Searching for Google's Value:

Using Prediction Markets to Forecast Market Capitalization Prior to an IPO

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Abstract

Difficulties in predicting post-IPO market values often result in under-pricing and, consequently, under-utilization of capital markets. More accurate forecasts of post-IPO valuations may help solve this problem. The Google IPO was unique in using an auction to try to create stable prices "in the days following the IPO." Still they underpriced their IPO by 15% (>$300 million in funds raised). We propose that prediction markets can help set IPO prices to avoid under-pricing and analyze a real-money prediction market conducted prior to Google's IPO. Google could have used this market to set an IPO price much closer to its post-issue market price.

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The recent Google initial public offering (IPO) was closely watched and unique. A search of Lexis/Nexis for the words "Google" with "IPO" or "initial public offering" within 25 words, yields 769 hits between October 24, 2003 (when the IPO is first mentioned in the *Wall Street Journal*) and August 19, 2004 (when trading in the stock commenced). Google's IPO was unique because the use of an auction mechanism to help set the IPO price is uncommon in the U.S. The stated goal was to set an IPO price close to the ensuing market price. Evidence from the French stock market (Derrien and Womack (2003)) suggests an auction mechanism may have helped Google achieve this goal. However, Google's IPO price fell short of both its opening and its closing market prices on the first day of trading by just over 15%, an amount close to the average initial under-pricing of 15.3% for US IPOs according to Jenkinson and Ljungqvist (2001) p. 27) and somewhat higher than the 11.9% average underpricing reported by Smart and Zutter (2003) for IPOs of companies with dual-class shares (like Google) between 1990 and 1998.

Initial under-pricing of IPOs is endemic. Jenkinson and Ljungqvist (2001) show that the effect holds internationally and averages 15% in developed countries. This underpricing represents the largest corporate cost of issuing securities.[1] If companies could set IPO prices closer to ensuing market prices, they would achieve substantially higher net IPO proceeds, less dilution and perhaps both. In this paper we analyze a prediction market designed to forecast market capitalization of a company at the close of the first day of trading in the newly issued securities.

Prediction markets are futures markets with contracts designed specifically to aggregate information about a future event. Though other markets have a predictive component (e.g., futures markets), prediction markets are designed specifically for forecasting purposes. Their payoffs are tied directly to the future event of interest (in this paper, Google's eventual market capitalization) and they have several design features which encourage revelation of true underlying expectations.[2] Prices in prediction markets provide forecasts about features of the associated event, for example its probability of

occurring or the consequences of its occurrence. The most well-known prediction markets are the Iowa Electronic Markets (IEM for short, reviewed in Berg, Forsythe, Nelson and Rietz (2003)), which have been used for more than 16 years to forecast election outcomes, other political and economic events, prices and returns of stocks, corporate earnings and movie box office receipts. These markets have proven remarkably accurate in both the short run (Berg, Forsythe, Nelson and Rietz (2003)) and the long run (Berg, Nelson and Rietz (2003)). This accuracy stems in part from the fact that the IEM are the only futures markets in the United States designed for experimental and research purposes that use real money.

The IEM conducted two prediction markets designed to predict the market value of Google at the close of the first day of trading after the IPO. If markets such as these generate accurate predictions, companies could use the forecasts to set IPO prices that avoid under-pricing. The benefits could be substantial. For example, in their IPO, Google issued 19,605,052 shares at $85 per share, for a total of $1.67 billion. Had they issued the same quantity at the next day's opening price of $100.01 or closing price of $100.34, the difference would have been about $300 million in total proceeds (without including the over-allotment option). This difference affected more than just the company's coffers. Of the 19,605,052 shares sold, existing shareholders sold 5,462,917 shares (without the over allotment option). Assuming the same percentage spread for investment bankers, the underpricing shorted these shareholders by over $81 million relative to closing prices the next day (without the over allotment option). Assuming the same spread, investment bankers shorted themselves by more than $8 million.[3]

The IEM Google IPO prediction markets performed well, especially considering that this is a new area for prediction markets and that complicated and unique factors surrounded Google's IPO. The night before Google filed its final prospectus, the more active and liquid of the two IEM prediction markets forecasted $104.34 as the closing price of Google's stock after the first day of trading.[4] Google stock actually closed at $100.34, only $4.00 or 3.8% below our prediction. In contrast, the closing price was $15.34 or 18.0% higher than the IPO price.[5] Had Google set the IPO price closer to the prediction market forecast, they could have raised significantly more money for the company and its shareholders.[6,7]

I. History of the Google IPO

A. Timeline of Events

Google's potential IPO was first reported by the *Wall Street Journal* on October 24, 2003. The *Journal r*eported that Google had contacted an investment banker and that an IPO was under consideration for 2004. Speculation about the IPO continued until the initial filing with the SEC on April 29, 2004 (SEC file number 333-114984). Google filed nine amended prospectuses. Its final prospectus was approved on August 18, 2004 and officially filed the next day. Table I lists the filing dates and summarizes major changes included in each amendment.

The initial filing contained little information about quantities of shares.[8] There was no initial price range and there was no target IPO date. The fourth amended filing on July 26 supplied projected share quantities, the initial price range ($108 to $135) and an August target IPO date. Quantities were revised in Amendment 5 on August 9 and in Amendment 9 on August 18. Amendment 9 also adjusted the initial price range down to $85-$95. The final prospectus, declared effective on August 18 and filed on August 19, set the IPO price at $85. On August 21, the San Francisco Chronicle reported that the underwriters had exercised the full over-allotment option to purchase 2.94 million more shares.[9] Google stock closed at $108.31 on August 20, even with this exercise.

B. Unique Features and Stated Goals of the Google IPO

Instead of using the usual bookmaking process to determine the IPO price, Google used an auction process.[10] The auction mechanism was similar to a second price auction: there would be a single market price with all bids above that price receiving shares at that price. However, unlike a second price auction, Google reserved the right to set the market price below the market clearing price, creating excess demand. In such a case, bid quantities would be used to determine actual shares allocated to successful bidders using one of two pre-specified apportionment rules. The Google IPO auction opened on August 13 and closed on August 18.

While IPO auctions are common in other countries[11] and the potential of using the Internet to dis-intermediate U.S. IPOs has been discussed (e.g., Jenkinson and Ljungqvist (2001) p. 9), the use of an auction mechanism for an IPO of this size in the United States is novel. The major features of this process were outlined in the initial filing on April 29 and refined throughout the amended filings. The stated goal of the auction process was to set "an initial public offering price that results in the trading price for our Class A common stock not moving significantly up or down relative to the market in the days following our offering" (page 28 of the initial S-1 filing); "to have a share price that reflects a fair market valuation of Google" (page v of the initial S-1 filing); and to avoid "boom-bust cycles" (page v of the initial S-1 filing).[12] Thus, the goal appears to have been to set the IPO price near the actual market price in the days following the IPO, avoiding the typical under-pricing that characterizes most IPOs. This would be beneficial for Google. The typical 15% under pricing of IPOs in the United States and other developed countries (Jenkinson and Ljungqvist (2001)) leaves a great deal of money on the table.[13] If companies could set IPO prices closer to eventual market prices, they would raise substantially more money and/or incur substantially less dilution on average.

While an auction process was used to gauge interest from potential shareholders and, with sufficient confirmation, used to generate binding orders for shares, it was not, strictly speaking, an auction of shares. For example, Google and its underwriters retained the right to reject bids they found manipulative or disruptive at their sole discretion without notifying bidders who submitted these bids. Moreover, the prospectus clearly states that the IPO price need not be the auction clearing price. Page 38 of the amended S-1 filing on August 13, 2004 (the day the auction began) states (emphasis added):

> The initial public offering price will be determined by us and our underwriters after the auction closes. We intend to use the auction clearing price to determine the initial public offering price and, therefore, to set an initial public offering price that is equal to the clearing price. ***However, we and our underwriters have discretion to set the initial public offering price below the auction clearing price.*** We may do this in an effort to achieve a broader distribution of our Class A common stock or to potentially reduce the downward price volatility in the trading price of our shares in the period shortly following our offering relative to what would be experienced if the initial public offering price were set at the auction clearing price.

