15.567 The Economics of Information

Prediction Markets

http://damien.acheson.online.fr/prediction.markets/index.html

12 December 2007

DAMIEN ACHESON, RODRIGO MAZZILLI, LUIS PRATA

Table of Contents

Abstract

Predictive markets are set to radically improve information gathering and analysis by providing tools with great potential for improving the efficiency of government and the productivity of industry. Also known as information markets, predictive markets have been popularized by author James Surowiecki in the book *The Wisdom of the Crowds*.

After providing a background on the theoretical and practical mechanics of predictive markets, our study focus on its potential for decision making in the enterprise world and on the economics of information-gathering mechanisms. We compare some user cases and business models of current applications such as HP BRAIN, HedgeStreet, NewsFutures and Inkling Markets. The study also looks into the future applications of prediction markets and the technical, commercial and organizational challenges they pose to organizations.

Lastly, our study takes a case in example and examines the benefits and challenges associated to implanting prediction markets in organizations.

Part I – Introduction to the Prediction Markets

Introduction

Mostly known as “prediction markets”, but also named “information markets” or “future markets”, these markets produce dynamic, objective probabilistic predictions on the outcomes of future events by aggregating information traders bring when they agree on prices during their transactions. The market participants trade in contracts whose payoff depends on unknown future events.

The rationale for the success of prediction markets assumes the efficient markets hypothesis. So, the market price will be the best predictor of the event, and no combination of other available information can be used to improve on the market-generated forecasts. Even if not all the market agents behave rationally, the prediction market accuracy still holds provided that the marginal trader is rational.

Contract types

Prediction markets will typically implement one or more of three kinds of contracts: winner-take-all, index, and spread contracts. Table 1 summarizes the three main types of contracts as a method for estimating uncertain quantities or probabilities. First, in a “winner-take all” the price represents the market’s expectation of the probability that an event will occur. Second, in an “index”

contract, the amount that the contract pays represents the mean value that the market assigns to the outcome. Finally, when spread betting is combined with an even-money bet (winners double their money while losers receive zero), the outcome can yield the market's expectation of the median outcome.

Contract Types

Contract	Example	Details	Contract Price Reveals…
Winner-take-all	Event: George W. Bush wins the popular vote.	Contract pays $1 if event occurs.	Probability that event occurs.
Index	Contract pays $1 for every percentage point of the popular vote won by Bush.	If Bush wins 51% of the vote, then the contract pays $51.	Mean value of expected outcome.
Spread	Contract pays additional money if Bush wins more than a given percentage of the popular vote.	Contract costs $1. If spread fixed at 50% and Bush wins >50%, contract pays $2. If not, contract pays nothing.	Median value of expected outcome.

Table 1 - Source: Justin Wolfers and Eric Zitzewitz, "Prediction Markets," Journal of Economic Perspectives (Spring 2004).

The basic forms of these relevant contracts will reveal the market's expectation of a specific parameter: a probability, mean or median. In addition, prediction markets can also be used to evaluate uncertainty about these expectations. So, by combining a family of 10 to 20 "winner take-all" contracts one can identify the probability distribution shape of the market expectations or with 3 spread contracts identify the key points in that distribution (i.e. 5%, 50%, 95%).

Markets accuracy

As one would expect, the prediction markets accuracy as a forecasting tool is not perfect. However, there is evidence that shows that prediction markets outperform other sources of predictions (i.e. independent analysts and polls), both in public events like presidential elections or private events like sales forecasts within firms.

Comparing markets with polls accuracy in predicting the elections winners, Berg, Forsith, Nelson and Rietz (2000) conducted an extensive research in 41 elections across 13 countries to conclude that the average poll error was 1.93% while the average market error was 1.49%. Moreover, they also concluded that market results were more stable across the pre-election period than polls. The edge of markets over polls comes from the traders' ability to incorporate polls info, previous market information and other relevant information into their trade.

A research conducted by Servan-Schreiber, Wolfers, Penncock and Galebach (2004) allows comparing the forecasting ability of the markets with that of 1947 individual human (self-declared) experts. The experiment started at the beginning of the US professional National Football League (NFL) spanning 208 games. By the end of the NFL season, which included a total of 21 weeks, the markets predictions ranked 6th among almost two thousand participants. For comparison, the experts averages ranked 39th, performing better than the vast majority of

individuals, but not as well as the markets. Therefore, we can also conclude that the markets outperform experts in its prediction accuracy.

Finally an experiment carried by Plott and Chen in Hewlett Packard (2002) in a total of twelve predictions over a period of three years concluded that markets outperformed the official HP forecasts. Further details of this experiment will be covered later in this Paper.

Market design and implementation

The Information Revolution has greatly improved our ability to find out what others have said but it has done much less to improve our ability to find out what other people know. Information markets main objective is to aggregate information, instead of to hedge risk (i.e. financial markets) or entertain (i.e. gambling). We will cover some issues in the design and implementation of such markets. A successful predictive market must provide three important roles:

- Truthful revelation – each trader should be incentivized to act in line with what he truly knows and believes about the likelihood of the contract outcome;
- Information discovery - motivates each participant to research and seek for new information;
- Aggregating opinions – as it gives a weighted collective view of the expected outcome by aggregating diverse opinions.

The experiment carried by Servan-Schreiber, Wolfers, Penncock and Galebach (2004) on NFL football results showed no significant differences between real-money markets and play-money markets. Theory suggests that real money may better motivate information discovery, while in play-money markets there is potential for more efficient aggregating of individual opinions as those with substantial wealth are those with a history of successful prediction. These were positive news for the implementation of prediction markets in corporate settings due to the ethical and anti-gambling restrictions applying to real-money markets.

The table 2 below identifies and explains four key success factors for effective prediction market value maximization:

Success Factors	Explanation
Matching buyers to sellers	The method of continuous double action, where buyers submit bids and sellers submit asking prices and trades execute when buyers meet sellers, is the most common mechanism for executing trades on-line.
Specifying the contract type	Contracts must be clear, easily understood and adjudicated, and tied to a specific event occurring by a fixed point in time.
Determining incentive structure	Markets must be properly incentivized to make buying and selling worth the time and effort of participants. Even well-designed markets with a proper matching mechanism and contract types will fail without creating a motivation to trade.
Ensuring information diversity	Research suggests some prediction markets will work better when they concern widely-discussed events, to enhance the quantity of relevant information held collectively by market participants, facilitating more informed predictions.

	On the other hand, concentrations of private information will drive out uninformed traders, repressing trade and disrupting the market's predictive power. So, the best markets operate when information is widely disperse and is asymmetric across traders.

Table 2 - *Source: Justin Wolfers and Eric Zitzewitz, "Prediction Markets,"* Journal of Economic Perspectives *(Spring 2004).*

Markets limitations

Apparently, prediction markets display few opportunities for arbitrage. When different exchanges trade the same security or related securities it looks like the securities prices move very close to each other. In addition, betting on future prices based on past price behavior is also not likely to provide relevant profit opportunity as price evolution does not follow a predictable path.

It seems that the risk of behavioral biases driven by personal preferences (i.e. party preference or sports team preference) is off set in the market price by the fact that marginal traders tend to act rationally. The rise of speculative bubbles seems also to be limited due to the short selling possibilities and low capital constrains in such a small scale market. For the same reasons, the risk of market manipulation seems to be restricted to a short period transition phase.

