

# Using Prediction Markets to Enhance US Intelligence Capabilities

## A "Standard & Poors 500 Index" for Intelligence

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In 2001, the Defense Advanced Research Project Agency (DARPA) started experimenting with methods for applying

DARPA's Future Markets Applied to Prediction (FutureMAP) program tested whether prediction markets, markets in which people bet on the likelihood of future events, could be used to improve upon existing approaches to preparing strategic intelligence. The program was cancelled in the summer of 2003 under a barrage of congressional criticism. Senators Ron Wyden and Byron Dorgan accused the Pentagon of wasting taxpayer dollars on "terrorism betting parlors," and that "Spending millions of dollars on some kind of fantasy league terror game is absurd and, frankly, ought to make every American angry."

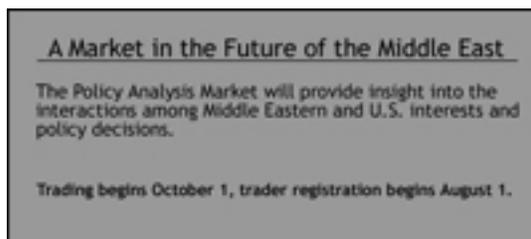
Americans need not have been angry about FutureMAP. It was neither a terrorism betting parlor nor a fantasy league. Rather, it was an experiment to see whether market-generated predictions could improve upon

"Prediction markets can contribute to US Intelligence Community strategic and tactical intelligence work"

conventional approaches to forecasting. Since 1988, traders in the Iowa Electronic Markets have been betting with remarkable accuracy on the likely winner of the US presidential elections.<sup>[1]</sup> Eli Lilly, a major pharmaceutical company, found that prediction markets outdid conventional methods in forecasting outcomes of drug research and development efforts.<sup>[2]</sup> Google recently announced that it was using prediction markets to “forecast product launch dates, new office openings, and many other things of strategic importance.”<sup>[3]</sup>

The decision to cancel FutureMAP was at the very least premature, if not wrong-headed. The bulk of evidence on prediction markets demonstrate that they are reliable aggregators of disparate and dispersed information and can result in forecasts that are more accurate than those of experts. If so, prediction markets can substantially contribute to US Intelligence Community strategic and tactical intelligence work.

## FutureMAP and the Policy Analysis Market



The Policy Analysis Market logo and masthead as they appeared on DARPA's Web site before they were removed in 2003.

When the FutureMAP project began in 2001, DARPA solicited proposals for “market-based techniques for avoiding surprise and predicting future events.”<sup>[4]</sup> Two proposals were selected for further funding, but Net Exchange’s Policy Analysis Market (PAM) became the public face of the FutureMAP project until it was terminated.

PAM would have offered trading on the following kinds of contracts: (1) political, economic, and military indicators for Egypt, Iran, Iraq, Israel, Jordan, Saudi Arabia, Syria, and Turkey; (2) global economic and conflict indicators; and (3) on events as they came up, e.g. the likelihood of Hamas recognizing the state of Israel.<sup>[5]</sup> It also would have offered contracts called conditional derivatives, which would have allowed traders to

speculate on events conditional on the occurrence of other related events (e.g., a trader might bet on the likelihood that the Saudi regime will fall if the United States withdraws from Iraq).<sup>[6]</sup> PAM's creators believed that the conditional derivative would have enhanced the "prediction power" of the market.<sup>[7]</sup>

## Prediction Markets: Theory and Evidence

The theories underlying PAM and other prediction markets are the Efficient Capital Markets Hypothesis (ECMH) and the Hayek hypotheses.<sup>[8]</sup> These hypotheses explain how information is aggregated such that market prices provide accurate estimates on the likelihood of future outcomes.<sup>[9]</sup> According to ECMH, capital markets are "extremely efficient in reflecting information about individual stocks and about the stock market as a whole," such that no amount of analysis in an attempt to forecast future stock prices can beat the market.<sup>[10]</sup>

Expanding on this hypothesis further was the idea of a "random walk." The logic of the random walk is that if information flows without impediments and stock prices immediately reflect that information, then tomorrow's price changes will reflect only tomorrow's news and are independent of today's price changes. But since news is unpredictable, then price changes are also unpredictable. Consequently, prices fully reflect all known information, and even uninformed investors buying a diversified portfolio at market prices will obtain a rate of return as generous as that achieved by the experts.<sup>[11]</sup> Thus "[i]n an efficient capital market, asset prices reflect all relevant information and thus provide the best prediction of future events given the current information."<sup>[12]</sup> Oil futures prices, for example, have been demonstrated to act as a function of the spot price and *an estimate about the cost of carrying the commodity until the time of delivery*.<sup>[13]</sup>

For prediction markets, the theory that price instantaneously reflects information is only part of the story. The other part rests with the Hayek hypothesis. Hayek, criticizing central planning in 1945, sought an answer to the following question: how does one effectively aggregate disparate pieces of information that are spread among many different individuals, information that in its totality is needed to solve a problem?<sup>[14]</sup>

Hayek's answer was that market prices are the means by which those disparate pieces of information are aggregated. "The mere fact that there is one price for any commodity...brings about the solution which...might have been arrived at by one single mind possessing all the information which is, in fact, dispersed among all the people involved in the process."<sup>[15]</sup>

Additionally, the market works even when people have limited knowledge about their surrounding environment and the people with whom they transact.<sup>[16]</sup> An interesting application of the Hayek hypothesis was the explosion of the NASA space shuttle Challenger in 1986. Within minutes of that explosion, Wall Street traders seemed to identify who would be held responsible for the crash while a presidential commission took nearly four months to conclusively pinpoint the cause of the tragedy.<sup>[17]</sup> The Challenger study authors' note that "What the Challenger episode adds to Hayek's insights is that securities markets are vehicles for amalgamating unorganized knowledge."<sup>[18]</sup>

