# Prediction Markets as Decision Support Systems

**Joyce E. Berg**
**Department of Accounting, Henry B. Tippie College of Business,**
**University of Iowa, Iowa City, Iowa 52242-1000, USA**

**Thomas A. Rietz**[*]
**Department of Finance, Henry B. Tippie College of Business,**
**University of Iowa, Iowa City, Iowa 52242-1000, USA**
**E-mail: Thomas-Rietz@uiowa.edu**

**Abstract.** *Valuations from "prediction markets" reveal expectations about the likelihood of events. "Conditional prediction markets" reveal expectations conditional on other events occurring. For example, in 1996, the Iowa Electronic Markets (IEM) ran markets to predict the chances that different candidates would become the Republican Presidential nominee. Other concurrent IEM markets predicted the vote shares that each party would receive conditional on the Republican nominee chosen. Here, using these markets as examples, we show how such markets could be used for decision support. In this example, Republicans could have inferred that Dole was a weak candidate and that his nomination would result in a Clinton victory. This is only one example of the widespread potential for using specific decision support markets.*

**Key Words.** *prediction markets, decision support, decision markets, election stock markets, Iowa Electronic Markets, experimental economics, 1996 Presidential election*

## 1. Introduction

Berg, Nelson, and Rietz (2001) define "prediction markets" as those run for the primary purpose of using the information content in market values to make predictions about specific future events. For example, since 1988, the Iowa Electronic Markets (IEM) have been running such markets, including markets designed to predict the outcomes of elections, box office receipts for movies, earnings reports, stock prices and returns, etc. In these markets, values of traded contracts depend directly on future outcomes and, hence, prices give information about these outcomes. For example, in 1996, the IEM ran a market in which the value of traded contracts depended on the percentages of the vote taken by major candidates in the U.S. Presidential election that year. As Berg, Nelson, and Rietz (2001) show, values in

such markets are efficient advance forecasts of the vote shares ultimately received. Depending on the contract payoff structure, market values can convey information about nearly any event that will be determined by a measurable future outcome.

Here, we define "conditional prediction markets" as those run for the primary purpose of making predictions about future events *conditional* on other events. For example, in the 1996 Presidential election, the IEM ran a market with a set of conditional prediction contracts related to candidate vote shares. Contracts paid liquidating dividends of the form "$1 times the Democratic nominee's (two-party) vote share *conditional* on Lamar Alexander being the Republican nominee," "$1 times the Republican nominee's vote share *conditional* on Lamar Alexander being the Republican nominee," "$1 times the Democratic nominee's vote share *conditional* on Robert Dole being the Republican nominee," "$1 times the Republican nominee's vote share *conditional* on Robert Dole being the Republican nominee," etc. As a result, values in these markets forecast the eventual election vote split *conditional* on the eventual Republican nominee.

Hanson (1999) uses the concept of conditional prediction markets to illustrate his idea of "decision markets." Decision markets are those designed primarily for the purpose of using the information in market values to make decisions. In such cases, markets become decision support systems. We argue that both prediction and conditional prediction markets can be used for decision support, either alone or in

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combination. Prediction markets can support decisions by providing information about the current situation or to evaluate effects of decisions across time. For example, in the 1996 Presidential election, candidates could have used market values to decide whether changes in strategy were needed and, if implemented, the effects of the change could have been measured through changes in valuations.

For some decisions, conditional prediction markets are even better suited for decision support than ordinary prediction markets. For example, political parties use primaries to nominate Presidential candidates. This system does not necessarily result in the strongest nominee for either party. In fact, it is more likely to pick a candidate who appeals more to his or her own party than the population at large. But, if a party wants to nominate a winning candidate, they need to appeal to the population at large. Parties could use conditional prediction markets to inform this choice. For example, in 1996, the Republican party could have used the IEM conditional prediction markets to select a candidate. For major candidates, there were conditional contracts that forecast how each would fare in an election against Clinton. Given information from the markets, Republican voters or the party could have voted for or chosen the strongest candidate from the set to maximize the chance of a Republican president. Instead, the primary process chose Dole, even though the market evidence suggested that Dole was known to be a weak candidate.

Why use prediction markets to support decisions? First, the markets give continuously updated dynamic forecasts. Second, through the price formation process, the markets aggregate information across traders, solving what would otherwise be complex (at best) aggregation problems. Third, the evidence suggests that such markets give unbiased, relatively accurate forecasts well in advance of outcomes (Berg, Nelson, and Rietz, 2001). Fourth, these forecasts can outperform existing alternatives (Berg et al., 2001; Berg, Nelson, and Rietz, 2001; Forsythe et al., 1992; Plott, 2000). Fifth, the evidence suggests that market dynamics can overcome biases that individual traders may have, effectively eliminating them from forecasts (Forsythe, et al., 1992; Forsythe, Rietz, and Ross, 1999). Finally, the markets can be designed to forecast a variety of issues and provide a variety of types of information (see Berg, et al., 2001; Plott, 2000; Ortner, 1997, 1998, for some examples from markets already run and Hanson, 1999, 2000, for some discussion of other possible decision support areas).

In this paper, we illustrate the potential use of markets for decision support using the only known set of large-scale conditional decision markets: the IEM conditional prediction markets for the 1996 Presidential election. Evidence from these markets combined with evidence from simultaneous traditional prediction markets suggest that Colin Powell would have been a particularly strong candidate against Clinton. In contrast, Robert Dole was a particularly weak candidate against Clinton. Had the Republican party or even large numbers of primary voters conditioned their decisions on market information, they could well have nominated a stronger candidate.

Why would we expect prediction markets for decision support to help in the particular case of Presidential nomination? While there is much debate over the efficacy of the nomination process (e.g., see Keeter and Zukin, 1983), Abramson et al. (1992) show that voters *do* respond to perceptions of viability in the nomination process and ultimate electability.[1] Momentum reinforces early perceptions of viability. Berg, Nelson, and Rietz (2001) show that prediction markets produce advance forecasts of election outcomes that outperform the natural alternative of polls. Thus, using prediction markets to form early perceptions may reduce errors in inference, leading to more viable nominees.

While the nomination process provides an interesting example for this paper, the potential of prediction markets for decision support goes far beyond elections. For example, using markets based on movie box office receipts, studio executives could evaluate the efficacy of marketing campaigns. By running conditional box office markets, executives could compare several possible endings by running them on test audiences and, by trading contracts based on revenues conditional on the ending chosen, evaluate which ending would lead to the highest expected revenue. Plott (2000) and Ortner (1997, 1998) discuss decision support applications for other businesses. Hansen (2000) suggests that governments could evaluate policies for efficacy in reaching social goals. Structured correctly, such markets could support a wide variety of decisions.