However, prediction markets suffer from some of the limitations displayed by the financial markets. Evidence shows that traders tend to over-value low probability

events and under-value high probability events which suggest that prediction markets may perform poorly in predicting both small and high probability events.

Part II - The Competitive Landscape

There exists a wide variety of prediction market companies, ranging from pure academic players, to business to business and business to consumer companies. Below are listed the principal existing players in the field of prediction markets.

1. NewsFutures

http://us.newsfutures.com

NewsFutures has created and operated over 40,000 markets since its founding in 2000. The company claims status as a pioneer in the business applications of prediction markets. Initially, the company partnered with media outlets, developing prediction trader communities to generate future insights. Through this experience, NewsFutures developed its market trading platform. The company operates on three levels: licensing its platform and implementing markets, operating its own prediction markets, and sharing expertise with corporate sponsors through predictive polling.

NewsFutures has implemented prediction markets for clients in the automotive, pharmaceutical, insurance, defense, cable, food and beverage, chemicals, advertising, and publishing industries.

2. Interdisciplinary Center for Economic Science (ICES)

http://www.ices-gmu.org/;

The Interdisciplinary Center for Economic Science (ICES) at George Mason University (GMU) is a research center and laboratory specializing in experimental economics. Its seven faculty members founded the Center in 2001. While ICES is not a consultancy, most of the professors have longstanding research experience in testing and establishing prediction markets. Robin Hanson led the DARPA project as a consultant for Net Exchange, while several other academics at ICES maintained a high level of involvement in that project. They now consult primarily with Net Exchange and its subsidiary Common Knowledge Market and August Systems, which specializes in interfaces, large networks, and live streaming.

One of the academics involved in consulting, Vernon Smith, was the 2002 Nobel Prize laureate in Economics for his pioneering work in experimental economics and alternative market mechanisms.

3. Common Knowledge Markets

http://www.ckmarkets.com/;

Common Knowledge Market (CKM) offers software solutions for aggregating group knowledge through market mechanisms. The firm is a subsidiary of Net Exchange (http://www.nex.com/), the company that led design on a Middle East Policy Analysis Market (PAM) for the Defense Advanced Research Projects Agency (DARPA). John Ledyard, professor at California Institute of Technology, is the chairman of Net Exchange. His former students, led by Charles Polk, now run CKM. Net Exchange conducted two years of research before establishing the Policy Analysis Market for DARPA, which the Department of Defense eliminated after it received negative publicity as a "terrorism futures market." Common Knowledge Market now possesses full and exclusive rights to the technology developed for the Pentagon. CKM has since upgraded the software's user interface to improve ease-of-use. The company markets its software as having relevant business applications inside and outside the firm: "A company that needs a better view into what its customers want will often hire an opinion survey firm to find out 'What the market knows.' A company that needs a better view into information inside is operations will often hire a consulting firm to help find out 'What the building knows.' In either case the company is hiring a vendor of information research. CKM's prediction market process can augment or replace both types of information acquisition." The company has conducted market research trials and has begun offering software to external clients.

4. Iowa Electronic Markets (IEM)

http://www.marteksys.com/;

Market Technology Systems is a business venture started by four University of Iowa Business professors. It oversees all commercial applications of the prediction market software designed jointly by Professors Forrest Nelson and Joyce Berg. The software's research applications are conducted through the Iowa Electronic Markets (http://www.biz.uiowa.edu/iem/). The Iowa Electronic Markets (IEM) is among the oldest prediction markets in existence. They began in 1988 on a university mainframe, and transferred to telnet services in the early 1990s. The current internet trading site represents the third generation of the software designed by Nelson and Berg. The IEM most famously features political markets that allow investors to bet on presidential elections. The market has consistently outperformed polling and pundit predictions.

5. Intellimarket

http://www.wrsasc.com;

Charles Plott is Edward S. Harkness Professor of Economics and Political Science at the California Institute of Technology and chairman of Intellimarket, which designs and implements customized online exchange programs. Plott received a Ph.D in economics from the University of Virginia in 1965. Dr. Plott

focuses his research on testing, proving and applying economic and market theory. As Director of the Laboratory for Experimental Economics and Political Science, Plott has spent over 10 years developing the proprietary electronic bidding system that is utilized by Intellimarket. Additionally, he has conducted studies on market behaviour, pricing mechanisms, and auction markets.

Plott has worked on a number of prediction markets, including Hewlett Packard's internal market to estimate new hardware sales and two markets for film industry experts—one trading opening box office figures and one trading aggregate film reviews.

6. HP Labs

http://www.hpl.hp.com/;

HP Labs is the advanced research laboratory at Hewlett-Packard (HP). It aims to produce breakthrough technological advancements to drive business and growth strategies for HP, and to produce disruptive growth through new business opportunities. The Information Dynamics Lab's project on Behaviourally Robust Aggregation of Information in Networks BRAIN), used to predict the future using tacit organizational knowledge, is one of its newest breakthroughs. HP pioneered the corporate use of prediction markets as the first company to use markets to make internal sales forecasts. The firm's use of markets resulted in what Dr. Leslie Fine called "a marginal success," and for the last four years, a team led by

Drs. Fine, Bernardo Huberman, and Kay-Yut Chen researched and developed a non-market information aggregating alternative. This alternative mechanism aimed to address two perceived shortcomings of the market set up. First, in addition to aggregating information, markets disseminate information through price statistics. An organization may not want all participants to have access that information. Second, HP concluded that markets did not work well with smaller groups (a claim others dispute).

The company implemented BRAIN two years ago in a pilot program for HP Services. The graphics at right explain BRAIN's operating procedure and the outcome for HP Services, where 14 managers yielded such impressive results that the division has integrated BRAIN into its regular forecast.6

Part III - A Case in Example: HP's BRAIN

Typical information markets suffer from much fragility as they are time-consuming to implement and participate in while exposing potentially sensitive data to every participant. They also do not work well for small groups. BRAIN for "Behaviourally Robust Aggregation of Information in Networks", an HP Labs creation, enables an enterprise to create prediction inquiries which address the fragilities of traditional information markets.

The Challenge of Enterprise Forecasting

Enterprises have traditionally forecasted future performance by extrapolating historical trends. But in recent years, this relationship between past and future has become less reliable. Today's major drivers of change do not adhere to predictable historical patterns: competition has grown more intense; product cycles have accelerated; and the variability of customer demand has increased. As a result, for many enterprises, historical data no longer provides an accurate guide to future performance. Instead, companies are forced to rely on the estimates, intuition, and judgment of small groups of employees to create forecasts. Those employees collectively have knowledge of likely outcomes, but they have no way of distilling that collective wisdom into an actionable forecast. Instead, they find themselves in endless meetings, producing forecasts which are skewed by the personalities involved, their position in the corporate hierarchy, and people's inherent biases. Existing processes tend to be either data-driven (and therefore lacking agility) or ad hoc and therefore fraught with personality.

Information Dynamics Lab within HP Labs has been working on this problem for over the last 4 years. The project, code named BRAIN for "Behaviourally Robust Aggregation of Information in Networks" enables an enterprise to create prediction inquiries to forecast revenue, operating profits, the probability that event "X" will happen, product delivery dates, or other quantifiable business metrics. This approach removes the personality, hierarchy, and bias that lead to

inaccurate forecasts. The break-through behind BRAIN is the ability to achieve the forecasting accuracy of a market with a small number of participants (10-20 people). This is possible because of proprietary algorithms that BRAIN uses for aggregating forecasts, which weight each individual's forecast according to his or her predictive ability and behavioural profile. Additionally, BRAIN ensures that the only the sponsor of the BRAIN prediction activity is privy to the aggregated wisdom, not the participants.