### **Trading Mechanics**

Trading in prediction markets is similar to any haggling kind of transaction: buyers and sellers exchange offers and counter-offers until they agree on a price.<sup>[19]</sup> In a double auction, the most common mechanism used to clear prediction markets, buyers submit bids and sellers submit asking prices, which are ranked from highest to lowest to generate supply and demand curves. Trades are executed when two prices match (i.e., bid-ask spread is zero or supply intersects demand). In describing Eli Lilly's 2003 experimental prediction market, Vice President for Lilly Research Laboratories Alpheus Beingham noted that, "When we start trading stock [in the drug], and I try buying your stock cheaper and cheaper, it forces us to a way of agreeing that never really occurs in any other kind of conversation."<sup>[20]</sup>

In prediction markets payoffs are determined by the occurrence (or lack thereof) of outcomes. Consider the following contract: *Senator Hillary Clinton will declare her candidacy for the 2008 presidential election by 1 January 2007*. If the contract has a share price ranging from 0 to 100 cents, the contract would pay 100 cents if, in fact, the senator declares before then. In this case, a trader who bought 10 shares of the contract at 67 cents would realize a profit of 330 cents ( $1000 - 670 = 330$ ); if she doesn't declare, that trader gets nothing.<sup>[21]</sup> The same trader could also profit by selling his shares to another trader at a price higher than 67 cents before the

closing period of the contract.

Prediction market proponents claim that market prices for contracts can be interpreted as probabilities of an expected outcome. In the above example, a contract closing at 67 cents would mean there is a 67 percent probability that Senator Clinton will declare her presidential candidacy before 1 January 2007.

The contention that market prices can be interpreted as probabilistic estimates of future events is not without controversy.<sup>[22]</sup> One specialist, Charles Manski, argues that it is dangerous to read market prices as probabilities.<sup>[23]</sup> Others note that little is known about why a trade occurs in prediction markets.<sup>[24]</sup>

Numerous studies have suggested, however, that markets do lead to predictions that are more accurate than traditional forecasting techniques, including those that rely on expert opinions. A study of the Iowa Electronic Markets during the 1988 US presidential election concluded that market predictions of the two candidates' vote shares were closer to the actual vote shares than were the polling data of six major organizations.<sup>[25]</sup> Orange juice futures prices have been shown to be better predictors of weather than the National Weather Service's forecasts.<sup>[26]</sup> A preliminary study of the Goldman Sachs and Deutsche Bank's Economic Derivatives market, which allows traders to hedge against surprises in economic statistics like unemployment and GDP data, concluded that prediction markets, "may be useful as a supplement to the other relatively primitive mechanisms for predicting the future like opinion surveys, politically appointed panels of experts, hiring consultants or holding committee meetings."<sup>[27]</sup>

## **From Orange Futures to Market Intelligence and Policy**

### **Analysis**

While some prediction markets outperform experts and polls in predicting winners of presidential elections and weather in Florida, at least two other experiments suggest the markets can perform intelligence and policy analysis functions.

#### ***HP Labs and Market Intelligence***

In 1996, HP Labs and Caltech conducted a three-year experiment using an

“information aggregation mechanism,” (IAM) or prediction market.<sup>[28]</sup> Echoing Hayek’s information aggregation problem, the study noted that responsibility in businesses for aggregating information in a timely way lies with many different individuals throughout the company and that such efforts have been costly and by most standards inefficient.<sup>[29]</sup> Moreover, “business practices such as quotas and budget settings create incentives for individuals not to reveal their information.”<sup>[30]</sup>

The IAM experiment involved 12 predictions over a three-year period. Traders were paid if and only if they owned the security that corresponded to the actual sales outcome (e.g., trader owns stock that forecasts the actual unit sales within a given range of units). The IAM aggregated information from 20 to 30 people across different parts of the United States and from HP business, finance, and market divisions. They were selected because they possessed “different patterns of information” (e.g., pricing strategies and client specific data) that “were in need of aggregation.”<sup>[31]</sup> To “provide market liquidity” five participants from HP Labs who were ignorant of HP business-related information also participated.<sup>[32]</sup>

The experiment was a success. In 75 percent of the predicted events for which there were HP official forecasts, IAM predictions came closer to the actual outcomes than did the official forecasts.<sup>[33]</sup> The experiment also gave credence to the theory that prediction market prices act as probabilistic estimates of future sales targets.

Thus, if a stock that corresponds to a sales projection interval of 1,201 to 1,300 has a share price of 20 cents, it means that there is a 20 percent probability that actual sales will fall within this range. The study noted that the advantages of using an IAM lie in its ability to “aggregate any type of information possessed by different people,” to quantify and give weights “to the opinions of different people,” and in its scalability.<sup>[34]</sup>

### ***The “Saddam Security” Policy Analysis***

In contrast to the HP Labs experiments, the Saddam Security study was an experiment to determine if decisionmaking could be informed in real time by existing prediction, financial, and energy markets.<sup>[35]</sup> One month prior to the US invasion of Iraq in March 2003, Wolfers and Zitzewitz attempted an estimate of the effects of a US decision to go to war with Iraq. The authors examined the relationship between equity and oil spot and futures prices and the Saddam Security, a Tradesports.com

contingent security, that paid if and only if Saddam Hussein was out of office by 30 June 2003.

