Impolite Innovation – The Technology and Politics of “Terrorism Futures”

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THINK ABOUT IT. AFTER THE NEXT ATTACK, DID YOU REALLY WANT TO ANNOUNCE, "WE HAVE A WINNER"?....
What Is Our Intelligence Problem?

- Programmer’s problem
  - Given inputs, how compute desired outputs?
- Statistician’s problem
  - Given data, model, how infer probabilities?
- Analyst’s problem
  - What topics study, sources examine?
- Manager’s problem
  - Who to believe, and pay?
- Economist’s problem
  - What institution to believe, and pay?
Buy Low, Sell High

“Pays $1 if Bush wins”

Will price rise or fall?

E[ price change | ?? ]

Lots of ?? get tried, price includes all!

(All speculation is “gambling”!)
Today’s Prices

9-11%  Bin Laden neutralized in 2003
15-18% S. Hussein neutralized in 2003
9-14%  Arafat out Isr./Palestine in 2003
62-63% Bush re-elected US Pres. 2004
15-25% Palestinian State est. by 2006

TradeSports.com
Information Markets

- Most speculative markets aggregate info well
  - Very hard to find info to beat average return
  - Some make markets for info aggregate purpose
- In direct compare, beat other institutions
  - Racetrack odds beat track experts (Figlewski 1979)
  - OJ futures improve weather forecast (Roll 1984)
  - I.E.M. beat president polls 451/596 (Berg et al 2001)
  - HP market beat sales forecast 6/8 (Plott 2000)
  - Stocks beat Challenger panel (Maloney & Mulherin 2003)
Info Markets Benefits

- People self-select as experts – we not choose
- Incentive to be honest with yourself, and to stay out if you don’t know.
- If not honest, eventually lose money & leave.
- Precise and continually updated
- Consistent across diverse contexts
- Can specialize in prices, correct biases see.
Regulation of Speculation

- Capitalize Firms
- Hedge Individual Risk
- Hedge Common Risk
- Aggregate Information
- "Entertain"
- Gamble
Troop Move Decision Advice

$1 if War & Move Troops

$1 if War & Not Move Troops

$1 if Not Move Troops

$1 if Move Troops

P(M)

P(not M)

P(W | M)

P(W | not M)

Compare!
Decision Market Applications

E[ firm stock price | fire CEO? ]
E[ f(inflation,unemploy) | Fed raise rates? ]
E[ my years to live | opt for surgery? ]
E[ crime rate | gun control bill pass? ]
E[ Democrat win | Nominate Kerry? ]
E[ GDP | Bush re-elected? ]
E[ SA civil war | US moves troops out? ]
…OBJECTIVE: Develop electronic market-based methods and software for decision analysis, to aggregate information and opinions from groups of experts. … demonstrate market-based methods applied to analyses of interest to the DOD.  

PHASE I: [100K$, 2002] Design one or more markets to predict events in a limited domain of interest to the DOD. This will include selection of a domain for assessment, identification of … participants, design of an incentive system …, integration of hardware and software for market operations and management, …  

PHASE II: [750K$, 2003,2004] Manage the markets … until the outcomes are known, and analyze their performance. Evaluate the accuracy of market predictions against predictions of the same events by other institutions. Develop more general techniques and software …
My Role in Policy Analysis Market

- Saw call, teamed with: John Ledyard, Charles Polk, Takashi Ishida
- Choose application area
  - World military instability – wars, coups, ...
- Designed Core Tech
  - Won internal competition via lab test
When Is Cost Worth Benefit?

- Cost to make info markets varies little
  - Mainly participant, manager time
- Benefit is value to getting estimate
  - HP dropped printer sales markets
- Lesson: Do highest value estimates 1st
  - And work to lower costs

What are highest value DoD questions?
We Want:

Every nation*quarter:
- Political stability
- Military activity
- Economic growth
- US $ aid
- US military activity
& global, special
& all combinations
If US military involvement in Saudi Arabia in 3rd Quarter 2003 is not between 105 and 125, this trade is null and void. Otherwise, if Iraq civil stability in 4th Quarter 2003 is below 85, then I will receive $1.43, but if it is not below 85, I will pay $2.04.
Thin Market Problem

