Prediction markets may serve as viable alternatives or additions to more conventional forecasting methods. Begun in 1988, the Iowa Electronic Markets (IEM) have played a prominent role in the arguments used to promote prediction markets as valuable forecast tools. In this paper, we investigate the general lessons we have learned from the IEM, outline features of the IEM that affect the generalizability of its results, and point to areas that require future research.

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Prediction markets, markets in which contracts are specifically designed so that prices forecast particular future events, appear poised for acceptance as alternatives to more conventional forecasting methods (for reviews see Berg, Forsythe, Nelson and Rietz, 2003, and Wolfers and Zitzewitz, 2004). One frequently mentioned reason to believe that such markets could be successful forecasting tools is the predictive accuracy of the Iowa Electronic Markets’ (IEM) presidential election markets. To our knowledge, these markets are the longest running real-money prediction markets to date. Created in 1988, they continue to be used as a research and teaching tool as well as a more practical forecasting tool. In this paper, we examine what has been learned from these markets, and more importantly, what is still to be learned.

While the Iowa Electronic Markets have proven quite accurate in forecasting through the years, they do not behave in ways that one might expect from efficient markets populated by rational traders. Large market volumes stand in contrast to Milgrom and Stokey’s, 1982, no-trade theorem. IEM traders exhibit biases and lack self insight (see Forsythe, Nelson, Neumann and Wright, 1992, Forsythe, Rietz and Ross, 1999, and Oliven and Rietz, 2004). And, we know of traders who claim attempts to manipulate IEM prices (see BoCowgill.com and Wolfers and Zitzewitz, 2004). Nor are these markets simply polls. IEM traders are clearly not a representative sample of the population (see Berg, Nelson and Rietz, 2003).

With all of these issues, how can we hope that prediction markets like the IEM would aggregate information and make efficient forecasts? Yet IEM prices respond quickly to information, are accurate in both a relative and absolute sense immediately before the event and well in advance, and they appear to exhibit little bias (see Berg, Forsythe, Nelson and Rietz, 2003, and Berg, Nelson and Rietz, 2003). Empirically, prediction markets “work.” As Nobel Laureate Vernon Smith (1990, pp. 2-3) writes “things sometimes work better than we had a right
to expect from our abstract interpretations of theory.” He encourages us to pursue the “exciting implications” of this conundrum. This paper follows in that vein. We investigate some intriguing results from the Iowa Electronic Markets, using the 2004 election markets as our primary examples and examine the potential for future research.

IEM Overview

The IEM is a real-money, small-scale futures market that focuses on the information revelation and aggregation roles of market prices rather than their role in determining allocations. Though the IEM is best known for its U.S. and worldwide election markets, it has also conducted markets on political appointments, outcomes of legislative processes, international relationships, economic indicators, movie box office receipts, post IPO market capitalizations, corporate earnings forecasts, corporate stock price returns, and the incidence of influenza.¹

IEM contracts take several payoff forms. The primary forms are linear payoff contracts (called “vote-share” contracts when used in elections), binary payoff contracts (called “winner-take-all” contracts), and conditional contracts (generally combining a linear payoff form that will be implemented only if some second event happens).² Contract payoff form determines the interpretation of market prices.

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¹ The IEM began conducting earnings forecast, corporate stock returns, and economic indicator markets in 1993. Movie markets based on individual movie four-week box office receipts were begun in 1995. Since that time commercial exchanges have created similar event markets. See as examples, the Goldman Sachs Economic Derivative markets, the Hedge Street markets (which incorporate the IEM innovation of using bundles), the Hollywood Stock Exchange (HSX) markets (a “fake money” market trading IEM-like contracts on box office receipts as well as other contracts), and TradeSports (an online betting operation that has incorporated IEM-like contracts on political events, sometimes even duplicating IEM contracts).

² The IEM first introduced conditional contracts in the 1996 Presidential election vote-share market. Berg and Rietz (2003) describe how prices from these conditional contracts consistently indicated that Dole was a poor choice to run against Clinton. This information could have been used to inform the choice of Republican nominee.
Linear contracts are so named because their liquidation values are a linear function of the associated event.\footnote{There is no theoretical reason that the functional form needs to be restricted to one that is linear. Any function that will give an understandable, known, unique relationship between outcomes and payments and that bounds payments appropriately would do. In fact, in many cases the payoff functions used by the IEM are “flat” (bounded at 0 or 1) when the associated event measure is outside a pre-specified range. For example, the IPO_UP contract in the Google IPO Market Capitalization Linear Market had a payoff specified as $0 if the IPO did not take place by March 31, 2005, \((\text{Market Cap in billions.})/(100 \text{ billion})\) if the Market Cap was above $0 billion but less than or equal to $100 billion, and $1 if the Market Cap was above $100 billion. Such contract forms complicate the interpretation of prices. The IEM typically uses linear contracts because their payoff function is simple to explain to traders and the informational interpretation of price is straightforward.} For example, the 2004 KERR contract’s liquidation value was specified as $1 times Kerry’s share of the two-party popular vote. Because the expected value of a linear contract is a multiple of the expected value of the associated event, contract prices should reflect expected values of events (for instance, in the case of KERR, Kerry’s expected two-party vote-share).