In the weeks preceding the invasion of Iraq, the authors reasoned that the higher the price of the Saddam Security then the higher the probability of the United States going to war. If during the same trading period oil futures prices on contracts for delivery toward the end of 2003 were relatively high, then that would suggest investors expected the war to cause medium disruptions in supply (i.e., no destruction of oil fields). Similarly, if S&P 500 futures prices for one-year ahead during the same period were negatively correlated with the Saddam Security, that would suggest investors believed the war would negatively affect the broader global economy. The rationale for using equity and oil futures prices was that they reflected traders' best guesses on the economic and political conditions at the time of the contract delivery date.

Researchers Looney, Schrady, and Brown performed similar correlations, but on historical events. Observing that oil-futures prices tended to sharply increase when a crisis breaks and steadily fall back to pre-crisis levels once US naval forces arrived on the scene, the three calculated that these price declines “produced significant cost savings to the United States economy” in the range of \$55.2 billion for the US economy in the immediate aftermath of the Iraqi invasion of Kuwait in 1990.<sup>[36]</sup>

Exploring the possibilities of prediction markets further, others have proposed that these markets should serve as mechanisms to help decide which of several policies options should be implemented. Hanson, for instance, hypothesized the creation of markets to guide policymaking in which, “people could bet on future crime rates, conditional on allowing concealed weapons.”<sup>[37]</sup> Hahn and Tetlock argue that the markets have the potential to provide informed evaluations of policy proposals before they are adopted.<sup>[38]</sup>

## **Using Prediction Markets to Enhance Intelligence**

### **Capabilities**

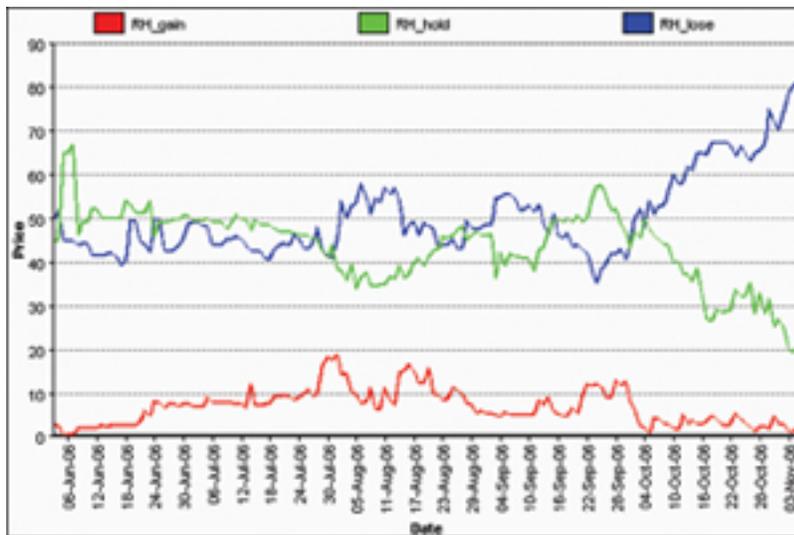
How then can prediction markets improve the performance of the US Intelligence Community? In many respects the challenge of intelligence goes to the core of the Hayek hypothesis: *How do you aggregate, in a timely way, disparate pieces of information that are spread among and within 15 US intelligence agencies into relevant products?* Putting aside market design

questions for now, prediction markets can help address shortcomings in analytical organization and processes, improve long-term intelligence estimates, and perform real-time and ex-ante policy evaluations.<sup>[39]</sup>

### ***Information and Analytical Aggregation***

The 9/11 Commission, in its discussion of how to reorganize the US Intelligence Community, cited the lack of unity of effort in information sharing as the “biggest impediment to all-source analysis—to a greater likelihood of connecting the dots.”<sup>[40]</sup> The lack of information sharing is further compounded by a culture that emphasizes information compartmentalization, suffers from stovepipe mentalities, and bureaucratic distrust.<sup>[41]</sup> One way to solve these problems is to work on IC-wide software and databases and develop improved protocols for accessing classified information and for providing better coordination of interagency analyses. Another way is to use prediction markets to aggregate information and analyses. In the way HP’s IAM fused together information and judgments from different corporate divisions into probabilistic estimates of future outcomes, a prediction market could perform the same function for the Intelligence Community.

A good illustration of the way in which an Intelligence Community prediction market might have worked in the months before the beginning of the 2003 Iraq war is the case of the contested meaning of Iraq’s purchase of specialized aluminum tubes in 2001. As is now well-known, Intelligence Community analysts disagreed sharply about their significance, some believing they were intended for Iraq’s putative nuclear program. Irrespective of major disagreements, the conclusion that the tubes were part of Iraq’s reconstituted nuclear program worked its way into the case for war that Secretary of State Colin Powell made before the United Nations in February 2003.<sup>[42]</sup> In hindsight, the judgment was wrong.



This chart, showing the fluctuation in prices in the 2006 US Congressional Control Market of the Iowa Electronic Markets, illustrates the way in which market players' collective judgment unfolded in the five months before the November mid-term election. (Image courtesy of University of Iowa, Henry B. Tippie College of Business.)

Turning back the clock, imagine that in February 2001 analysts throughout the community had the opportunity through an Intelligence Community-wide prediction market to bid on the following yearly futures contract (share price ranging between 0 and 100 cents): *The Iraqi-purchased high-strength aluminum tubes are for use in a uranium enrichment program.*<sup>[43]</sup> *The specificity of the contract is noteworthy because it eliminates the ambiguity surrounding a judgment about whether the aluminum tubes could be used in a uranium enrichment program.*<sup>[44]</sup> If demand (buyers) exceeds supply (sellers) for the contract (i.e., analysts believe that the tubes are destined for use in the Iraqi nuclear program), then the share price rises. Conversely, if supply exceeds demand (i.e., analysts believe the tubes are not destined for use in the Iraqi nuclear program), then the share price decreases. In other words, the market price of the contract depends on the price at which analysts are willing to bid and ask.