## 2. Definitions and Concepts

Prediction markets have become common.[2] The longest running set of such markets know to us are the Iowa Electronic Markets, started in 1988 to predict election outcomes.[3] Berg, Nelson, and Rietz (2001)

discuss extensively the forecasting nature of simple prediction markets. Simple prediction markets are all structured similarly and the 1996 Presidential markets serve as illustrations here.

We start with "linear" markets, so named because of their contract payout structure. To understand how these contracts work, consider a set of measurable future outcomes denoted by $V_1, V_2, \ldots, V_n$, where the outcomes can be normalized to sum to 1.[4] Prediction markets designed to forecast these outcomes would have liquidating dividends tied to the normalized outcome values. For example, the outcomes might be the percentage of votes received by major candidates in an election. They can be normalized by dividing each major candidate's vote total by the sum of vote totals received by the (pre-defined) set of major candidates. Specifically, for the 1996 election, the outcomes were the votes received by the Democratic nominee and the votes received by the Republican nominee, both measured as percentages of the two-party vote. A market is created in which participants can trade contracts with liquidation values that equal the outcomes. For example, a "Clinton" contract[5] in the 1996 IEM Presidential vote-share market had a liquidating dividend of $1 times the Democratic nominee's share of the two-party vote and the "Dole" contract[6] had a dividend of $1 times the Republican's share. Combined with a market structure that guarantees no aggregate risk, this payoff structure implies that contract valuations should be forecasts of the associated outcomes; in this case, the election vote shares.[7]

Alternatively, contracts could be based on whether a particular event occurred. To understand these contracts, consider an exhaustive set of possible future outcomes denoted by $E_1, E_2, \ldots, E_m$. Prediction markets designed to forecast the probabilities of these outcomes would have liquidating dividends tied to the occurrence of each event. For example, the events might be a list of possible "winners" of the election. Specifically, for the 1996 election, the IEM Presidential winner-takes-all contracts were associated with various possible election winners defined as receiving the largest share of the popular vote. A "Clinton" contract in this market paid $1 if Clinton "won" the election by receiving more popular votes than any other candidate and $0 otherwise, a "Rep" contract paid $1 if the Republican nominee "won," an "OtDem" contract paid $1 if a Democratic nominee other than Clinton "won" and an "Other" contract paid $1 if any other candidate "won." Again, combined with a market structure that guarantees no ag-

gregate risk, this payoff structure implies that contract valuations should be the forecast probabilities of each event occurring (see footnote 7). In this case, contract valuations reflect each candidate's chance of success in the ultimate election. We call such markets "winner-takes-all" markets, denoting their payoff structure.

As forecasts, prediction market valuations and changes in them could be used to support decisions. For example, each candidate in the 1996 election could have evaluated his campaign strategy by looking at changes in IEM forecasts while strategies were being executed. They could have made decisions about strategies accordingly.

Conditional prediction markets could also be used as decision support systems. To see how conditional prediction markets work, consider a measurable set of possible future outcomes denoted by $V_1, V_2, \ldots, V_n$. Let $i$ index these outcomes. Also consider a second set of outcomes denoted by $E_1, E_2, \ldots, E_m$. Let $j$ index these outcomes. Examples of such outcomes could be linear (e.g., vote-share markets) or binary (e.g., who "wins" the election). If the second outcome is measured at the same time or before the first, we can define a set of conditional outcomes by $V_i \mid E_j$. Conditional contracts have liquidating dividends based on the conditional outcomes. For example, early in the 1996 election, the IEM ran markets for contracts with liquidation values depending on conditional election outcomes. One set of contracts was based on the (two-party) vote share for the Democratic nominee (presumably Clinton) versus the share for the Republican nominee *conditional* on Lamar Alexander being the Republican nominee. There were similar sets of contracts conditional on Bob Dole, Steve Forbes, Phil Gramm or "any other Republican nominee." Values of these contracts are forecasts of vote shares conditional on various potential Republican nominees in advance of the actual nomination. Thus, voters could have used these markets to identify and vote for the strongest contender instead of their favorite among the field of potential nominees. Similarly, the Republican party could have chosen the strongest nominee for the general election instead of the one that was most popular within the party itself.

## 3.   Decision Support in Action: Markets for the 1996 Republican Nomination

In the 1996 election, the Democrats ran the incumbent Bill Clinton who faced no serious challenge as the

nominee. In contrast, the Republicans had to choose from a field of potential nominees. Major candidates[8] included Lamar Alexander, Bob Dole, Steve Forbes and Phil Gramm. During the Fall of 1995, many speculated that Colin Powell would run, but he announced his decision not to run on November 8, 1995. Gramm dropped out of the race on February 14, 1996. Alexander dropped out on March 6. Forbes dropped out on March 13. While Pat Buchanan stayed in the primary race against Dole longer than any other contender, he never received sufficient support in major polls for the IEM to consider him a major candidate. Dole had become the de facto nominee by March 12 (Super Tuesday). During this race, the IEM ran several markets that gave information that the Republicans could have used in choosing a nominee, including:

(i) The Colin Powell nomination market, a winner-takes-all market designed to predict the chances that Powell would have his name placed in nomination at the Republican convention,

(ii) The Presidential winner-takes-all market, designed to predict the probabilities that various candidates would "win" the election by receiving the most popular votes and

(iii) The Presidential vote-share market divided into two phases:

 a. A conditional vote-share market designed to predict the percentages of the two-party vote taken by the Democratic and Republican nominees *conditional* on the Republican nominee (before the nominee was determined) and

 b. An ordinary vote-share market designed to predict percentages taken after the Republican nominee was determined to be Bob Dole.

### 3.1. Description of the IEM and relevant markets

The Iowa Electronic Markets are designed specifically as prediction markets. IEM markets are computerized, electronic, real-time exchanges where traders buy and sell futures contracts with payoffs based on the outcomes of interest. Because real money is used, traders are subject to the monetary risks and returns that result from their trading behavior. Following the reasoning in Berg, Nelson, and Rietz (2001), we use normalized, bid/ask midpoints as the market forecasts for analysis.[9]

As described above, contracts in the political markets (used as examples here) are designed to make three kinds of forecasts: (i) the probabilities of specific events such as winners of elections or nominations, (ii) the

expected value of a variable such as the vote shares received by candidates and (iii) conditional probabilities of events such as the winner of an election conditional on the nomination of a particular candidate. Brief descriptions of the individual markets follow. For details, see the prospectuses in the Appendix.

