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PETER A. COLES

KARIM R. LAKHANI

ANDREW P. MCAFEE

Prediction Markets at Google

In late March of 2007, Bo Cowgill, Ilya Kirnos, Doug Banks, Patri Friedman, and Piaw Na sat down to lunch at Google's headquarters in Mountain View, California, and reviewed the most recent results from the company's internal prediction markets. The five Googlers (as Google employees referred to themselves) had launched the company's prediction markets, built the information systems that supported them, and overseen them during the previous seven quarters, all while working at their "normal" jobs. The markets had grown in popularity and demonstrated their accuracy during that time, and the team was proud of its accomplishments.

Prediction markets were very much like stock markets. They contained securities, each of which had a price. People used the market to trade with one another by buying and selling these securities. Because traders had differing beliefs about what the securities were worth, and because events occurred over time that altered these beliefs, the prices of securities varied over time.

In a stock market like the New York Stock Exchange the securities being traded were shares in companies, the prices of which reflected beliefs about the value of the companies. In a prediction market, in contrast, the securities being traded were related to future events such as an American presidential election. In this case, the market could be designed so that each security was linked to a candidate, and its price was the same as the estimated probability that the candidate would win, according to the market's traders.

Prediction markets on the Internet had proved to be remarkably accurate at predicting the results of political elections and other events, and the Googlers had wanted to see if they could also be productively used within companies to forecast events of interest such as the launch date of a product or whether a competitor would take a specific action. The experiences of the previous seven quarters had shown that Google Prediction Markets (GPM) were in fact quite good at predicting such events. Googlers put none of their own money at risk when they traded within GPM; instead, they bought and sold securities within GPM using "Goobles," an artificial currency.

Over lunch, the team members talked about next steps for GPM.

"We've got a huge amount of market and trading data and we've hardly begun to analyze it, but all of our work so far shows that our markets continue to be accurate and decisive. I was a believer from the start, but even I didn't think they'd work this well," said Cowgill.

Professors Peter A. Coles, Karim R. Lakhani, and Andrew P. McAfee prepared this case. HBS cases are developed solely as the basis for class discussion. Cases are not intended to serve as endorsements, sources of primary data, or illustrations of effective or ineffective management.

"But do we know that they *always* work well?" Banks asked. "We should dig in to our data to find out if some kinds of markets work better than others."

"Well, one thing we know even without doing much analysis is that all markets work better as they get more traders," Friedman replied. "In fact, I'm amazed that some of our markets worked as well as they did—they didn't attract a lot of people or a lot of trades."

"I think that's the biggest challenge we face right now," Kirnos agreed. "We have a group of active traders every quarter, but it's a pretty small group. We get a lot more people who sign up, then only make one or two trades. Why aren't they doing more, and how do we encourage them to be more active?"

Cowgill had a ready answer. "You all know what I think—we should make the trading more social and more personal, so that if you want to reveal your trades or positions, GPM will let you. Right now everything's anonymous, and I think that works against us."

"We already identify the best and most active traders every quarter and reward plenty of other people with T-shirts. It already feels pretty social to me," Kirnos responded.

"Hold on," said Friedman. "I think our biggest challenge isn't getting more people to participate in the markets, it's figuring out how to use their results. Is GPM a cool, fun curiosity, or is it actually a useful tool for running this company?"

"Good question," the others replied, almost in unison.

Google

Google was founded in 1998 by Larry Page and Sergey Brin, two Ph.D. students at Stanford. At that time, many Internet search engines ranked pages based on how many times they contained a certain word or phrase. If, for example, a user typed "Boston Red Sox" into the search box of one of these engines, its first result might be the page that contained the phrase "Boston Red Sox" the most times.

Website operators soon learned how these search engines worked and found it easy to take advantage of them. They would, for example, build pages that had nothing to do with the Sox but still contained "Boston Red Sox" hundreds or even thousands of times in order to attract traffic. Such pages quickly proliferated and made Internet searching difficult.

The Google founders' insight was that the "best" page about the Boston Red Sox was not the one that used that phrase most often but instead the one that was *most linked to* using that phrase. Web pages typically contained many links to other pages, and this link structure provided a huge amount of information. The page that the most other pages linked to on a given topic was likely to be the best page on that topic and the one that a searcher was looking for. Google also assessed the "reputation" of each page on the Web; if it was a page that a lot of other pages linked to, its own links were given more credibility.

The algorithm that took all this into account, called PageRank, proved to be enormously powerful and popular. Google soon became a leader in Internet searching, and the company also found a way to generate revenue by selling advertising space on its search-results page. By March of 2007, "to Google" had become a verb meaning "to search for information on the Internet," and the company had a market capitalization of over $140 billion. Google employed over 10,000 people and in addition to its main campus in Mountain View (called The Googleplex) had over a dozen engineering centers

around the world. The company described its mission as "to organize the world's information and make it universally accessible and useful."

The Birth of GPM

Bo Cowgill joined Google in 2003 after finishing his undergraduate degree in public policy at Stanford and worked at first in the company's support organization. As an undergraduate, he had been fascinated by prediction markets for elections and impressed with their accuracy. In June of 2004 he went on vacation and took along James Surowiecki's book *The Wisdom of Crowds*. The book's theme was that it was often possible to harness the "collective intelligence" of a group of people, yielding better or more accurate information than any individual within the group possessed. Many readers found this a powerful and novel message. They were accustomed to thinking that groups usually yielded the lowest common denominator of their members' contributions or, even worse, that groups could turn into mobs that were actually less intelligent than *any* of their members.

The Wisdom of Crowds provided many examples of collective intelligence and discussed prediction markets including the Iowa Electronic Markets (IEM), which had interested Cowgill at Stanford. The IEM, which was founded in 1988, established markets to predict the winners of political elections in the United States and elsewhere. In these markets, security prices could be interpreted as the percentage of the vote each candidate was predicted to get, according to traders. Participants in the IEM traded using their own money and could set up accounts with $5–$500.[1] In general, IEM results were quite accurate and compared favorably with other ways of predicting events. Across 12 national elections in five countries, for example, the average margin of error of the last large-scale voter polls taken before the election was 1.93%. The average margin of error of the final IEM markets prices was 1.49%.[2]

Surowiecki wrote:

> . . . the most mystifying thing about [prediction] markets is how little interest corporate America has shown in them. Corporate strategy is all about collecting information from many different sources, evaluating the probabilities of potential outcomes, and making decisions in the face of an uncertain future. These are tasks for which [prediction] markets are tailor-made. Yet companies have remained, for the most part, indifferent to this source of potentially excellent information, and have been surprisingly unwilling to improve their decision making by tapping into the collective wisdom of their employees.

Cowgill became intrigued by the idea of starting a prediction market at Google. He knew he would need colleagues, particularly ones with programming expertise, to help build one, and he also knew how to find them. When he returned to work he wrote the following note on an internal online message board where employees could post their new ideas:

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[1] The IEM's website states, "The IEM is an experimental market operated for academic research and teaching purposes. The IEM is not regulated by, nor are its operators registered with, the Commodity Futures Trading Commission or any other regulatory authority.

"The IEM has received two no-action letters from the Division of Trading and Markets of the Commodity Futures Trading Commission. Without explicitly asserting jurisdiction over the IEM or any of its submarkets, these letters, dated February 5, 1992, and June 18, 1993, extended no-action relief to the IEM's Political and Economic Indicator Markets." http://www.biz.uiowa.edu/iem/faq.html#Regulated, accessed February 27, 2007.