- Trade requires coordinate in Assets and
  - *Time:* waiting offers suffer adverse selection
  - Call markets, combo match, can help some, but
- Most possible info markets do not exist
  - Most are illegal, and for most of the rest
  - Expect few traders, so don’t make offer
- *If known that only one person has opinion on a topic, price of simple market not reveal it!*
Market Scoring Rules

Simple Info Markets

Best of Both

Accuracy

Estimates per trader

opinion pool problem

thin market problem
Market Scoring Rules

- MSRs combine scoring rules, info markets
- Scoring rule: report \( r \), state is \( i \), reward \( s_i(r) \)
  
  \[ p = \operatorname{argmax}_r \sum_i p_i s_i(r), \quad \sum_i p_i s_i(p) \geq 0 \]

- MSR: User \( t \) faces \$ rule: \( \Delta s_i = s_i(p^t) - s_i(p^{t-1}) \)
  “Anyone can use scoring rule if pay off last user”

- Is auto market maker, price from net sales \( s \)
  - Tiny sale \( \$ \epsilon_i \) if \( i \)
    fee: \( \approx p_i(s) \epsilon_i \quad (s_i \rightarrow s_i + \epsilon_i) \)
  - Big sale \( \$ s(1)-s(0) \)
    fee: \( \int_0^1 \sum_i p_i(s(t)) s_i \dot{}(t) \, dt \)
**MSR Scaling Issues**

- **Simple**: store $2^N$ states
- **Feasible**: overlapping var patches
  - Simple MSR per patch
  - Allow trade only if all vars in same patch
  - Users share assets across patches
- **How make patches agree?**
  - Arbitrage neighbors is robust, non-modular
  - Bayes Net modular, money pump possible?
Laboratory Tests

- Joint work with John Ledyard, Takashi Ishida, of Net Exchange
- Caltech students, get ~$30/session
- 6 periods/session, 12-15 minutes each
- Trained in 3var session, return for 8var
- Metric: Kulback-Leibler $\sum_i q_i \log(p_i/q_i)$ distance from market prices to Bayesian beliefs given all group info


Environments: Goals, Training

Want in Environment:
- Many variables, few directly related
- Few people, each not see all variables
- Can compute rational group estimates
- Explainable, fast, neutral

Training Environment:
- 3 binary variables X,Y,Z, \(2^3 = 8\) combos
- \(P(X=0) = .3, P(X=Y) = .2, P(Z=1) = .5\)
- 3 people, see 10 cases of: AB, BC, AC
- Random map XYZ to ABC

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Sum: 9 - 3

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<td>C</td>
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Theory Benchmarks

3 Variables

- Uniform Distribution
- Prior Distribution
- Individual Posterior

KL Distance from Group Posterior
**Simple Double Auction**  
3 Variables

![Graph showing KL Distance from Group Posterior for different distributions.](image-url)

- **CDF**
- **Uniform Distribution**
- **Prior Distribution**
- **Individual Posterior**
- **Independent DA (24)**

**Graph Details:**
- X-axis: KL Distance from Group Posterior
- Y-axis: CDF
- Various lines representing different distributions.
Combinatorial Call

3 Variables

CDF

KL Distance from Group Posterior

Uniform Distribution
Prior Distribution
Individual Posterior
Independent DA (24)
Combined Value (24)
**Individual Scoring Rule**

3 Variables

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**Diagram Description:**

- **CDF (Cumulative Distribution Function):** Represents the cumulative distribution of the KL distance from the group posterior.
- **Legend:**
  - Blue: Uniform Distribution
  - Purple: Prior Distribution
  - Cyan: Individual Posterior
  - Light Cyan: Independent DA (24)
  - Light Blue: Combined Value (24)
  - Yellow: Individual (72)

**Axes:**

- **X-axis:** KL Distance from Group Posterior
- **Y-axis:** CDF

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**Key Points:**

- The graph illustrates how different distributions (Uniform, Prior, Individual, etc.) are represented across the KL distance.
- The individual scoring rule is evaluated for 3 variables, as indicated in the title.
**Best of Three Individuals**

