When More is Better-Design Principles for Prediction Markets in Defense Acquisition Cost Forecasting

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- We wish to thank Adam Siegel of Inkling Markets for his suggestions on prediction market design.

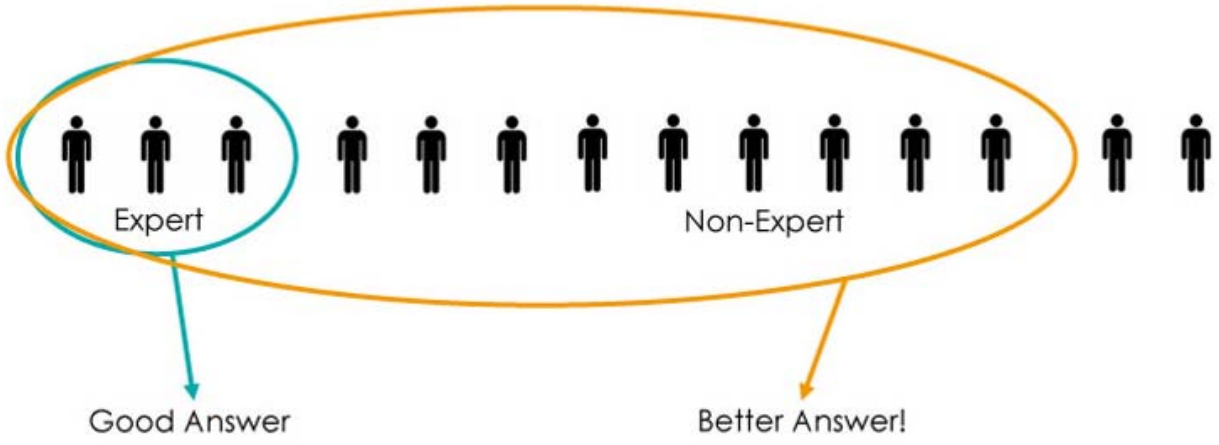
Prediction Markets: History & Purpose

Prediction markets are speculative markets for predicting outcome of uncertain future event. E.g.: Presidential elections or Printer sales.

Buy and Sell contracts for future event

Incentivizes participants to gather and reveal information

Provide dynamic reflection of wisdom of group as a whole

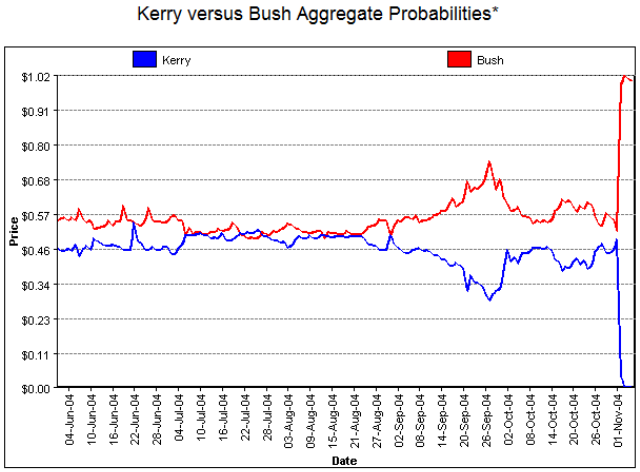


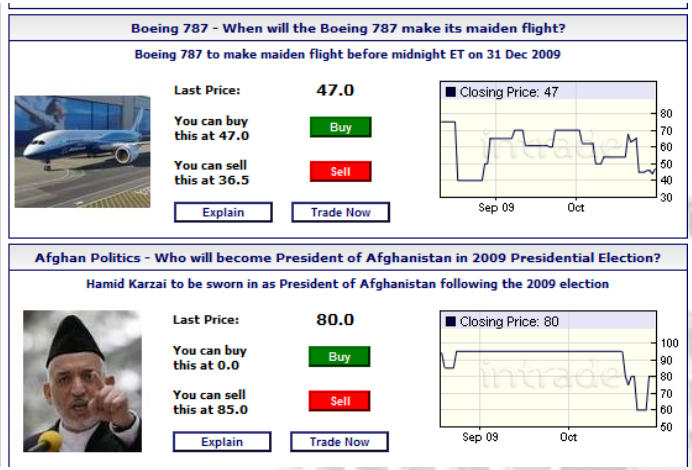
http://www.crowdclarity.com/learnmore.htm