As a result, the IPO price could fall below the actual auction market clearing price. This possibility required a potential allocation mechanism in which bidders would not receive the full number of shares for which they bid. Two allocation mechanisms were described in the prospectus, with the decision about which would be used left to management discretion. This inhibited the truth-revealing properties of what would otherwise have been an incentive-compatible, truth-revealing, second-price auction. Bidders may have had incentives to overstate quantities at given prices. Thus, the IPO price was not necessarily the auction market clearing price and, further, the auction market clearing price did not necessarily reflect the true underlying beliefs of bidders.

These factors actually made the auction process quite similar to the usual book building process followed in the U.S. where underwriters retain "considerable discretion" in setting price (Jenkinson and Ljungqvist (2001) p. 18). Since the auction order book and clearing prices have not been made public (in accordance with prospectus rules), we do not know how much "discretion" may have been exercised and how far the IPO price may have been set below the auction market clearing price. Nor to we know how close the auction market clearing price may have been to eventual trading prices.

We do know that the IPO price was set below the market clearing price. According to their prospectus, if Google had set the IPO price equal to the auction market clearing price for the shares offered plus the over allotment, they would not have rationed shares. If they set the price lower than the auction market clearing price, they would have rationed shares using one of two mechanisms (pro rata or maximum share allocation). On August 20, a *Wall Street Journal* article (Lucchetti, Sidel and Simon, 2004) reported that Turner Investment Partners bid for 1 million shares at $85 per share and received only 700,000 or 70% of their bid. Internet reports (e.g., Kawamoto and Olsen (2004), www.buygoogle.com, 8/19/04 and messages at the Google Stock discussion board at http://www.google-ipo.com/) suggest that small bidders were also rationed and put the percentage at up to 75%. This indicates that Google used the pro rata allocation process. This would mean that the quantity they sold including the over allotment option (22,545,809 shares) was 70%-75% of the total bid quantity at the $85 price. This would imply total bids of 30,061,079 to 32,208,299 shares at or above $85 per share (i.e., an excess demand of 33.3%

to 42.9% of the quantity sold).[14] While we do not know the slope of the demand function, one might speculate that either number indicates considerable underpricing.[15]

Whether an auction mechanism could have been used to set a price equal to the ensuing open market value (we do not know) and whether Google and its underwriters actually used it to do so (they appear not to have), or whether there was another means of setting the IPO price equal to the eventual market value, could have made a difference of hundreds of millions of dollars.[16]

II. The Iowa Electronic Markets Google IPO Markets

A. Description

The Iowa Electronic Markets conducted two markets associated with the Google IPO. Both markets traded contracts with liquidation values based on the total market capitalization implied by the closing price of Google stock at the end of the first day of trading. The market structure was the same as other IEM markets. Since descriptions of IEM markets are available elsewhere, our description of them will be brief.[17]

Investors invest their own money in the market (initial investments can range from $5 to $500) and reap the real money benefits or pay the real money costs associated with their trading activities and contract holdings at liquidations. Each market is organized as a continuous, electronic, multiple-unit, double auction. Traders can submit bids or asks (place limit orders and act as market makers) and accept outstanding bids or asks (place market orders and make trades) at any time.[18] Bids and asks are kept in queues ordered by price and time. Traders can set their own bid and ask expiration dates and withdraw any bids or asks that have not yet traded. Traders can buy or sell risk-free sets of contracts (one of each contract in the market at a fixed price of $1, called “fixed price bundles”) from or to the exchange at any time. They can trade individual contracts purchased as parts of bundles. Finally, they can trade bundles at market prices (selling at the sum of the best bid prices or buying at the sum of the best ask prices). At all times traders see the best available bids and asks for all contracts, and they can retrieve histories of

daily trading summaries (daily high, low, last, and average trade prices as well as volume in both units and dollars).

The IEM Google contracts expired after the first day of trading following the Google IPO. Contract liquidation values were tied to Google's market capitalization at the end of the first day of trading in its public shares. As a result, we can build forecasts of Google's capitalization using IEM market prices. We used these forecasts, the quantity of stock issued, the IPO price of Google and the first-day closing price of Google to:

(1) judge whether the forecasted market capitalization was close to the actual capitalization;

(2) determine whether the forecasted market capitalization was closer to the actual capitalization than that implied by the IPO price;

(3) determine the impact of announcements or news on the forecasted capitalization during the course of the prediction market and

(4) learn about how and when the price formation process aggregated information for these markets.

In addition, the combination of the two markets we conducted allows us to generate two different forecasts for Google's market capitalization, compare them and analyze whether contract structure matters for prediction markets.

1. The Google Linear Market

The Google Linear market opened on June 29, 2004 with two contracts.[19] Contract liquidation values were determined as follows:

Contract	Contract Liquidation Values
IPO_UP	= $0 if the IPO does not take place by March 31, 2005; = (Market Cap.)/$100 billion if $0 bil. < Market Cap. <= $100 bil; = $1 if Market Cap. > $100 bil.
IPO_DN	= $1 if the IPO does not take place by March 31, 2005; = ($100 bil.-Market Cap.)/$100 billion if $0 bil. < Market Cap. <= $100 bil; = $0 if Market Cap. > $100 bil.

In the absence of hedging demand, prices should equal expected values in this market.[20] Thus, the price of IPO_UP times $100 billion is the IEM's forecast of the market capitalization of Google stock after the first day of trading according to the closing market price.[21]

Figure 1 shows the normalized prices of the IPO_UP contract.[22] Trading in the Google Linear market was light.[23] From July 8, the first day after which all contracts had traded, through August 17, the day before the final registration statement was filed, 143 contracts traded. There was no discernable trend in prices. The lowest normalized closing price for the IPO_UP contract was $0.248 and the highest was $0.375, implying a forecasted market capitalization of $24.8 to $37.5 billion. On August 18, the date the prospectus was declared effective, trading volume was 228 contracts and the normalized closing price was $0.267 implying a predicted market capitalization of $26.7 billion. While the market capitalization according to the August 18th IPO price was considerably below this (23.1 billion), the market capitalization at the open on August 19th was 27.1 billion. It closed at 27.2 billion.

2. The Winner-Takes-All Market

The Google Winner-Takes-All (WTA) market opened on June 29, 2004 with six "interval" contracts.[24] Liquidation values of the initial contracts were determined as follows:

Contract	Contract Liquidation Values
IPO_0-20	$1 if market cap is less than or equal to $20 billion or if the IPO does not occur by March 31, 2005.
IPO_20-25	$1 if market cap is greater than $20 billion but less than or equal to $25 billion.
IPO_25-30	$1 if market cap is greater than $25 billion but less than or equal to $30 billion
IPO_30-35	$1 if market cap is greater than $30 billion but less than or equal to $35 billion
IPO_35-40	$1 if market cap is greater than $35 billion but less than or equal to $40 billion
IPO_gt40	$1 if market cap is greater than $40 billion.

On August 5, the IPO_gt40 contract was split into three contracts: IPO_40-45, IPO_45-50 and IPO_gt50 each with a $1 payoff in the associated capitalization range. At the split, traders holding IPO_gt40 contracts received 1 share of each of the three new contracts in exchange for each IPO_gt40 contract they held so that they incurred neither a gain nor loss in expected value from their previous portfolio position. Again, in the absence of hedging demand, prices should equal expected values in this market (see

footnote 20). Expected value pricing implies that the price of each contract should equal the probability that actual market capitalization will be in the associated capitalization range (E(value)=p×$+(1-p)×$0=p, where p is the probability of being in the range). Thus, at each point in time prices map out discrete parts of a forecast distribution for future market capitalization.