The following contracts were traded in the Powell nomination market:

| Contract | Liquidation value |
|---|---|
| P.YES | $1 if Powell's name is placed in nomination at the Republican convention |
| P.NO | $1 if Powell's name is not placed in nomination at the Republican convention |

The market opened on June 30, 1995 and active trading picked up around September 1. While liquidation had to wait until after the Republican convention, for all intents and purposes, the liquidation values were determined on November 8, 1995, when Powell announced he would not run for the nomination. This market provides direct predictions of the likelihood that Powell's name would be placed in nomination and, indirectly, the likelihood that he would be nominated. In addition, when combined with information from the Presidential winner-takes-all market (described below) this market provides evidence about who would have won had Powell run against Clinton.

The following contracts were traded in the Presidential winner-takes-all market:

| Contract | Liquidation value |
|---|---|
| CLIN | $1 if Clinton (as the Democratic nominee) receives the most popular votes in the November election |
| OTDEM | $1 if a Democratic nominee other than Clinton receives the most popular votes |
| REP | $1 if the Republican nominee receives the most popular votes |
| ROF96 | $1 if any other candidate receives the most popular votes |

The market opened on October 25, 1994 and active trading began shortly thereafter. This market provides direct predictions of the likelihood that various candidates would win the popular election. We use the correlation between values in this market and those in the Powell nomination market to measure Powell's strength as a potential candidate against Clinton. We also use it to measure the impact of the Republican

primary process on Clinton's chances of winning the election.

The Presidential vote-share markets were divided into two phases. The first phase included conditional vote-share contracts. The initial contracts were listed in pairs that represented the shares of the two-party vote received by the Democratic nominee versus the Republican nominee, both conditional on the Republican nominee. The initial contracts were:

| Name | Liquidation value |
|------|-------------------|
| V.DOLE | $1 × the % of votes received by the Republican nominee conditional on Robert Dole being the Republican nominee |
| CL|DOLE | $1 × the % of votes received by the Democratic nominee conditional on Robert Dole being the Republican nominee |
| V.FORB | $1 × the % of votes received by the Republican nominee conditional on Steve Forbes being the Republican nominee |
| CL|FORB | $1 × the % of votes received by the Democratic nominee conditional on Steve Forbes being the Republican nominee |
| V.GRAM | $1 × the % of votes received by the Republican nominee conditional on Phil Gramm being the Republican nominee |
| CL|GRAM | $1 × the % of votes received by the Democratic nominee conditional on Phil Gramm being the Republican nominee |
| V.OREP | $1 × the % of votes received by the Republican nominee conditional on another candidate being the Republican nominee |
| CL|OREP | $1 × the % of votes received by the Democratic nominee conditional on another candidate being the Republican nominee |

The market opened on February 4, 1996 and active trading began shortly thereafter. On February 19, the "other" contracts split, resulting in two new contracts: one for the percent of votes received by Lamar Alexander conditional on him being nominated and one for the percent of votes received by the Democratic nominee in this case. After the split, the V.OREP and CL|OREP contracts included all other remaining potential nominees. When the Republican nominee was determined, all but two contracts became worthless and were delisted. At this point, the vote-share market became a traditional prediction market for the votes received by the Democratic nominee (Clinton) and the Republican nominee (Dole). For all intents and purposes, this occurred on Super Tuesday, March 12, 1996. Forbes, the last serious candidate against Dole dropped from the race the next day. We use this market for

two purposes. Pairs of contracts forecast the relative strengths of each candidate against Clinton (the presumed Democratic nominee). Second, since the vote shares (and liquidation values) for any pair of contracts will sum to 1 *if* the associated Republican wins the nomination, the summed value of each pair of contracts forecasts the probability of that candidate winning the Republican nomination. We use this to forecast the probability of each candidate winning the nomination and correlate it with Clinton's chances of winning the November election from the winner-takes-all market.[10]

### 3.2. Results

***Result 1: Powell would have been a strong candidate against Clinton.*** As discussed above, the Colin Powell nomination market forecasted the probability that Powell's name would be placed in nomination at the 1996 Republican convention. The winner-takes-all Presidential market forecasted the chances of Clinton winning the popular vote. Fig. 1 shows the forecasts in these two markets from September 1 to November 30. As Powell's chances of nomination increased, Clinton's chances of winning decreased through November 7th. On the 8th, Clinton's value rose dramatically as Powell withdrew.

The correlation of forecasts between the two contracts over the 68 days before Powell's announcement (September 1 to November 7) and 68 days after (November 9 to January 15) was $-0.6008$ (significant at the 95% level of confidence) and the correlation of *changes* in the forecasts was $-0.1405$ (significant at the 90% level of confidence). When November 8 is added to this sample, the correlations become $-0.6046$ and $-0.3895$, respectively (both significant at the 95% level of confidence). Relative to the rest of the data set, the size of the drop in Powell's forecast on November 8 was 21.43 standard deviations away from the mean and the size of the rise in Clinton's was 4.66 standard deviations away.

Regression coefficients show that for each 1% increase in the likelihood of Powell's name being placed in nomination, Clinton's likelihood of winning the popular vote fell by about 0.04 percent (with or without November 8 included in the data set). The estimated regression equation using all 137 observations is:

$$P_{\text{Clinton}} = 0.4525 - 0.0441 \times P_{\text{Powell}} \tag{1}$$
$$(0.0016) \quad (0.0046)$$

where $P_{\text{Clinton}}$ is the forecast probability of Clinton receiving the most popular votes in the election, $P_{\text{Powell}}$ is
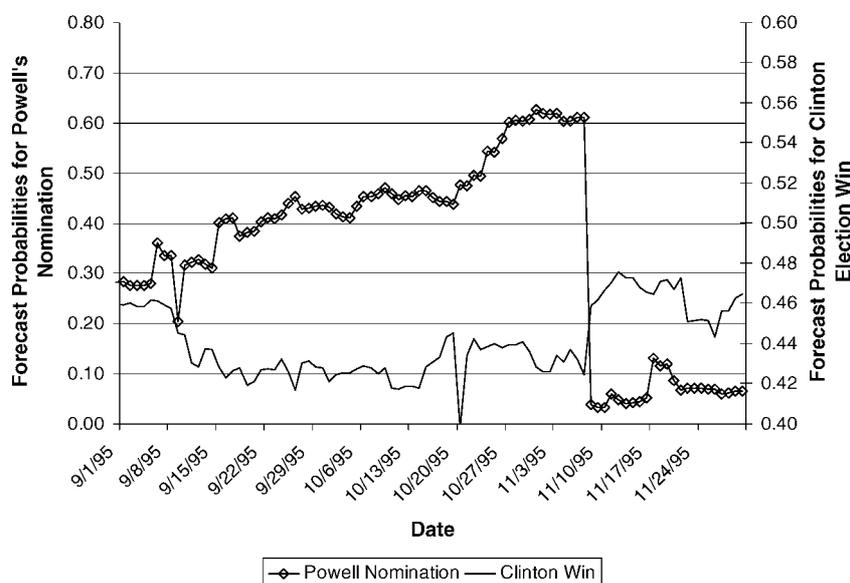
**Fig. 1.** *Forecast probabilities for Powell's name being placed in nomination at the Republican convention from the Powell nomination market and forecast probabilities for Clinton winning the election (defined as receiving the most popular votes) from the Presidential winner-takes-all market.*

the forecast probability of Powell's name being place in nomination at the Republican convention and robust standard errors appear in parentheses. Both coefficients are significant at the 95% level of confidence. The adjusted $R$-squared is 0.3656 and the root mean square error of the regression is 0.0117.