Prediction possibilities

BRAIN is aimed to enable group prediction for well formulated questions that can be definitively answered in finite time (the shorter the better). 'Do people like our product?' is not a good question. 'Our revenues will increase by X% by date Y' is a good question. Further, it cannot create knowledge where it does not exist. If a team in a corporation collectively has wisdom but no mechanism or incentive to aggregate it, BRAIN can be used to collect that knowledge.

HP has developed a set of industry specific questions to illustrate the applicability of BRAIN in a variety of areas.

Pharmaceutical Industries

In the pharmaceutical industry, BRAIN can be applied in many areas: questions concerning the R&D pipeline, clinical protocols, marketing campaigns, sales forecasts, etc. Some sample questions are listed in Table 1.

If we modify the clinical protocol for “scenario B” when will we be able to show drug efficacy?" (2-4 months, 5-6 months, 7-8 months, 9-10, 11-12 months, not at all)
Marketing scenario “X”, with no changes in sales force alignment, will increase product sales by “Y”% in the next 6 months (10-20%, 21-40%, 41-60%, 61-80%, not at all)
What will product sales reach in US$ by the end of this year? (0-500K, 501k - 1 Million, 1.01M-10 Million, X-100 Million, x-1 Billion)

Table 1 - Pharmaceutical industry questions

Communications, Entertainment, and Media (CME) Industry

Within the telecommunications industry, there are number of areas where BRAIN can be applied. For example, in the area of predicting adoption rates of new services (like IPTV, mobile TV, Video Calling). Some example questions are listed in Table 2.

In North America, 3 months after launching IPTV, the subscriber

penetration rate (x) will be: (<5%, 5<x<10%, 10<x<15% or >15%)
In EMEA, 3 months after launching IPTV, the subscriber penetration rate (x) will be: (<5%, 5<x<10%, 10<x<15% or >15%)
In 3G enabled geographies, during 2HCY07, 3G video call will reach service penetration of 0-5%, 6-8%, 9-11%, 12-14%,15-17% or18-20%, 20%+ of the 3G active subscribers
IPTV will be adopted by 15% of your subscriber base in (0-3 months, 4-6 months, 7-9 months, 10-12 months, 13-15 months / 15-18 months / over 18 months)
The media and entertainment biz will rely on the monetization of the "personalized" end user (home based) distribution channel for over 5% of its total revenue in the next (0-3 months, 4-6 months, 7-10 months, etc)
In the next year this new "personalized" distribution channel should become (0-5%, 5-10%, 11-15%, 16--20%, >20%) of your overall business revenues
Where available, during 2QCY07, 3G video call will reach service penetration of (0-5%, 6-8%, 9-11%, 12-14%,15-17% ,18-20%, 20%+)

Table 2 - Telecom service adoption questions

Revenue forecasting

BRAIN can easily be applied to revenue forecasting. Quarterly and yearly predictions can be made for individual business units within an enterprise or by product lines.

Some sample questions in these areas are listed in Table 4.

What will the 1st quarter operating profits be? (Appropriate profitability choices must be created).
What will the 1st quarter revenues be? (Appropriate revenue choices must be created).

Table 4 - Revenue forecasting questions

How BRAIN Works

BRAIN enables anonymous, well incented, behaviourally-adjusted, and aggregated prediction capabilities for small groups. The steps depicted in figure 1 are the recipe for accomplishing these goals and enabling a repeatable lightweight process and a low cost mechanism to achieve more accurate predictions.

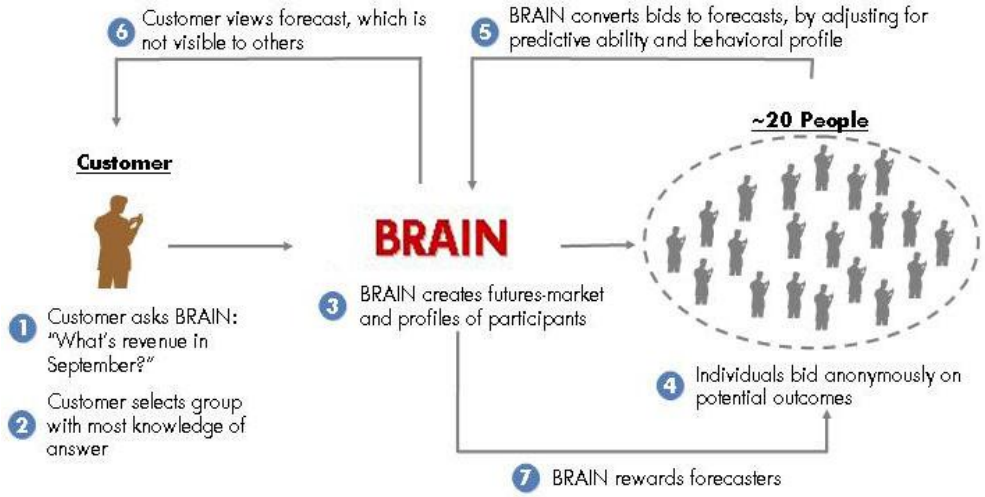

Figure 3 - How HP BRAIN works

Defining the Question

The BRAIN prediction process is shown in Figure 1. Before prediction can begin, a well formulated question that can be definitively answered in finite time (the shorter the better) must be developed. 'Do people like our product?' is not a good question. 'Our revenues will increase by X% by date Y' is a good question. Other types of questions that one could imagine include: future pricing of a commodity, market share of a new item, conditional questions (this would require two linked sessions, one for each side of the conditional), etc.

Choosing the Prediction Participants

The more individuals participate, the better the outcome. The targeted participants should be knowledgeable experts in their field and bring some expertise to the table. They should have knowledge about the question being asked and can collectively answer the question. While BRAIN has been successful with as few as 12 players, 20-25 participants are ideal and can allow for schedules, illness, travel, i.e.., for the occasional absence.

Creating the Futures Market

The BRAIN system is a set of web pages and algorithms used for the actual design and administration of each “Prediction” or “Question”. For each question to be answered, the following steps must be followed prior to conducting the actual training and prediction sessions.

Add any new prediction participants. This can be done using the web interface or a bulk user tool to add new users.

Define User Groups. Add users to a new prediction group. This group is the set of folks who have the knowledge to collectable answer a prediction question (finance managers for a business unit, VP’s of marketing, etc)

Define and enter a new prediction. This entails naming the prediction, defining the groups which will be participating in this market. For example, “Memory Pricing” could be the prediction and “Procurement” the department, and the group could be “DRAM Experts”.

Define the Asset Bins. These are the definitions of the potential betting states or ranges. These need to represent the likely outcomes for the "question" being asked. This could be a range (revenue range, or the likely hood of an outcome, etc...). For example, outcomes can be dollar values for revenues and operating profits (for example: "Revenues will be: 'Between $100m and $150m,' or 'between $150m and $200m'" and so on. The betting states are often referred to as "Bins". The bins should be inclusive and represent the entire range of possibilities. These bins can be manually defined or created using historical data which provides a mean and standard deviation for the likely outcomes from the past.