Trading in the Google WTA market was much heavier than in the linear market.[25] From July 8 through August 17, 3,021 contracts traded. Figure 2 shows prices of the WTA contracts in an area chart. Each band corresponds to one contract. The width of the band is the normalized price of the contract. Each contract price is interpreted as the probability that Google's market capitalization will be within the associated range (in billions of dollars) after the first day of trading. The sum of normalized prices (probabilities) equals 1. The actual first-day, closing market capitalization of Google was $27.2. The median of the predicted distribution was in the range corresponding to the actual market capitalization from August 8 through the end of the market on August 17.

As news came out, various IEM contracts changed in price. Late in the market (around August 10), IPO_25-30 and IPO_30-35 emerged as the most likely outcomes and the median of the distribution fell in the 25-30 billion range (as shown in Figure 2). On August 18, the volume of trade on the IEM Google WTA market was 3,148 contracts. Prices collapsed to less than $0.05 for all but the IPO_20-25 and IPO_25-30 contracts, and most queues were cleared.

B. Analysis of correlation of predictions across markets

The WTA markets can also be used to derive a forecast for market capitalization. In its simplest form the WTA price vector is a vector of risk-neutral probabilities of six events (and after August 4, eight events). Knowledge of the CDF of a random variable allows one to calculate any moments of interest. However, because the highest interval (greater than $40 billion prior to August 4 and greater than $50 billion afterwards) is unbounded above, some assumption must be made abut the distribution of outcomes in this range when this contract trades above a zero price. For this reason, we assume that at any point in

time, *t*, the future (unknown) capitalization is distributed log normally with mean μ_t and standard deviation σ_t. We further assume that the probability of no IPO equals zero.[26]

Intuitively, we assume that the normalized closing prices of contracts on date *t* reflect estimates of the probabilities of observing outcomes in each range each day. For given μ_t and σ_t, integrating the log normal distribution over each range yields probabilities of being in each range, resulting in predicted frequencies. We derive estimates of the distribution mean and standard deviation by minimizing the distance between observed and predicted frequencies.

Formally, assume there are *K* securities traded each day and that they have a payoff, X_i, of

$$\begin{aligned} X_i \quad &= \$1 \text{ if } Z_{i-1} < \text{Market Capitalization (MC)} \le Z_i \\ &= \$0 \text{ otherwise} \\ &\text{for } i = 1,...,K \end{aligned} \tag{1}$$

For concreteness assume that Z_0=0 and that $Z_K = \infty$. The probability that market capitalization (MC) lies in interval *i* is

$$P_t(\theta_t) = F(Z_i \mid \theta_t) - F(Z_{i-1} \mid \theta_t) \tag{2}$$

where *F* is the cumulative distribution function of the random variable MC. One of these securities is redundant because both the normalized prices and actual probabilities of being in each range always sum to 1.

On date *t*, the log normal distribution parameter vector is characterized completely by the mean, μ_t and the standard deviation σ_t (i.e., $\theta_t=(\mu_t,\sigma_t)$). Because there are $K>2$ securities traded, it is possible to estimate the parameter vector θ_t for each trading date, *t*. There are several methods that could be used to estimate θ_t. We chose a minimum χ^2 criterion as the method, although we also estimated the parameters using generalized method of moments and maximum average log likelihood criterion to see if any significant differences existed. None were found.

Specifically, for each day, denote the objective function as $V(\theta_t)$ and solve the following for the estimates of μ_t and σ_t:

$$\hat{\theta}_t = \underset{\theta_t}{ArgMin}\, V(\theta_t) = \sum_{i=1}^{K} \frac{(p_{i,t} - P_i(\theta_t))^2}{P_i(\theta_t)} \tag{3}$$

where $p_{i,t}$ is the price of security i (or market based probability forecast for range i) on date t and $P_i(\theta_t)$ is its expected value according to the estimated log normal distribution.

Figure 3 shows the expected market capitalization estimated from the WTA prices each day. We also include the predicted market capitalization from the linear market in Figure 1 for comparison. The forecasts from the WTA market follow the linear market forecasts fairly closely.[27] Their correlation is 0.71. The WTA low forecast was $23.2 billion and the high was $36.5 billion (compared to $24.8 billion and $37.5 billion from the linear market). On August 18 (the day of the final S-1 filing), several WTA contract prices fell to zero, which made identification of the two parameters imprecise without finer contract intervals (i.e., we cannot estimate the parameters precisely when all or nearly all of the forecast distribution lies in one interval). However, from August 11 through August 17, the estimates of market capitalization fell between $28.2 and $28.9 billion and closed at 28.3 billion on August 17.

In Figure 4, we plot the estimated volatility of the WTA market forecast ($\hat{\sigma}_t$). Implied volatility (i.e., uncertainty about the market capitalization forecast) falls dramatically as the IPO date approaches. Volatility, measured by the estimated standard deviation of the logarithm of forecast market capitalization, declined by about two thirds from its high point (the day after the market opened) to the day before of SEC final approval.

III. Results

Our results are straightforward. First, at any point in time, the predicted market capitalizations are similar across the two IEM prediction markets. They are highly correlated even though the different contract structures and thin trading in the linear market make inter-market arbitrage difficult at best. While predictions in the two markets are similar, the higher trade volumes give us greater confidence in the WTA predictions.

Second, the predictions were quite accurate. Inaccurate early predictions would not be surprising. As noted above, there was little information about quantities of shares and price ranges in early versions of the prospectuses. Nevertheless, from July 8 (the first day after which all contracts had traded) through July 25 (the day before the filing of Amendment 4, which contained the first estimates of share quantities and price ranges), forecasted market capitalization from the WTA market ranged from $23.2 to $32.1 billion with an average of $29.0 billion. This is higher than most independent estimates reported in the press. While two news reports forecast a maximum market capitalization of Google at $30 billion, typical reports forecast a max of 20-25 billion.[28] Actual market capitalization on the close of the first day of trading (August 19) was $27.2 billion, only 6.16% less than the average prediction over this early forecast period. By the next day, market capitalization had risen to $29.4 billion, significantly closer to the IEM forecast, even after the exercise of the over allotment option.

After Amendment 4 was filed on July 26, the IEM forecasted market capitalization rose, likely in response to the relatively high preliminary price range ($108-$135 per share). However, it had fallen to $30.4 billion by the date of the 5th Amendment (August 9) and to $28.3 billion by the date of the 6th Amendment (August 11). From August 11 through August 17, the IEM forecast ranged from $28.2 to $28.9 billion and averaged $28.5 billion, just 4.8% above the actual August 19 capitalization of $27.2 billion (a price of $100.34 per share). The closing price the night before the final filing forecasted a market capitalization of $28.3 billion and, given the number of shares in the prospectus, a market price of $104.34. The actual closing market capitalization was only 3.84% less than this final IEM forecast. Given the apparent difficulty in forecasting eventual market capitalization of IPOs, we think this is remarkably accurate.[29]

Third, setting IPO prices according to predictions would make a substantial difference. Table II shows the difference it might have made. Google actually set an IPO price of $85, implying a market capitalization of $23.1 billion. The closing market price and market capitalization were 18% above this after the first day of trading. According to the final prospectus, Google sold 14,142,135 shares and existing shareholders sold 5,462,917 shares for a total of 19,605,052 total shares at a net price of

$82.6161. At the IPO price, Google raised $1,168.4 million for itself and selling shareholders received $451.3 million (Table II, column 1). Had Google managed to set the price equal to the closing price on the first day and sold the same number of shares and paid the same percentage spread to investment bankers, Google would have raised $1,379.2 million (or $210.9 million more) for itself and Google's existing shareholders would have received $532.8 million (or $81.5 million more), without the exercise of the over-allotment option.[30] Adding the difference in investment bank proceeds brings the total difference to $300.7 million that was clearly "left on the table" (see calculations in Table II, column 4). Had Google set its IPO price at the IEM forecast and managed to sell the same number of shares (which seems likely, as discussed above), the total foregone proceeds increases to $37.29 million (calculations in Table II, column 5).[31]

IV. Conclusions

Given the initial under pricing of IPOs, companies have incentives to set IPO prices closer to ensuing market values. Under-pricing results in lost IPO proceeds and greater dilution, and typically represents the largest cost of the issue.