In this example a prediction market could have aggregated the different information and analytic judgments of the different agencies into a single market price. Hypothetically, share prices for this contract would have fluctuated from a high of 87 cents in March 2001 when reports of attempted aluminum purchases were first received to a low of 38 cents in February when uncertainty remained about the end uses of the tubes. Thus when trading closed in February 2003, the closing share price of 46

cents would have told policymakers that the Intelligence Community believed that there was only a 46 percent chance that the aluminum tubes were for use in Iraq's nuclear program.<sup>[45]</sup>

The judgment about the aluminum tubes was only one of many inaccuracies that underlined the conclusion of the October 2002 National Intelligence Estimate, which said that Iraq was reconstituting its nuclear program. The commission investigating pre-invasion intelligence stated that, "the NIE [October 2002 National Intelligence Estimate] too often failed to communicate the paucity of intelligence supporting its assessments and also contained several inaccurate statements."<sup>[46]</sup> Prediction markets could have been especially helpful in the formulation of the October 2002 NIE because with prediction markets, uncertainties and certainties are expressed through a probabilistic collective judgment (the market price) rather than through a consensus.

In this respect, because dissenting views affect market prices they have considerably more value in prediction markets than they do in intelligence estimates, where they may end up as unnoticed footnotes. Markets also work better when traders disagree on what is the "truth" since trading by its very nature means that an individual is attempting to profit from another person's perceived poor judgment.<sup>[47]</sup> Analysts buy (or sell) based on the information they possess. Those willing to pay a higher price to engage in a transaction in expectation of a higher payoff will do so, especially when they think they are right.

### ***Long-Term Estimates (Avoiding Strategic Surprise)***

Long-term intelligence estimates provide judgments on the likely path of major issues affecting national security. These issues can range from the proliferation of weapons of mass destruction to terrorism. However, problems of ambiguity of judgment sometimes render an analysis useless and ambiguity of evidence can further muddy the analysis.<sup>[48]</sup> Criticisms of past intelligence estimates have also pointed out their lack of timeliness. For instance, as the 1979 Iranian revolution unfolded, a long-term estimate on the outlook for Iranian political stability in the works deemed Iran politically stable.<sup>[49]</sup> Under these circumstances, policymakers may find it difficult to draw any useful conclusions from the intelligence.

How would the IC arrive at a community-wide judgment if intelligence both supports and undercuts the contention that the balance of power in the Taiwan Straits will shift in favor of the Chinese against the United States in

2008? Imagine that analysts bet on the following contract (share prices ranging between 0 and 100 cents):

*In 2008, China will prevail against the United States in a clash in the Taiwan Straits, conditional on China successfully fielding supersonic sea-launched cruise missiles.*

Further assume that policymakers want the long-term estimate to be completed in three months and that trading occurs during the three-month time frame. Therefore if the closing share price on the final day of trading is 87 cents then policymakers can interpret the closing share price as the IC's estimate that there is an 87 percent probability that the balance of power in the Taiwan Straits will shift in China's favor in 2008. The closing share price of 87 cents also signals that: (1) the fielding of supersonic ship-killing missiles by 2008 is a critical determinant in estimating whether China will prevail in the straits; and (2) the US Navy does not possess adequate countermeasures against sea-borne cruise-missile attacks.

To provide more depth to this analysis, analysts could bet on the probability that China successfully fields sea-launched cruise missiles by 2008, provided that China's current rate of research and development remains constant. They could also bet on China's intentions by speculating on the likelihood that Chinese leaders will seek to forcibly reunify Taiwan by 2008, conditional on Taiwan introducing another referendum on independence.

Prediction markets can function as powerful complements to the traditional process by which long-term estimates are performed. Their power is further multiplied when one imagines that the time and resources saved in running such markets means that several long-term estimates can be run concurrently and updated periodically. At the very least, had a prediction market existed on Iran's long-term political stability in 1979, fluctuations in the share prices of the appropriate contract would have quickly reflected the import of unfolding events and shifts in analytical judgments. Moreover, by allowing analysts to hedge their estimates in the form of conditional contracts, policymakers gain valuable probabilistic estimates, as opposed to wishy-washy judgments which policymakers may easily ignore.

### ***Attack Warnings (Avoiding Tactical Surprise)***

Can prediction markets help avoid tactical surprise? Here there are no clear answers. An attack that is truly surprising necessarily results from a failure of strategic intelligence—“*We had no idea they were going to attack us.*”

But a glance at the record of historical intelligence failures suggests that such surprises are the exception and that failures most often result from failure to communicate appropriate warnings or failure to assess evidence correctly.

Thus one difficulty in using prediction markets to forecast tactical problems is that the market requires contracts for explicitly anticipated events. (e.g., what is the probability that Al-Qa’ida will hijack planes and fly them into the World Trade Center, Capitol Hill, and the Pentagon on or around September 11, 2001?)<sup>[50]</sup>

Such specificity is hard to come by, a fact aptly demonstrated by the often ambiguous nature of the Department of Homeland Security’s Threat Advisory warnings. Even if specificity were possible, there remains the question of how much a share price needs to rise (e.g., 38 cents, 52 cents, 61 cents) before it is taken seriously by policymakers.