[2] J. Berg, R. Forsythe, F. Nelson, and T. Rietz, "Results from a Dozen Years of Election Futures Markets Research," *Handbook of Experimental Economics Results*, 2001, available at http://www.biz.uiowa.edu/iem/archive/BFNR_2000.pdf.

> By aggregating the number and nature of incoming links to a webpage, Google already uses the collective genius of crowds to rank search results. "Democracy on the web works," is part of our corporate culture. But PageRank isn't the only way to harness the collective intelligence of large groups.
>
> The Iowa Electronic Markets, the Policy Analysis Market, the Hollywood Stock Exchange as well as numerous academic studies have shown that large, diverse crowds of independent thinking people are better at predicting the future of solving a problem than the brightest experts among them. This is especially true when the individuals in the crowd have a personal financial stake in getting it right.
>
> Google has exactly what such a market needs to perform well: A large, diverse user base and the ability to give financial incentives and lower barriers to entry. To some extent, Google can even ensure that our crowd thinks independently.
>
> So, I propose creating Google Decision Markets.

(See **Exhibit 1** for the remainder of Cowgill's post.)

All Google engineers had "20% time," or the equivalent of one day a week during which they were free to pursue projects of interest within the company that were not directly related to their jobs. Cowgill was hoping to convince some Googlers to devote their 20% time to building a prediction market. He was also looking for quick feedback about the idea, and the message board let people rate posted ideas.

Ilya Kirnos posted a reply less than 10 hours after Cowgill submitted his idea:

> "Hey Bo
>
> I had a similar idea and have written some code in that direction. I agree that markets have a lot of predictive power, much more so than surveys or polls for most things. . . .

Kirnos was a computer science and applied math major from Princeton who had joined the advertising systems group at Google in 2004 after working at Oracle. Earlier in his career he had participated in a project that he and many other engineers knew would not succeed but that continued to get support and funding. He wondered why it seemed so hard to communicate accurate information within companies in some circumstances, and he thought that it might be possible to use technology to address this problem. Kirnos built a simple application called "itoldyouso" that allowed people to offer and accept nonmonetary bets and kept track of them over time. Employees could use it, for example, to essentially say to their colleagues, "I'll bet you this project won't be finished on time; any takers?" When they won a bet, the system helped them say, "I told you so!"

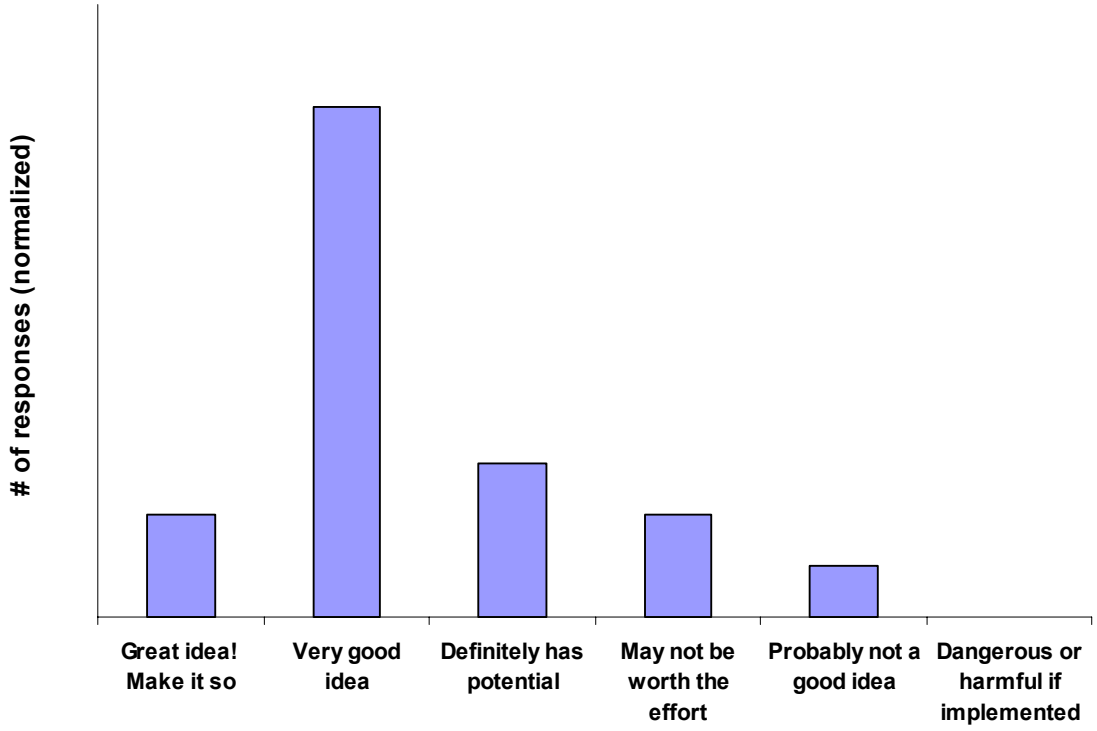
Kirnos saw that Cowgill's proposed prediction market could be used to accomplish many of the same objectives as his betting system and volunteered to help with the project. Na and Banks also replied to Cowgill's post and became part of the GPM team (Freidman joined the team a few months later after hearing about the project).

Another respondent to Cowgill's post was an associate of Hal Varian, a well-known Berkeley economist who consulted at Google. The respondent told Cowgill that Varian had an interest in prediction markets and had written columns about them in his *New York Times* economics column.

Cowgill contacted Varian to solicit his help, and Varian began attending the group's regular meetings. He later offered crucial advice about how to design the markets, how to implement them, and how to sell them to the larger company.

Cowgill's idea yielded the following ratings (**Figure A**):

Figure A Histogram of Responses to Bo Cowgill's Post on a Google Prediction Market



Source: Google.

Market Design Considerations

The team felt that for GPM to be effective, the markets would have to be intuitive and easy for participants to use. Cowgill knew that many people found the idea of trading stocks to be daunting, so he wanted everything about Google's prediction markets to be as simple and straightforward as possible.

Early on, a debate ensued over the best market design. There were two leading candidates: the IEM model, and a design that let traders engage in short selling. Short selling meant betting *against* a future event, such as the New York Yankees beating the Boston Red Sox in a seven-game playoff series.[3]

[3] As an example of short selling, suppose a security called "Yankees-to-win" pays out one dollar if the Yankees win and zero otherwise. To bet on the Yankees, a trader would simply buy this security at the going ask price. To bet against the Yankees, the trader would sell short. This means that the trader would receive the current bid price for the security on the spot, in exchange for an obligation to pay a dollar should the Yankees win. Because the trader in this case is "on the hook" for a dollar, a dollar of funds will be frozen in her account until the game is over. Unlike short selling of stocks, short selling of contracts in

Some members of the team felt that a short-selling feature would be complicated enough to deter some potential GPM traders. The sticky issue was that short selling was not intuitive to many people because it involved selling something that a trader *did not own*. Others argued that Web-based prediction markets that allowed short selling, such as the Ireland-based company Tradesports, showed this was not the case. After all, they reasoned, Tradesports was a successful profit-seeking company, so it *must* be using the model that would attract the greatest number of participants. After consultation with Varian, the team ultimately decided on the IEM model.

The IEM model relied on the use of "baskets"—mutually exclusive securities that covered all possible outcomes for an event. For example, suppose the team wished to run a market on users for application A as of the end of Q4 2007. A basket might consist of the following securities:

Security A1 pays off 1 if users < 1m
0 otherwise

Security A2 pays off 1 if users ≥ 1m and <3m
0 otherwise

Security A3 pays off 1 if users ≥ 3m
0 otherwise

To make a bet that A will have ≥ 3m users by the end of Q4, a participant could buy security A3. To make the opposite bet, the traders could buy securities A1 and A2. The market prices of these securities could then be interpreted as probabilities. If, for example, A1 was trading at a price of 0.25, the market "believed" there was a 25% chance that application A would have <1m users by the end of Q4 2007.