3 Variables

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![Graph showing CDF (Cumulative Distribution Function) for KL Distance from Group Posterior. The graph compares different distributions and values including Uniform Distribution, Prior Distribution, Individual Posterior, Independent DA (24), Combined Value (24), Individual (72), and Best of 3 Individuals. The x-axis represents KL Distance from Group Posterior ranging from 0 to 0.4, and the y-axis represents CDF ranging from 0 to 1.](image-url)
Log Opinion Pool
Market Scoring Rule

3 Variables

KL Distance from Group Posterior

CDF

0 0.05 0.1 0.15 0.2 0.25 0.3 0.35 0.4

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1

0 0.05 0.1 0.15 0.2 0.25 0.3 0.35 0.4

KL Distance from Group Posterior

- Uniform Distribution
- Prior Distribution
- Individual Posterior
- Independent DA (24)
- Combined Value (24)
- Individual (72)
- Best of 3 Individuals
- Log Opinion Pool
- Market Maker (36)
**MSR Info vs. Time – 3 vars**

\[
\% \text{ Info Agg.} = 1 - \frac{\text{KL}(\text{prices}, \text{group})}{\text{KL}(\text{uniform}, \text{group})}
\]
Market Maker Histogram – 3 vars

![Histogram of Market Maker Log(KL distance)](image-url)
8 binary vars: STU VWXYZ

2^8 = 256 combinations

20% = P(S=0) = P(S=T) = P(T=U) = P(U=V) = ...

P(X=Y) = P(Y=Z)

6 people, each see 10 cases: ABCD, EFGH, ABEF, CDGH, ACEG, BDFH

random map STU VWXYZ to ABCDEFGH
Theory Benchmarks

8 Variables

KL Distance from Group Posterior

CDF

- Uniform Distribution
- Prior Distribution
- Individual Posterior

Variables
Simple Double Auction

8 Variables
Combinatorial Call

8 Variables
Individual Scoring Rule

8 Variables

KL Distance from Group Posterior

CDF

0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2

Uniform Distribution
Prior Distribution
Individual Posterior
Independent DA (18)
Combined Value (18)
Individual (144)
Market Scoring Rule

CDF

KL Distance from Group Posterior

- Uniform Distribution
- Prior Distribution
- Individual Posterior
- Independent DA (18)
- Combined Value (18)
- Individual (144)
- Market Maker (17)

8 Variables
Log Opinion Pool

8 Variables
Best of Three Individuals

8 Variables
MSR Info vs. Time – 8 vars

\[
\% \text{ Info Agg.} = 1 - \frac{\text{KL(\text{prices,group})}}{\text{KL(\text{uniform,group})}}
\]
Conclusions

- Experiments on complex info problems
  - Bayesian estimates far too high a standard
- 7 indep. prices from 3 people in 5 minutes
  - Simple DA < Indiv. Score Rule ~ Opinion Pool ~ Combined Value < Market Scoring Rule
- 255 indep. prices from 6 people in 5 minutes
  - Combined Value ~ Simple DA ~ Indiv. Score Rule < Market Scoring Rule ~ Opinion Pool
Timeline - Policy Analysis Market

- **2001**
  - May – DARPA seeks info market proposals
  - Fall – We start Phase I ($100K+$100K)

- **2002**
  - Poindexter heads IAO, we run experiments

- **2003**
  - Spring – We start Phase II ($750K)
  - Plan: register 8/1, few test 9/1, open 1/1
  - 7/28 – Senators complain: “repugnant"
  - 7/29 – DARPA FutureMAP Killed
  - 7/31 – Poindexter quits
  - After – much media, as much pro as con
Analysts often use prices from various markets as indicators of potential events. The use of petroleum futures contract prices by analysts of the Middle East is a classic example. The Policy Analysis Market (PAM) refines this approach by trading futures contracts that deal with underlying fundamentals of relevance to the Middle East.

Initially, PAM will focus on the economic, civil, and military futures of Egypt, Jordan, Iran, Iraq, Israel, Saudi Arabia, Syria, and Turkey and the impact of U.S. involvement with each.

The contracts traded on PAM will be based on objective data and observable events. These contracts will be valuable because traders who are registered with PAM will use their money to acquire contracts. A PAM trader who believes that the price of a specific futures contract under-predicts the future status of the issue on which it is based can attempt to profit from his belief by buying the contract. The converse holds for a trader who believes the price is an over-prediction – she can be a seller of the contract. This price discovery process, with the prospect of profit and at pain of loss, is at the core of a market's predictive power.