Winner-take-all contracts have binary payouts: the contract is liquidated for a fixed positive amount (for instance, $1) if the associated event happens, and zero otherwise. For example, the 2004 DEM04_G52 contract’s liquidation value was $1 if the Democrats received more than 52% of the two party popular vote, and $0 otherwise. Because the expected value of a winner-takes-all contract is the probability that the associated event will happen, contract prices should reflect each event’s probability.

Finally, conditional contracts are based on combinations of events and, as a result, give information about potential combinations of events. For example, before the Democratic nominee was known for the 2004 U. S. Presidential Election, the IEM traded contracts tied to the vote-shares that each potential nominee would receive in a race against Bush if that nominee actually became the Democratic candidate for president. In this market, the contract GEPH was associated with Dick Gephardt and, had Gephardt actually become the nominee, would have liquidated at $1 times the vote-share received by Gephardt in the election. An associated
contract, BU|GEPH, would have liquidated at $1 times the vote-share received by Bush if Gephardt had become the nominee. Since Gephardt did not become the nominee, both contracts liquidated at $0. However, the contracts KERR and BU|KERR (associated with John Kerry as the nominee) did have positive liquidation values because Kerry did become the Democratic nominee. These two contracts became the sole vote-share contracts after the Democratic convention and were liquidated at the relative vote-shares received by Kerry and Bush after the election. Because the values of conditional contracts are tied to combinations of events, prices reflect expectations about the combination of events (in this case, the relative vote-shares received by the candidates conditional on the nomination).

IEM traders are voluntary participants that invest between $5 and $500. Though the 1988 IEM traders were all University of Iowa affiliates (students, faculty, staff), current IEM political market traders include both academic and non-academic traders from around the world. The percentage of non-academic traders in political markets has increased greatly as the Internet, and therefore the markets, have become more accessible. In the IEM 2004 Presidential Election markets, non-academic traders represented 44% of traders in the vote-share market and 64% of the traders in the winner-take-all market. Typically between 25 and 1,500 traders are active in any one market.

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4 Later we will argue that, under the right conditions, prices will do more than reflect expectations, they will equal expected values.
5 In some markets used primarily for classroom purposes, students may be required to trade as part of their class assignments.
6 Some markets are open to academic traders only. While those markets are developed primarily for classroom purposes, they also provide data for prediction market research.
7 Though there is a higher percentage of non-academic traders in the winner-takes-all markets, the percentages of dollar volume traded by trader type does not differ much between the two 2004 election markets. In the winner-takes-all market, 71% of purchases and 58% of sales were by non-academic traders. In the vote-share market, 73% of purchases and 64% of sales were by non-academic traders. The asymmetry in purchases versus sales reflects that fact that when trades involve one academic trader and one non-academic trader, the academic trader is more likely to be on the sell side of the transaction.
IEM contracts are traded in a continuous double auction market. There are no fees charged for trading or liquidating contracts. The trading is anonymous, with the trader’s market information set consisting of the current best feasible bid, current best feasible ask, and last trade price. This information is updated every 15 to 30 seconds, with traders having the option of refreshing their information more often. Traders also have access to a daily price history that reports daily quantity and dollar volumes and high, low, average and last (before midnight) prices. They can also see historical graphs of the daily last prices at any time. Finally, they know their own cash and contract holdings and can access historical records pertaining to their own bids, asks and trades.

As part of the market structure, the IEM issues contracts in sets called fixed-price bundles. Each fixed-price bundle consists of a set of contracts guaranteed to have a fixed total payout. For instance, after Kerry was determined to be the Democratic nominee, the 2004 U.S. Presidential Vote Share market bundle consisted of two contracts: KERR and BU|KERR (that is, Bush in a match against Kerry), where the liquidation value for each contract was the associated candidate’s share of the two-party vote.8 Because, as defined, total vote-share is always 100%, holding one of each of the contracts (a contract bundle) to liquidation always results in receiving $1. At any time and at no cost, traders can exchange dollars for bundles, increasing the market supply of contracts, or exchange bundles for dollars, decreasing the market supply of contracts. This creates instantaneous and intertemporal arbitrage relationships that restrict the risk free rate to zero in these markets.9 No short sales or margin purchases are permitted. However, traders can always replicate short positions synthetically by purchasing bundles (which are equivalent to

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8 As discussed above, prior to the determination of Kerry as the nominee, additional contracts corresponding to different potential nominees traded in this market.

9 Because there is no need to bear risk, there is no reward for bearing risk.
cash in this market) and selling individual contracts.\textsuperscript{10} The bundle and short sale features replace
the need for a banking/credit function that would guarantee traders’ promises to pay.

\textbf{Stylized Facts from IEM Markets}

1. Traders are not a random sample of the voting population.

IEM traders are typically more educated, richer, and “more male” than both the average
U.S. citizen and the average U.S. voter. Among IEM 2004 election market traders responding to
a voluntary survey, 95\% reported they planned to vote, 90\% reported they were male, 90\%
reported they were white, 89\% reported they have college degrees, and 60\% reported household
incomes greater than $75,000.\textsuperscript{11} In apparent contrast to previous IEM election markets, traders’
self-reports classified nearly equal proportions as Democrat and Republican (37.5\% and 35.5\%
respectively; previous IEM markets reported that traders were overwhelmingly Republican).

While these “non-representative” features would invalidate a poll, it does not necessarily
present a problem for prediction markets. Polls typically ask traders how they would vote if the
election were held today and rely on random sampling for the validity of the prediction. In
contrast, to profit in the IEM, traders need to forecast how the entire population will vote in the
election, independent of how they feel about the candidates themselves. Market action, rather
than statistical averaging, determines IEM prices and predictions.