Based on this analysis, we conclude that Powell would have been a strong candidate against Clinton. His likelihood of nomination was highly negatively correlated with Clinton's likelihood of winning the election. It was not just a time trend; changes in forecasts were also negatively correlated. How could these markets have been used for decision support? If Powell was interested in the likely strength of his candidacy as an input to his decision, these markets indicated he was a strong candidate. Noting this market information, the Republicans could have recruited him more actively as a candidate.

***Result 2: Dole was predicted to be a weak candidate against Clinton.*** To assess Dole's strength as a candidate, we examine the relationship between Clinton's probability of winning and Dole's probability of being the Republican nominee. Recall that the Presidential winner-takes-all market forecasted the likelihood that Clinton, another Democrat nominee, the Republican nominee or another candidate would "win" the election

by receiving the most popular votes. The likelihood that Dole would win the nomination (denoted $P_{Dole}$) could be forecasted by the conditional Presidential vote-share contracts as follows. Consider the contract V.DOLE, which liquidated at a value of \$1 times Dole's percentage of the two-party vote if Dole was selected as the Republican nominee. Because contract values should equal expected values (as discussed above), the value of this contract should equal the forecast probability that Dole would be nominated times Dole's vote share in this event. Denote this by $V_{V.DOLE} = P_{Dole} \times VS_{Dole|Dole}$. The paired contract CL|DOLE liquidated at a value of \$1 times Clinton's percentage of the two-party vote if Dole was selected as the Republican nominee. The value of this contract should equal the forecast probability that Dole would be nominated times Clinton's vote share in this event. Denote this by $V_{CL|DOLE} = P_{Dole} \times VS_{Clinton|Dole}$. The sum of the two contract values equals $V_{V.DOLE} + V_{CL|DOLE} = P_{Dole} \times (VS_{Dole|Dole} + VS_{Clinton|Dole}) = P_{Dole}$ because, as defined and measured, the two-party vote shares must sum to 1. As one measure of Dole's strength as a candidate, we use the correlation between the forecast probability that Dole would be the Republican nominee and the forecast probability that Clinton would win the election. We also use Dole's percentage of delegates awarded to date from the primary elections as
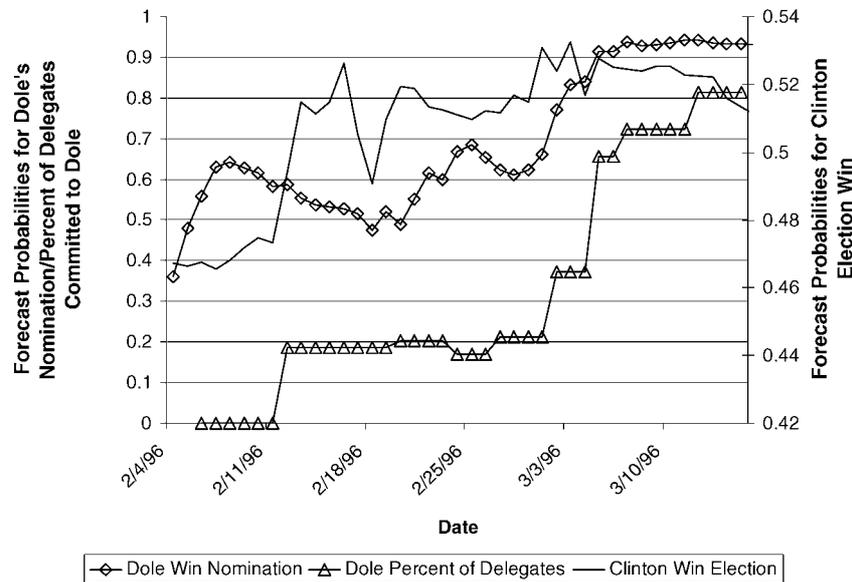
**Fig. 2.** *Forecast probabilities for Dole becoming the Republican nominee from conditional contracts in the Presidential vote-share market, the percentage of delegates committed to Dole from primary and caucus results and forecast probabilities for Clinton winning the election (defined as receiving the most popular votes) from the Presidential winner-takes-all market.*

an indirect measure of Dole's likelihood of becoming the nominee. Again, we measure Dole's strength by correlating this with Clinton's likelihood of winning.

Fig. 2 shows the forecast likelihood that Dole would win the nomination, the percentage of delegates committed to Dole to date and the forecast likelihood that Clinton would win the election between February 4 and March 13, 2001 (the day after Super Tuesday, when Forbes withdrew and Dole's nomination was virtually assured). The correlation between Dole's forecast likelihood of nomination and Clinton's likelihood of winning the election was 0.5472. The correlation between the percentage of delegates committed to Dole and Clinton's likelihood of winning was 0.6450. Both are significant at the 95% level of confidence.

Regression coefficients show that for each 1% increase in the likelihood of Dole's nomination, Clinton's forecast probability of winning the popular vote increased by about 0.07 percent. The estimated regression equation using the 41 observations is:

$$P_{\text{Clinton}} = 0.4625 + 0.0657 \times P_{\text{Dole}} \qquad (2)$$
$$(0.0109)\ (0.0126)$$

where $P_{\text{Clinton}}$ is the forecast probability for Clinton winning the popular vote in the election, $P_{\text{Dole}}$ is the forecast probability of Dole winning the Republican

Nomination and robust standard errors appear in parentheses. Both coefficients are significant at the 95% level of confidence. The adjusted $R$-squared is 0.2946 and the root mean square error of the regression is 0.0178.

A similar regression shows the effect of Dole's percentage of committed delegates through the early primary season. The estimated regression equation using the 41 observations is:

$$P_{\text{Clinton}} = 0.4951 + 0.0444 \times PCNT_{\text{Dole}} \qquad (3)$$
$$(0.0047)\ (0.0088)$$

where $P_{\text{Clinton}}$ is the forecast probability for Clinton winning the popular vote in the election, $PCNT_{\text{Dole}}$ is percentage of delegates committed by the primary/caucus system to date to Dole and robust standard errors appear in parentheses. Both coefficients are significant at the 95% level of confidence. The adjusted $R$-squared 0.4160 and the root mean square error of the regression is 0.0148.