Calibrate the reward payoffs. One of the keys to the BRAIN mechanism is providing incentives to the participants in the form of real money. The incentives, although small, are actually proven to improve individual betting behaviours. The currency used is referred to as francs. The exchange rate for francs is set by the market designer (for example 300 francs = $1) and determines the payout for a correct answer. Historically this is calibrated to earn players an average of $75 per period. Obviously, the sponsor of the market must budget appropriately. This is real money, and participants are normally paid quarterly for their participation based on the accuracy of their predictions.

Create the Prediction Periods. Choose Start and End Dates for the open periods for placing bets. This can be monthly or quarterly, whatever makes sense.

Designing and running the training Session

Invite all the participants to a 45 minute training session where they will predict the outcome of a fictional game – namely predicting which ball has been pulled from an urn. This session is used to familiarize all participants with the interface, and is also used to determine the initial risk profiles of each participant. See below.

Profiling the Risk Attitudes

Since all individuals have different preferences for risk, BRAIN relies on an individual's observed risk profile to help temper the strength of their opinions (forecasts) within BRAIN. BRAIN currently employs three mechanisms to extract and continuously update an individual's risk profile: a survey, results from a fictional betting-training game, and the observed predictive capabilities of the participant over time (see appendix).

Individuals Bid Anonymously on Potential Outcomes

For each period, participants place bets on the likelihood an outcome might occur. This is accomplished by placing a percentage of tickets (100 in all) in each of the bins representing the likelihood of the outcome. As the participants

place their bets, they can see what their likely payoff/reward will be if they predict correctly. An actual prediction period screen is shown in Figure 3 below.

At the close of each session, BRAIN aggregates the weighted predictions and presents the sponsor with the prediction for that period. This is the secret sauce of BRAIN. Aggregated, weighted prediction has been shown in laboratory experiments to outperform a traditional information market, as well as, the best individual in the room. The sponsor is then able to use the predictive data in the course of managing their business.

Reward participants based on their accuracy

At the predetermined intervals, the participants are rewarded with monetary payoffs based on their prediction accuracy in previous periods. Prediction rewards are calculated when the “actual” outcome has occurred and can be measured against each individuals prediction.

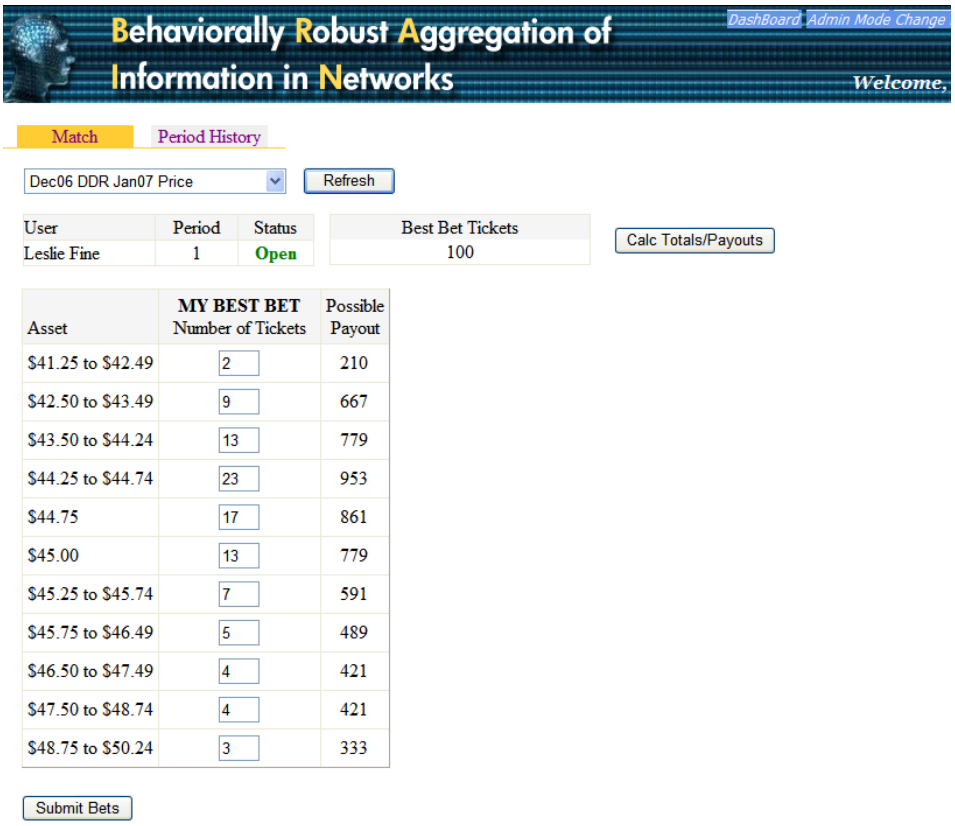

Figure 1 - BRAIN betting screen for DRAM memory pricing prediction

Since the results of the predictions are ultimately measured against live results (this is used to calculate the monetary rewards), the effectiveness of BRAIN can be easily measured. This is a natural feedback mechanism which should be implemented so that the sponsoring organizations understand how BRAIN is actually performing.

If a benchmark prediction system is in place before the introduction of BRAIN, the results of the BRAIN system should also be compared against the original

prediction systems to see what the BRAIN improvement (or degradation) rates actually are.

Conclusion

BRAIN is a powerful example of prediction markets applied in the appropriate context: when the right people are engaged in predicting well formulated questions, the wisdom of the group can far exceed traditional prediction mechanisms. In its current implementation, much of the “secret sauce” and complexity of the BRAIN has been packaged and hidden from the actual participants of the BRAIN predictions. This is the beauty of BRAIN as it exists today: the simplicity of the process to engage with customers once the prediction sets have been designed cannot be beat. The solution is simple yet elegant.

Part IV - The Future of Prediction Markets

One way to move forward in the application of prediction Markets is making inferences on the relationships between different variables. So, by relating the evolution of a futures security price (i.e. likelihood of the U.S. invading Iraq) with the evolution of the oil price over the same period one could have estimated the price oil increase in case of war. However, as with any other regression analysis, one must be aware of potential issues like reverse causation, omitted variables, statistical significance, etc.

In addition, it is possible to design conditional prediction market contracts which show the relation between an event and other variables. As an example, let's imagine we set a conditional security A which would pay $**p** if Hillary Clinton is elected as U.S. president, being **p** the price of oil after the Election Day, and a security B which would pay $**p** if Hillary is not elected. By comparing both security prices one could have a good estimation of Hillary's impact in the future oil price and its evolution during the election campaign.

The use of these contingent markets may transform the "prediction markets" into "decision markets" in the sense that these expectations should be used to guide decision making. However, one must be aware of the "selection effects" in these scenarios which could undermine the causality of each event. This research area

is still untested but it looks like that there may be interesting and important applications in situations where selection problems are minimal.

The Prediction markets may play an important future role as a supplement to less sophisticated prediction tools like opinion surveys, panel experts, consultants or committee meetings. It is likely that private-sector firms will continue increasing its interest as providers of these public markets. However, the fact that the valuable information generated by the markets is not fully captured by those private firms may limit the development of the public prediction markets.

Private prediction markets have been proven to effectively help organizations collect the knowledge of their members. These markets however can only be effective when their members do collectively possess information and their use is lined with a reward policy. Many start-ups have started to explore commercially this field and its myriad of possible models to monetize it. At the present moment no business model has established itself as *de facto*.