Prediction Markets: Value Proposition

Probable limitations of existing cost methods	Possible value propositions of Prediction Markets
Technical factors rather than "soft" factors	Information leveraged from **diverse sources**
	Incentivize Traders
Not dynamically updated as the program evolves	**Frequent sampling** of information
Few decision makers under time pressure or **biased**	**Mitigation of biases**
	Shift of focus from estimating by **individuals to groups**

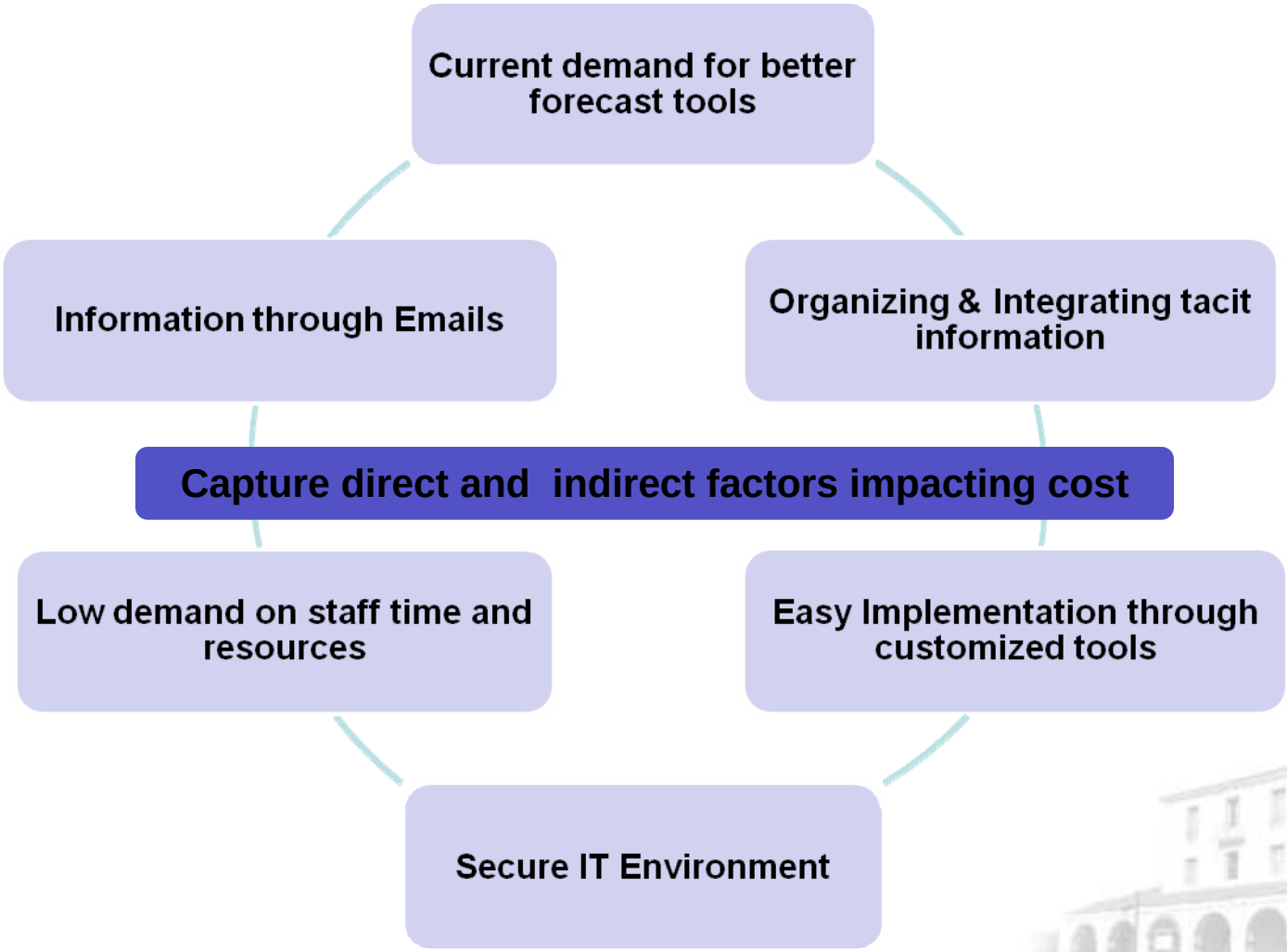
Prediction Markets: Examples



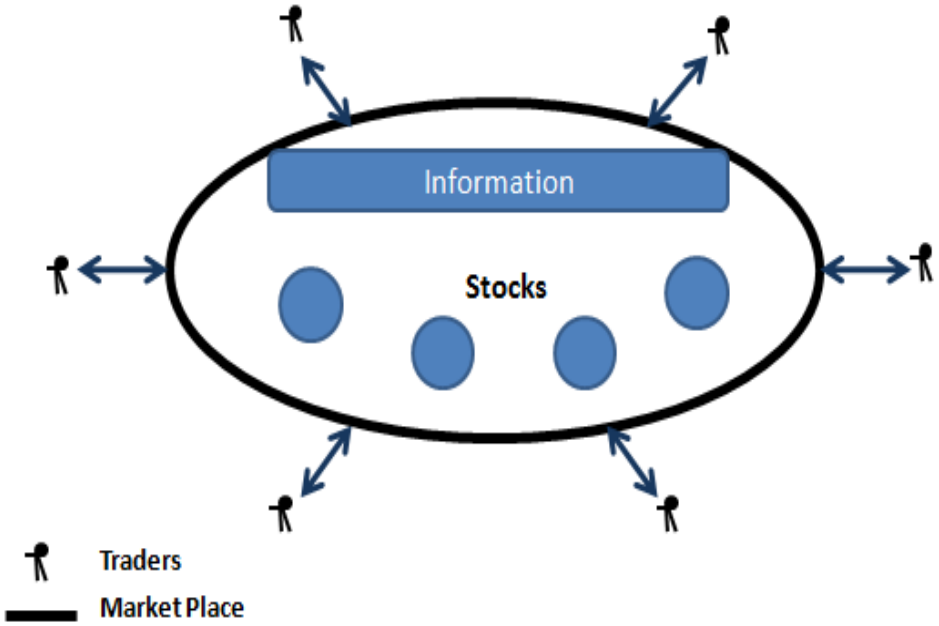


www.intrade.com http://128.255.244.60/graphs/graph_pres04_wta.cfm http://128.255.244.60/graphs/graph_pres04_wta.cfm http://a.fsdn.com/sd/firehose/009/908/692-1.png

Prediction Markets: Management Tool



Prediction Markets: Structure & Types



Winner Takes All

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Spread

Prediction Markets: General Principles

- Unbiased tacit knowledge of crowd
- Well - incentivized environments
- Non – hierarchical environment
- Well defined end dates or closing criteria
- Mutually exclusive choices with a definitive outcome

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

Collaboration with MITRE to share best practices: Hanscom Air Force Base

http://picasaweb.google.com/lh/photo/mT93SQ-87NjVTxJdalU2zA

http://www.hanscom.af.mil/photos/mediagallery.asp?galleryID=2583

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 Markets: SWCS – Design

Stocks: Designing the Questions

Questions of the First Order: Program of interest

- Will SWCS be certified by August 1, 2010?
- The cost of the first unit will be $x.