Where a prediction market might be useful is in speculating on the probability that a certain method would be used in an attack. For example, in the years leading up to 11 September 2001, analysts could have speculated on a yearly futures contract associated with the likelihood of terrorists hijacking planes and using them as aerial suicide bombs. In theory, an NIE on terrorist threats against the United States would display a graph of rising futures prices associated with the aerial suicide bomb contract. But again, this presupposes that analysts had contemplated the method of attack and issued the appropriate trading contract before 11 September 2001.<sup>[51]</sup>

Hanson has proposed an alternative use for tactical prediction markets in which trading revolves around the probability of red teams (US security teams that act as terrorist cells) penetrating US homeland security defenses (e.g, placing fake explosives on Capitol Hill). He suggests that markets could trade on the rate of red team “wins” conditional on the type of security measures (e.g., private vs. government airport security screeners) used to thwart the mock terrorists.<sup>[52]</sup> The value of such a market is in identifying weaknesses in homeland defenses without having

to experience a market test of an actual terrorist attack.

### **Assessing Policy Choices**

Is the United States winning in Iraq? Will the Andean Regional Initiative decrease the supply of cocaine to the United States? These are just some of the questions policymakers might ask that prediction markets could help answer. If the United States goals in Iraq are to quell the insurgency and to establish a bulwark of democracy in the Middle East, futures contracts issued to the market might revolve around a composite index of economic and political freedoms in Iraq and in the broader Middle East, indicators of civil stability and economic growth, or measurements of oil output and kWh of electricity generation. If analysts believed that the United States was losing the war in the short-term but winning in the long run, then one would expect share prices for short-term contracts to be relatively lower than those for longer-term contracts. These futures contracts could be quarterly, yearly, or two-year contracts. Thus different share prices at different points in time for different futures contracts would provide policymakers with a more nuanced real-time evaluation of whether US policy in Iraq is working.

Prediction markets could also be used to make ex-ante evaluation of policies. Take the question of whether the United States should continue to fund the Andean Regional Initiative (ARI). Analysts could bet on two futures contracts: (1) *the tons of cocaine that will be exported from the countries affected by the ARI to the United States in 2009, conditional on the United States continuing ARI*; and (2) *the tons of cocaine that will be exported if ARI is terminated*. The difference in the two estimates would tell policymakers how much of a reduction (or increase) in cocaine analysts expect from the implementation of ARI. A more realistic assessment would most likely involve analysts speculating on several futures contracts with different expiration dates.

### **Prediction Market Design Issues**

Before a system of Intelligence Community prediction markets could be implemented, key market design issues need to be addressed. For example, does the number of traders in a market matter? The HP experiment was successfully conducted with fewer than 30 participants, but contracts traded at Tradesports or the Iowa Electronic Markets have participants many times that number. Must traders be subject matter experts on the issue for which they are betting, or can they be somewhat in the dark, like the traders in the Hayek's story or the HP Labs participants?

### ***Public versus Private Prediction Markets***

Prediction markets aggregate information and judgments, but whose information and judgments should be aggregated for the best estimate of future events? The report on the HP experiment noted that there is only limited theoretical knowledge about the proper balance between participants with much relevant information versus those without any or limited relevant information.<sup>[53]</sup> Hanson has suggested that prediction markets “can be used to aggregate information from any given set of participants.”<sup>[54]</sup>

Since the objective here is to effectively aggregate information and analyses of the entire Intelligence Community, implementation of prediction markets on a community-wide basis is preferable to intra-agency markets. Ideally, anyone with the relevant information should trade. If the traded contract relates to aerial suicide bombs, then even airport luggage screeners, in addition to homeland security analysts, are potential market participants. This necessarily means that expert knowledge on a particular subject is not required before making a bet.

A more difficult question is whether there are circumstances under which the general public should be allowed to trade. Certain issues might require the aggregation of information and opinions on subjects intelligence officers may know little or not enough about. On the other hand, making public certain markets might be inadvisable because doing so might signal adversaries about intelligence interests.

A compelling case can be made for making diversity a key criterion. Diversity means that market participants have different pieces of information about their surrounding environment and consequently different judgments on the event for which they are betting. The HP experiment aggregated information across several corporate divisions. Economic theory and empirical evidence suggests that “thick” markets are preferable to “thin” ones.

### ***Contract Specification and Determination***

The market prices of prediction markets are only meaningful if the contracts address the right questions and address them clearly. Wolfers and Zitzewitz note that a prediction market works best when contracts are clear, “easily understood and easily adjudicated.”<sup>[55]</sup>

Another consideration is avoiding situations in which traders are punished for guessing correctly. This happens, for example, when traders are asked

to speculate on whether Boeing's Future Combat Systems will deliver a battlefield communications network to the Army on time, and in response to sagging market prices the Army extends the deadline. The solution to this example is to specify two conditional contracts: (1) what is the likelihood that Boeing will deliver the product on time, conditional on a contractual change; and (2) the same question but conditional on *no* contractual changes.

The final consideration in contract specification is in determining whether the contract is realized when it expires. Someone has to act as the final adjudication authority in deciding whether, in fact, the balance of power in the Taiwan Straits has tilted in China's favor against the United States—short of the market test of an actual conflict. For contracts involving measurements such as the real-time or ex-ante evaluation of policies (e.g., US cocaine imports), the methodology of measurement should be fixed in advance. Traders need certainty that they will be rewarded for advice that is correct. Serious thought needs to be given to deciding who in the Intelligence Community should set the contracts for trading and judge whether the contractual outcomes are realized.