There are a number of mechanisms that may help firms set IPO prices closer to market values. Here, we discuss using a prediction market to do so. The results from a unique set of prediction markets designed to predict Google's market capitalization at the end of its first day of trading and conducted in advance of the Google IPO suggest that prediction markets can be successful in forecasting post-IPO values of stocks. This result held for Google even before many aspects of the issue (e.g., the number of shares, initial price range indications, etc.) were revealed.

Why might prediction markets be able to forecast market capitalizations and, as a result, allow companies to reduce the costs of initial underpricing? At one level, given the pervasive underpricing, one might argue that prediction markets may perform well by simply forecasting a market capitalization higher than that predicted using the indicated preliminary price ranges from the prospectus. However, since IEM prices predicted well even before preliminary price ranges and share quantities were available,

evidence from the Google markets suggest that traders do more than simply forecast above preliminary price ranges from the prospectus. Why might this be possible? Recent evidence suggests that the degree of underpricing may be predicted from publicly available information that underwriters and/or companies do not build into prices (e.g., Bradley and Jordan (2002)). Participants in prediction markets may be able to incorporate this information with out the biases and conflicts frequently hypothesized to affect both firms and investment bankers.

Some issues cause difficulties for prediction markets. For example, expected value pricing in such markets depends on traders not using the markets for hedging purposes. Significant hedging demand could drive prices away from fundamental values that markets are trying to forecast. But this simply means that a model of hedging demand needs to be grafted onto market prices to reveal true probabilities. Other mechanisms have the potential to be even better for determining IPO prices. A "when-issued" market for the stock (similar to the when-issued Treasury market) would work in a manner similar to prediction markets and would give a more direct measure of traders' willingness to pay for IPO stocks. However, a when-issued market would probably require that the company determine in advance many more items in the prospectus (e.g., quantities issued) than Google did and may face regulatory constraints. Another alternative would be a direct auction to the public. Appropriately designed, auctions can be incentive compatible and truth revealing. However, auctions are often afflicted by the winners curse.[32]

Given the difficulty in determining IPO prices that reflect true market values and the large stakes involved, we suggest that all of these potential means of determining IPO prices are worthy of further study.

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Footnotes

[1] Chen and Ritter (2000) document that underwriting fees seldom rise above 7% and are considerably below 7% for large IPO's.

[2] Some of these design features are discussed later in this paper.

[3] Including the over allotment option increases the difference in total proceeds to nearly $346 million, shorting existing shareholders by more than $125 million and investment bankers by nearly $10 million. All figures quoted here come from Table II, which will be discussed later.

[4] This is the final, August 17, 2004, forecast from the Winner-Takes-All market computed as discussed in section II.B of the text.

[5] This corresponds to 15.3% under-pricing: (85-100.34)/100.34 = -0.153.

[6] While we cannot know for certain, the trading activity in the days immediately after Google's IPO suggests that Google could have issued the full allotment of shares (including the overallotment option) at prices at or near the IEM prediction (104.13). The closing price on the second day of trading (after the public announcement that the entire overallotment option had been exercised) was $108.31. In addition, evidence suggests considerable underpricing relative to what would have been Google's auction market clearing price for their pre-IPO auction and there was considerable excess demand at the IPO price. See section I.B in the text and footnote 15.

[7] While we would like to compare our forecast to Google's auction clearing price, we cannot. The order book and, hence, the market clearing price has not been made public (which accords with the rules stated in their prospectus).

[8] Missing were the total quantity of shares expected after the offering, the number sold to the public by the company, the number sold by existing shareholders, the size of the over allotment option and the numbers of shares subject to various lock up rules. While the joint issue of new shares and sales by existing shareholders may seem unusual, Jenkinson and Ljungqvist (2001, p. 3) point out that "many" IPOs share this feature.

[9] According to prospectus rules, these shares could be purchased by the investment bankers from pre-IPO shareholders (at a net price of $82.6161) only to cover shorts created in the IPO (sold to the public at $85).

[10] Interested readers can obtain details of the Google auction process from the prospectus available from the SEC through EDGAR (http://www.sec.gov/edgar.shtml) by searching for file number 333-114984.

[11] According to Jenkinson and Ljungqvist (2001) they have been common in Israel, England (in the 1980's), and Japan (in the 1990's). France uses a mixture of auctions and bookmaking.

[12] To further emphasize this objective , the prospectus and amendments also state "Our goal is to have an efficient market price—a rational price set by informed buyers and sellers—for our shares at the IPO and afterward. Our goal is to achieve a relatively stable price in the days following the IPO" (on page v of the initial S-1 filing).

[13] One might argue that, because of its pervasive nature, underpricing is an equilibrium phenomenon under current IPO mechanisms. That may be. Jenkinson and Ljungqvist (2001) summarize a variety of arguments that underpricing may solve various information asymmetry and incentive problems. In fact, other mechanisms (e.g., Google's auction, when-issued markets, prediction markets, etc.) may solve some of these problems. The specific reasons for underpricing and potential solutions are beyond the scope of this paper. Here, we merely ask if prediction markets *could* forecast the eventual market price of an issue. If so, companies may be able to use them to set IPO prices closer to ensuing market prices. Whether companies would choose to do so would depend on the cost of underpricing versus the value of solving any information asymmetry and incentive problems that may remain in the presence of prediction markets.

[14] 22,545,809/0.75=30,061,079 and 22,545,809/0.70=32,208,299.
(30,061,079-22,545,809)/22,545,809=33.3% and (32,208,200-22,545,809)/22,545,809=42.9%.

[15] However, this does give us two points on the demand function. Investors were willing to buy about 30 million shares at a price of $85 according to the allocation information available. The next days opening price implied that they were willing to buy the actual 22.5 million shares (including the overallotment option that had been issued) at about $100. This gives us further evidence on the question: could Google have sold 19.6 million shares at the IEM suggested price of $104.34? The answer is yes. Solve for a linear demand curve (as an approximation) given the two points ($85, 30) and ($100,22.5). This gives a demand curve of $Q^D = 72.5$ million $- 0.5p$. Using the IEM suggested price of $104.34 yields a predicted sales quantity of 20.33 million > 19.6 million. A constant elasticity demand curve (fit to the same data points) gives a predicted sales quantity of 20.10 million > 19.6 million. Again, the available evidence suggests that the IEM implication of foregone revenues in the $380 million range is reasonable.

[16] Another possible reason for using the auction mechanism is to decrease underwriting fees. According to Google's final prospectus, underwriting discounts and commissions accounted for $2.3839 of the $85 offer price. Thus, fees were 2.8% of the offer price. Only one IPO in Chen and Ritter's (2000) data set on fees in IPOs approaches Google's size. The fees on this $1.3 billion IPO were 2.97%. The next two largest IPOs had fees of 4%. So, while fees for smaller IPOs typically average 7%, the fee here seems in line after considering IPO size. The auction may have allowed Google to more accurately assess demand and avoid the costs associated with over allotment options. However, Google's over-allotment option was exactly 15%, the "typical" amount in the U.S. according to Brealey and Myers (2003, p. 413).

[17] See Forsythe, Nelson, Neumann and Wright (1992), Berg, Forsythe and Rietz (1997) and Forsythe, Rietz and Ross (1999).

[18] This market was open to all traders, not just academic traders. Any person, worldwide, could become a trader by sending an investment to the IEM.

[19] The appendix contains the prospectus for this market.