Questions of the Second Order: Traders and the trading process

- What is your motivation for trading? (e.g. to win/ to solve the problem/ to validate my knowledge)
- What is your role in the Organization?

Questions of the Third Order: Behavior outside the markets

- Did trading improve your confidence in your opinion?
- Did Prediction Markets encourage you to change your communication habits?

Prediction Markets: SWCS - Design

Marketplace

Software Environment

- Easy to access and use
- Commercially available
- IT security considerations
- Dashboard and administrative capabilities
- Share information
- Close or open new markets

Market Manager

- Continuous Double Auction
- Automated Market Maker

Prediction Markets: SWCS - Design

Traders

- Markets will be implemented for duration of 3 to 6 months
- Traders will include administrative personnel, sub-contracts, engineers, end users, consultants etc
- Anonymity of traders will be maintained
- Participants from all smaller projects, as well as people from other departments

Prediction Markets: SWCS - Design

Incentives

Declaring winners based on the maximum portfolio value at market closure

Maintaining a leadership board displaying the top players

Results from the market be used by decision makers and have an influence on real outcomes

Recognition **Opportunity to Contribute** **Social Competition**

Prediction Markets: 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

Prediction Markets: Design Principles

- Ensure liquidity and avoid volatility
- Support of senior management
- Compatibility with political and regulatory contexts
- Review of market with regular reports
- Length of market and closure of questions

Prediction Markets: Q & A

Prediction Markets: Backup

Prediction Markets: SWCS - Design

Sample Risk Mapping for First Order Questions

Question Type	First Order Questions	Measured Risk	Alternate way of asking the question	
Type I	Will SWCS be certified by August 1, 2010?	Schedule Overrun	When will SWCS be certified?	Or
			By how many days will the certification date be exceeded?	
Type I	The cost of the first unit will be $x.	Cost Overrun	What do you think is the most significant cost driver for the first Unit? Follow up question: Based on the below ranking of cost drivers for the first Unit, what do you think the cost of first Unit will be?	
Type I	The final cost of the program will exceed the baseline estimate by x%.	Cost Overrun		
Type I	What will be the 2011 Fiscal Year appropriation for the SWCS?	Cost and Schedule		
Type II	The SWCS program will be adequately resourced to meet its milestones?	Resource Allocation Errors	By how many days/months will the milestone be missed?	Or
			Which resource do you think is most necessary to meet the program's schedule objective?	Or
			Given the available resources, will the project be able to meet its planned schedule?	

Prediction Markets: Pilot Studies

Sunday Night Football : Pilot Study I

- Group of students asked to participate in a private marketplace for predicting the **Nielsen Rating (NBC – USA) for Sunday Night Football (Oct 25)**
- Time – 5 days, Market close 30 minutes prior to game
- Winning Criteria – Generate maximum worth
- Incentive – Points for Class Grade and a popular book for winner
- Minimum of four trades per person
- Each participant allotted $5000 for trading

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Prediction Markets: Pilot Studies

Sunday Night Football : Pilot Study I

- Each rating range assigned equal probability (9.09%) to start with (11 ranges)
- Every time a user buys a share for a particular idea, price goes up. Similarly, each time users sell a share, price goes down. Your account will also be credited or debited based on your choice.
- Direct correlation between price and probability – share price of $9.09 indicates 9.09% chance of that particular rating range.

What will be the Neilson Ratings for the NBC Sunday Football Game (Oct 25)?

Question will be judged on: 10/25/09 @ 05:00 PM PDT

TIP: Current value = probability prediction will occur, e.g. $10 = 10% chance prediction will occur.