To keep the markets topical and maintain a reasonable time horizon, the team decided to choose an entirely new set of markets each quarter, all of which would close no later than at the quarter's end. In some cases, markets could end early. If, for example, an event occurred midquarter that eliminated uncertainty, then the securities in that market would pay off as specified and would no longer be traded on the market.

The team also decided to use play money, with a unit of currency called the Gooble. At the start of each quarter, traders' accounts were reset, and all traders were given 10,000 Goobles and 1,000 randomly selected baskets. Securities could be bought and sold during the quarter in a standard continuous double auction with bid/ask spreads (see **Exhibit 2** for an explanation of these terms). At the end of the quarter all remaining securities would pay off as specified, and final holdings would be tabulated. This quarterly "level playing field" approach was designed to keep a wide range of participants interested.

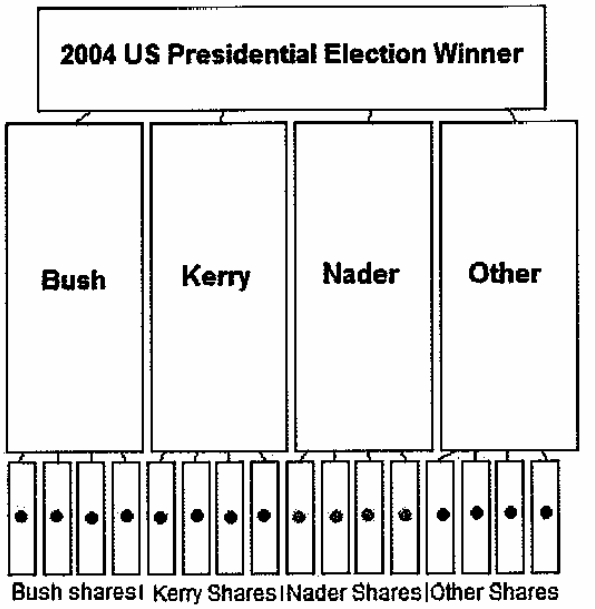
GPM consisted of markets, outcomes, and shares, as **Figure B** illustrates.

prediction markets does not result in unlimited liability for the trader. In this example, the worst-case scenario is that the Yankees win and the trader loses one dollar.

Figure B Markets, Outcomes, and Shares in GPM

Terms	Definitions
Market	There is a market associated with every event we're trying to predict. Each market has several outcomes associated with it, representing the various different ways that event could go.
Outcome	Each market has several types of outcomes underneath it. Every outcome has a particular "market" associated with it. These outcomes cover all possibilities for how the event specified in the market will be settled. Outcomes are sometimes known as "stocks" or "securities." Each outcome has several shares associated with it …
Shares	Shares are what users buy, own, and sell. Every share has a particular outcome associated with it. Each share associated with an outcome that comes true will pay its owner 1 Gooble. At any given time, the number of shares per outcome is the same across all outcomes. To increase this number, use a basket order.

Example



At any given time, the number of Bush shares = the number of Kerry shares = the number of Nader shares = the number of Other shares. To increase this number, use a basket order.

Source: Google.

Rewards

Googlers did not buy and sell within GPM using real money, but the team still wanted to have monetary rewards for successful traders. They foresaw, however, that if they simply gave out cash prizes to the most successful traders at the end of each quarter, some people might be tempted to behave counterproductively. They could, for example, simply buy as much of a low-priced outcome as possible. If this unlikely outcome actually occurred in the real world (if, for example, Ralph Nader actually won the presidency), they would make a huge amount of money in the market. If the event did not occur, of course, they would have a balance of zero Goobles inside the market at the end of the quarter, but they would experience no financial losses in the real world.

The GPM team did not want to encourage this kind of trading; instead, they wanted to design the market so that participants would trade based on true beliefs about the future. They decided to convert each participant's final balance—their balance at the end of the quarter after all markets had been settled—into lottery tickets. The team would draw six tickets at random and give $1,000 to each winning ticket holder. They felt that this approach would provide the right incentive to traders. It

would encourage them to maximize the number of tickets they had in the lottery, which meant trading as intelligently as possible throughout the quarter so as to have the highest possible final balance, and to build a portfolio that did *not* rely heavily on the occurrence of a single unlikely event.

The team also decided to award $1,000 to the most active trader each quarter and to give gift certificates and special T-shirts to other top performers. They hoped that these rewards would encourage many people to participate in GPM.

Proposal

After finalizing the market design, the newly formed GPM team started programming and had a working version of a prediction market in less than a month. They then decided to seek more formal support and recognition from Google, as well as funding for rewards. Some successful initiatives, including Google News and the Adsense advertising sales program, had started as employee proposals.

Cowgill submitted a proposal for Google Prediction Markets in December of 2004. It received favorable reviews and sparked interest among several executives. One of them committed to providing $10,000 from his department's budget each quarter to fund GPM prizes.

Launch

On April 8, 2005, the following e-mail went out to all Googlers:

> Googlers:
>
> In *The Wisdom of Crowds* (Random House, 2004), James Surowiecki argues that the crowd is generally smarter than its smartest individual. For Surowiecki, our emotions and potentially incorrect assumptions preclude us from making optimal judgments individually. But if you take a crowd of diverse people and correctly aggregate their judgments, the crowd's collective intelligence typically wins in accuracy.
>
> We see the wisdom of crowds in action every day. For example, collective intelligence drives Wall Street—the markets generate probabilities on a company's success, and reflect their hypotheses in stock prices. It's no coincidence that our financial planning libraries carry copies of the book.
>
> We're going to test Surowiecki's thesis at Google through GPM, an application dreamed up by some Googlers in their 20% time. GPM will give us a chance to find out if groups of Googlers are smarter than even our smartest individual. And to make this interesting, we have a total prize pool of US$10,000 to be given to the winning predictors at the end of the quarter.
>
> Now that you can't wait to sign up, let me digress for a moment and tell you how GPM came about. Bo Cowgill enlisted fellow 20% timers—Doug Banks, Patri Friedman, Ilya Kirnos and Piaw Na—and built the GPM prototype. For their creativity and perseverance I volunteered the budget to sponsor them with US$10,000 to use for this contest.
>
> The Google GPM team has turned several of Google's Q2 goals into futures markets where Googlers worldwide can speculate on anticipated outcomes. While participation is voluntary, everyone can watch Google's collective wisdom take shape. Here's how you get started—

*Sign up for a password.

*Read the "Getting Started" information that will be mailed to you.

*Begin placing bets in the markets!

Congratulations to the GPM Team for their hard work and enthusiasm on this project.

During its first quarter of operation, which ran from April through June, there were 24 markets (questions) within GPM and 95 total different securities (answers) being traded. The team had decided on these markets by interviewing Google managers to find events of interest that would occur during the quarter. These included when a specific international Google office would open and how much demand there would be for a particular product. The team also created markets based on the company's list of important corporate objectives, which was updated each quarter. In addition, the team included markets for events that would occur outside the company, such as product launches by a competitor. Finally, GPM also contained "fun" markets related to events such as the opening of the movie "Star Wars: Episode III," the TV contest "The Apprentice," and the NBA finals. Fun markets were intended to draw in participants and show them how easy and enjoyable it was to trade.