[20] This argument can be made in numerous ways. For example, modern option pricing theory implies that prices should equal expected liquidation values according to the risk neutral distribution

discounted back at the risk free rate. Risk neutral probabilities are driven away from true probabilities by imbalances in hedging demand. The small size of these markets along with evidence on behavior and prices in political markets (e.g., Forsythe, Nelson, Neumann and Wright (1992), Forsythe, Rietz and Ross (1999) and Oliven and Rietz (2004)) suggest that hedging demands are not significant factors in determining prices. The risk free rate in these markets is zero because contract bundles (one risk free asset) and cash (the other risk free asset) both earn a zero return and can be freely exchanged for each other. As a result of these two factors, option pricing theory implies that prices should equal actual expected liquidation values at each point in time. Similar arguments (using the absence of systematic risk factors and a zero risk free rate) can be made using CAPM, APT or general equilibrium theory to get the same result. Whether prices actually reflect expected values is an empirical matter and the evidence suggests that they do in IEM markets in general (see, for example, Berg, Forsythe, Nelson and Rietz (2003) and Berg, Nelson and Rietz (2003)).

[21] Technically, we need two further assumptions to make this the forecasting relationship. We need to assume that the probability of no IPO before March 2005 is zero, which is consistent with Google's stated strong intention to issue in the summer of 2004. We also need to assume that the probability of a market capitalization greater than $100 is effectively zero. Below, we will estimate a distribution of expected market capitalizations from the other IEM market we ran. This distribution is consistent with essentially zero likelihood of a market capitalization above $100 billion.

[22] Note that the price of IPO_UP should equal 1 minus the price of the IPO_DN contract. However, due to asynchronous trading and bid/ask bounce, prices of IPO_UP and IPO_DN do not necessarily sum to exactly $1 at any given point in time. To adjust for this, we use normalized prices. The normalized price of each contract is the price of the contract divided by the sum of contract prices.

[23] While this is a concern, it does not necessarily imply an inefficient market. Prediction market research typically relies on higher volume markets with thick queues in the argument for efficiency (e.g., Berg, Forsythe and Rietz (1996)). However, experimental research suggests that even small double

auction markets (e.g., with as few as four traders) can converge to efficient outcomes (e.g., Smith, Williams, Bratton and Vannoni (1982)). Further, IEM prediction markets are similar to those modeled theoretically by Milgrom and Stokey (1982). We should see no trade according to their theory if traders have concordant preferences and are risk averse (which would make holding only cash and unit portfolios a Pareto optimal distribution). In this case, shadow prices would, nevertheless, be efficient.

[24] The appendix contains the prospectus for this market.

[25] This trading pattern also holds in our political markets, with much heavier trading in WTA contracts than in linear (vote share) contracts. See Berg, Nelson and Rietz (2003).

[26] The log normal distribution is uncontroversial while assuming that the probability of no IPO is zero is consistent with Google's stated strong intention to issue in the summer of 2004 and the long horizon on the contracts.

[27] A similar estimation procedure performed on data from the 2004 WTA Presidential Election markets on the IEM shows that estimates derived in this manner follow estimates from the linear market closely, but may be more stable. This evidence, combined with the higher volumes in the WTA market, leads us to have more confidence in the estimates from the WTA market.

[28] Wall Street Journal stories on 10/24/03, 4/23/04, 4/26/04, 4/28/04, 4/30/04 and 5/10/04 all capped the estimated market capitalization at $25 billion. A separate Wall Street Journal story on 4/30/04 stated only a $25 billion estimate. A Wall Street Journal story on 5/13/04 estimated the range to be $20 to $22 billion. Washington Post stories estimated the market capitalization at $15 to $20 billion on 1/13/04. Stories in the Wall Street Journal on 7/19/04 and the Washington Post on 5/2/04 both give a maximum of $30 billion. Later articles did not make independent capitalization estimates. Most articles simply quoted price and capitalization ranges that were derived from Google's own indicated price range and quantities as given in their prospectus.

[29] Given just these two markets, one might be tempted to argue that the IEM was simply "lucky." But the IEM experience with other prediction markets indicates that prediction markets do appear to forecast accurately.

[30] The entire over-allotment option was sold by existing shareholders. Had they sold the full over-allotment at the IEM predicted net price (assuming the same spread) instead of the actual $82.6161, existing shareholders would have made $158.0 million more than they actually did.

[31] We have already discussed how the excess demand information can be used to judge the likelihood that the same number of share could have been sold at the IEM predicted price (footnote 15). In addition, Google closed above the IEM forecasted price on the second day of trading and has risen above this level even after the exercise of the over allotment option had been made public.

[32] See Thaler (1992).

Tables

Table I: Filing Dates and Major Changes Included

In Amendments during the Google IPO Process

Date	Filing	Major Changes
4/29/2004	Initial Prospectus	
5/21/2004	Amendment 1	Filled in some warrant and option information Added underwriters Some adjustment in financial data
6/21/2004	Amendment 2	Modified some auction details Modified warrant and option information Some modifications to Risk Factors
7/12/2004	Amendment 3	Some additional details of auction mechanism Small change in purpose of offering Stock plan approved and reclassification of insider shares Applied for NASDAQ listing
7/26/2004	Amendment 4	Estimate 268,519,643 Shares after offering Estimate 24,636,659 shares for sale, offering 14,142,135 by company, 10,494,524 shares by selling stockholders, with over allotment option of 3,695,498 shares Range $108-$135 per share Approved for listing on NASDAQ, ticker GOOG Target date set for August Adjustment to warrant and option information Lock up period details revealed Some modifications to auction process June financial information available Change in underwriter list Added “road show” presentation
8/9/2004	Amendment 5	Increased shares for sale to 25,697,529 (increase from selling shareholders) Some modification to the auction process Yahoo settlement discussed
8/11/2004	Amendment 6	Slight changes in auction process and relationships with underwriters Added notes to financial statements regarding settlement with Yahoo
8/13/2004	Amendment 7	Adds potential fallout from Playboy interview to risk factors Entire text of interview added to notes Slight changes in auction process
8/16/2004	Amendment 8	Minor changes only
8/18/2004	Amendment 9	Reduced shares for sale to 19,605,052 (reduction from selling shareholders) Reduced over allotment option to 2,940,757 Reduced range to $85-95 per share and changed some example and pro-forma numbers accordingly Small adjustment in number of shares in lock-up Changed insider share distributions
8/19/2004	Final Prospectus	Set price at $85 finalizes pro-forma statements and examples accordingly Some changes in lock up periods Allocations to underwriters set Declared Effective

Table II: Potential Google IPO Prices and Proceeds

	Actual IPO (Column 1)	1st Day Close (Column 2)	IEM Prediction (Column 3)	1st Day Close - IPO Price (Column 4)	IEM Prediction - IPO Price (Column 5)	IEM Prediction - 1st Day Close (Column 6)
Google Share Prices						
IPO Price	$85.0000	$100.3400	$104.3416	$15.3400	$19.3416	$4.0016
Spread (@ 2.8%)	$2.3839	$2.8141	$2.9264	$0.4302	$0.5425	$0.1122
Per Share Proceeds to Google & Existing Shareholders	$82.6161	$97.5259	$101.4152	$14.9098	$18.7991	$3.8894
Quantities and Total Proceeds without Exercise of Over-Allotment Option (x1 mil.)						
Quantity Sold by Google	14.142	14.142	14.142	14.142	14.142	14.142
Quantity Sold by Existing Shareholders	5.463	5.463	5.463	5.463	5.463	5.463
Total Proceeds to Google	$1,168.3680	$1,379.2241	$1,434.2279	$210.8561	$265.8598	$55.0038
Total Proceeds to Existing Shareholders	$451.3249	$532.7758	$554.0230	$81.4509	$102.6981	$21.2472
Total Proceeds to Investment Bankers	$46.7365	$55.1710	$57.3713	$8.4346	$10.6348	$2.2002
Total Proceeds	$1,666.4294	$1,967.1709	$2,045.6222	$300.7415	$379.1927	$78.4512
Quantities and Proceeds with Exercise of Over-Allotment Option (x1 mil.)						
Quantity Sold by Google	14.142	14.142	14.142	14.142	14.142	14.142
Quantity Sold by Existing Shareholders	8.404	8.404	8.404	8.404	8.404	8.404
Proceeds to Google	$1,168.3680	$1,379.2241	$1,434.2279	$210.8561	$265.8598	$55.0038
Proceeds to Existing Shareholders	$694.2788	$819.5757	$852.2605	$125.2969	$157.9818	$32.6849
Proceeds to Investment Bankers	$53.7470	$63.4467	$65.9770	$9.6997	$12.2300	$2.5303
Total Proceeds	$1,916.3938	$2,262.2465	$2,352.4654	$345.8527	$436.0716	$90.2189