We believe prediction markets will eventually migrate into corporate and open social networks as a way to partially reduce the infrastructure needed to operate them and become part of the corporate decision process. Decision makers should and will slowly utilize prediction markets to support and guide their decisions. Until them, many leaders will see prediction markets as a threat to their decision power.

References

- Robin Hanson, et. al., "Information Aggregation and Manipulation in an Experimental Market, http://hanson.gmu.edu/biastest.pdf.

- Barbara Kiviat, "The End of Management?" *Time* (July 2004) http://www.time.com/time/insidebiz/printout/0,8816,660965,00.html.

- Erica Klarreich, "Economists explore betting markets as prediction tools," *Science News Online*, 18 October 2003.

- "Learn More: A Simple Example," *NewsFutures*, http://us.newsfutures.com/home/example.html.

- "Prediction Market," *Wikipedia*, http://en.wikipedia.org/wiki/Prediction_market.

- Howard Rheingold, *Smart Mobs: The Next Social Revolution* (New York: Perseus Book Group, 2002).

- James Surowiecki, *The Wisdom of Crowds: Why the Many Are Smarter Than the Few and How Collective Wisdom Shapes Business, Economies, Societies and Nations* (New York: Doubleday, 2004).

- Justin Wolfers and Eric Zitzewitz, "Prediction Markets," Journal of Economic Perspectives (Spring 2004) http://bpp.wharton.upenn.edu/jwolfers/Papers/Predictionmarkets.pdf.

- Joyce Berg, Robert Forsyth, Forrest Nelson, Thomas Rietz, "Results from a Dozen Years of Election Futures Market Research, University of Iowa (November 2000) http://www.biz.uiowa.edu/iem/archive/BFNR_2000.pdf

- Charles R. Plott, Kay-Yut Chen, "Information Aggregation Mechanisms: Concept, Design and Implementation for a Sales Forecasting Problem", California Institute of Technology (March 2002) http://www.hpl.hp.com/personal/Kay-Yut_Chen/paper/ms020408.pdf

- Emile Servan-Schreiber, Justin Wolfers, David Pennock and Brian Galebach,"Prediction Markets: Does Money Matter?" *Electronic Markets, 14(3), September 2004.* http://bpp.wharton.upenn.edu/jwolfers/Papers/DoesMoneyMatter.pdf

- http://money.cnn.com/magazines/business2/business2_archive/2006/09/01/8384339/index.htm

- http://www.hpl.hp.com/research/idl/papers/future/index.html;

- http://www.hpl.hp.com/research/idl/papers/public/index.html;

- Does Liquidity Affect Securities Market Efficiency by Paul C. Tetlock, Assistant Professor of Finance, McCombs School of Business;

- Approximate Transcript of Presentation to the Prediction Market Conference in NYC. by John Delaney, CEO, Trade Exchange Network, delivered on Feb 03 2006 ;

- Manipulating Political Stock Markets: A Field Experiment and a Century of Observational Data by Paul W. Rhode (UNC Chapel Hill and NBER) & Koleman S. Strumpf (UNC Chapel Hill);

- The Real Power Of Artificial Markets by Pennock, Lawrence, Giles, & Nielsen, in Science -- 02/09/2001

- Prediction Markets as Decision Support Systems by Berg & Rietz, in Information Systems Frontiers -- 5:1, 79-93, 2003

- Information Aggregation Mechanisms: Concept, Design and Implementation for a Sales Forecasting Problem by Chen, (Hewlett-Packard Laboratories - 1997)

- Information (in) Efficiency in Prediction Markets; By Erik Snowberg, Justin Wolfers, and Eric Zitzewitz (The Wharton School, February 2005)

APPENDIXES AND EXHIBITS

1. NewsFutures

NewsFutures

36 South Charles Street, 18th Floor

Baltimore, MD 21201

Telephone: (443) 321-2700

http://us.newsfutures.com

Contact Name: Norris Clark

Vice President, Sales

Telephone: (609) 425-3755

E-mail: norris@newsfutures.com

Overview:

NewsFutures has created and operated over 40,000 markets since its founding in 2000. The company claims status as a pioneer in the business applications of prediction markets. Initially, the company partnered with media outlets, developing prediction trader communities to generate future insights. Through this experience, NewsFutures developed its market trading platform. The company operates on three levels: licensing its platform and implementing

markets, operating its own prediction markets, and sharing expertise with corporate sponsors through predictive polling.

NewsFutures has implemented prediction markets for clients in the automotive, pharmaceutical, insurance, defense, cable, food and beverage, chemicals, advertising, and publishing industries.

Available Services:

NewsFutures licenses its proprietary “Prediction Trader V4” platform, a patent-pending software program that features anonymous trading and scalable attributes, including:

• Multiple trading accounts per user allow independent trading in different groups of markets.

• Account openings can require either specific registration data, or a fee, or nothing.

• Trading accounts are ranked by net worth, holdings, performance, transactions record, and standing orders.

The company offers a live demonstration of their market software through MIT Technology Review’s Innovative Futures website http://www.innovativefutures.com/), which offers free registration.

For implementing prediction market solutions, NewsFutures offers a line of consulting services in the following areas:

Market Design

• Translates predictive interests into market designs

• Determines appropriate participants

• Creates reward structure to encourage participation

Market Implementation

• Derives from a proprietary prediction trading software platform

• Enables interface customization

• Allows secure server hosting or installs platform on client's servers

Market Operation

• Creates and closes markets

• Supports traders

• Monitors transactions for fraud or abuse

• Monitors message boards

Clients:

• Dentsu

• Eli Lilly

• HVG (Hungarian newsweekly)

• MIT Technology Review

• Siemens

• Yahoo!

2. Interdisciplinary Center for Economic Science (ICES)

Interdisciplinary Center for Economic Science

4400 University Drive, MSN 1B2

Fairfax, VA 22030

Telephone: (703) 993-4850

http://www.ices-gmu.org/

Contact Name: Robin Hanson

Associate Professor, Economics

James M. Buchanan Center

Telephone: (703) 993-2326

E-mail: rhanson@gmu.edu

Overview:

The Interdisciplinary Center for Economic Science (ICES) at George Mason University (GMU) is a research center and laboratory specializing in experimental economics. Its seven faculty members founded the Center in 2001. While ICES is not a consultancy, most of the professors have longstanding research experience in testing and establishing prediction markets. Robin Hanson led the DARPA project as a consultant for Net Exchange, while several other academics at ICES maintained a high level of involvement in that project. They now consult primarily with Net Exchange and its subsidiary Common Knowledge Market and

August Systems, which specializes in interfaces, large networks, and live streaming.

One of the academics involved in consulting, Vernon Smith, was the 2002 Nobel Prize laureate in Economics for his pioneering work in experimental economics and alternative market mechanisms.

Available Services:

The ICES professors consult to other vendors of prediction market software, but also consult directly to companies. They use their collective expertise to assess feasibility, proper incentive structures, and timelines. Robin Hanson, who has specialized in and written about prediction markets since 1989, has developed his own software. He does not offer it for sale but could help set up trials.