\textsuperscript{10} In essence, this is simply short selling with a margin account that cash covers the trader’s position to the worst
possible outcome.

\textsuperscript{11} Berg, Nelson and Rietz, 2003, document this “non-random sample” phenomenon for U.S. election markets prior
to the 2004 election.
2. Traders are biased.

IEM traders do not appear to be fully rational. Their reported beliefs are biased by their preferences and the bias appears to be reflected in their portfolio choices (Forsythe, Nelson, Neumann, Wright, 1992; Forsythe, Rietz and Ross, 1999). In addition, traders frequently “leave money on the table,” trading in ways that do not take advantage of the best available prices (Oliven and Rietz, 2004).

Survey results from 2004 also indicate that trader’s beliefs are skewed by their preferences. In response to the question “Regardless of your preferences, who do you think will receive the most popular vote in the upcoming U.S. presidential election?” 68% of self-reported Democrats reported that they believed Kerry would win the election. Among self-reported Republicans, only 5% reported that they believed Kerry would win the election. The bias is also present in IEM traders’ reported beliefs about which candidate “won” the 2004 Presidential debates as well as who “rightfully” won the 2000 presidential election. These biases are similar to the bias reported in Granberg and Brent, 1983.

Further evidence that traders lack self-insight appears in trader’s responses to the question “relative to other traders, how informed do you believe you were about the 2004 presidential election?” 89% of traders responding to the survey reported that they believed they were more informed than other traders in the market. This “Lake Wobegon” characteristic accords with Svenson’s (1981) observation, that by and large, we all think we are more skilled than our peers.
3. Some traders are robots.

While there may have always been robot traders in the IEM election markets, 2000 and 2004 were the first elections in which the presence of robot traders was obvious to us.\textsuperscript{12} In the 2004 election markets, fewer than a dozen traders appear to be robots. But, these robot traders are involved in a large percentage of our trades. For instance, in the 2004 winner-take-all presidential market, a single robot trader was involved in 21% of the 1,106,722 units traded in the market (or 20% of the $327,385 total trade volume as measured in dollars). A similar, though smaller, effect is seen in the 2004 vote-share market.

Our preliminary investigations of these robots’ strategies indicate that they execute one of two strategies. Some appear designed to take advantage of arbitrage opportunities; others appear to rely on price movement strategies. Robots that take advantage of arbitrage opportunities appear to make positive profits. The single robot trader referred to above, earned an average of $0.002 per unit traded. That trading on arbitrage opportunities can be profitable is consistent with data reported in Oliven and Rietz (2004) using the 1992 Presidential markets and Rietz (2003) in laboratory markets. We have not yet completed our analysis of the other robot traders’ behavior.

4. Large orders to trade can move price.

As with any market, changes in demand and supply will impact prices. Large orders to buy (sell) may result in upward (downward) price movements. In finance, this is known as the

\textsuperscript{12} A robot trader is a computer program that executes trades according to a predefined set of rules (such programs are sometimes referred to as “programmed trading”). We have three primary means to identify robot traders. First, robot traders are sometimes self-reported by their creators by asking whether there is a rule against robot traders (to date there is not). Second, robot traders frequently use their own interface for accessing our markets rather than using our web pages. Reading our Internet server logs allows us to detect these differences. Finally, robot traders can process trades more quickly than human traders because they do not need to type their requests. So, we can detect robots by examining the speed and frequency with which orders are submitted to the markets.
adverse price effect of the order. However, due to the particular market mechanism implemented by the IEM, not all large orders affect prices.

In IEM markets, large market orders (orders to sell or buy at the best currently available bid or ask) will have very little impact on prices because market orders are cancelled after clearing the quantity available at the top of the opposing queue. For example, if the current best ask is $0.520 for 10 shares of a contract and a trader puts in an order to purchase 10 shares, 10 contracts will trade and the new best ask will be the next ask in the queue, say, $0.525. If the trader puts in an order to purchase 20 or 100 or even 1000 shares, the same thing happens: 10 contracts will trade and the new best ask will be the next ask in the queue. The rest of the trader’s order is cancelled.

Further, in IEM markets large limit orders (bids and asks) that do not cross the opposing queue will not affect prices at all. For a trade to occur and, hence, a price to be recorded, an outstanding bid (ask) must be accepted by a trader submitting a sale (purchase) market order. The order will only trade the smaller of the quantity of the order or, as discussed above, the quantity available at the top of the opposing queue. Thus, the net effect of large limit orders that do not cross the opposing queue, is to prevent prices from moving past the price specified in the order.