### ***Soundness of the Theoretical Basis***

The fact that prices in prediction markets fully and instantaneously reflect and aggregate all known information is an extension of the Efficient Capital Markets and Hayek hypotheses. In recent years behavioral finance theory has challenged the efficient markets hypothesis, which holds that rational actors account for stock market volatility.<sup>[56]</sup> Behavioral finance theory asserts that human psychology affects financial markets. It argues, for instance, that the feedback phenomenon in which enthusiasm begets enthusiasm explains the rise and burst of the Internet stock market bubble. In response, proponents of ECMH argue that markets are efficient in spite of irrational human behavior because in the long-run “true value” overcomes the “voting mechanism.”<sup>[57]</sup>

For intelligence consumers the concern is that speculative bubbles will drive prices away from the “true price,” thereby misleading policymakers. And even if speculative bubbles eventually burst, policymakers do not always have the time to wait for that to occur. There are also the problems of recognizing a speculative intelligence bubble and what to do if one occurs. Could one establish, for example, an instrument like the Federal Funds rate that an Intelligence Community equivalent to the Federal Reserve chairman could use to deflate a bubble? Wolfers and Zitzewitz note that further lab experiments are central to learning more about

bubbles in prediction markets since “it is possible for the experimenter to know the ‘true price’ and, hence, to observe deviations.”<sup>[58]</sup>

Regardless, the possibility of speculative bubbles in prediction markets should not be the sole basis for a decision not to implement prediction markets if, on average, prediction markets outperform conventional forecasting methods. Certainly, the October 2002 NIE was prone to a form of speculative intelligence bubble. The stock market, in spite of its drawbacks, still manages to allocate hundreds of billions of dollars of equity capital to industry sectors more efficiently than any other social institution, especially those that rely on central planning.

### ***Market Manipulation and Bias***

In the summer of 2003, one criticism of PAM was that market manipulation would render its results useless. Analysts might engage in trading behavior to fit a certain policy outcome (a specialized form of politicization) or worse, terrorists could manipulate the market to mislead the IC or even use the market to finance attacks. “Historical, field, and laboratory data, however, have failed to find substantial effects of such manipulation on average price accuracy” and instead attempts to manipulate markets actually increase the accuracy of information markets.<sup>[59]</sup>

Rhode and Strumpf noted that attempts to manipulate presidential betting markets in the early 20th century as well as their own attempts to manipulate prices of presidential candidates during the 2004 election year had a negligible impact on prices.<sup>[60]</sup> Empirical evidence notwithstanding, one simple preventative would be to limit participation in prediction markets.<sup>[61]</sup> The key consideration in implementing this measure is similar to considerations in deciding the scope of the prediction market: what scale and level of participation is required for information aggregation to work?

In addition to market manipulation, there may be concerns that trader’s judgment or behavioral bias might influence market prices. This bias occurs when traders trade according to the outcomes they desire rather than a dispassionate assessment of what is likely. An analogy is that in the run-up to the Iraq war, intelligence analysts were so convinced that Iraq had reconstituted their WMD programs that any evidence, regardless of its veracity, only served to harden their earlier convictions.

Forsythe, Nelson, Neumann, and Wright examined the phenomenon of

judgment bias in their study of the Iowa Presidential Stock Market in 1988 and concluded that these biases were prevalent.<sup>[62]</sup> However, despite those biases, market predictions proved remarkably accurate on account of the marginal-trader hypothesis. Under this hypothesis, the marginal trader determines market prices. The authors noted that marginal traders essentially act as arbitrageurs by profiting in buying stocks from one set of biased traders and selling them to another set of biased traders. And by engaging in arbitrage, the marginal traders set the market price despite the fact that the average trader was biased.<sup>[63]</sup>

### ***Real- vs. Play-Money: Accuracy, Motivation, Legal, and Moral Issues***

The evidence on whether real-money prediction markets lead to forecasts that are more accurate than those of play-money markets is inconclusive. Some experts believe that markets in which traders have to “put their money where their mouth is” produce better results than markets in which traders do not risk their money.<sup>[64]</sup> Essentially, these experts argue that the profit-motivation in real-money markets contributes to a working market.

One study that compared the predictions of the two markets (Tradesports, a real-money market, v. NewsFutures, a play-money market) concluded that the play-money markets performed as well as the real-money markets.<sup>[65]</sup> The implications of this finding go beyond the accuracy issue since there are also legal, financial, and ethical issues involved in setting up a real-money market. PAM, for instance, was forced in part to consider conducting a public market trial due to restrictions on government inter-agency transfers of money. In any event, PAM presumably would have had to comply with US gambling laws; TradeSports, which deals in real-money trades, is based in Ireland so as not to run afoul of US gambling laws.

If real-money markets are set up, then decisions are needed on the value of the payoff per outcome (e.g., 100 cents is paid if event “A” occurs) and whether to allocate cash to market participants, and if so how much.<sup>[66]</sup> Morally, one might limit the value of the payoff per outcome to as low as 100 cents to avoid the appearance of rewarding analysts for correctly predicting bad outcomes (e.g., US troop deaths in Iraq will exceed 3,000 by some date). In a public real-money market payoff limits could mitigate concerns of “bad guys” using the market to finance their illicit activities. If play-money markets were implemented, other incentives might be needed, for example, mechanisms for granting “community bragging rights.”<sup>[67]</sup>

# Conclusion

The record of prediction markets is impressive. For the US Intelligence Community, prediction markets offer a method by which to improve analytical outcomes and to address some of the deficiencies in analytical processes and organization. In the realm of intelligence analysis, prediction markets can contribute to more accurate estimates of long-term trends and threats and better cost-benefit assessments of ongoing or proposed policies.

Further study is needed on how prediction markets can improve tactical intelligence, and much more thought is required to ensure that policymakers and intelligence chiefs will value the results of prediction markets if they are attempted. Without their engagement, there would be no motivation to trade, and market performance would suffer.<sup>[68]</sup>

Despite everything that prediction markets can do to enhance US intelligence capabilities, at the end of the day, prediction market results are just probabilistic estimates of future outcomes. A stock price that shows a 15 percent probability of a Sino-Japanese clash over disputed territory in the East China Sea in 2010 still only means that there is a chance, albeit a low one, that the outcome will occur. Policymakers still must decide on the threshold for action. And as often is the case, human intuition will carry the day when definitive intelligence is lacking.