All markets were open to all employees once they opened an account, and all Googlers could browse the markets and see their current prices and price histories, even if they did not have a GPM account. A randomly selected market appeared prominently on Google's intranet. GPM documentation included an overview and list of frequently asked questions.

Activity

During the first quarter, 1,085 Googlers signed up for a trading account with GPM. A total of 7,685 trades were made, and 436,843 shares changed hands. Most of the traders came from the engineering, sales, operations, or product management functions within the company. A group of 13 very active traders developed; this group accounted for 48% of total trades across all markets in the first quarter (see **Exhibit 3** for statistics on GPM growth and trading).

Over time, a few Googlers also wrote *bots*, which were programs that traded automatically based on predetermined rules. Some of these bots took advantage of opportunities for *arbitrage*, or illogical discrepancies in outcomes' prices. For example, outcome prices were supposed to reflect probabilities, and the outcomes in each market were supposed to be *collectively exhaustive*; in other words, they were supposed to cover all possible results in the real world. They were also set up to be *mutually exclusive*, so there was no chance that two outcomes could both occur. This implied that at all points in time the prices for all outcomes in a market should add up to one. However, GPM itself contained no automated mechanism to ensure that this was the case. The team deliberately left out this feature to reward the serious traders who would notice this discrepancy. The marketplace would rely on such traders for liquidity.

At least one employee wrote a bot that continually scanned all markets within GPM. Whenever a market consisted of outcomes whose current bid prices added up to more than one, the bot immediately bought a market basket, then immediately sold it for more than a dollar. Because of bots and other sharp-eyed traders, arbitrage opportunities rarely cropped up or lasted long with GPM.

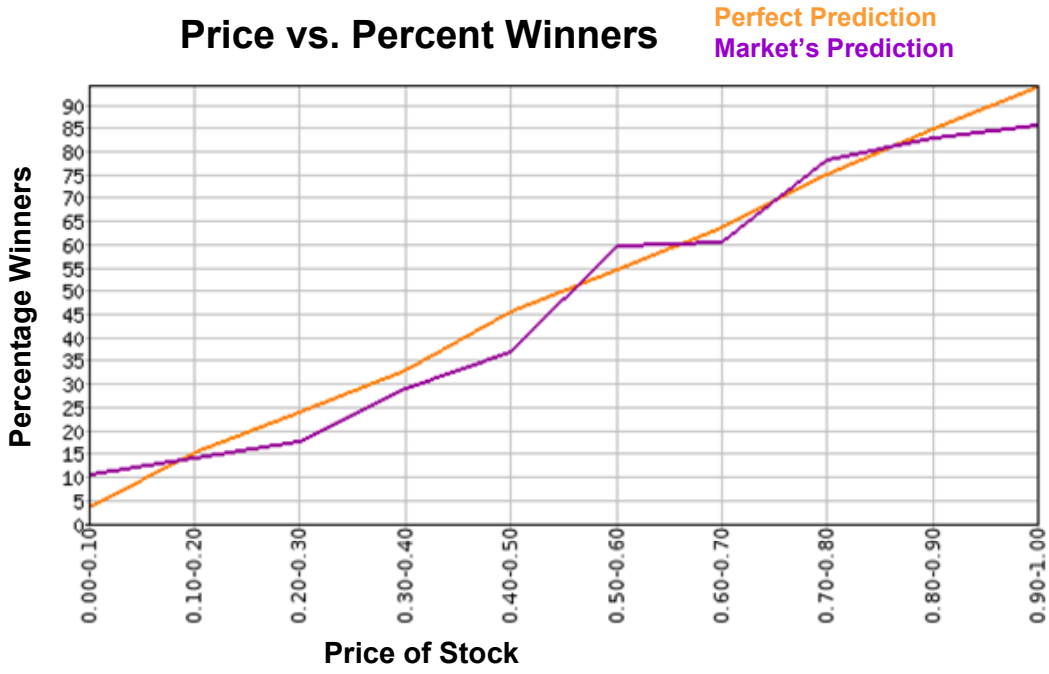
Results

As data accumulated, the GPM team started to analyze it to learn how the markets were working and how well. One of the main things they were interested in, of course, was the *accuracy* of the markets: how well they forecast what would actually happen.

To assess accuracy, Cowgill took the final prices for a large sample of outcomes in GPM, then divided them into 10 ranges: 0.0–0.1, 0.1–0.2, . . . 0.9–1.0. If these prices really were equivalent to probabilities that the events would occur, he reasoned, then outcomes priced between 0.0 and 0.1 should occur somewhere between 0% and 10% of the time in the real world. In a large enough sample, they should occur on average 5% of the time.

Cowgill compared real-world outcomes to GPM prices for each of the 10 price ranges. As **Figure C** shows, final market prices were, in general, good probability estimates.

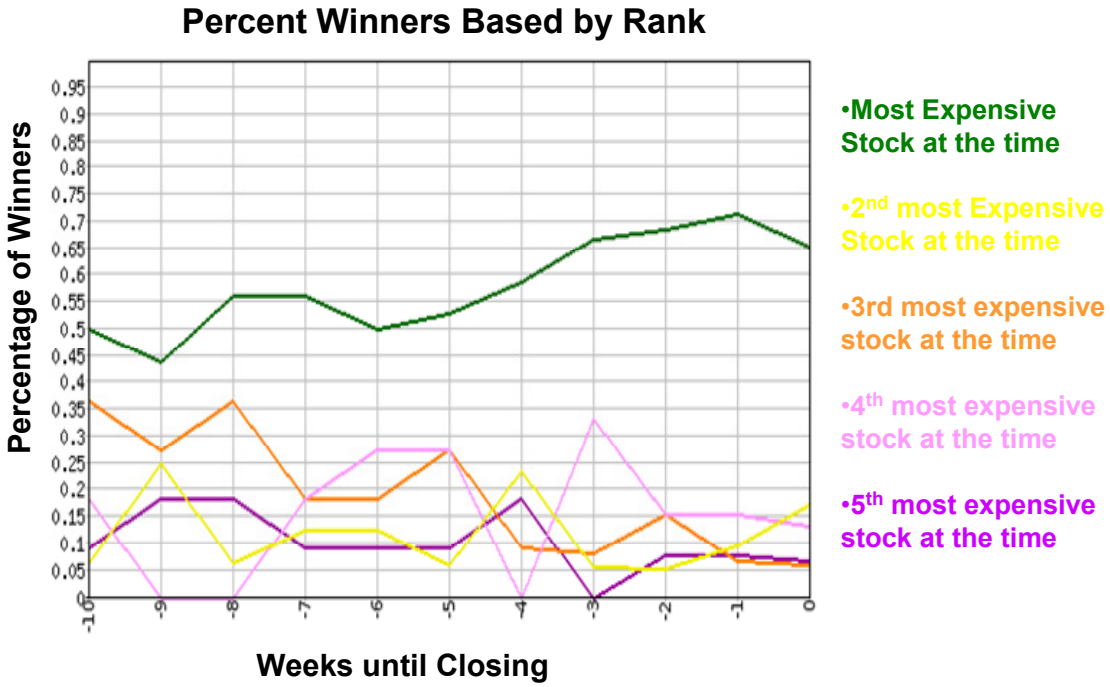
Figure C GPM Accuracy



Source: Google.

Analyses also revealed that at every point in time, even as much as 10 weeks away from the closing date of the market, the most expensive outcome was the one most likely to actually occur (see **Figure D**). It seemed that GPM, in other words, could quickly and accurately distinguish among possible outcomes, identify the one most likely to occur, and attach a high price to that outcome.