Figures

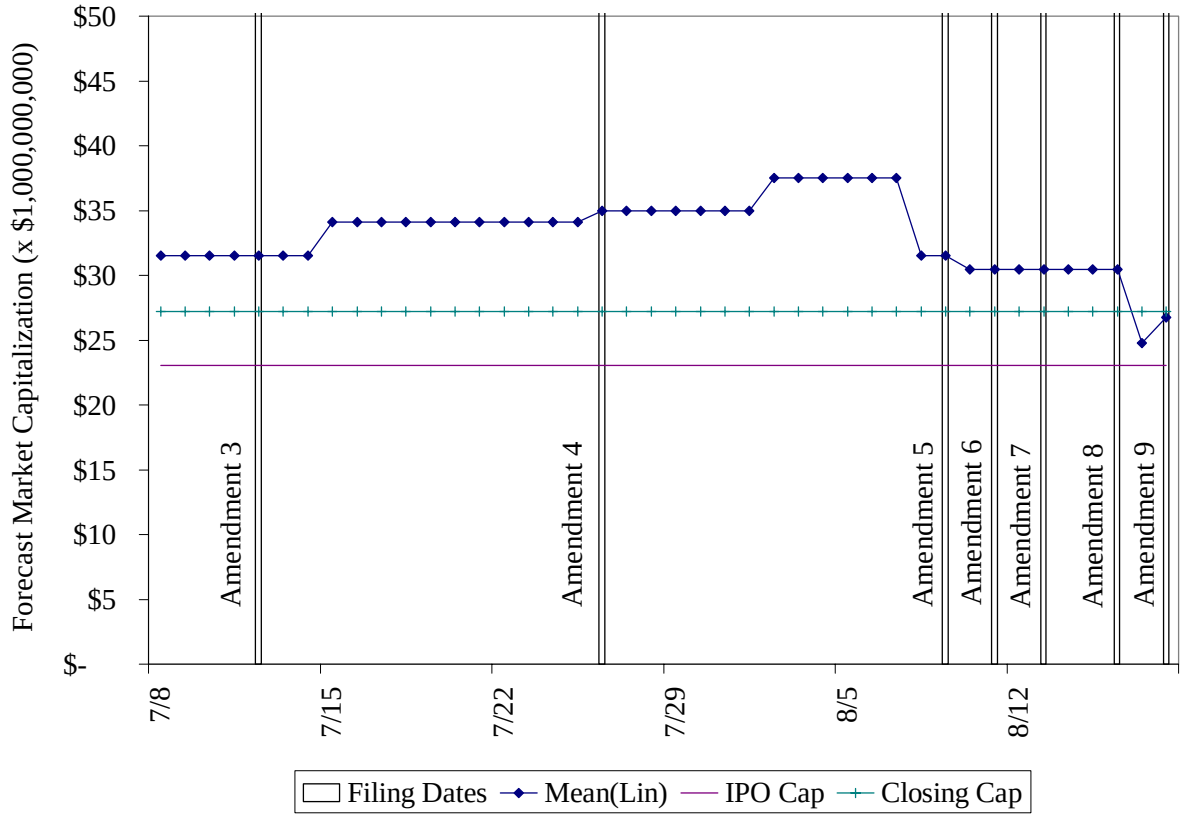

Figure 1: Predicted Google market capitalization from normalized closing prices in the IEM Google Linear Market (Mean(Lin)). For comparison the actual market capitalization according to the IPO price (IPO Cap) and first-day closing price (Closing Cap) are shown. For context, S1 amendment filing dates are also shown.

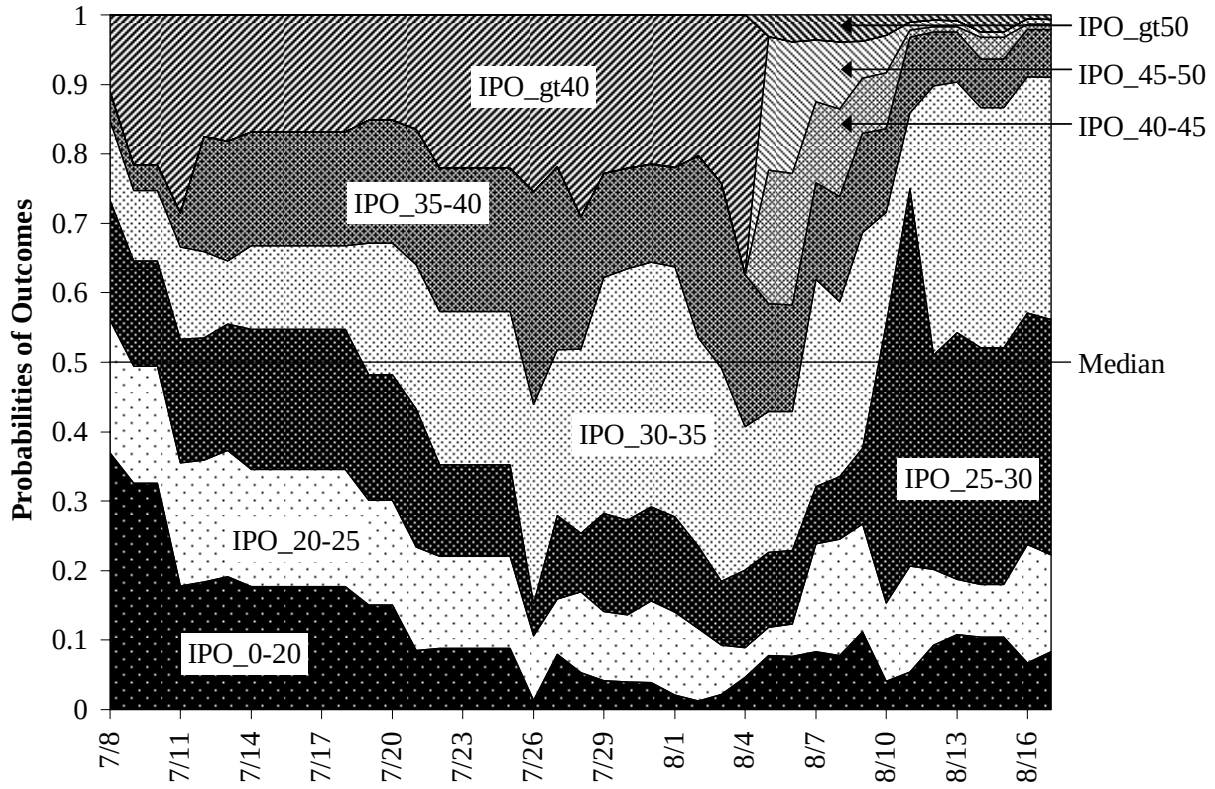

Figure 2: Prices of IEM Google WTA Contracts. This is an area chart. Each band corresponds to the price of one contract. The width of the band is the normalized price of the contract. Each contract price is interpreted as the probability that Google's market capitalization will be within the associated range (in billions of dollar) after the first day of trading. The sum of normalized prices (probabilities) equals 1.