[1][http://www.biz.uiowa.edu/iem/media/su\\_mmary.html](http://www.biz.uiowa.edu/iem/media/su_mmary.html).

[2]Rana Foroohar, "A New 'Wind Tunnel' for Companies: Testing economic theories through experiments," *Newsweek*, October 20, 2003.  
<http://msnbc.msn.com/id/3087117>.

[3]<http://googleblog.blogspot.com/2005/09/putting-crowd-wisdom-to-work.html>.

[4]The FutureMAP Web site or DARPA's Information Awareness Office no longer exists. However, numerous other Web sites have snapshots of the original, displayed above, including their content. See <http://hanson.gmu.edu/policyanalysismarket.html> and [http://www.ratical.org/ratville/CAH/linkscopy/PAM/pam\\_home.htm](http://www.ratical.org/ratville/CAH/linkscopy/PAM/pam_home.htm)

[5] John Ledyard, Robin Hanson, and Takashi Ishikida, "An Experimental Test of Combinatorial Information Markets," (February 2005): 4.  
<http://hanson.gmu.edu>.

[6] [http://www.ratical.org/ratville/CAH/links copy/PAM/pam\\_home.htm](http://www.ratical.org/ratville/CAH/links%20copy/PAM/pam_home.htm). See also Robert Looney, "DARPA's Policy Analysis Market for Intelligence: Outside the Box or Off the Wall?", *Strategic Insights* II, Issue 9 (September 2003), 3 (on <http://www.ccc.nps.navy.mil/>) and Robin D. Hanson, "Impolite Innovation: The Technology and Politics of Terrorism Futures and Other Decision Markets," at <HTTP://hanson.gmu.edu/PAM/HansonTalks/ImpoliteInnovation>, 10–11.

[7] [http://www.ratical.org/ratville/CAH/links copy/PAM/pam\\_home.htm](http://www.ratical.org/ratville/CAH/links%20copy/PAM/pam_home.htm).

[8] Justin Wolfers and Eriz Zitzewitz, "Prediction Markets in Theory and Practice," in *The New Palgrave Dictionary of Economics*, eds. Lawrence E. Blume and Steven N. Durlauf, November 15, 2005 Draft (London: Palgrave Macmillan): 4. See also Robert Forsythe, Forrest Nelson, George R. Neumann, and Jack Wright, "Anatomy of an Experimental Political Stock Market," *The American Economic Review*, 82, No.5 (December 1992): 1143.

[9] Theoretical explanations for prediction markets have been made on the basis of either hypothesis but not both at the same time. See Charles F. Manski, "Interpreting the Predictions of Prediction of Markets," *NBER Working Paper 10359* (March 2004): 1.

[10] Burton G. Malkiel, "The Efficient Market Hypothesis and Its Critics," *Journal of Economic Perspectives* 17, No.1 (Winter 2003): 59.

[11] *Ibid.* This is essentially behind the proposition that stock market index funds, on average, will out perform actively managed funds.

[12] Paul W. Rhode and Koleman S. Strumpf, "Historical Presidential Betting Markets," *Journal of Economic Perspectives* 18, No.2 (Spring 2004): 136.

[13] Anthony E. Bopp and George M. Lady, "A comparison of petroleum futures versus spot prices as predictors of prices in the future," *Energy Economics* 13, No. 4 (October, 1991): 274–76.

[14] F.A. Hayek, "The Use of Knowledge in Society," *The American Economic Review* 35, No.4 (September, 1945): 520.

[15] *Ibid.*, 526.

[16] *Ibid.*

[17] Michael Maloney and J. Harold Mulherin, “The complexity of price discovery in an efficient market: the stock market reaction to the Challenger crash,” *Journal of Corporate Finance* 9, No. 4 (2003).

[18] *Ibid.*, 474.

[19] The Iowa Electronic Markets ([http://www.biz.uiowa.edu/iem/trmanual/EMManual\\_3.html](http://www.biz.uiowa.edu/iem/trmanual/EMManual_3.html)), InTrade (<http://www.intrade.com>), and NewsFutures (<http://news.us.newsfutures.com/guide.html>) provide good users manuals detailing how their respective market platforms operate. Although there are differences, generally they rely on the principle of a double auction. Note that at InTrade, the users guide confuses the meaning of bid and ask.

[20] Barbara Kiviat, “The End of Management?” *Time*, July 6, 2004. <http://www.time.com/>.

[21] At NewsFutures, traders are given the option to trade two contracts: outcome occurs and outcome does not occur.

[22] Justin Wolfers and Eric Zitzewitz, “Prediction Markets,” *Journal of Economic Perspectives* 18, No.2 (Spring 2004): 109.

[23] Charles F. Manski, “Interpreting the Predictions of Prediction of Markets,” 6.

[24] Justin Wolfers and Eric Zitzewitz, “Prediction Markets in Theory and Practice,” *The New Palgrave Dictionary of Economics*, eds. Lawrence E. Blume and Steven N. Durlauf, November 15, 2005 Draft (London: Palgrave Macmillan): 4.

[25] Robert Forsythe, Forrest Nelson, George R. Neumann, and Jack Wright, “Anatomy of an Experimental Political Stock Market,” *The American Economic Review* 82, No.5 (December 1992): 1148-1149.

[26] Richard Roll, “Orange Juice and Weather,” *The American Economic Review* 74, No. 5 (December 1984).

[27]Justin Wolfers and Eriz Zitzewitz, "Prediction Markets," 125.

[28]For a survey of experiments related to the information aggregation problem (testing of the Hayek Hypothesis) see Shyam Sunder, "Experimental Asset Markets: A Survey," *The Handbook of Experimental Economics*, eds. John H. Kagel and Alvin E. Roth (Princeton: Princeton University Press: 1995).