Based on this analysis, we conclude that Dole was a weak candidate against Clinton in absolute terms. His likelihood of nomination was positively correlated with Clinton's likelihood of winning the election. How could these markets have been used for decision support? With this knowledge, Republican voters could have supported candidates other than Dole with their votes

in primary elections and with their campaign contributions, thus increasing the chances that another, stronger Republican candidate would have been nominated.[11] The Republican party could have put resources behind other, stronger candidates as well.

***Result 3: Through Super Tuesday and beyond, at least one other candidate always appeared stronger than Dole.*** As discussed above, conditional contracts in the Presidential vote-share market could be used to forecast the chances of each potential nominee winning the Republican nomination. In addition, the contracts could be used to forecast the relative vote shares taken by the nominee and the Democratic nominee (presumably Clinton). To see how, consider again the V.DOLE and CL|DOLE contracts. Again, the value of the V.DOLE contract should equal $V_{V.DOLE} = P_{Dole} \times VS_{Dole|Dole}$. Similarly, the value of the associated contract, CL|DOLE, should equal $V_{CL|DOLE} = P_{Dole} \times VS_{Clinton|Dole}$. Consider normalizing the values by dividing each individual value by their sum. For the V.DOLE contract, this becomes:

$$\frac{V_{V.DOLE}}{V_{V.DOLE} + V_{CL|DOLE}}$$
$$= \frac{P_{Dole} \times VS_{Dole|Dole}}{P_{Dole} \times VS_{Dole|Dole} + P_{Dole} \times VS_{Clinton|Dole}}$$
$$= VS_{Dole|Dole} \qquad (4)$$

because the vote shares (as defined) must add to 1. A similar normalization gives the forecast vote share for Clinton conditional on Dole being nominated. A "spread forecast" is created by subtracting one vote

share forecast from the other. This and similar forecasts for other candidates indicate the relative strengths of the candidates.

The vote-share market opened on February 4, 1996 with pairs of contracts for Bush, Forbes, Gramm and one pair for all other potential nominees. All contracts had traded by February 8. On February 19, the split option (described in the prospectus in the Appendix) was utilized to create 2 pair of contracts for Alexander. By Super Tuesday (March 12), Dole was virtually assured of the nomination and Forbes pulled out of the race the next day. Powell had effectively dropped out on November 8, 1995. Gramm quit on February 14 and Alexander quit on March 6. Buchanan was the primary candidate included in the "other" contract. While he stayed in the race, he was not a serious contender. As shown in Fig. 2, the likelihood of Dole's nomination had risen to more than 90% when Alexander dropped out and remained there for the rest of the race.

The effective trading horizon in this market was short. There were 39 trading days between February 4, when the market opened, and March 13, the day after Super Tuesday when Forbes dropped out. However, while the horizon was short, Table 1 shows that the market was quite active, with nearly 9,000 contracts trading during this time, averaging 222 contracts per day.

Fig. 3 shows the Republican vote margin from the spread forecasts for each pair of contracts between February 4 and either the date the candidate dropped or March 13. In addition, it shows the maximum and average of the active non-Dole candidates. Several interesting observations come from the graph. First, apart

***Table 1.*** *Trading horizons and volumes for the conditional vote-share market through March 13*

| | | Race | | | | |
|---|---|---|---|---|---|---|
| | | Clinton vs Alexander | Clinton vs Dole | Clinton vs Forbes | Clinton vs Gramm | Other |
| | Contracts | CL\|ALEX V.ALEX | CL\|DOLE V.DOLE | CL\|FORB V.FORB | CL\|GRAM V.GRAM | CL\|OREP V.OREP |
| Trading horizon | Contracts Open | 2/19/1996 | 2/4/1996 | 2/4/1996 | 2/4/1996 | 2/4/1996 |
| | Earlier of 3/13/96 or candidate drop date | 3/6/1996 | 3/13/1996 | 3/13/1996 | 2/14/1996 | 3/13/1996 |
| | Days in horizon | 17 | 39 | 39 | 13 | 39 |
| | Active trading days | 15 | 38 | 33 | 10 | 31 |
| Contract volume | Total volume | 1506 | 1777 | 2985 | 465 | 2158 |
| | Average per day across active days | 100.400 | 46.763 | 90.455 | 46.500 | 69.613 |
| | Maximum daily | 689 | 265 | 728 | 265 | 415 |
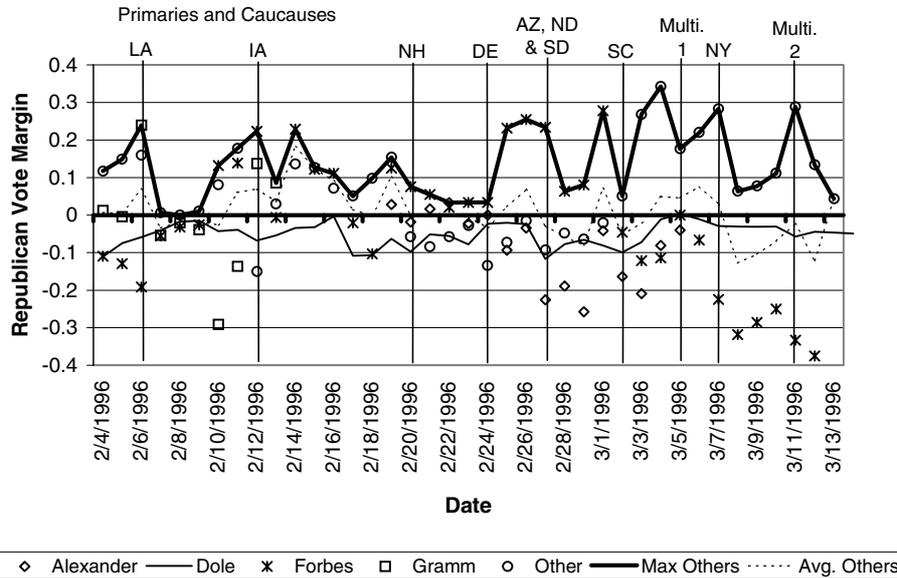
**Fig. 3.** *Predicted winning margins for potential Republican nominees as forecast by conditional contracts in the Presidential vote-share market. Multiple primaries listed under "Multi. 1" were in Colorado, Connecticut, Georgia, Maine, Maryland, Massachusetts, Rhode Island and Vermont. Multiple primaries listed under "Multi. 2" were in Florida, Louisiana, Mississippi, Oklahoma, Tennessee, Texas and Oregon.*