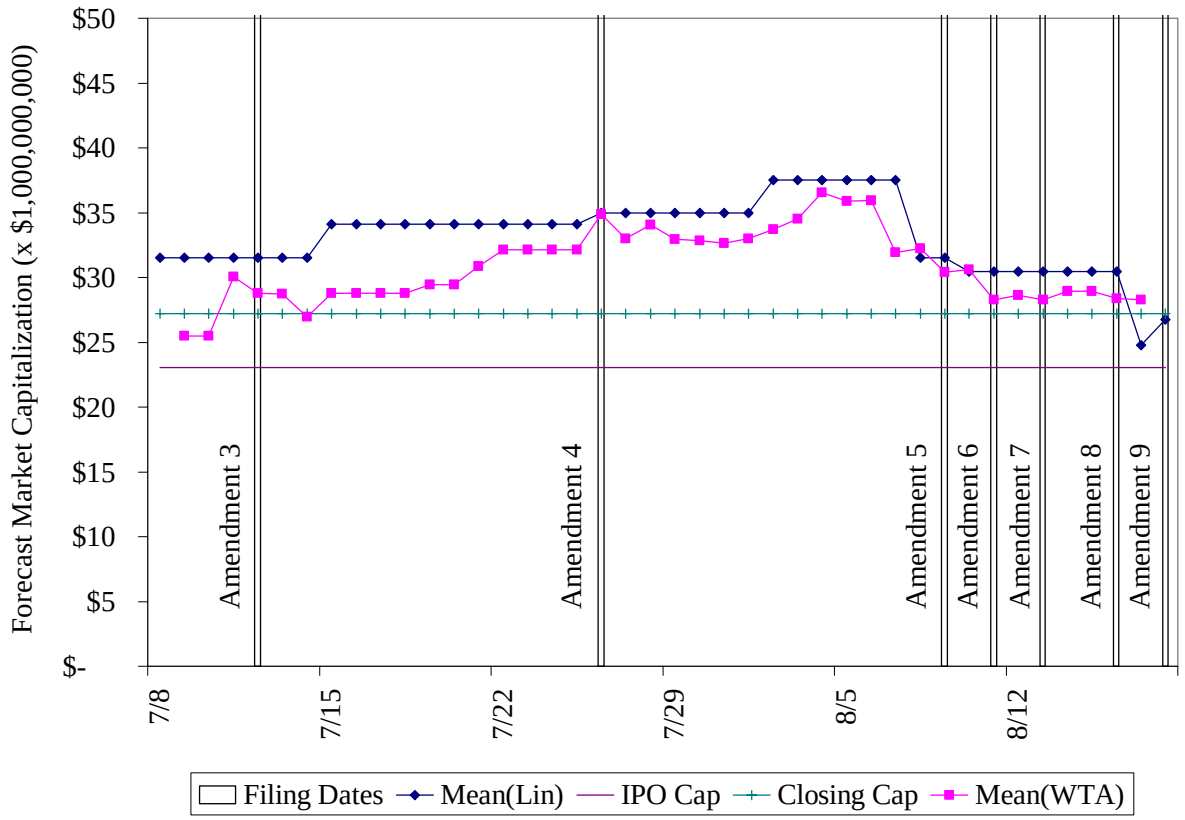

Figure 3: Predicted Google market capitalization from normalized closing prices in the IEM Google Winner-Takes-All Market (Mean(WTA)). For comparison, the prediction from the IEM Google Linear Market (Mean(Lin)), the actual market capitalization according to the IPO price (IPO Cap) and the first-day closing price (Closing Cap) are shown. For context, S1 amendment filing dates are also shown.

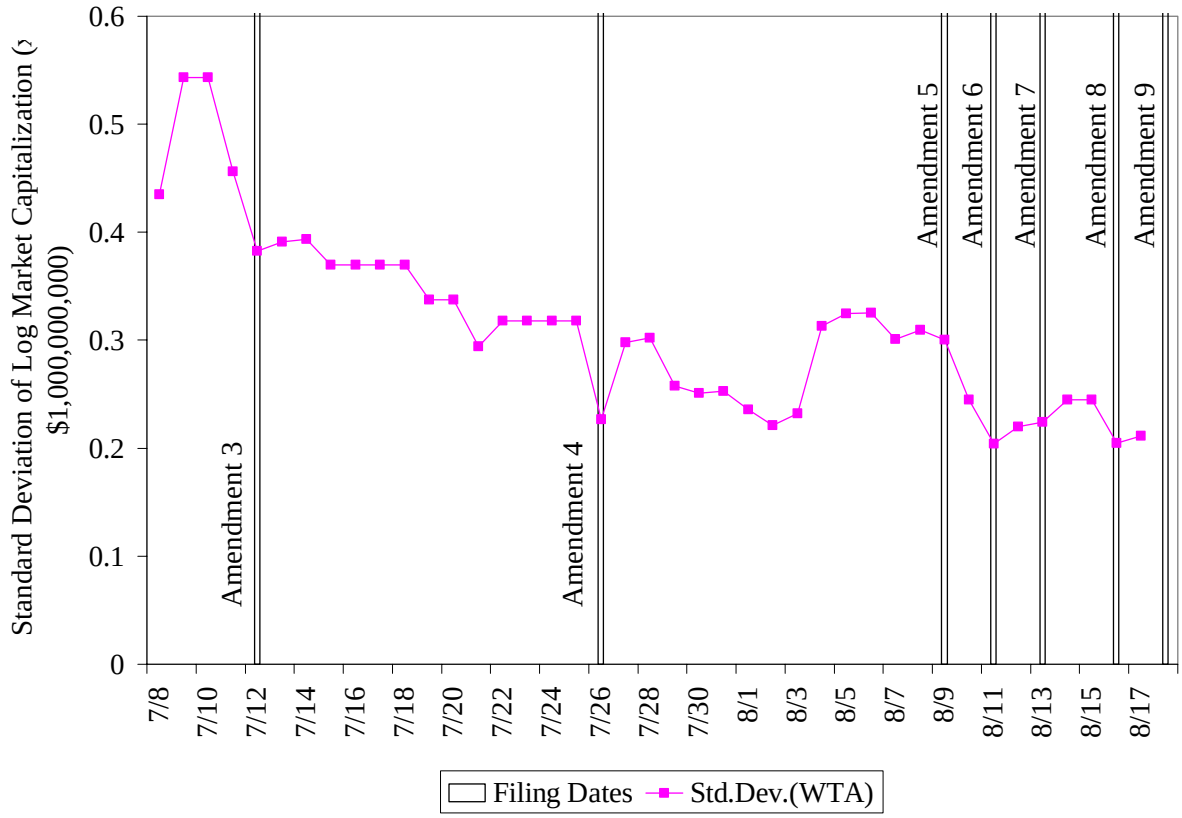

Figure 4: Estimated (log) Google market capitalization forecast volatility from the IEM Google Winner-Takes-All market.

Appendix: Google Market Prospectuses

IEM PROSPECTUS: GOOGLE_LIN
GOOGLE IPO MARKET CAPITALIZATION
LINEAR MARKET

On Tuesday, June 29, 2004, at 1:00pm CDT, the Iowa Electronic Market (IEM) will open trading in a market based on the market capitalization value (closing price multiplied by the number of Class A and Class B shares outstanding) of Google Inc.'s stock at the end of the first day of trading on the stock exchange named in Google's S-1 filing.

Two contracts with linear payoff rules will trade in this market. The liquidation value of the first (up) contract will increase from $0.00 to $1.00 as Google's market capitalization increases from $0 billion to $100 billion. The second (down) contract will have a liquidation value that decreases from $1.00 to $0.00 as Google's market capitalization increases from $0 billion to $100 billion.

This document describes that market and should be viewed as a supplement to the Trader's Manual. Except as specified in this prospectus, trading rules for this market are the same as those specified in the Trader's Manual for the Iowa Electronic Market.