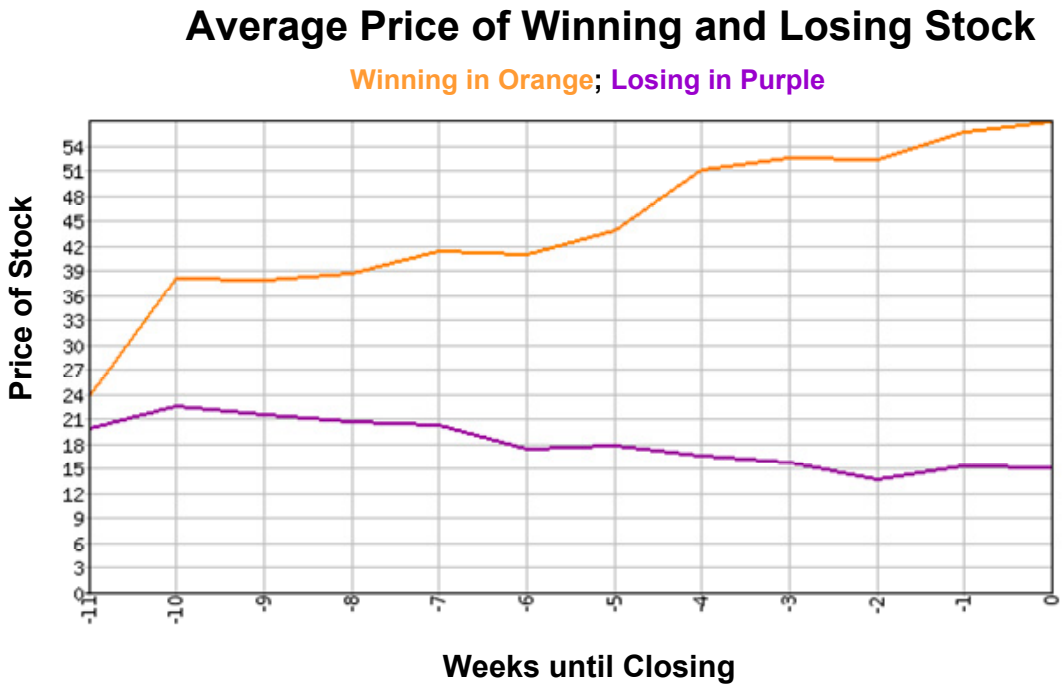
Figure D GPM Outcome Prices over Time



Source: Google.

Graphs like **Figure D** also indicated that traders became more confident about the "winning" outcome as time passed. The markets within GPM, in other words, had high *decisiveness*—they tended to contain only one outcome with a high price, and the difference between this price and all others increased over time as events unfolded in the real world. Furthermore, the GPM outcome with the highest price usually corresponded to the real-world outcome that actually occurred. **Figure E** summarizes these findings.

Figure E GPM Decisiveness



Source: Google.

Viewpoints

Attitudes toward GPM varied widely among Googlers. Clay Quilty, an active trader, participated because he found it enjoyable:

> I never play the real-world stock market, but GPM is different. I mainly trade in the fun markets for things like gas prices and the World Cup winner. The one time I thought I had good information on a Google project, where there was a market I traded like crazy on it.
>
> If I have an overall strategy, it's that I tend to bet on negative outcomes. In a market like "Will project x leave beta by this date?" I'll generally bet on "no" because in my experience most things get done late, and not enough people realize that. I've seen all the weird things that you hear about in the big stock markets—panics, herd behavior, and stampedes. It's amazing to me that our markets work as well as they do, especially because there's no real downside to taking big risks. After all, you're not playing with your own money!
>
> I haven't won one of the big cash prizes yet, but I'm often among the top 10 traders, and I wear the T-shirt I won with pride. I sometimes wonder, though, if there's a perception that we top traders are spending too much time on GPM—that we're not doing our real jobs. I know that's not the case, at least for me, but I wonder what people think.

Vladimir Humber, an early Google employee with a Ph.D. in computer science, was also an active trader but had a very different approach:

I sometimes make trades that I hope will mislead the market. For example, I'll buy a couple shares of a very low-priced outcome to try to convince other traders that there's actually a *reason* to buy. If they jump in and drive the price up, I can profit from that. I also try to gather as much information as I can on our projects so I can determine if their market's prices are incorrect.

I've also built my own user interface for GPM because I don't like the standard one. Mine shows me my portfolio right next to the market as a whole; on the standard one you have to go back and forth between pages to do the comparisons.

Patri Friedman was an active trader as well as being a GPM team member:

Lots of people think that financial incentives are essential for prediction markets to work well, but I think the opposite might be true, at least for us. A chance at $1,000 is just not that meaningful to most people here, and if Googlers see GPM primarily as a way to earn a chance at $1,000 most of them will dismiss it. We have a T-shirt economy in this company—people will volunteer for all sorts of things and do work for other teams just to get a cool T-shirt. We should be taking more advantage of this within GPM.

I'm also concerned that with the constant flow of super-high-priority projects here GPM will never get the attention that we think it deserves. Things move *very* fast at Google—are we yesterday's news?

Cowgill agreed that people participated in GPM largely for fun, for T-shirts, and for bragging rights. He came to believe that prediction markets within companies should let people build their reputations as good traders and that this was more important than letting them build their bank accounts. Cowgill spoke at a December 2006 conference on prediction markets. He began: "Today I'm going to be talking about how operators of predictive markets can best encourage participation. I don't think that rewards—even cash rewards—are adequate to induce participation. Market operators should focus more on social rewards and the infrastructure and processes to deliver them." (See **Exhibit 3** for the full text of Cowgill's speech.)

Dolores Haze, a manager on the search quality team, did not believe that GPM could greatly help her:

It's my job to know about the status of all my projects, and I haven't seen the markets tell me anything I don't know. There was a "yes or no" market a while back related to the outcome of a project within our group. I knew what most Googlers thought the outcome would be, but I also knew what it would actually be because I was very close to the project and because I understood what its dashboard was telling me.[4] Sure enough, the market agreed with me, and we were both right. So what did the market do for me? It didn't tell me anything I didn't know; it just confirmed my intuition.

I think that prediction markets are really interesting, and maybe they serve to generate some excitement and get people motivated to learn about what's going on, but I'm not sure that they're really that useful within companies.

[4] Many projects at Google had "dashboards," or online summaries of project status. These dashboards were typically visible throughout to all Googlers. If GPM contained a market related to a project that had a dashboard, the market page included a link to the dashboard. By 2007, many companies in the high-tech industry and elsewhere used dashboards to track project status.

Olympia Press, a vice president in the online sales group, thought that there were better and faster ways than GPM to get useful information:

> Sure, we could set up a market with a question like, "How many new advertisers will we get by this date?" but I already have really smart people and teams dedicated to answering exactly these questions. They have the best available data and very sophisticated forecasting tools. And it's their job to answer these sorts of questions quickly and accurately. So I just go to them.

Conclusion

Analyses had convinced GPM team members that Google's prediction markets worked—that they yielded accurate and decisive predictions about future events. The team wondered, though, if they could make the markets work better and also do more work within the company.

Virtually all markets work better as they gain more *liquidity*, or the ability for a participant to quickly execute a desired trade without causing a significant movement in the price. The best way to bring more liquidity, the team members knew, was to encourage more Googlers to set up GPM accounts and execute many trades. As they ate lunch, they brainstormed how to do this.

Friedman suggested, "Let's make the launch of the markets each quarter a big deal—e-mails, signs in the cafeterias, a countdown until trading opens. . . ."

"We could also do the same for the lottery drawing and prize handout. We could make it a party and invite everyone who traded," added Cowgill.