Select a prediction:

PREDICTIONS	CURRENT VALUE	TODAY
Between 8.0-8.5	$9.09	0.00
Between 8.6-9.0	$9.09	0.00
Between 9.1-9.5	$9.09	0.00
Between 9.6-10.0	$9.09	0.00
Between 10.1-10.5	$9.09	0.00
Between 10.6 - 11.0	$9.09	0.00
Between 11.1-12.0	$9.09	0.00
Between 12.0 - 13.0	$9.09	0.00
Between 13.0 - 16.0	$9.09	0.00
Over 16.0	$9.09	0.00
Below 8.0	$9.09	0.00

Buying Shares

- Buying shares means you think this answer will happen.
- The more shares you buy, the stronger you feel this answer will happen.
- If the answer happens, you will make money. If the answer does not happen, you will lose money.

- Your cost is the price you will pay for buying that amount of shares.
- The estimated new price is what impact you will have on the price. Remember, by buying you are saying the probability this will occur is higher than the current price, so we raise the price according to how strongly you (and others) feel.

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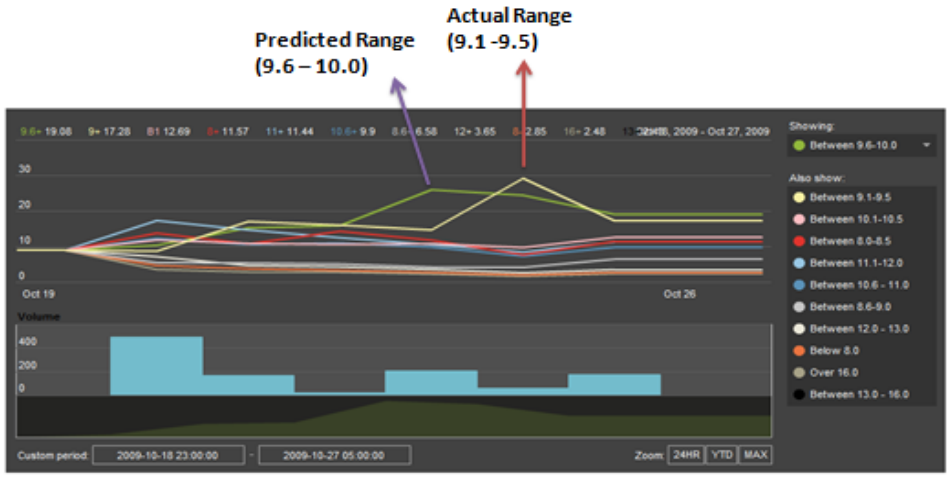
Prediction Markets: Pilot Study I Result

- Around 236 trades conducted in total by 17 traders
- **Highest Rating Range (9.6 – 10) (19% chance), followed by range (9.1 – 9.5) (17.3% chance); Actual rating – 9.1**
- World Series game ran into overtime, reducing the ratings for Sunday Night Football



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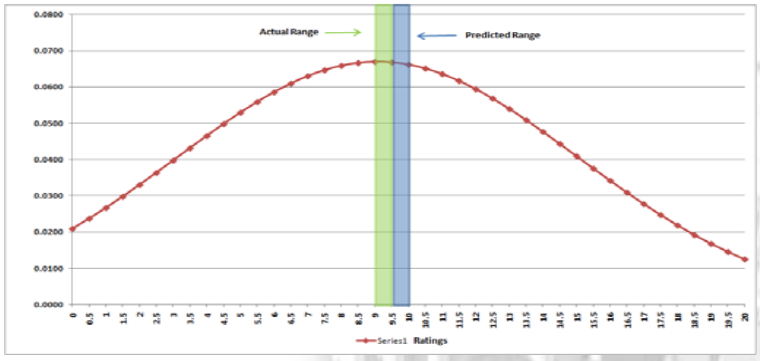
TIP: Current value = probability prediction will occur, e.g. $10 = 10% chance prediction will occur.