from March 5 when Dole was projected as a winner by 0.3%, Dole was never predicted to beat Clinton. Clinton's average forecast winning margin over Dole during this time was 5.18% with a standard deviation of 3.20% and no significant time trend (*p*-value on date in a regression is 0.3). Clinton's actual winning margin (in the two-party race) was 9.2%. According to a binomial test, we can reject the hypothesis that forecasts are evenly distributed around zero ($p = 0.000$) in favor of the hypothesis that Dole was predicted to lose to Clinton.[12] Second, forecasts for other candidates were more volatile. While some of this may arise from the normalization,[13] it may also arise because the market was integrating information about these (lesser known) candidates from primary and fundraising performance.[14] Only Alexander appeared significantly likely to lose to Clinton over his trading horizon according to a binomial test like that for Dole discussed above. Third, while there was much volatility, the market appeared to look favorably on *any* candidate other than Dole. This shows up clearly in both the maximum and average spreads for other candidates. Individually, each other candidate (with the possible exception of Alexander) appeared strong enough to beat Clinton at some point. There was *always* at least one other candidate that the market forecast would be stronger than

Dole and, in fact, beat Clinton. The average spread across active candidates other than Dole was 0.86% with a standard deviation of 6.64%. Dole fell significantly below this average according to a *t*-test at the 95% level of confidence ($t = -5.4993$). Even after all other candidates dropped out, the market forecast a favorable result if the Republicans found someone else to nominate (this includes both Powell and Buchanan as well as anyone else not included in the IEM named contracts).

How could these results have been used for decision support? The markets give a signal of the ultimate viability of the potential candidate in the election, not just the nomination process. Again, voters who are responsive to viability could use this information to support their voting and contribution decisions. Of course, candidates, knowing that viability and momentum matter, could have pointed to the market results, indicating a loss for Dole, in an attempt to lure voters. Perhaps more important, candidates could have used the market results to support the decision of continuing to campaign or dropping out. More dramatically, parties could abandon the primary/caucus system altogether and let conditional vote-share or conditional winner-takes-all election markets determine the most viable candidate.

## *4. Discussion*

In this paper, we show how both prediction and conditional prediction markets can be designed and used for decision support. We present evidence from a set of political prediction markets and a unique set of conditional prediction markets to show how such markets could be used as decision support systems. Run during the nomination process for the 1996 US Presidential election, the decision support implications of these markets are clear. If the Republican party could have convinced Powell to run, he would have been a strong candidate against Clinton. Dole was known to be weak in both absolute terms and relative to other potential candidates. This information could have been used by voters to decide which candidates to support, by candidates to make campaign decisions and by parties to make nomination decisions. Perhaps the Democratic party should consider such systems as they choose a nominee for the 2004 Presidential election.

Voting, nomination and election choices conform to two conditions that we believe are important for using prediction markets as decision support systems. First, in these contexts, optimal decisions depend critically on forecasting outcomes and conditional outcomes that are likely to result from the decision. Second, markets can aggregate diverse information in ways that prove more efficient than existing methods.

We propose that markets could prove valuable whenever these conditions are met. Consider, for example, conditional oil futures markets. Ordinary oil futures can forecast the expected future spot price of oil. Conditional markets could give more information. For example, suppose a potential Middle Eastern conflict threatened oil supplies. Oil futures may rise (as they did during the Gulf War) to reflect increasing probabilities of a conflict. But, conditional markets could forecast the probability of a Middle Eastern War (if one could adequately define "war" for liquidation purposes) *and* the expected spot prices conditional on a war and conditional on no war. This extra information could serve valuable decision support roles. It would help individuals decide when to buy fuel oil or replace furnaces (especially if they were military personnel who might spend considerable time away from home in the event of war). Investors could evaluate oil companies more efficiently because, presumably, a regional conflict would affect companies differently depending on the location of their reserves

and purchasing relationships. Oil companies themselves could make better decisions about exploration, development and extraction. At the very least conditional forecasts might change regional plans. Finally, the government could use this information for decisions about the strategic oil reserve and to support diplomatic and military decisions affecting the region. Thus, conditional oil futures could support a wide array of decisions. Other potentially valuable applications abound.

## *Appendix*

### *IEM prospectus Colin Powell nomination market winner-takes-all market*

On Friday, June 30, 1995, the Iowa electronic market (IEM) will open trading in a winner-takes-all market based on whether Colin Powell's name is placed in nomination as a Republican presidential candidate at the 1996 Republican national convention. 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 financial contracts traded in this market are:

| Code | Contract name |
|------|---------------|
| P.YES | Powell's name is placed in nomination |
| P.NO | Powell's name is not placed in nomination |

***Determination of liquidation values.***    This is a winner-takes-all market. If Powell's name is placed in nomination as a Republican Presidential candidate at the Republican national convention, the P.YES contract will pay off $1.00 and the P.NO contract will expire worthless. If Powell's name is not placed in nomination, then the P.NO contract will pay off $1 and the P.YES contract will expire worthless. These liquidation formulas can be viewed by first selecting display options and then choosing liquidation formulas.

***Market closing.***    This market will close at noon, two days following the close of the 1996 Republican

national convention. As soon as feasible thereafter, liquidation values will be declared and funds credited to the cash accounts of the market participants.

***Unit portfolios.***    Unit portfolios consisting of one share of P.YES and one share of P.NO can be purchased from or sold to the IEM system at any time. The price of each unit portfolio is $1.00. Since exactly one contract will pay off $1.00, the total payoff from holding a unit portfolio until the market closes is $1.00.

To buy unit portfolios from the system, use the "Purchase" option from the TRADING MENU and enter 1$ as the contract name. To sell unit portfolios to the system, use the "Sell" option from the TRADING MENU and enter 1$ as the contract name. Purchases will be charged to your cash account and sales will be credited to your cash account.

Unit portfolios may also be purchased from and sold to other traders at current market prices. Use the Purchase and Sell options as above but enter MKT as the contract name. The price charged for market portfolio purchases will be determined as the sum of current ask prices, and the price received for market portfolio sales will be the sum of current bid prices. Should no corresponding bid or ask be present for one of the contracts, that contract will be excluded from the portfolio; otherwise the number of contracts purchased or sold will be the same in each contract.

***Market access.***    Current and newly enrolled IEM traders will automatically be given access rights to the Colin Powell nomination market. Access to this market is achieved via the "Market Selection" option on the Login, Market, and other menus. Funds in a trader's cash account are fungible across all markets so new investment deposits are not required. Additional investments up to the maximum of $500 can be made at any time. With five days' advance notice, funds may be withdrawn on the 15th of any month.