"And should we offer more and bigger prizes, or more prizes for trading heavily?" asked Banks.

"Maybe," Cowgill replied. "But whatever else we do, we should build in more social features and personalization into GPM. It's pretty clear that Googlers trade to build their reputations. We should make these reputations more visible on an opt-in basis."

After a while, the discussion turned to the uses of GPM within the company.

"How do we get decision makers here to use what the markets are telling them?" asked Na.

Friedman responded, "We need to get our data in front of them. We should put together a presentation of our results and offer to give it to whoever's interested. We could also turn it into a podcast or a webinar and put it on our intranet."

"Do we know enough yet to recommend *how* people should use the data from the markets? If we present our results and someone says, 'I'm convinced; now what do I do?' would we know what to tell them?" asked Banks.

"For one thing," Cowgill replied, "we'd tell them to stop using whatever short-term planning or forecasting technique they're using currently and start using GPM. If they want to know how many servers they're going to need to support New Product X, they should ask us to set up a market on demand for New Product X. The answer they'll get from the market will be better, at every point in time, than the answer they'll get any other way."

"Are you sure about that?" Na replied.

"Yes. But let's go gather some data and find out if I'm right."

Exhibit 1 Text of Cowgill's Proposal for a Google Prediction Market, Submitted to Google's Internal Message Board for Innovation Proposals

By aggregating the number and nature of incoming links to a webpage, Google already uses the collective genius of crowds to rank search results. "Democracy on the web works," is part of our corporate culture. But PageRank isn't the only way to harness the collective intelligence of large groups.

The Iowa Electronic Markets, the Policy Analysis Market, the Hollywood Stock Exchange as well as numerous academic studies have shown that large, diverse crowds of independent thinking people are better at predicting the future of solving a problem than the brightest experts among them. This is especially true when the individuals in the crowd have a personal financial stake in getting it right.

Google has exactly what such a market needs to perform well: A large, diverse user base and the ability to give financial incentives and lower barriers to entry. To some extent, Google can even ensure that our crowd thinks independently.

So, I propose creating Google Decision Markets… Here's how this would work. We would allow users to both create markets and participate in them. To create a market, a user would have to enter a unique question with a verifiable answer, a variety of possible answers and an end date at which the answer will be known.

To participate in a market, a user would select an answer to the market's question and place a trade that the answer is correct. This trade would be financed by the user himself; or, trades in the market could be financed by the market's creator. The answer and trade would be kept confidential.

Research has shown that the markets will be right more often than any individual expert. For example, the Iowa Electronic Markets have consistently predicted election outcomes better than any individual pundit or pollster.

Similarly, the futures price on orange juice does a better job of forecasting the weather in Florida than any meteorological service to date. The Hollywood Stock Exchange predicts movie sales better than any independent analysis…

Google wouldn't be the first high-tech company to take interest in this area. Microsoft finances the Iowa Electronic Markets, and HP has used internal markets to predict sales growth.

Anyone want to work on this with me?

Source: Company document.

Exhibit 2 Explanation of a Continuous Double Auction

The c*ontinuous double auction* (CDA) is a mechanism to match buyers and sellers of a particular good and to determine the prices at which trades are executed. At any point in time, traders can place *limit orders* in the form of *bids* (buy orders) and *asks* (sell orders). Outstanding orders are maintained in an *order book*. Traders may at any time place a *market order* to buy or sell immediately at the market price, which is determined by the set of orders in the order book. Trades are *executed* whenever a new limit order comes in and the highest bid exceeds or is equal to the highest ask price, or else when a new market order comes in and the order book contains orders with which the market order can be matched. These terms are described in greater detail below.[a]

Goods While the good traded can be any commodity, in the case of prediction markets, a good will be a *contract* that pays out a specified amount if a particular event takes place. In the market for an upcoming Red Sox-Yankees game, one unit may be a contract that pays $100 if the Yankees beat the Red Sox and $0 otherwise.

Limit orders An ask specifies the good to be sold, the number of units, and an ask price. A bid specifies the good to be purchased, the number of units, and a bid price.

Order book and price quotes Outstanding orders are maintained in an order book in bid and ask priority queues. In the bid queue, bids are ordered by price; the highest bid is at the front of the queue. Equal-priced bids are ordered by time of submission. Asks are ordered similarly but with priority given to the lowest-priced ask. In some exchanges, only some of the information in the order book is available to traders for viewing, such as the prices of the current high bid and low ask. This information is known as a *price quote.*

Sample Order Book

Bid		Ask	
Qty.	Price	Price	Qty.
25	33.5	33.7	44
50	33.4	34.3	100
275	33.0	34.8	50
27	32.7	34.9	20
28	32.4	35.5	55

Sample Price Quote

Security	Bid	Ask	Last
"Y to Win"	33.5	33.7	33.7

New limit orders and trade execution When a new limit order comes in, the order is added to the order book, and a trade is executed if the highest bid exceeds or is equal to the highest ask price. The transaction will involve the orders at the top of the bid and ask queues and at the price of the older of the two orders involved. If the number of contracts specified in these orders is not identical, then the number of contracts traded will be the lower of the two. Upon execution, trader accounts are updated, and the contracts involved in the trade are deleted from the order book. The portion of any new limit order that goes unfulfilled is maintained in the order book. Transactions continue in this manner until the highest bid no longer exceeds or is equal to the highest ask price.

Market orders and trade execution A market order specifies either "buy" or "sell," the good to be traded, and the number of units. Market orders are matched with existing orders in the order book. For a buy market order, the price used is the lowest ask price in the ask queue. If the number of units in the buy market order exceeds the number of queued units at this price, then the excess demand goes unfulfilled.[b] Sell market orders are matched similarly with orders in the bid queue.

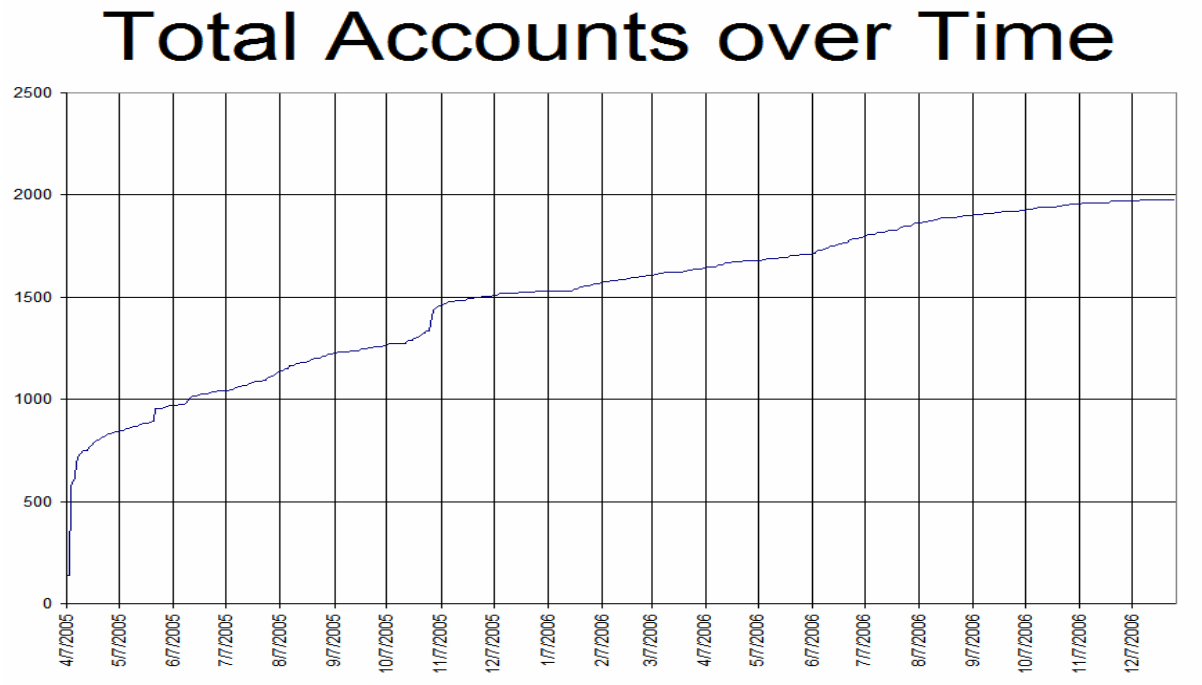
Feasibility and bookkeeping Continuous double auctions are usually linked to cash accounts and portfolios of traders. Upon execution of a trade, goods and cash are exchanged in trader accounts as specified in the trade. If a trader's account holds insufficient funds or goods, the trade is deemed infeasible, and the offending orders involved are canceled.