Client List:

• DARPA

• EAE Systems

• FCC

• Federal Energy Regulatory Commission

• Microsoft

• NASDAQ

• Pfizer

• Qualcomm

Source: Corporate Executive Board 2005, ICES

3. Common Knowledge Markets

Common Knowledge Markets

119 W. 72nd St., #175

New York, NY 10023

Telephone: (858) 945-2415

http://www.ckmarkets.com/

Contact Name: Charles Polk

President

Telephone: (858) 945-2415

E-mail: cpolk@ckmarkets.com

Overview:

Common Knowledge Market (CKM) offers software solutions for aggregating group knowledge through market mechanisms. The firm is a subsidiary of Net Exchange (http://www.nex.com/), the company that led design on a Middle East Policy Analysis Market (PAM) for the Defense Advanced Research Projects Agency (DARPA). John Ledyard, professor at California Institute of Technology, is the chairman of Net Exchange. His former students, led by Charles Polk, now run CKM. Net Exchange conducted two years of research before establishing

the Policy Analysis Market for DARPA, which the Department of Defense eliminated after it received negative publicity as a “terrorism futures market.” Common Knowledge Market now possesses full and exclusive rights to the technology developed for the Pentagon. CKM has since upgraded the software’s user interface to improve ease-of-use. The company markets its software as having relevant business applications inside and outside the firm: “A company that needs a better view into what its customers want will often hire an opinion survey firm to find out ‘What the market knows.’ A company that needs a better view into information inside is operations will often hire a consulting firm to help find out ‘What the building knows.’ In either case the company is hiring a vendor of information research. CKM’s prediction market process can augment or replace both types of information acquisition.” The company has conducted market research trials and has begun offering software to external clients.

Available Services:

Common Knowledge Market offers on-site demonstrations and feasibility assessments at a nominal fee. The company provides server space for its web-based market software, deployed as a password-protected Active Server Pages (ASP) program, and helps tailor a proper incentive structure. An administrative password is also available, as is the ability to set up anonymous trading to encourage honest, unbiased bidding. Their trading software is based on a combinatorial automated market maker (CAMM), which coordinates the trading of predictions among participants.

Client List:

• DARPA

• General Motors (Marketing)

• Gerson Lehran

• Kodak

• Microsoft

• Pfizer (R&D)

Source: Corporate Executive Board 2005, CKM Markets

4. Iowa Electronic Markets (IEM)

Market Technology Systems, LLC

W386 PBAB, University of Iowa

Iowa City, IA 52242

Telephone: (319) 335-0854

http://www.marteksys.com/

Contact Name: Forrest Nelson

Professor of Economics

Telephone: (319) 335-0854

E-mail: forrest-nelson@uiowa.edu

Overview:

Market Technology Systems is a business venture started by four University of Iowa Business professors. It oversees all commercial applications of the prediction market software designed jointly by Professors Forrest Nelson and Joyce Berg. The software's research applications are conducted through the Iowa Electronic Markets (http://www.biz.uiowa.edu/iem/). The Iowa Electronic Markets (IEM) is among the oldest prediction markets in existence. They began in 1988 on a university mainframe, and transferred to telnet services in the early 1990s. The current internet trading site represents the third generation of the software designed by Nelson and Berg. The IEM most famously features political markets that allow investors to bet on presidential elections. The market has consistently outperformed polling and pundit predictions.

Available Services:

MarTek offers consulting and implementation services. When consulting, Dr. Nelson and his associates will determine the appropriate contract structures, time frames, and incentives. The company has the commercial rights to a software suite that contains a Windows-based trading engine, a database that collects trading information, and a separate database that stores market information and trade history.

During implementation, the company will set up its software on a client's servers, but prefers the cost-effective alternative of hosting on its own servers. The

trading platform offers full confidentiality of both participants and the commodities traded.

Running the market of MarTek's servers would enable clients to conduct trial runs.

Partial Client List:

MarTek operated as a subcontractor on the Pentagon's DARPA project on prediction markets. The company is currently in the exploratory stage with several potential business clients, including those seeking insight into new product development and project completion.

Source: Corporate Executive Board 2005, MarTek

5. Intellimarket

Charles Plott (Intellimarket)

228-77, California Institute of Technology

Pasadena, CA 91125

Telephone: (626) 395-4209

http://www.wrsasc.com

Contact Name: Charles Plott

Edward S. Harkness Professor,

Economics and Political Science

Telephone: (626) 395-4209

E-mail: cplott@hss.caltech.edu

Overview:

Charles Plott is Edward S. Harkness Professor of Economics and Political Science at the California Institute of Technology and chairman of Intellimarket, which designs and implements customized online exchange programs. Plott received a Ph.D in economics from the University of Virginia in 1965. Dr. Plott focuses his research on testing, proving and applying economic and market theory. As Director of the Laboratory for Experimental Economics and Political Science, Plott has spent over 10 years developing the proprietary electronic bidding system that is utilized by Intellimarket. Additionally, he has conducted studies on market behaviour, pricing mechanisms, and auction markets.

Plott has worked on a number of prediction markets, including Hewlett Packard's internal market to estimate new hardware sales and two markets for film industry experts—one trading opening box office figures and one trading aggregate film reviews.

Available Services:

Dr. Plott's software establishes devices that aggregate existing information but do not create new information. They yield observable, repeatable outcomes. He emphasizes that his prediction market software provides improved results over

time, as participants gain experience in trading. Thus, prediction markets function best with short-term horizons.

Although he has not designed a market to supplement a client's internal decision process around new business development, Plott can offer consulting services to ascertain feasibility of such a project. He can also conduct preliminary tests of the market, but to do so he requires a high level of input to properly align incentives and tailor the market to make useful, targeted predictions. As an academic, Plott stresses that his interest in business applications of market interactions derive from purely scholarly interest. As such, he has no incentive to pursue a project he deems unfeasible, and would be forthright with potential clients that will not benefit from his services.

Partial Client List

- Hewlett-Packard
- International Natural Rubber Organization
- KB Homes

Source: Corporate Executive Board 2005, Intellimarket

6. HP Labs

3000 Hanover St.

Palo Alto, CA 94304

Telephone: (650) 857-1501

http://www.hpl.hp.com/

Contact Name: Leslie Fine

Scientist, Information Dynamics Lab

Telephone: (650) 857-1502

E-mail: leslie.fine@hp.com

Overview:

HP Labs is the advanced research laboratory at Hewlett-Packard (HP). It aims to produce breakthrough technological advancements to drive business and growth strategies for HP, and to produce disruptive growth through new business opportunities. The Information Dynamics Lab's project on Behaviourally Robust Aggregation of Information in Networks BRAIN), used to predict the future using tacit organizational knowledge, is one of its newest breakthroughs. HP pioneered the corporate use of prediction markets as the first company to use markets to make internal sales forecasts. The firm's use of markets resulted in what Dr. Leslie Fine called "a marginal success," and for the last four years, a team led by Drs. Fine, Bernardo Huberman, and Kay-Yut Chen researched and developed a non-market information aggregating alternative. This alternative mechanism aimed to address two perceived shortcomings of the market set up. First, in

addition to aggregating information, markets disseminate information through price statistics. An organization may not want all participants to have access that information. Second, HP concluded that markets did not work well with smaller groups (a claim others dispute).

The company implemented BRAIN two years ago in a pilot program for HP Services. The graphics at right explain BRAIN's operating procedure and the outcome for HP Services, where 14 managers yielded such impressive results that the division has integrated BRAIN into its regular forecast.6

Available Services:

BRAIN is a hosted service designed to increase the accuracy of enterprise forecasting in revenue, operating profit, input prices, product delivery dates, and other uncertain outcomes. HP claims their system adjusts for individual predictive ability and risk attitudes, and is anonymous, well-incented, and behaviourally robust. The bidding tool is ready for pilot deployments.