One type of large order can affect prices in IEM markets: large bids or asks that cross the opposing queue. For example, if the current best ask is $0.520 for 10 shares of a contract and a trader puts in a bid to purchase 100 shares at $0.60, 10 contracts will trade at $0.520. Then, the next best ask, provided it is lower than $0.60 will trade against the bid order, etc., until the order is filled or no compatible asks remain in the queue. Thus, depending on the depth of the opposing queue, large order that cross the opposing queue could move prices substantially.
There are several reasons one might submit an order that crosses the opposing queue. First, it may be a mistake. Communications from traders suggest that this does happen from time to time. We should see queues recover quickly and prices reverse if mistakes are the cause. Second, crossing the queue is a much faster and more efficient way to make informed trades than submitting a series of market orders to clear each opposing bid or ask. For example, suppose a trader had advance information that Dean would lose the Iowa caucus and, hence, lose the Democratic nomination. The most efficient way for that trader to make the maximum profit from that information is to cross the Dean bid queue with a large ask at a price of zero before other traders have a chance to withdraw their bids. If the information proves valid, prices would remain at their new levels or, potentially, drift even further in the same direction. If not, prices may reverse. Similarly, suppose someone wanted to manipulate the market. The fastest and most efficient way to move prices is to act in exactly the same manner. If the manipulation were successful, prices would stay at the new values and the trader could unwind his position at a profit. If not, we would see prices reverse. We will discuss manipulation in more detail later. Here, we simply document the price impact of queue-crossing orders.

We have documented several large bids that cross the ask queue and large asks that cross the bid queue. The immediate effect of these orders depends on the depth of the opposing queue. In the 2004 Winner-Takes-All Presidential market prior to the election, large bids or asks crossed the opposing queue (<1.2% of the 179,930 total submitted bids and asks). The largest price movement from a crossed ask queue was an $0.11 increase resulting from a bid for 100

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13 Orders entered before midnight November 1. On Election Day, we would expect and do observe orders crossing the queues in order to take advantage of the arrival of new definitive information about the outcome of the election.
Most of this price change ($0.105) reversed within an hour, and it more than completely reversed within two hours. The largest price movement resulting from a crossed bid queue was $0.038 resulting from an ask for 530 contracts. This price movement completely reversed within one minute. Because of the reversals, neither movement appears in histories of closing prices.

Some price movements that reverse do appear in closing price data because of the timing of the trading activity. For example, Kerry’s price in the 2004 vote share market was at $0.488 at 9:00pm on October 7. With a sequence of small trades, two different traders drove the price up to $0.700 by 9:06pm. Another small trade occurred at $0.650 cents at 9:56pm. While no other trade occurred before midnight, the best ask had fallen back to $0.482 cents by 10:18pm. At 1:36am the next morning, the next trade occurred at $0.480 cents. In this case, the reversal in the price series took three and a half hours and the recording time for closing prices happened to occur before the reversal. Note that the reversal in asks had occurred well before this, even though no trade had yet occurred.

In the final analysis, it appears that large orders are not significant factors in IEM prices.

5. IEM prices are accurate, both relative to the next best alternative (polls) and absolutely.

Our most straightforward measure of IEM accuracy comes from the linear markets because prices in those markets predict vote-share (an externally verifiable measure) rather than probability. As reported in many papers, IEM vote-share prices appear to be accurate both in an

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14 This was on the contract that would pay off $1 if Bush took more than 50 and less that 52% of the popular vote. The price moved from $0.223 to $0.333 on September 28 at 9:54 pm. Prices fell back to $0.227 at 10:55pm and the contract closed at $0.210 at midnight.

15 This was on the contract that would pay off $1 if Bush took more than 52% of the popular vote. The price moved from $0.461 to $0.423 on September 30 at 5:24 pm. The price had gone back up to $0.468 at 5:25 pm and closed at $0.485 at midnight.
absolute sense (that is, relative to what actually happens) and relative to polls. Figure 1 is an expanded (to include the 2004 election results) version of a similar figure in Berg, Forsythe, Nelson and Rietz, 2003. It shows the accuracy of IEM election eve contract prices for all IEM election vote-share markets conducted since 1988. The average absolute percentage error for presidential election eve contracts is 1.33%. While we have not completed our analysis of poll performance for 2004, previous analyses of IEM accuracy relative to polls (for elections prior to 2004) indicate that final projection poll error averages 2% (Berg, Forsythe, Nelson, Rietz, 2003).

![Figure 1: IEM election eve predictions versus actual vote-share outcomes.](image-url)

IEM prices also appear to outperform polls in advance of the election. Figure 2 shows Bush’s relative vote-share margin as reported in 2004 IEM prices and major national polls (all vote-shares and poll-shares have been normalized to sum to 1; Bush’s vote-share margin is
calculated as Bush’s normalized vote-share less Kerry’s normalized vote-share). IEM prices are more stable than polls, respond less to transient events than polls, and are closer to election outcomes than the average poll when the election is more than one week away. Previous elections show strikingly similar results. Berg, Nelson and Rietz (2003) report that, when polls are compared to corresponding IEM prices over the course of the election, IEM prices are closer to the actual election vote-share than polls in 76% of the cases.¹⁶

![Figure 2: Bush vote-share margin in the IEM and polls (polls results are indicated by x’s).](image)

Our results about the accuracy of IEM winner-take-all prices are mixed. When both linear and winner-take-all markets are focused on the same event, the price distribution and its

¹⁶ Berg, Nelson, Rietz (2003) analyze 596 national polls conducted while the 1988, 1992, 1996, and 2000 IEM election markets were open. Compared to contemporaneous IEM prices, 76% of the polls examined were less accurate in forecasting election outcomes than IEM prices.
central tendency extracted from winner-take-all market prices are consistent with the prediction implied by the linear market prices. By extension, then, prices in the IEM winner-take-all prices would seem to have the same accuracy characteristics as the linear markets. But, we are also able to document some bias in winner-take-all markets.