Source: Casewriter.

[a]There are many variations of the continuous double auction, most of which share the fundamental features described here. For discussion, see "Everything you wanted to know about double auctions but were afraid to (bid or) ask," http://www.sci.brooklyn.cuny.edu/~parsons/projects/mech-design/publications/cda.pdf. The method discussed here is based on that used in the Iowa Electronic Markets, http://www.biz.uiowa.edu/iem/trmanual/IEMManual_3.html.

[b]An alternative mechanism is to fulfill the order with the next-highest-priced orders in the ask queue.

Exhibit 3 GPM Volume and Trading Statistics



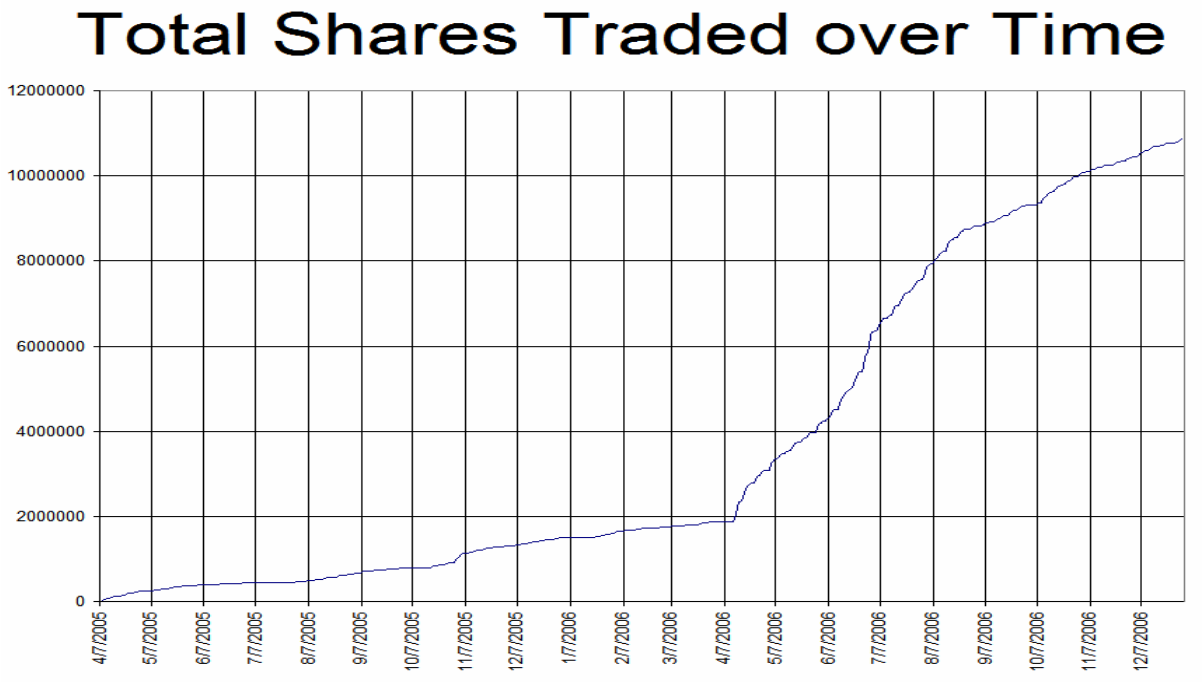
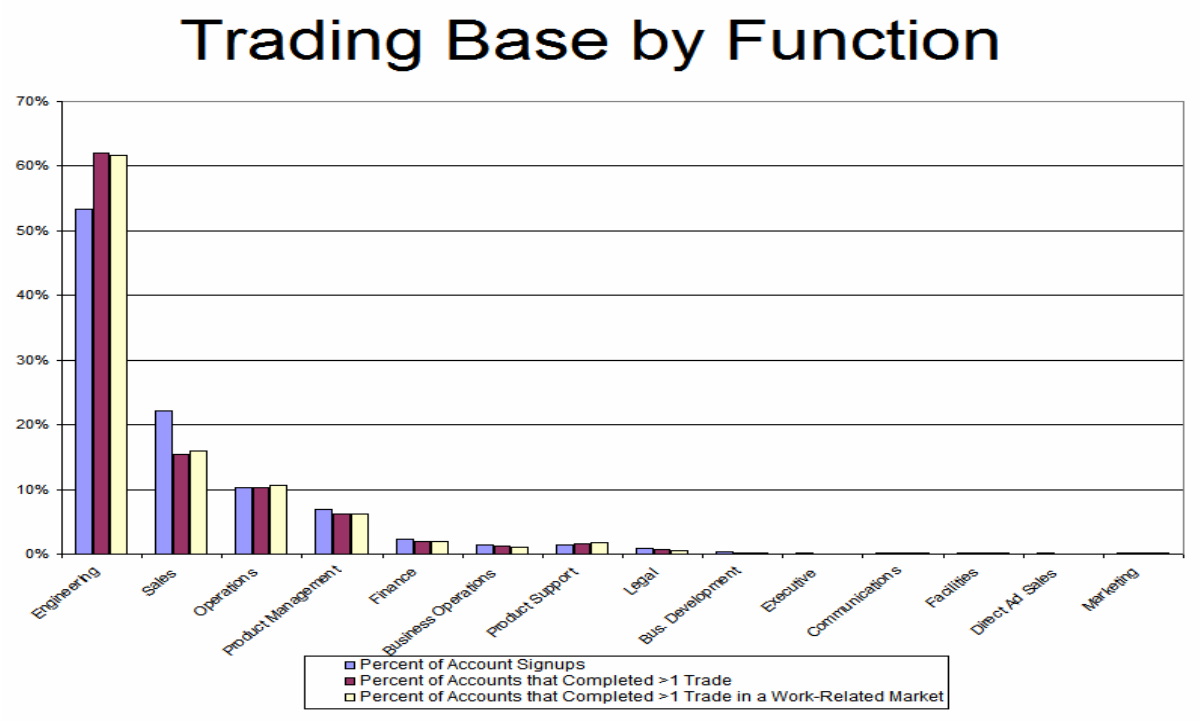
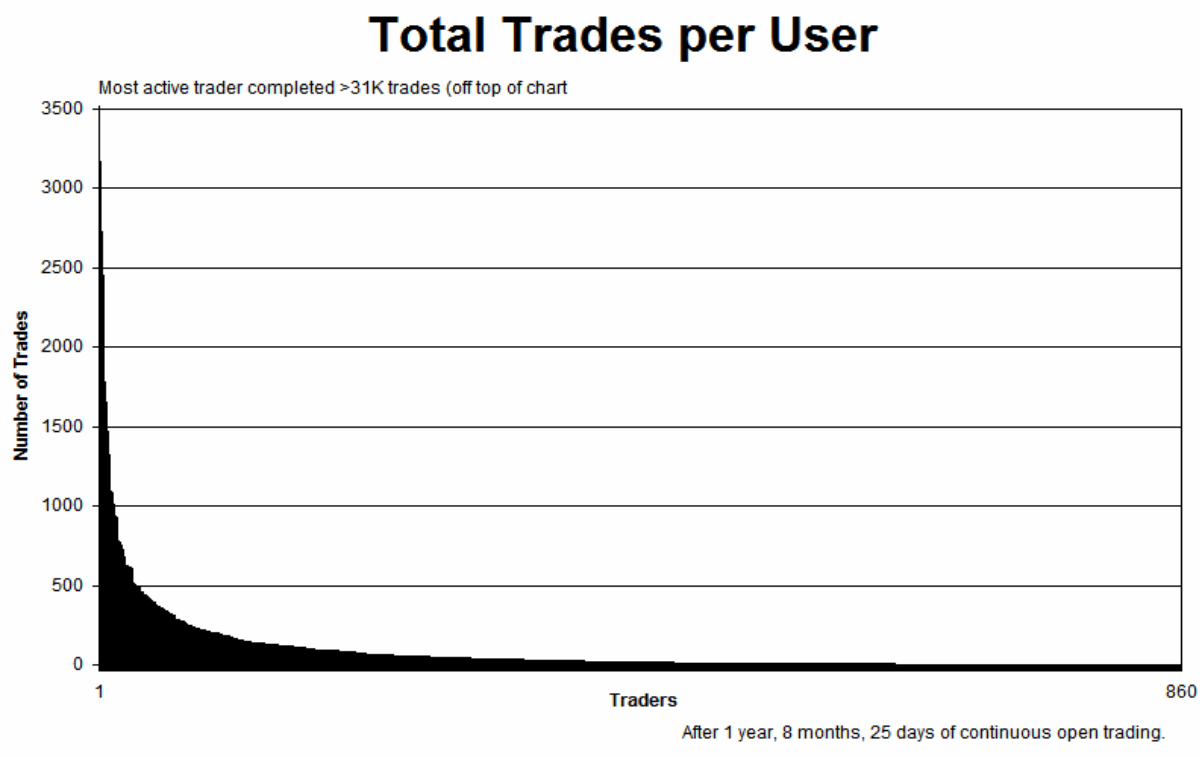


