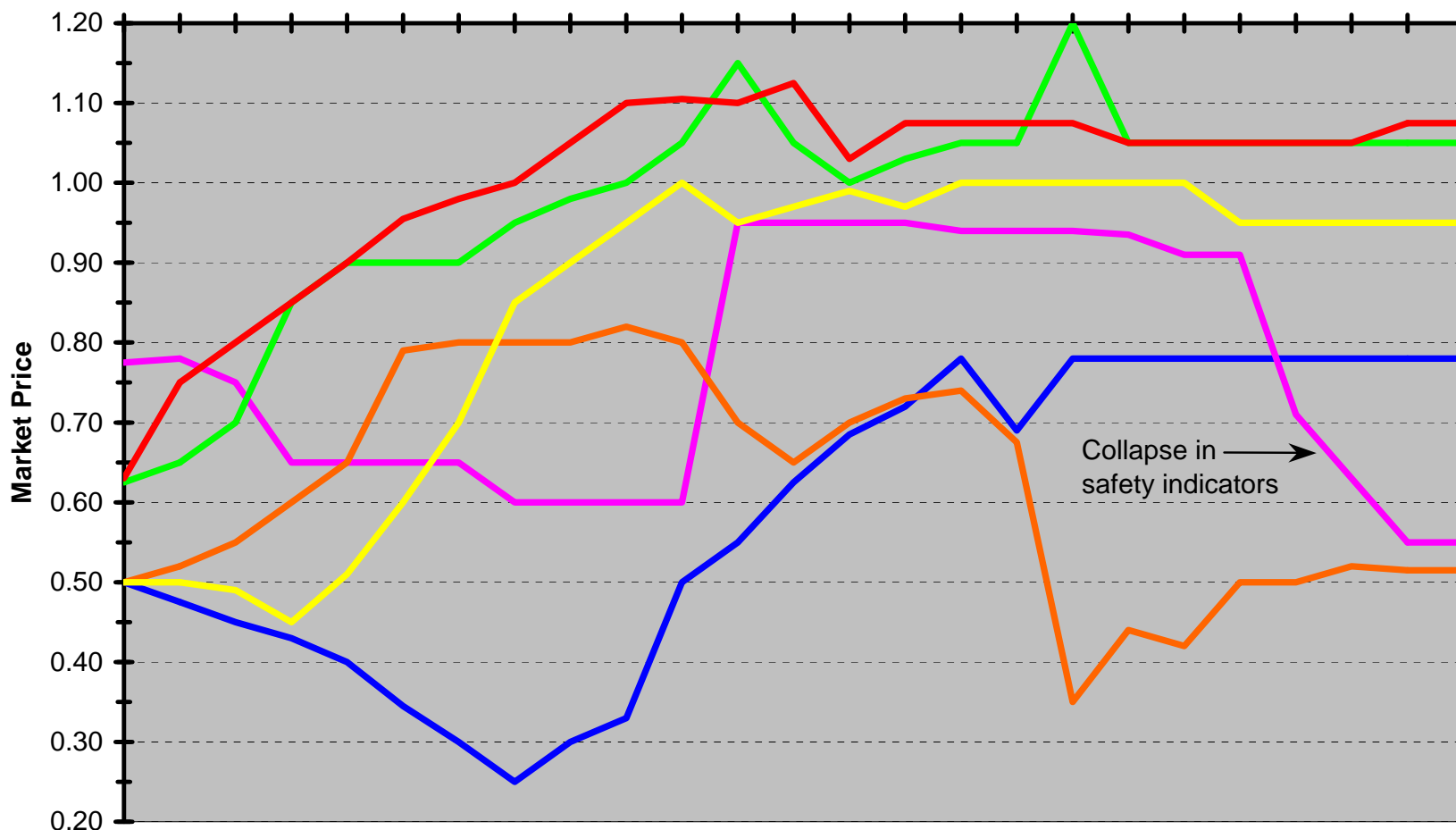
Information Aggregation (Kalovcova 2007)

- Six equally likely possible states
  - A, B, …, F
  - True state: A

- Five individuals have private signal of true state
  - Represented by balls in an urn
    - A represented by five balls; B – F by two each

- Draws:

AAB	AEE	ABF	ACD	CDF
↓	↓	↓	↓	↓
A	E	?	?	?

- Aggregate Information: AAAAA, BB, CC, DD, EE, FF

- HP found results promising for using prediction markets to predict future sales com

- HP and Siemens found motivating employees to trade a major challenge

- Microsoft limits participation to informed traders; uninformed traders are less likely to participate (risks omitting informed trader)