Berg and Rietz (2002) document that prices in a large sample of IEM computer returns markets do not exhibit the same longshot bias documented in the betting literature (in a longshot bias, the probabilities of low-frequency events is overestimated). For short horizons, these IEM markets appear to be unbiased. However, for most horizons longer than one day, the same markets exhibit the reverse of the longshot bias: prices for events that actually happen with low frequency are too low, while prices for events that actually happen with high frequency are too high. Berg and Rietz (2002) interpret this as an overconfidence bias and document the potential gains to trade available by trading against this bias.

6. IEM prices respond quickly to news.

IEM market prices appear to respond quickly to news, sometimes well in advance of the official public announcement. A most striking example occurs in the 1996 Powell Nomination Market, an IEM market focusing on whether Colin Powell’s name would be placed in nomination in the 1996 Republican Convention. During the fall of 1995, speculation was high that Powell would be nominated. IEM prices reflected that speculation, with the price of the P.YES contract (a contract that would pay $1 if Powell’s name was placed in nomination at the convention in August 1996 and $0 otherwise), growing to more than $0.60 by November 7, 1995. On November 8, 1995, at 8:10am C.S.T., Powell announced that he would be holding a
press conference later that afternoon. As shown in Figure 3, prices reacted immediately to that announcement even though it contained no explicit information about the content of the upcoming press conference. Within minutes, the IEM price dropped from above $0.60 to almost zero, correctly forecasting the content of the announcement that was not made until more than seven hours later. Apparently traders put together the announcement that there would be “news” later in the day and the fact that there were few rumors about a campaign committee, to conclude that there would be no campaign.

Figure 3: IEM price response to announcement that Powell would hold a press conference later in the afternoon

A similar permanent effect of news can be seen in the response to the January 19, 2004, Iowa Caucuses. Surprising both pollsters and the IEM, Dean lost the Iowa Caucuses badly. Late
in the evening, he made a speech that some say was the death knell of his campaign. As Figure 4 shows, the IEM 2004 Democratic Nomination Market actually portended this fall. Though Dean was the most likely nominee according to IEM prices before the Iowa Caucuses, his price had already fallen from a high of $0.76 on December 9, 2003, to $0.51 on January 18, 2004, the day before the caucus (a drop of $0.25). In contrast, he fell by only $0.16 (to $0.35) on the day of the caucus.

Some “announcement effects” are not permanent. Some of these events appear to be related to information that, if proven correct, would have a large effect, but is later proven incorrect. One such event occurred in the 2004 Democratic Nomination Market. As shown in Figure 4, on February 11, 2004, Kerry’s price in the IEM Democratic Nomination market stood at $0.95. On February 12, 2004, at 10:45am C.S.T., the Drudge Report posted a “world exclusive” claiming that several news agencies were about to release information that John Kerry

![Figure 4: 2004 Democratic Convention Market Prices](image_url)
had had an affair with an intern. Seconds later, sell orders began to flood the market. Within 10 minutes, Kerry’s price dropped to $0.75. Were Drudge’s claims true, it surely would have hurt Kerry’s chances of nomination. This was reflected in market prices. However, Drudge’s report remained unconfirmed and within two days, Kerry’s price returned to $0.86.

Election day, 2004, also provides an interesting view of IEM price response. Early election exit poll results were leaked on mydd.com at 12:58pm C.S.T. At 2:15pm C.S.T., Slate posted additional exit poll results. At 4:00pm C.S.T., Zogby posted its prediction that Kerry would take 311 electoral votes. Figure 5 shows the IEM winner-takes-all price responses to these news events. For clarity, the graph collapses all four contracts in that market into a single statistic: the spread between the probability that Bush would get the most popular vote and the probability that Kerry would get the most popular vote.18

Though there was some price reaction to the mydd.com report, most of the price reaction occurs after the Slate report and the Zogby forecast, possibly indicating sensitivity to both the tentative nature of exit polls and the quality of the news source. This downward trend begins to reverse at 7:45pm C.S.T. as actual poll results from the East Coast and Midwest begin to be reported on the national news. By 11pm C.S.T., a full hour in advance of national networks beginning to call Ohio for Bush, IEM prices reflected a 90% probability that Bush would win the most popular vote.

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18 Note that when market prices assess the probability of a Republican getting the most popular vote at 90% (and therefore the corresponding probability of a Democratic getting the most popular vote at 10%), the spread statistic will be measured as 0.80. Note also that the traders are forecasting popular vote-share and not electoral votes, so they must translate state by state announcements into a popular vote forecast.
While IEM prices appear to respond quickly to news, whether prices move by the "correct" amount in response to any particular orders is difficult to document because there is no contemporaneous externally accurate and verifiable measure of expectations. In fact, it is difficult to imagine a non-market measure that could move with the speed of the market.

Open Issues

1. Theoretical Model

That IEM prices are efficient aggregators of information is generally motivated by a simple Arrow-Debreu asset pricing model. In an Arrow-Debreu world, with rational, common expectations, it is easy to show that general equilibrium IEM contract prices should equal expected future values weighted by marginal utilities of wealth across various states. That is, IEM contracts should conform to the familiar Arrow-Debreu asset pricing relationship with no
time value of money factor (which drops out because of the arbitrage-induced zero risk free rate discussed above). In this weighted sense, prices will always reflect expectations. However, under the right conditions, this model gives prices that actually equal expected values. For expected value pricing to hold, the marginal trader must have equal expected marginal utilities across the state outcomes. When might this be the case? There are several possible answers:

(1) If marginal traders are risk neutral, the marginal utility of wealth is always 1.