Partial Client List:

HP has not yet determined whether to incorporate its prediction tool into the products and services offered through the company's consulting arm or to spin the program off into its own separate business. However, a number of HP Consulting's clients have expressed interest in BRAIN. W.L. Gore and HP Computing started trials in April.

Other players in the Prediction Markets

Hollywood Stock Exchange

www.hsxresearch.com

Perhaps the most well-known virtual stock market and research company, HSX has been around since 1996 and boasts more than 1.6 million registered traders. HSX provides data culled from trading on their system to numerous major motion picture studios, advertising agencies and other clients. Their clients include Warner Home Video, MGM and Fuse Networks. They are also a white label provider of trading systems for bet.com, a site focused on celebrity life, entertainment and lifestyle.

PollDaddy.com

www.PollDaddy.com

Offers webmasters the possibility to create or serve online polls for their websites. Their principal clients are pure internet players and publishers such as PCWorld, Wired, Tech Crunch and RTE.

Inkling Markets

www.inklingmarkets.com

Offers customers a “software as a service” prediction market that can be hosted on their own website. Proposed advanced customization features. Clients include Abbot Labs, Acxiom, ABC, Cisco, Chrysler, Electronic Arts and Wells Fargo.

ZiiTrend

www.ziitrend.com

A free user-driven online community for predicting future events and trends. Their website is focused on general consumers and general news events.

The SimExchange

www.thesimexchange.com/

Free fantasy video game prediction market for forecasting the number of copies games will sell.

Trade Sports

http://www.tradesports.com/

UK website that enables users to bet real money on sports results. Trade Sports require a $500 deposit and claims to be the largest sports trading exchange.

Profiling the Risk Attitudes

The Risk Survey

This survey is web based and is used to create the individuals initial risk profile. A small sample of the set of questions used in the survey is listed below.

- A bat and a ball cost $1.10 in total. The bat costs a dollar more than the ball. How much does the ball cost?
- If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets?
- In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake?
- Would you prefer $1000 for sure or a 90% chance of $5000
- Would you prefer $100 for sure or a 90% chance of $500
- Would you prefer $1000 for sure or a 75% chance of $4000
- Would you prefer $100 for sure or a 50% chance of $300
- Would you prefer to lose $100 for sure or 3% chance to lose $7000
- Compared to other others, how do you rate your willingness to take financial risks?
- How easily do you adapt when things go wrong financially?
- When you think of the word “risk” in a financial context, which of the following words come to mind first? [Danger, Uncertainty, Opportunity, Thrill]

This questionnaire is scored on a scale of 0 to 100. When the scores are graphed they follow the familiar bell-curve. The average score is 50. Two-thirds of all scores are within 10 points of the average. Only 1 in 1000 is less than 20 or more than 80. These questions leverage the Cognitive Recognition Test, which has been proven to strongly correlate to risk attitudes, and uses classic expected value trade-off choices and other questions which can be analyzed to determine a participants risk attitudes.

A Practice Betting Game

A fictional betting game is designed in which every participant participates during the initial 45 minute training session. Individual betting styles are observed and used to additionally jump start the calibration of each participants risk profile. In this training session, the participants are run through 15 betting periods, each lasting 1-2 minutes each. The betting bins are labelled 'Outcome A' through 'Outcome J' and represent 10 possible outcomes. At the beginning of each period, one of the outcomes will be drawn RANDOMLY to be the "true state," that is, the thing that actually happens. The probability of a given outcome being drawn is equal to any other, and an outcome being drawn in a given period has no effect on its likelihood of it being drawn in another. On the betting screen, each person will be given some PRIVATE information about the outcome that has been drawn. There is an electronic urn, with three balls in it representing the true state, and one ball in it for each of the other nine (for a total of 12 balls). Each participant will get some "draws" from that urn, WITH REPLACEMENT.

That is, we draw a ball, record its value, replace it in the urn, and make another draw. Based on these draws, the players are asked to make bets as to what they believe the 'true state' to be. After the 15 periods, each individual initial "Betting" risk profile is calculated. This profile is aggregated with the information derived from the risk profile to arrive at each person's initial Risk Score. A typical training screen is found below.

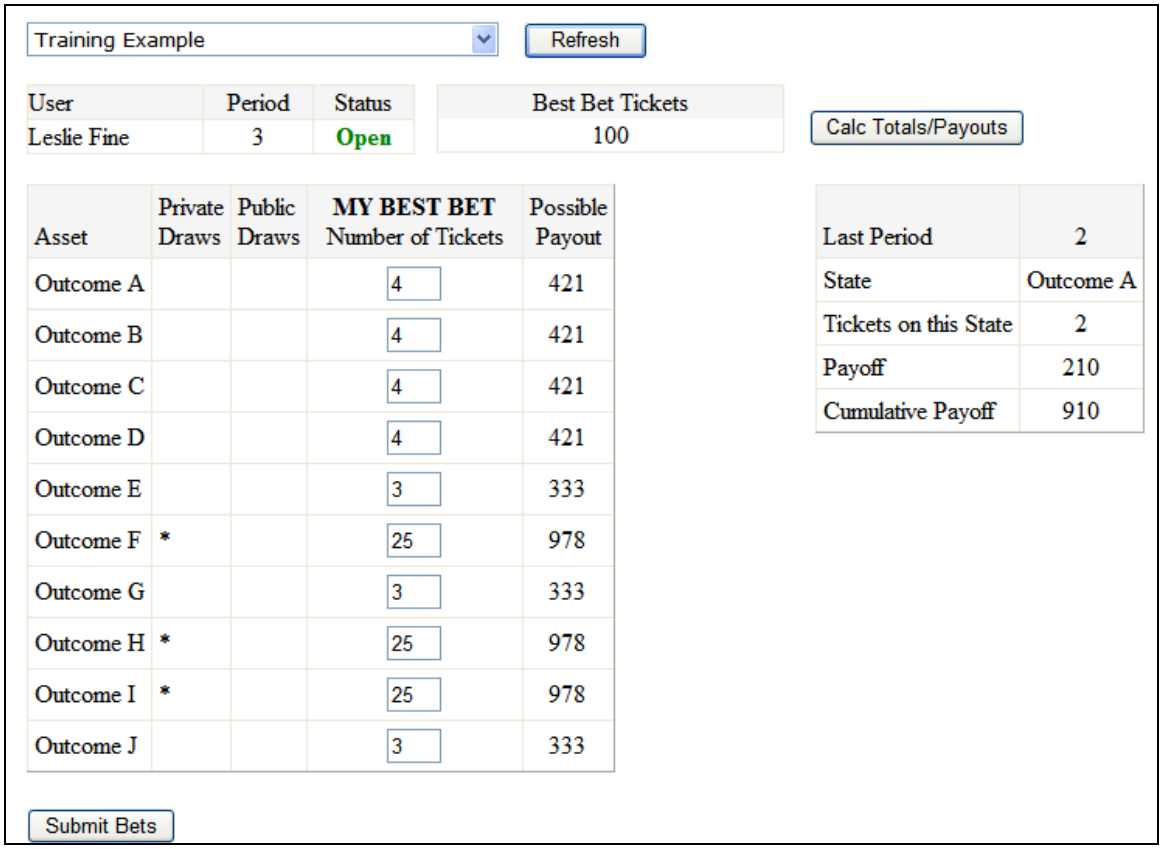

Figure 4 - Sample Training Session Screen

The BRAIN system is also able to observe the predictive capability of a participant over time by tracking their betting performance. Using this data,

BRAIN can amplify or temper the future predictions of each individual accordingly.