***IEM prospectus: 1996 Presidential election winner-takes-all market***
On Tuesday, October 25, 1994, the Iowa electronic market (IEM) opened trading in a winner-takes-all market based on the 1996 Presidential election. 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.

Payoffs in this winner-takes-all Presidential market are determined solely by the candidate who receives the largest number of popular votes in the November 12, 1996 Presidential election. Contracts in the candidate receiving the largest number of popular votes will payoff $1 each, all others will expire worthless. Payoffs are NOT affected by the outcome of the electoral college or any vote taken by the House of representatives should such vote be necessary.

***Contracts.***    The financial contracts traded in this market are:

| Code | Contract name |
|------|---------------|
| CLIN | Clinton-Democrat |
| OTDEM | Other non-Clinton Democrat |
| REP | Republican candidate |
| ROF96 | Other candidate (neither Democrat nor Republican nominee) |

The label "CLIN" denotes the joint outcome that Bill Clinton wins the Democratic nomination AND the Democratic nominee subsequently receives the largest number of popular votes in the Presidential election. Should Clinton be nominated and subsequently drop out of the race and be replaced by another nominee from the Democratic party, shares in Clinton will automatically be transferred to shares in the replacement.

The label "OTDEM" denotes the joint outcome that some Democrat other than Bill Clinton wins the Democratic nomination AND subsequently receives the largest number of popular votes in the Presidential election. OTDEM contracts can only payoff if Clinton does not receive the Democratic nomination.

The label "REP" denotes the outcome that the candidate nominated by the Republican convention receives the largest number of popular votes in the Presidential election. The label "ROF96" denotes the outcome that some candidate other than the Democratic and Republican nominees receives the largest number of popular votes in the Presidential election. Neither of these two contracts are tied to specific candidates.

***Determination of liquidation values.***    This is a winner-takes-all market. Contracts representing the

candidate who receives the largest number of votes in the election will be paid $1.00 each. All other contracts will be declared worthless.

Contracts labeled CLIN will each payoff $1 if Bill Clinton wins the Democratic nomination AND the Democratic nominee subsequently receives the largest number of popular votes in the Presidential election. If Clinton does not win the Democratic nomination, then all CLIN contracts will expire worthless at the time the Democratic convention announces its candidate.

Contracts labeled OTDEM will each payoff $1 if some Democrat other than Bill Clinton wins the Democratic nomination AND subsequently receives the largest number of popular votes in the Presidential election. If Clinton wins the Democratic nomination, then all OTDEM contracts will expire worthless at the time the Democratic convention announces its candidate.

Contracts labeled REP will each payoff $1 if the candidate named by the Republican convention receives the largest number of popular votes in the Presidential election. Contracts labeled ROF96 will each payoff $1 if a candidate other than the ones nominated by the Democratic and Republican conventions receives the largest number of popular votes in the Presidential election. These liquidation formulas can be viewed by first selecting Display Options and then choosing liquidation formulas.

*Market closing.*    This market will close at noon, Wednesday, November 6, 1996, the day after the Presidential election. As soon after the election as official election returns are announced, liquidation values will be declared and funds credited to the cash accounts of the market participants.

*Unit portfolios.*    Unit portfolios 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 unit portfolio is $1.00. Since exactly one candidate will receive the largest number of votes in a particular election, the total payoff from holding a unit portfolio until the market closes is $1.00.

To buy unit portfolios from the system, use the "Purchase" option from the TRADING MENU and enter 1$ as the contract name. To sell unit portfolios to the system, use the "Sell" option from the TRADING MENU and enter 1$ as the contract name. Purchases will be charged to your cash account and sales will be credited to your cash account.

Unit portfolios may also be purchased from and sold to other traders at current market prices. Use the Purchase and Sell options as above but enter MKT as the contract name. The price charged for market portfolio purchases will be determined as the sum of current ask prices, and the price received for market portfolio sales will be the sum of current bid prices. Should no corresponding bid or ask be present for one of the candidates, contracts in that candidate will be excluded from the portfolio; otherwise the number of contracts purchased or sold will be the same in each candidate.

*Market access.*    Current and newly enrolled IEM traders will automatically be given access rights to the 1996 Presidential election winner-takes-all Market. Access to this market is achieved via the "Market Selection" option on the Login, Market, and other menus. Funds in a trader's cash account are fungible across all markets so new investment deposits are not required. Additional investments up to the maximum of $500 can be made at any time. With five days' advance notice, funds may be withdrawn on the 15th of any month.

### IEM prospectus: 1996 Presidential election vote-share market

On Sunday, February 4, 1996, the Iowa electronic market (IEM) will open trading in a vote-share market based on the 1996 Presidential election. 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.

Payoffs in the Presidential vote-share market will be determined by the percentage of the total Democratic and Republican popular vote each candidate receives in the 1996 U.S. Presidential election. For instance, contracts for a candidate that receives 32.4% of the total popular vote received by the Democratic and Republican nominees, will be worth 32.4 cents each.

*Contracts.*    Initially the market will consist of four pairs of contracts representing the Democratic Presidential nominee matched against each of four possible Republican convention outcomes. When the Republican nominee is determined, all contract pairs related to

other Republican nominees will expire worthless and be removed from the market. Two contracts will then remain in the market: one representing the Democratic nominee and one representing the Republican nominee. The payoff to the Democratic nominee contract will be $1 times the percentage of the total Democratic and Republican popular vote that the Democratic nominee receives in the 1996 U.S. Presidential election. Similarly, the payoff to the Republican nominee contract will be $1 times the percentage of the total Democratic and Republican popular vote that the Republican nominee receives in the 1996 U.S. Presidential election.

At market open, the financial contracts traded in this market are:

| Code | Contract name |
| --- | --- |
| V.DOLE | Robert Dole |
| CL|DOLE | Democratic nominee versus Dole |
| V.FORB | Steve Forbes |
| CL|FORB | Democratic nominee versus Forbes |
| V.GRAM | Phil Gramm |
| CL|GRAM | Democratic nominee versus Gramm |
| V.OREP | All other Republican candidates |
| CL|OREP | Democratic nominee versus all other Republican nominees |

The contract, V.DOLE, represents the Republican candidate, Robert Dole. The contract CL|DOLE represents the Democratic nominee in a race against Dole. If Dole does not become the official Republican nominee for President, then these two contracts will expire worthless and will be removed from the market.

Similarly, the contracts, V.FORB and V.GRAM, represent the specific Republican candidates, Steve Forbes and Phil Gramm, and the contracts, CL|FORB and CL|GRAM represent the Democratic nominee in a race against Forbes and Gramm, respectively. If the candidate does not become the official Republican nominee for President, then the associated contract pair will expire worthless and will be removed from the market.