Iowa Electronic Markets
Presidential Elections 1988 - 2000
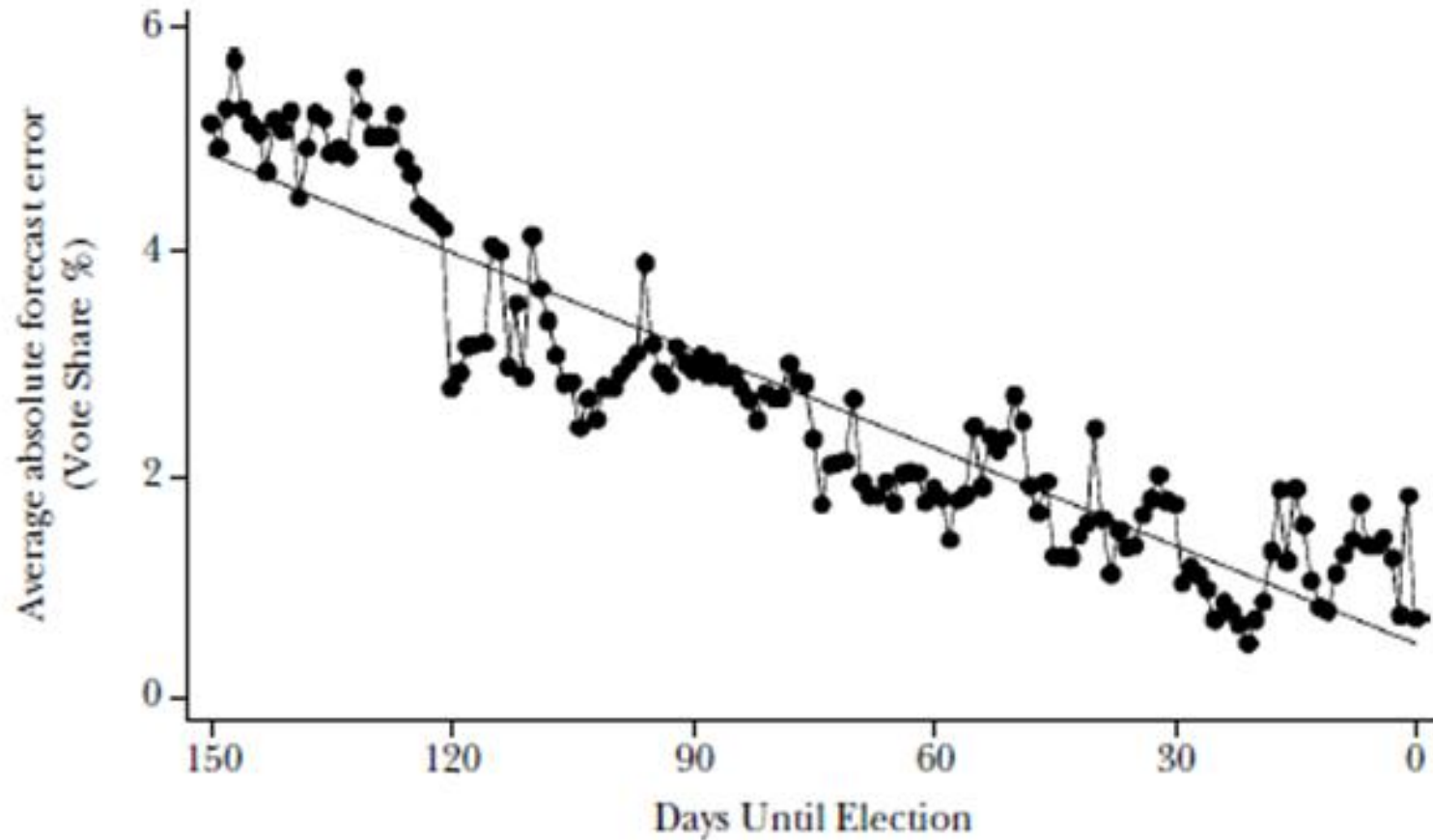
Source: Wolfers and Zitzewitz 2004

Anatomy of prediction markets: Most common trading mechanisms

- Continuous double auction:
  - Person-to-person selling
  - Needs to be a seller for a person who wants to buy
  - Examples: Intrade, Iowa Electronic Markets

- Market Scoring Rules Mechanism:
  - An algorithm determines prices based on demand for various outcomes
  - Needed when participation is low
  - Example: Inkling Markets

Most common types of securities

- Winner take all for an event occurring:
  - Price represents probability of event occurring
  - Sarah Palin's price for being 2012 Republican nominee is between 24.4 (bid) and 25.0 (ask)

- Index
  - For continuous variables
    - What will Dow Jones be?
  - Intervals often used instead:
    - N1 Marketplace: What was the unemployment rate going to be for Sept. 2009?
      - Separate securities for:
        - » <9%, 9 – 9.3%, 9.4 – 9.7%, …

Limitations

- Participation will often be limited
  - Small # experts for most outcomes
  - Many potential traders don't understand the market
  - Traders will fear some people have huge advantage from insider info
    - E.g., Those who have authority to set SRBs
  - But, uninformed traders are needed for knowledgeable traders to make money and have incentive to play
  - Unlike with stock market, there can be long periods of time with no activity

Limitations

- Thin markets (from low participation) cause:
  - Less accurate predictions
  - More volatility
  - Need for less ideal Market Scoring Mechanism

- Traders often don't understand short-selling
  - So difficult for people to bet against something

Limitations

- Manpower outcomes can be self-defeating
  - Suppose there's a market for whether we meet endstrength goal
  - Trader 1 makes a correct assessment that Navy won't meet goal and sells shares
  - Price goes down
  - Navy sees low probability of meeting goal
  - Navy ups reenlistment bonuses
  - Now Trader 1 will lose money
  - (Are there similar potential problems for Acquisitions?)

Lessons learned: need to phrase questions very clearly

- Inkling question: Did Juliet die on Lost? Question will close January 28, 2010 @ 09:34pm PST
  - Nope   **$26.51/ $100.00 (closed)**
  - Yes....well as far as we know $17.36/ $0.00 (closed)
  - Sort of but reincarnated $21.19/ $0.00 (closed)
  - Who knows - Alternative reality $34.94/ $0.00 (closed)

- Our question, posed August 7, 2009:
  - Will the Dow Jones Industrial Average (INDU) close above 9,400 by COB on Friday, Aug. 14, 2009?
  - Dow closed at around 9395 on August 12