(2) If marginal traders’ wealth levels are largely unaffected by or uncorrelated with the state outcomes, marginal utility for even risk averse traders will vary little across states.\textsuperscript{19}

(3) If the market is the entire source of wealth risk and can be modeled by a representative trader, then market clearing implies that the trader holds equal numbers of contracts (because of the bundle structure) and faces no risk. As a result, the traders wealth and, hence, marginal utility is constant across outcomes.

(4) If the market is the entire source of wealth risk in the economy and traders are risk averse, then Borch (1960), Caspi (1974) and Malinvaud (1974) all show that the Pareto optimal, competitive equilibrium distribution of contracts implies that all traders hold only complete bundles. This also implies that traders face no wealth risk and, hence, marginal utility does not vary across states.

The latter two possibilities are what would result from CAPM or APT models with no aggregate risk premium and zero time value of money.

Several other authors have also proposed agent-based models to explain IEM prices, with many of the models omitting the rational expectations assumptions. All these models typically omit features of the IEM market structure that appear empirically to be important. In IEM

\textsuperscript{19} The evidence on trading activity from Forsythe, Nelson Neumann and Wright (1992) and Forsythe, Rietz and Ross (1999) is consistent with this. Traders who seem to have a vested interest in the election trade to corners. The remaining price setting traders are less likely to have significant marginal utility differences across states.
markets, contract supply can expand and decrease as traders exchange dollars for contract bundles (which creates instantaneous arbitrage restrictions on prices), traders’ market power is limited by a $500 investment cap (which may create binding budget constraints, but limits market power), and traders appear to be differentially informed (which may create differential expectations). Because trader information may contain different pieces of the puzzle, it is not clear how prices should be related, if at all, to average trader beliefs.

Trader survey responses may also provide some insights valuable to theoreticians. As we noted above, most traders believe that they are more informed than other traders. This provides a possible reason that trade may occur even when the Milgrom and Stokey (1982) no-trade intuition appears applicable. Our 2004 survey results also indicate that traders differ in their trading strategies. Only 76% of the respondents reported that more than half of their trades were based on information. Further, in response to a question about trading strategy, it is clear that different traders use different strategies: 50% reported that they primarily followed buy and hold strategies, while 21% reported that they primarily acted as speculators (defined in the survey as trading with the intent of reversing the trade before the election was over) and 18% reported that they primarily acted as arbitragers (defined in the survey as taking advantage of short-term inconsistencies in price).20 Interestingly, traders do seem to have some self-insight about their trading strategies. At the close of the 2004 presidential election markets, 47% held more than 100 contracts in inventory (consistent with a buy and hold strategy), 18% held small inventories

20 The remaining 11% reported some other strategy. These survey results are preliminary. The survey was administered after the close of the 2004 election markets. As a result, our response rate is low relative to our other survey response rates. We are trying to increase survey sample size for this survey by sending traders email requests to complete the survey.
(20 or fewer contracts), and 19% of traders held zero contracts (consistent with a short-term arbitrage strategy).\textsuperscript{21}

Bundles and arbitrage may also play an important part in a theory of IEM prices. The costless, instantaneous conversions of cash into bundles and bundles into cash create arbitrage relationships that restrict the risk free rate to zero. Conversions also allow synthetic short sales. But, they may have an additional effect. Rietz (2003) documents that Arrow-Debreu contracts are consistently overpriced in markets similar to the IEM with contract bundles, but without the unlimited instantaneous conversion feature.\textsuperscript{22} Nevertheless, relative prices in those markets do appear to be accurate: normalizing prices (dividing each absolute price by the sum of all contract prices) results in prices that reflect true state probabilities. Because bundles facilitate arbitrage and drive the sum of contract prices toward $1.00, the IEM markets create largely endogenous normalization of prices. Thus the ability to costlessly and limitlessly trade fixed-price bundles may be at least partly responsible for the observed accuracy of IEM prices.

2. Manipulation

Whether prices can be manipulated may affect the predictive ability of the market. If successful price manipulation results in long-run price distortions, then the fact that IEM prices appear to be accurate suggests that IEM prices are not manipulated successfully. But, this does not rule out the possibility of short-term manipulation.

\textsuperscript{21} We use 20 contracts and 100 contracts as cutoffs because the average trader investment is about $200. Holding 20 contracts represents putting about $10 (5% of the investment) at risk, while holding 100 contracts represents putting about $50 (25% of the investment) at risk.

\textsuperscript{22} Unlike the IEM, which has instantaneous conversions of cash and bundles, Rietz (2003) has a fixed supply of bundles trading in a separate market. In contrast to the IEM, this results in many arbitrage opportunities between cash and bundles. However, there are few arbitrage opportunities between bundles and contracts in the laboratory markets.
To determine whether manipulation is a factor, one must ask a series of questions. First, is manipulation of prices possible? Second, if manipulation is possible, why would traders want to manipulate prices (that is, what are the benefits of manipulating prices)? Third, if manipulation is possible and traders do want to manipulate prices, how costly would it be? And finally, if manipulation is undertaken, can it be detected?