The label V.OREP represents all other Republican candidates. The contract CL|OREP represents the Democratic nominee in a race against all other Republican candidates. If a candidate represented by a candidate-specific contract becomes the Republican nominee for President, then the V.OREP and CL|OREP contracts will expire worthless and will be removed from the market.

Contracts related to specific Republican candidates will have a non-zero liquidation value only if the associated candidate receives the official Republican nomination. The contracts related to all other Republican candidates will have a positive liquidation value only if a candidate not represented by a candidate-specific contract becomes the official Republican nominee for President.

The label "CL" is used for ease of identification. Throughout the operation of the market, "CL" will always represent the Democratic Presidential nominee.

***Contract spin-offs.***    A pair of new candidate-specific contracts will be spun off in this market whenever the price of that candidate in the IEM Republican convention market exceeds $.10.

When new, candidate-specific contracts are created, they will be spun-off from the V.OREP and CL|OREP contracts. Each V.OREP contract will be replaced by two new contracts: a candidate-specific Republican nominee contract and a new V.OREP contract. The new V.OREP contract will represent all remaining un-named Republican candidates in the market. Each CL|OREP contract will be replaced by two new contracts: a new Democratic nominee versus specified Republican opponent contract and a new CL|OREP contract. The new CL|OREP contract will represent the Democratic nominee's vote share against all remaining un-named Republican candidates in the market.

Since the value of the V.OREP and CL|OREP contracts may change when new candidate-specific contracts are spun off, all outstanding V.OREP and CL|OREP bids and asks will be canceled at the time of the spinoff.

Contract spin-offs will be announced in the IEM News Screen at least two days in advance of the spin-off.

***Contract retirement.***    Once each party's nominee has been officially determined, trading in the contracts related to all unnominated candidates will cease and those contracts will expire worthless. The remaining Republican and Democratic parties' contract will represent the Republican and Democratic parties' nominee, respectively. If that candidate subsequently drops out of the Presidential race, his or her contract will denote the person designated as the official replacement by his or her party.

***Determination of liquidation values.***    Once the nominees have been determined, all other contracts will be

declared worthless and expire. The remaining contracts in this vote-share market will pay off $1.00 times that candidate's share of the popular vote received by the Democratic and Republican nominees in the 1996 U.S. Presidential election.

For purposes of determining liquidation values, we will use the vote shares reported in the New York Times on Friday, November 8, 1996. In the event that vote shares are not reported in that edition of the New York Times, we will use the vote shares last reported in the New York Times.

***Third party candidates.*** This market is based only on the Democratic and Republican popular vote in the 1996 Presidential election. It will remain unaffected by the entry of any third party candidates into the race.

***Market closing.*** This market will close at noon, Wednesday, November 6, 1996, the day after the Presidential election. As soon after the election as official election returns are announced, liquidation values will be declared and funds credited to the cash accounts of the market participants.

***Unit portfolios.*** Unit portfolios consisting of one of each of the contracts listed in the Presidential vote-share market can be purchased from or sold to the IEM at any time. The price of each unit portfolio is $1. Since the percentages of the popular vote received by each candidate must sum to one, the total payoff from holding a unit portfolio until the market closes is $1.00.

To buy unit portfolios from the system, use the "Purchase" option from the TRADING MENU and enter 1$ as the contract name. To sell unit portfolios to the system, use the "Sell" option from the TRADING MENU and enter 1$ as the contract name. Purchases are charged to your cash account and sales are credited to your cash account.

Unit portfolios may also be purchased from and sold to other traders at current market prices. Use the Purchase and Sell options as above but enter MKT as the contract name. The price charged for market portfolio purchases will be determined as the sum of current ask prices, and the price received for market portfolio sales will be the sum of current bid prices. Should no corresponding bid or ask be present for one of the candidates, contracts in that candidate will be excluded from the portfolio; otherwise the number of contracts purchased or sold will be the same in each candidate.

***Market access.*** Current and newly enrolled IEM traders will automatically be given access rights to the Presidential vote-share market. Access to this market is achieved via the "Market Selection" option on the Login, Market, and other Menus. Funds in a trader's cash account are fungible across all markets so new investment deposits are not required. Additional investments up to the maximum of $500 can be made at any time. With five days' advance notice, funds may be withdrawn on the 15th of any month.

## Acknowledgments

## Notes

1. The latter result is in an earlier version of the paper cited in the 1992 work. In laboratory experiments, Forsythe et al. (1993) and Rietz, Myerson, and Weber (1998) also show that perceptions of viability influence voters. Voters tend to shift votes to more viable, but slightly less preferred, candidates when their most preferred candidates are unlikely to win. This helps avoid wasting votes on candidates that are not viable, while supporting candidates that are still preferred to others by the majority of voters.
2. For a few examples, see the references in Berg et al. (2001).
3. Since 1993, these markets have expanded to predict many other types of events including other political outcomes, financial and accounting outcomes for companies, national and international economic phenomena, box office receipts for movies, etc.
4. Note, we call these linear markets because the liquidating dividend is a linear function of the normalized values. However, the normalization does not need to be linear.
5. Technically, this contract represented the Democratic nominee and was only named "Clinton" for convenient recognition.
6. Technically, after the nomination of Dole, this contract represented the Republican nominee and was only named "Dole" for convenient recognition.
7. See Berg, Nelson, and Rietz (2001) for a justification in context and Malinvaud (1974) for a general equilibrium proof.
8. As identified by the IEM according to their performance in major polls after 1/1/1996.
9. The bid/ask midpoint overcomes problems caused by bid/ask bounce. The normalization adjusts for possible asynchronicities and asymmetries in the bids and asks and implies that forecasts can be interpreted as vote shares or probabilities by insuring that they sum to 1.

10. At the same time, the IEM also ran a Republican nomination market designed to predict the chances that each candidate would be nominated directly. The set of candidates in this market did not match exactly the set of candidates in the vote share market. For internal consistency, we use the nomination forecasts implied by the vote share market as discussed here. It matters little. The correlation between the forecast probabilities for Dole between the two markets was 0.9781 and was similarly high for other candidates common to the two markets.

11. Rietz, Myerson, and Weber (1998) show that voters can use campaign finance levels to signal preferences for candidates and influence other voters to support candidates by contributing more to campaigns.

12. *T*-tests also reject.

13. Normalization divides the forecast conditional vote shares by the probability of nomination. This can cause some instability in candidates with low and varying probabilities of nomination.

14. By the time the Alexander contracts were listed, he was already running low on funds. This may explain the drop in his forecast. Gramm's surprising performance in Louisiana appears as a jump up in his forecast, followed immediately by a jump down. Forbes' surprising showings in Delaware and Arizona seem to have buoyed his forecast, but the effects of Dole's strong wins from March 2 through March 7 are apparent.

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