Exhibit 3 (continued)





Source: Google.

Exhibit 4 Text of Cowgill's Speech on Prediction Markets

Today I'm going to be talking about how operators of predictive markets can best encourage participation. I don't think that rewards—even cash rewards—are adequate to induce participation. Market operators should focus more on social rewards and the infrastructure and processes to deliver them.

In the classic view of prediction markets, financial self-interest drives participation. In this view, confidentiality is a good thing because it allows unpopular views to be heard. Lastly, the information coming from this market comes entirely in the form of prices and prices only.

I'd like to take issue with all of these points, and then propose solutions. First, it isn't as easy to drive participation using economic self-interest as one might think. There are several reasons why prizes do not motivate people to participate—even when you're using cash prizes.

The first reason is complexity and uncertainty. To avoid regulation as gambling, prediction market operators must create complicated payoff mechanisms that are difficult for players to understand. Payoffs often depend not only on whether the user has made correct predictions, but also on how other players bid and how many other players participate at all.

The larger reason is that expected payoffs are low. Suppose there is a $40K cash reward for the winner among 1,000 participants. Those odds are much more generous than anything I've seen in the real world. Still, I'm not sure how much participation this would motivate. Without knowing more about how well you will perform, the expected value is about $40. For the markets to work best, traders must be constantly engaged and updating the markets as new information arrives. Is $40 enough to encourage that type of monitoring if you're a busy, well-paid professional making over $100K annually? I don't think it is. And in reality, the odds are often worse.

As a side note, I don't think the same psychological dynamics would apply if people could use their own money. That's not the world we're living in, though. So I believe the answer is in rewarding participants with some form of reputation system.

This should involve a prominent leader board for participants in the market—ideally displayed on the company's intranet homepage. Perhaps there can be several different categories of winners. Each employee's listing in the company directory should include his or her ranking or holdings in the system. Data from an HR database could show participants which teams, job functions, or management levels are performing best in the markets. This would not only help market liquidity but also foster camaraderie among teams. Management should bestow additional public honors to the best traders.

In a large company, a reputation system will encounter problems. It is hard for employees to care about their ranking if it is in the thousands—even if they are ranked relatively high. The market software should allow users to define a group of peers for comparison purposes. Employees might choose friends, coworkers, people who started with them, or anyone else they compare themselves with. The software could pre-populate this list with people in the employees' team, department, starting class, or frequent meeting or e-mail contacts.

In addition, the market should provide each player his or her own profile page—complete with picture and introduction—where his or her best trades can be displayed. Market operators are making a mistake by embracing confidentiality too much. Confidential trading

prevents traders from proudly sharing their accomplishments. How often inside corporations do you hear some variant of "I told you so?" How often are people thinking it who aren't saying it? There is demand among employees to be able to take credit for accurate predictions on particular projects. To drive participation, market operators need to give employees the tools they need to share their predictions.

Future generations of corporate prediction markets should make confidentiality optional and disclosure by default. One hybrid way of gaining the benefits of both confidentiality and openness is: Create an option by which trades are confidential until the market closes, at which time money-earning shares are displayed. This would allow traders to share their accomplishments without creating copycat traders while the markets are open.

Being able to see who bet how could make the markets more interesting to watch and participate in. In addition to sharing the financial dimensions of trades, the market should allow traders to append an explanation. This, too, should be shared on a voluntary basis. It would show the world that the trader's fortune was the result of true insight and not fortuitous happenstance.

Adding trade explanations would also help make the market more useful from management's perspective. Without explanations for trades, it is hard for markets to have faith in what the market is saying. To make explaining as easy as possible, traders could be shown a list of reasons that other traders or observers have already submitted. Rather than typing a new explanation, they could select an existing explanation (or set of explanations) to attach to their orders.

I would like to end on a story that I think demonstrates the superiority of a reputation-based rewards system. This year, the World Cup finals happened right on the edge of the second and third quarters of 2006. So that we could keep these markets open a long time, we included the World Cup in the second-quarter contest. We left these markets open about a week into Q3 and promptly closed them and opened Q3 markets as soon as the World Cup was over.

As a result, people didn't have much time to see their final rankings. E-mails came pouring in asking to see their final ranks and about who would get a T-shirt. Because of other commitments, I didn't get around to identifying the T-shirt winners until later, but in the meantime e-mails were pouring in. When I finally sent out the winners e-mail, I accidentally forgot to announce who won our seven large cash prizes. Not a single person noticed. In the meantime, the e-mails continued coming in about when the shirts would be delivered.

A few weeks later, someone finally wrote in. "You said my rank was above 20, but I didn't get a shirt," the person said. Upon investigation, I learned that I removed this person from the shirt list because he also won the cash prize. I realized I hadn't identified the cash prize winners. The only reason I even knew about it was because of someone's concern about shirts!

Next, I again became caught up in other work and didn't deliver the cash prizes for almost a month later—and nobody spoke a word in the meantime. The point is that the traders didn't seem to care about the cash prizes at all. Instead, people wanted to know about reputational prizes—their ranking in the system and the shirts that would identify them as winners. Thank you very much, and if you have more questions we can talk during the break.

Source: Google.