Case Studies – Brain in Action

BRAIN has been piloted over the last 4 years by a number of HP internal groups. In addition, HP is actively engaged in a 6-month trial with a major pharmaceutical company and is in various stages of talks with a number of other firms. These engagements will be described briefly in this section.

Case Study – HP Services

BRAIN was used by HP Services for one year to predict month-to-month operating profits and revenues. In this scenario the data inputs to the process were “thin” and “lumpy” which made other types of statistical tools less useful. Fourteen finance executives from various regions and levels were recruited to participate in the BRAIN forecasting sessions and bet on the likely monthly outcomes. This required minimal time commitments from each participant: training took 3 hours (which has been dramatically shortened since then) and less than one hour was required to make their predictions. On average, the monthly earnings were about $75.00 per participant. The outcomes showed that BRAIN could actually achieve (best case) a 49% improvement in Operating Profit predictability

The difference between the HP Services traditional prediction and the BRAIN prediction over 4 quarters can be shown in figure 4. We can see that in each case the BRAIN estimate was actually closer to the actual outcome than the more traditional revenue forecasting mechanism.

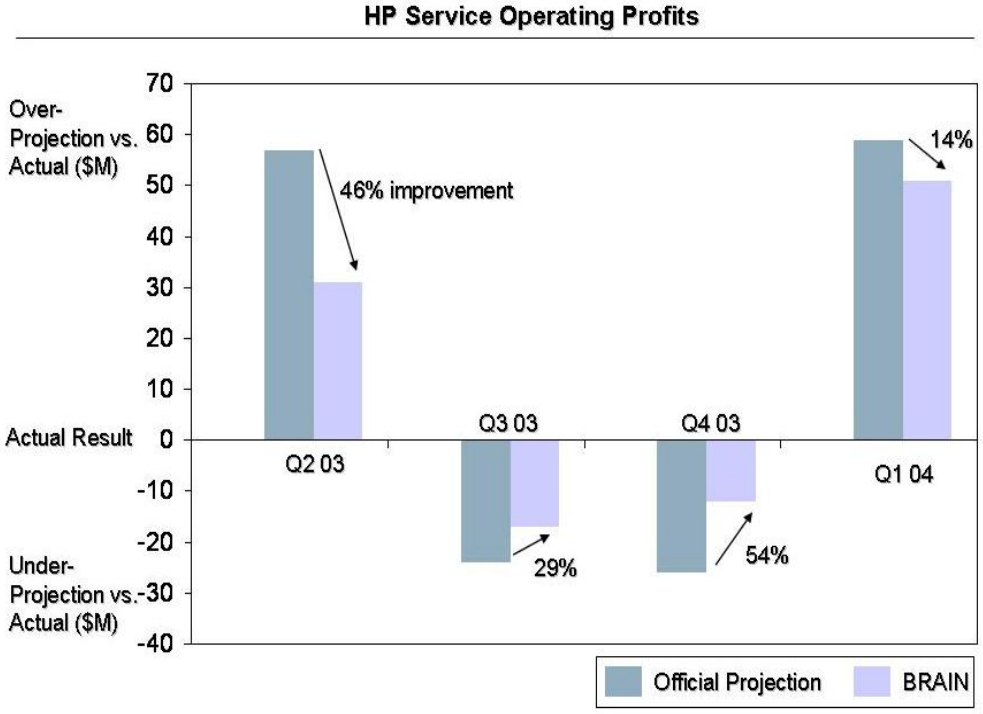

Figure 4 – HP Services operating profits

Case Study – DRAM Memory Pricing and Prediction

The accurate prediction of DRAM prices is key to successful forward pricing of many of HP's products since memory is a key component in almost everything HP makes: it is in IPAQs, laptops, desktops, servers, printers, etc. The challenge comes because DRAM is not only expensive but pricing of DRAM is also very volatile. The DRAM pricing team in HP employs a process which gathers the group of experts together to discuss views on future DRAM (DDR and DDR2

512MB) prices in the 1, 3, and 6-month time frames. The current mechanism taps tacit knowledge, but with a lot of personality and groupthink. During the BRAIN pilot the team supplemented their regular meetings with BRAIN to get a quantitative and private estimation from each participant after the conversational portion was concluded. With over 20 prediction sections completed the BRAIN predictions have successfully shown a prediction error improvement from 4% down to 2.5% error (37% improvement over existing systems). BRAIN also requires less time and less frequent iterations than the existing approach which they used. Of the 20 Predictions, BRAIN has beat the normal process 13 times and tied with it 3 times.

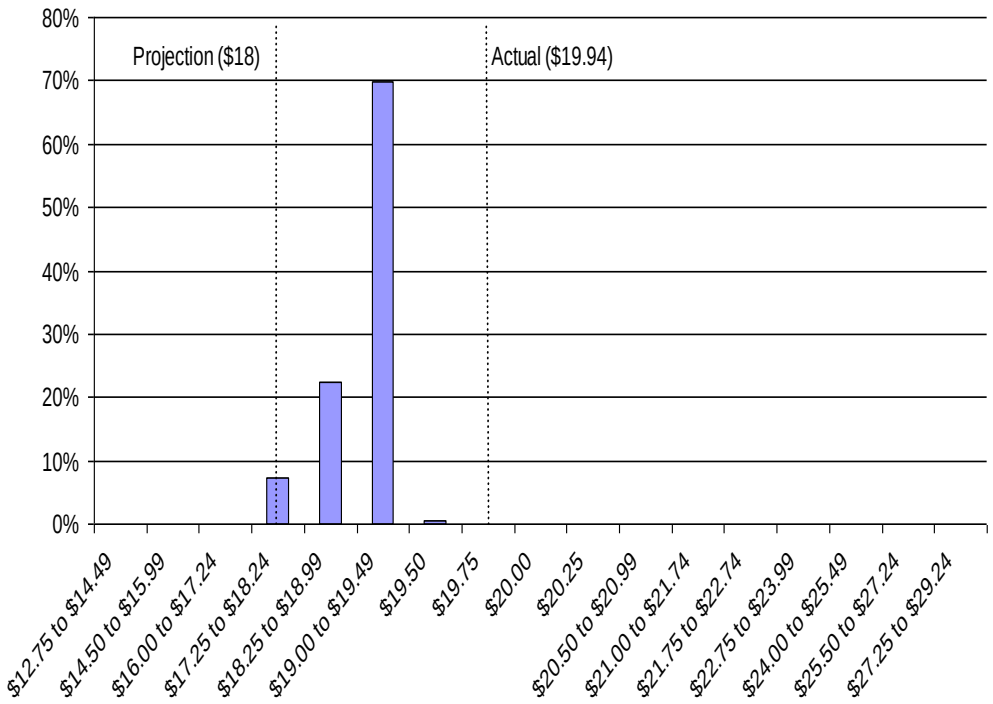

Figure 5 - April 2006 implied probabilities of pricing for July 2006