The issues represented by PAM contracts may be interrelated; for example, the economic health of a country may affect civil stability in the country and the disposition of one country’s military may affect the disposition of another country’s military. The trading process at the heart of PAM allows traders to structure combinations of futures contracts. Such combinations represent predictions about interrelated issues that the trader has knowledge of and thus may be able to profit from with substantial refinement.

The PAM trading interface presents a Market in the Future of the Middle East. Trading on PAM is placed in the context of the region using a trading language designed for the fields of policy, security, and risk analysis. PAM will be active and accessible 24/7 and should prove as engaging as it is informative.

**Issue A:** Overthrow of Jordanian Monarchy

<table>
<thead>
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<th>A</th>
<th>~A</th>
<th>Price</th>
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<tbody>
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<td>$0.30</td>
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A and ~A are futures contracts that span A

A~B is a derivative of the joint outcome

<table>
<thead>
<tr>
<th></th>
<th>A~B</th>
<th><del>A</del>B</th>
<th>Price</th>
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<tbody>
<tr>
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<td>$0.05</td>
<td>$0.45</td>
<td>$0.50</td>
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A |B (A given B) is a conditional derivative (a hedge)

**Issue B:** Iraqi Regime persists after One Month of Hostilities

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<tbody>
<tr>
<td></td>
<td>$0.35</td>
<td>$0.65</td>
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</table>
Possible Manipulation

- **Bad guys gain $ by giving info, changing acts**
  - More plausible if bet on specific details
  - A good deal for us if give few $, gain much info
  - Terror now effects big markets: oil, currency, ...
  - PAM not on specifics, max gain/trade < $100

- **Bad guys lose $ to obscure market info**
  - Worst case: get no info (they can’t make net bias)
  - $1M worth it if 0.1% chance gain 0.1% of $400B/yr
  - Usually “noise traders” attract others, net *add* info
  - We see little effect in lab, field experiments
Is Terror Betting “Unthinkable”?

- We deny trading sacred/secular (P. Tetlock)
  - E.g., money vs. death risk
  - Outraged at those we see do (really, we all do)
  - More outraged if they think a long time first
  - If catch ourselves, seek moral cleansing

- PAM painted as crossing a moral boundary
  - “None of us should intend to benefit when they hurt some of us.”
  - So politicians must not think long before rejecting
Impolite Innovation?

- Intelligence is by its nature in bad taste
  - For it, we lie, cheat, steal, kill, and worse
  - Bad guys benefit by informing us
  - Intentional misinformation misleads us
Potential Problems

- Decision selection bias
- Incentives to bias
- Thin markets
- Moral hazard
- Regulation
- Secrecy
- Bozos
- Reduce info sharing
- Rich more “votes”
- Risk distortion
- Bubbles
Three Premises and a Conclusion

1. It is not that hard to tell rich happy nations from poor miserable ones after the fact.
2. Governments largely fail by not aggregating available information.
3. Betting markets are the best known institution for aggregating information.

∴ Try to vote on values, but bet on beliefs.
Vote On Values But Bet On Beliefs

\[ E[ \text{GDP}+ | \text{Alternative} ] >? \]
\[ E[ \text{GDP}+ | \text{Status Quo} ] \]
Futarchy’s One Rule

When a market estimates currently-defined GDP+ to be higher given some proposed alternative policy, that policy becomes law.

- Unless market on future-defined GDP+ vetoes it
- Start with existing policies, fee to make proposal
- Like contract, proposal says how handle conflicts
- High standards at base, recurse to relax standards

http://hanson.gmu.edu/futarchy.html
Decision Selection Bias

- If traders think deciders will use info traders do not have, conditional market price advice may contradict trader info
- Related to “Newcomb’s Problem” in decision theory
A Decision State Space

Imagine a uniform distribution over this area.

Best to keep in this case.

Best to dump in this case.

Expected value over distribution is center of mass.
If No Selection Bias

Stock if keep CEO

Market prices here if decision not correlated with state

Better to dump

Stock if dump CEO
Well-Informed Deciders

Keep

Dump

Stock if keep CEO

Stock if dump CEO

Apparent center

True center
Problem Seems Uncommon