Is price manipulation possible? As discussed above, large trades can, at least temporarily, move prices by moving through the opposing queue. And, there is ad hoc evidence that IEM observers believe prices can be manipulated. During the 1996 Republican primaries, Pat Buchanan’s website listed trading on the IEM among the ways that supporters could “help Pat.” During the 2000 election markets, Strumpf (as reported in Wolfers and Zitzewitz, 2004) attempted to manipulate IEM prices by issuing random large trades, but claims the attempt had only limited success. During the 2004 election markets, several political blogs posted claims that IEM prices were being manipulated.²³ Also during the 2004 election markets, several individuals sent email to the IEM office claiming that George Soros was manipulating IEM prices.²⁴ However, evidence suggests that prices recover quickly after large trades that do not correspond to actual changes in the prospects of candidates (see the evidence on large trades discussed above).

Why would traders want to manipulate prices? Answering this question helps pinpoint the benefits of manipulation. One commonly cited reason for price manipulation on commercial exchanges is personal (wealth) gain. Political blogs offer another reason, suggesting that price manipulation in the IEM could be attempts to affect election outcomes. It is not clear that traders

²³ For example, see the June 11, 2004, postings on freerepublic.com.

²⁴ In fact, our response to one individual was subsequently posted on a political blog. See http://www.freerepublic.com/focus/f-news/1205670/posts
can create bandwagon effects in prices and profit by strategies such as pushing prices up by buying and later selling. The rapid reversals after large trades (discussed above) are evidence against this. Nor is it clear how voters respond to perceived relative strengths of candidates. For example, if a candidate is perceived to be too far ahead in an election, turnout among that candidate’s supporters may actually fall, hurting that candidate’s prospects. One might manipulate prices for “bragging rights” (to claim that one caused a price move). But, since trading is anonymous, any bragging is cheap talk: traders can always claim responsibility for price movements after the fact and all traders know that no such claim can be verified. Thus, clear reasons for manipulation are not obvious to us.

Assuming that manipulation is possible and there is a reason to manipulate prices, how costly would it be? Manipulating price in the IEM is costly and complex. As an example, consider the trades of an individual trader that appears to be responsible for transient price movement on February 27, 1996, in the 1996 Republican Convention market. That trader’s actions contributed to a $0.04 increase in Buchanan’s price. But the actions were also costly, at least in the short-run. The trader spent $348 purchasing Buchanan contracts while later in the day selling at least some of those contracts for $98. Also consider that, because contracts are tied together through bundles, successful overall manipulation of this type would require the manipulator to move prices in other contracts as well (i.e., a manipulator cannot just move up the price of one candidate, he has to force down the prices of the other candidates, too). This generates a need for additional trading and adds to the complexity and cost of executing a manipulation strategy. An obvious question is whether IEM price manipulation is the most effective way to achieve the desired effect.
Assuming that manipulation does take place, how can it be detected? In particular, can it be distinguished from either informed trading or noise trading? Our initial investigations suggest that detecting manipulation is difficult at best. Consider three types of potential manipulation:

(1) attempting to affect prices through fraudulent information (the usual definition of manipulation from traditional markets), (2) undertaking market activity that attempts to create short run distortions in prices and (3) undertaking market activity that attempts to create long run distortions in prices.

First consider manipulation defined as circulating information with an intent to fraudulently move price. To detect this we would need a way to (1) identify fraudulent releases of information, (2) show that the release was made by one of our traders, (3) show that the trader took a position surrounding the release that benefited him or her and (4) all this was done with intent. As the Drudge Report example above shows, information released on the Internet can affect prices. However, the anonymity associated with much of the information on the Internet often makes it impossible for us to associate information releases with our traders. Further, taking positions with respect to news, as a manipulator would, may also be the optimal response of an astute trader. (Who wouldn’t sell on rumors of an “intern problem” if there were some chance that the rumors were true?) So, identifying this type of manipulation is extremely difficult at best.

Next, consider market activity that attempts to distort prices in the short-run. Such behavior consists of traders’ actions in the market (which we observe) that are at odds with traders’ private beliefs (which we cannot observe). We have not had traders announce in advance that they plan to manipulate price, though we have seen a blog entry laying claim to an IEM Kerry price run-up and subsequent reversal on the first day of the 2004 Republican
Convention. As other bloggers were quick to point out, such claims are cheap talk after the luxury of observing the price sequence.

Finally, consider attempts to distort prices in the long-run. Because IEM contracts are tied to events that are actually observed, successful manipulation permanently distorting prices would be detected in the accuracy tests of IEM prices. We do not detect such effects. That the IEM is accurate supports the argument that even attempts at permanent manipulation, if they exist, must be short lived. This suggests that one feasible way to identify manipulation attempts is by looking for price reversals. Such examinations are hampered by not knowing the time horizon over which to look. Because election cycles are characterized by many news events, price changes over relatively long horizons are not unusual, making it difficult to tell whether individual traders are engaged in market manipulation (trades or offers at odds with their beliefs) or simply have changed their beliefs based on new information.

This leaves us looking for short term price reversals as signals of manipulation. But, short term price reversals indicate failed attempts to manipulate the market. Further, these reversals could be reactions to rumors and subsequent corrections as occurred in the 2004 Election Day trades. Short term price reversals could also indicate trader error or incorporation of information that later changes. For instance, our investigation of Buchanan prices during the 1996 primary revealed a second price run-up of about $0.04 that was reversed later in the day. This price change was caused by several new traders placing large orders for Buchanan contracts. Was it a manipulation attempt? Several factors confound this observation: because the traders are new, they are also the participants most likely to make errors, and the trades occurred the same Tuesday as the Republican primaries in Arizona, North Dakota, and South
Dakota. We cannot distinguish whether the trades were the result of trader error, an attempt to manipulate market prices, or reaction to early but erroneous exit polls.