Select a prediction:

PREDICTIONS	CURRENT VALUE	TODAY
Between 9.6-10.0	$19.08	(closed)
Between 9.1-9.5	$17.28	(closed)
Between 10.1-10.5	$12.69	(closed)
Between 8.0-8.5	$11.57	(closed)
Between 11.1-12.0	$11.44	(closed)
Between 10.6 - 11.0	$9.90	(closed)
Between 8.6-9.0	$6.58	(closed)
Between 12.0 - 13.0	$3.65	(closed)
Below 8.0	$2.85	(closed)
Over 16.0	$2.48	(closed)
Between 13.0 - 16.0	$2.43	(closed)



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Prediction Markets: Pilot Studies

Monday Night Football : Pilot Study II

- Instead of ranges, participants now saw only one rating. They had to predict if the rating as per their opinion was to be higher or lower. Based on their responses, the price or rating was adjusted automatically.
- The initial rating set was 10
- The price and rating scale was 1:1, i.e. a price of $10.00 meant the current projected value of rating was 10.00

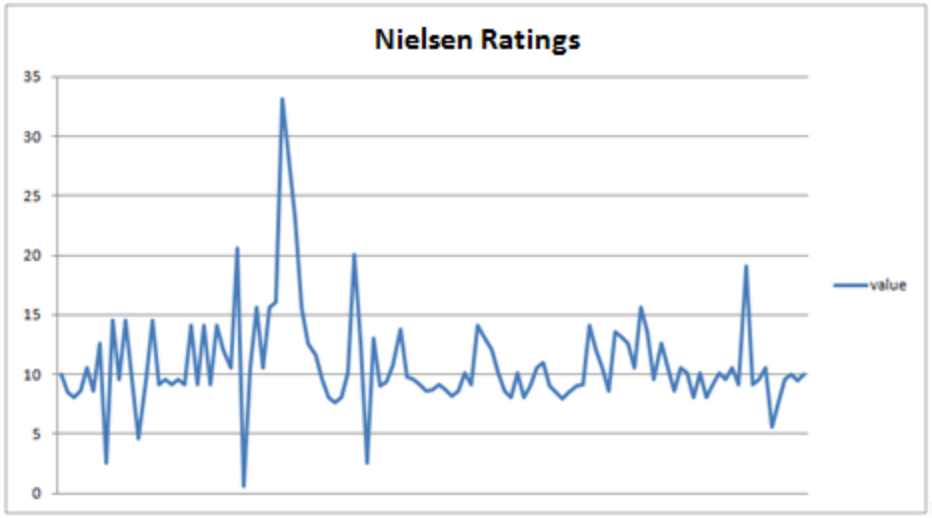
Prediction Markets: Pilot Study II Result

Monday Night Football : Pilot Study II

•Around 116 trades were conducted by 13 participants. The final rating predicted by the market was 10.00

•There was a huge variation in the ratings predicted, with the highest value being 33.1 and the lowest value being 0.6

•The actual rating came out to be 7.7 which was not close to the market value.



Prediction Markets: Observations

Behavioral Observations

- Increased participation due to Internal competition
- Attempts at market gaming
- Trying to make use of First mover advantages
- Forming alliances to manipulate the market
- High incentive to participate led participants to gain more knowledge on the subject.
- Use of statistical models by some participants to forecast ratings

Prediction Markets: Observations

Useful insights related to implementation

- Ensure enough liquidity
- Avoid volatility by choosing the right scale for trading in market
- Ease of Use
- Ensure regular information update
- Leads to increased awareness and interest
- Align incentives with the participants' interests

Prediction Markets: Case Study - SWCS

Stocks: Stocks traded or the questions answered give an indication of the beliefs of the participants, and the number of stocks traded show the level of confidence in their beliefs.

- **Type I questions:** Asking these questions can directly provide the required information.

$Q_1 \rightarrow A$

- **Type II questions:** Asking these questions can indirectly provide the required information, and a series of questions might be required for getting the information directly.

$Q_2 \rightarrow Q' \rightarrow Q'' \rightarrow A$