[29]Kay-Yut Chen and Charles Plott, "Information Aggregation Mechanisms: Concept, Design And Implementation For A Sales Forecasting Problem," California Institute of Technology Social Science Working Paper No. 1131 (March 2002): 3. *See also* Ajit Kambli, "You Can Bet on Idea Markets," *HBS Working Knowledge* (December 1, 2003): <http://hbswk.hbs.edu/pubitem.jhtml?id=3808&t=innovation>.

[30]Kay-Yut Chen and Charles Plott, 3.

[31]*Ibid.*, 5.

[32]*Ibid.*, 10.

[33]*Ibid.*, 11–13.

[34]Chen and Plott, 17.

[35]Justin Wolfers and Eriz Zitzewitz, "Using Markets to Inform Policy: The Case of the Iraq War," *NBER Working Paper* (June 2004).

[36]Robert E. Looney, David A. Schradly, and Ronald L. Brown, "Estimating the Economic Benefits of Forward-Engaged Naval Forces," *Interfaces* No. 31 (July-August 2001), 83-86.

[37]Robin D. Hanson, "Decision Markets," *IEEE Intelligent Systems* (May/June 1999):16-17.

[38]Robert W. Hahn and Paul C. Tetlock, "Using Information Markets to Improve Public Decision Making," AEI-Brookings Joint Center for Regulatory Studies, Working Paper 04-18 (Washington, DC: March 2005): 44-45.

[39]Richard K. Betts, "Analysis, War, and Decision: Why Intelligence Failures Are Inevitable?" *Strategic Intelligence: Windows into a Secret World*, eds. Lock J. Johnson and James J. Wirtz. (Los Angeles: Roxbury Publishing Company):

97–99.

[40]The 9/11 Commission Report, “Final Report of the National Commission on Terrorist Attacks Upon the United States,” 416.

[41]Mark M. Lowenthal, *Intelligence: From Secrets to Policy 2nd Edition* (Washington, DC: CQ Press, 2003): 76.

[42]Implementing prediction markets and other reform measures should not be mutually exclusive.

[43]This example sidesteps the question of how the initial allocation of shares of this contract and money are conducted in this hypothetical prediction market. The following section on market design issues will explore this issue. One way to do an allocation is to distribute a fixed amount of shares and money equally among “traders” within the 15 intelligence agencies so that the starting share price is at 50 cents.

[44]The Commission on the Intelligence Capabilities of the United States Regarding Weapons of Mass Destruction (March 31, 2005): 49.

[45]With a 46 percent likelihood of this outcome, policymakers would have had to decided if that was a high enough probability to cause them to act.

[46]The Commission on the Intelligence Capabilities of the United States Regarding Weapons of Mass Destruction, 74.

[47]Wolfers and Zitzewitz, “Prediction Markets,” 121.

[48]Betts, 101.

[49]Lowenthal, “Intelligence: From Secrets to Policy,” 103.

[50]Looney.

[51]The importance of issuing the “right” contracts is addressed in more depth in the Market Design section of this article.

[52]Robin Hanson, *Designing Real Terrorism Futures* (August 2005): 9. <http://hanson.gmu.edu/>.

[53]Chen and Plott, 9.

[54]Robin Hanson, "Chapter 6: Foul Play in Information Markets," *Information Markets: A New Way of Making Decisions in the Public and Private Sectors*, ed. Bob Hahn and Paul Tetlock (Washington DC: AEI-Brookings Press, 2006): 92. <http://hanson.gmu.edu>.

[55]Wolfers and Zitzewitz, "Prediction Markets," 120.

[56]See Robert J. Shiller, "From Efficient Markets Theory to Behavioral Finance," *Journal of Economic Perspectives* 17, No.1 (Winter 2003).

[57]Malkiel, "The Efficient Market Hypothesis and Its Critics," 61. Other economists have suggested that speculative bubbles are more prone in stock markets because of restrictions on short-selling; not all prediction markets restrict short-selling. See also Andrei Shleifer and Robert Vishny, "The Limits of Arbitrage," *Journal of Finance* 52, No.1 (1997) and Chapter 11 of Surowiecki, *The Wisdom of Crowds*.

[58]Wolfers and Zitzewitz, "Prediction Markets," 119.

[59]Robin Hanson and Ryan Opera, *Manipulators Increase Information Market Accuracy* (July 2004, revised): 9. <http://hanson.gmu.edu>.

[60]Cited in Wolfers and Zitzewitz, "Prediction Markets in Theory and Practice," 5.

[61]Robin Hanson, "Chapter 6: Foul Play in Information Markets," 92.

[62]Robert Forsythe et al., "Anatomy of an Experimental Political Stock Market," 1156–57.

[63]Ibid., 1157–60.

[64] Robin Hanson, "Impolite Innovation: The Technology and Politics of 'Terrorism Futures' and Other Decision Markets," 4.

[65]Emile Servan-Schreiber, Justin Wolfers, David M. Pennock, and Brian Galebach, "Prediction Markets: Does Money Matter?" *Electronic Markets* 14, No. 3 (September 2004): 9–10.

[66]At the very minimum, the costs of setting up either a real-money or

play-money prediction market include costs related to developing and fielding a trading software platform.

[67] See Emile Servan-Schreiber et al., “Prediction Markets: Does Money Matter?,” 10. NewsFutures, which is a US-based prediction market, uses play money and awards prizes to the market’s top predictors (top play money earners) and ranks its “richest” players.

<http://us.newsutures.com/topwin.html>.

[68] Wolfers and Zitzewitz, “Prediction Markets,” 121.

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