CONTRACTS

The contracts traded in this market have the payoff structure shown in column 2 of the following table:

Code Contract Description

Code	Contract Description
IPO_UP	= $0 if the IPO does not take place by March 31, 2005; = (Market Cap bil.)/100 billion if $0 bil. < Market Cap <= $100 bil; = $1 if Market Cap > $100 bil.
IPO_DN	= $1 if the IPO does not take place by March 31, 2005; = ($100 bil.-Market Cap)/100 billion if $0 bil. < Market Cap <= $100 bil; = $0 if Market Cap > $100 bil.

DETERMINATION OF LIQUIDATION VALUES

This is a linear market. Each security will have a liquidation value based on the exact market capitalization achieved on the first trading day on the market named in Google Inc.'s S-1 filing to the SEC. For example, if there are (hypothetically) 100 million shares of Class "A" and Class "B" stock and the closing price on the first trading day is $210.00, then market capitalization is $210 x 100 million = $21.0 billion. Each share of IPO_UP will pay $0.210 (=(21)/100) and each share of IPO_DN will pay $0.790 (=(100-21)/100).

The print edition of the Wall Street Journal will be the official source for the closing price of Google stock and the final, completed S-1 filing (that is, the last filing – including any re-filings — prior to the IPO) with the SEC will be the source for the outstanding number of shares

The judgment of the IEM Directors will be final in resolving questions of interpretation and typographical or clerical errors.

CONTRACT BUNDLES

Fixed price contract bundles, each consisting of one share of IPO_UP and one share of IPO_DN, can be purchased from or sold to the IEM system at any time. The price of each contract bundle is $1.00. The determination of liquidation values described above guarantees that the total payoff from holding a contract bundle until the market closes is $1.00.

To buy or sell fixed price contract bundles from the system, use the "Market Orders" option from the Trading Console. Select "GOOGLE_LIN (buy at fixed price)" from the Market Orders list to buy bundles. Select "GOOGLE_LIN (sell at fixed price)" to sell bundles.

Bundles consisting of one share of each of the contracts in this market may also be purchased and sold at current aggregate market prices rather than the fixed price of $1.00. To buy a market bundle at current ASK prices, use the "Market Order" option as above but select " GOOGLE_LIN (buy at market prices)." To sell a bundle at current market BID prices, select " GOOGLE_LIN (sell at market prices)."

Bundle purchases will be charged to your cash account and bundle sales will be credited to your cash account.

MARKET CLOSING

This market will remain open until contract liquidation. Liquidation values will be credited to the cash accounts of market participants.

MARKET ACCESS

Current and newly enrolled IEM traders will automatically be given access rights to the GOOGLE_LIN Market. Access to this market is achieved by logging into the IEM and choosing "GOOGLE_LIN" from the Navigation Bar.

Funds in a trader's cash account are fungible across markets so new investment deposits are not required. Additional investments up to the maximum of $500 can be made at any time. New traders can open accounts using the IEM OnLine Account Application page (http://iemweb.biz.uiowa.edu/signup). There is a one-time account registration fee of $5.00, and investments are limited to the range of $5.00 to $500.

Requests to withdraw funds may be submitted at any time by completing the IEM's Online Withdrawal Request form (www.biz.uiowa.edu/iem/accounts/withdrawalrequestform.html) or by completing and mailing the paper version of the request form. Additional information about requesting withdrawals is available at the IEM website at http://www.biz.uiowa.edu/iem/accounts/withdrawals.html.

IEM PROSPECTUS: GOOGLE_WTA
GOOGLE IPO MARKET CAPITALIZATION
WINNER-TAKES-ALL Market

On Tuesday, June 29, 2004, at 1:00pm CDT, the Iowa Electronic Market (IEM) will open trading in a market based on the market capitalization value (closing price multiplied by the number of Class A and Class B shares outstanding) of Google Inc.’s stock at the end of the first day of trading on the stock exchange named in Google’s final S-1 filing.

Initially, six contracts will trade in this market, each representing one of six possible unique and exhaustive outcomes. The liquidation value of the contract which represents the actual outcome of the IPO will be $1.00. All other contracts will have a value of zero.

This document describes that market and should be viewed as a supplement to the Trader's Manual. Except as specified in this prospectus, trading rules for this market are the same as those specified in the Trader's Manual for the Iowa Electronic Market.

CONTRACTS

The initial financial contracts traded in this market are as follows:

Symbol	Description
IPO_0-20	$1 if market cap is less than or equal to $20 billion or if the IPO does not occur by March 31, 2005.
IPO_20-25	$1 if market cap is greater than $20 billion but less than or equal to $25 billion.
IPO_25-30	$1 if market cap is greater than $25 billion but less than or equal to $30 billion
IPO_30-35	$1 if market cap is greater than $30 billion but less than or equal to $35 billion
IPO_35-40	$1 if market cap is greater than $35 billion but less than or equal to $40 billion
IPO_gt40	$1 if market cap is greater than $40 billion.

The range of values in the contract symbol represent the threshold values at which that contract will pay off.

DETERMINATION OF LIQUIDATION VALUES

This is a winner-takes-all market. The contract that corresponds to the actual market capitalization according to the closing price and shares outstanding at the end of the first trading day after the IPO will have a liquidation value of $1.00; all others will have values of $0.00. For example, if there are (hypothetically) 100 million shares of Class “A” and Class “B” stock and the closing price on the first trading day is $210.00, then market capitalization is $210 x 100 million = $21 billion and a share of IPO_20-25 will pay $1.00 while all other contracts pay $0.

The print edition of the Wall Street Journal will be the official source for the closing price of Google stock and the final, completed S-1 filing (that is, the last filing – including any re-filings – prior to the IPO) with the SEC will be the source for the outstanding number of shares.

The judgment of the IEM Directors will be final in resolving questions of interpretation and typographical or clerical errors.

CONTRACT SPIN-OFFS

The Directors of the IEM reserve the right to introduce new contracts to the market as spin-offs of existing contracts. When a contract spin-off occurs, an original contract will be replaced by new contracts which divide the payoff range of the original contract into sub-intervals. No holder of the pre-spinoff contracts will be adversely affected. Traders will receive the same number of each of the new contracts as they held in the original, and the sum of the liquidation values of the new contracts will equal the liquidation value of the original. Decisions to spin-off a contract will be announced at least two days in advance of the spin-off. The new contract names, the specifications regarding liquidation values and the timing of the spin-off will be included in the announcement. This announcement will appear as an Announcement on your WebEx login screen.

CONTRACT BUNDLES

Fixed price contract bundles consisting of one share of each of the contracts in this market can be purchased from or sold to the IEM system at any time. The price of each fixed price contract bundle is $1.00. Because exactly one of the market capitalization outcomes will result from the Google IPO, the total payoff from holding a contract bundle until the market closes is $1.00.

To buy or sell fixed price contract bundles from the system, use the "Market Orders" option from the Trading Console. Select "GOOGLE_WTA (buy at fixed price)" from the Market Orders list to buy bundles. Select "GOOGLE_WTA (sell at fixed price)" to sell bundles.

Bundles consisting of one share of each of the contracts in this market may also be purchased and sold at current aggregate market prices rather than the fixed price of $1.00. To buy a market bundle at current ASK prices, use the "Market Order" option as above but select " GOOGLE_WTA (buy at market prices)." To sell a bundle at current market BID prices, select " GOOGLE_WTA (sell at market prices)."

Bundle purchases will be charged to your cash account and bundle sales will be credited to your cash account.

MARKET CLOSING

This market will remain open until contract liquidation. Liquidation values will be credited to the cash accounts of market participants.

MARKET ACCESS

Current and newly enrolled IEM traders will automatically be given access rights to the GOOGLE_WTA Market. Access to this market is achieved by logging into the IEM and choosing " GOOGLE_WTA " from the Navigation Bar.

Funds in a trader's cash account are fungible across markets so new investment deposits are not required. Additional investments up to the maximum of $500 can be made at any time. New traders can open accounts using the IEM OnLine Account Application page (http://iemweb.biz.uiowa.edu/signup). There is a one-time account registration fee of $5.00, and investments are limited to the range of $5.00 to $500.

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