An examination of trades that occurred on the first day of the 2004 Republican conventions reveals a similarly ambiguous result. Beginning at about 10:00pm. C.D.T., the spread between Democrat and Republican winner-take-all contracts started to shrink. By midnight, the contracts were equally priced.\(^{25}\) By 2:00am C.D.T., prices returned to their previous levels, with Republicans leading Democrats. An investigation showed that many traders were involved in the trades that took place, eliminating the “single manipulator” explanation. So, what caused the price change -- a manipulation conspiracy, a temporary adverse reaction to something that happened during the convention (for example, Senator Zell Miller’s speech or the Bush daughters’ presentation), some Internet rumor?

Screening for large orders is similarly unproductive. For example, Strumpf claims (again, as reported by Wolfers and Zitzewitz, 2004) that he attempted to manipulate the IEM 2000 Presidential Election market prices by placing “random” large orders.\(^{26}\) In this market, 700 large (500 or more unit) orders were submitted by 113 different traders (including Strumpf). Increasing the minimum order size to 750 units, reduces the number of flagged orders to 753 orders by 88 different traders, but also eliminates Strumpf from the trader set.

Structural features of IEM markets may also limit the possibility of price manipulation. Recall that individual trader investments are limited to $500, so that each trader represents only a small part of the funds invested in the IEM (the total dollar amount invested in the 2004 IEM markets was about $360,000). In addition, the IEM’s fixed price bundles allow supplies to

\(^{25}\) It was this price change that caused observers to write to the IEM office claiming that prices were being manipulated.

\(^{26}\) One can question whether “random” orders can be considered manipulation attempts. Such orders seem more akin to noise trading (generally a desirable feature in markets) than deliberate manipulation.
expand or contract and provides the opportunity for low cost arbitrage of contract mispricing. Information features of the election may also limit price manipulation by limiting the informational advantage that particular traders hold. No single individual or small group of individuals controls the actual election outcome, so no single individual or small group of individuals will have perfect private information.

In summary, we do not find strong evidence of successful manipulation of the IEM. In fact, we cannot determine the difference between large orders placed in error and failed attempts at manipulation. Nor can we determine the difference between the results of informed trading and successful manipulation in the short run. The long run accuracy of the IEM suggests that long run manipulation does not occur or succeed. However, because the benefits, costs and ease of manipulation are likely to vary across prediction market settings, insights from IEM may have limited generalizability to other prediction market settings. The extent to which prediction market can be manipulated and the circumstances under which traders may attempt and, possibly, succeed in manipulation are important open questions that require further study.

3. Why/when are prices accurate?

In order for prediction markets to be valuable forecasting tools, users need to know when markets are likely to be accurate in both absolute and relative terms. For example, if the role of markets is simply to find the average of traders beliefs, incentive compatible survey techniques could be just as accurate as markets. Gruca, Berg, and Cipriano (2004) report the results of movie box office receipt markets conducted by the IEM. In many of those markets, traders were also required to prepare individual forecasts before participating in the market. Predictions constructed from market prices and the average forecast of traders were generally not statistically
different. But, the variance of the market predictions was much smaller than the variance of trader forecasts. One limitation in interpreting these results is that forecasts were all prepared before market prices were observed, so that the reduction in variance could be attributable to more public information being available before the market opened.

Berg and Rietz (2004) propose a more systematic investigation of the factors influencing the relative accuracy of prediction market prices in a series of experiments designed to compare individual forecasts, Delphi forecasts, and market forecasts. Because both Delphi techniques and markets allow traders to revise their beliefs, these experiments enable the experimenters to isolate the effects of incentives, feedback, and underlying information structure. Note that all three of these factors are confounded in traditional IEM markets: prices provide both feedback and incentives, and the underlying information structure is not controlled by (and often unknown to) the experimenter.

Berg and Rietz (2004) posit that information structure will be an important determinant of whether markets outperform simple averages of individual forecasts and/or Delphi forecasts. Three information structures are examined: public information where each trader interprets the public information with noise, private information where a subset of traders has perfect information, and private information where traders have different pieces of information. Results from these experiments are not yet available.

4. **What are the characteristics of the “marginal trader”?**

Forsythe, Nelson, Neumann, and Wright (1992), Forsythe, Rietz, and Ross (1999) and Oliven and Rietz (2004) document that “marginal traders” or “market making traders” appear to be responsible for the accuracy of IEM prices. But, who these traders are and exactly why they
drive market efficiency remains largely a mystery. Identifying the characteristics of traders that appear to be crucial to market accuracy should enable market administrators to create prediction market trader pools that are more likely to result in accurate prices. But, the only characteristic identified in Forsythe, Nelson, Neumann, and Wright (1992) is that their marginal traders are all male. Because most traders in the 1988 IEM markets were male, this result could be coincidence. Oliven and Rietz (2004) document that market makers tend to be even more male and more highly educated than the already overwhelmingly male and highly educated trader population and that they tend to be more experienced than average traders. Nevertheless, they also document a “low power to discriminate” between who will take on the role of market maker.

Barrick, Berg, Rietz, and Stewart (2004) take a different approach, investigating whether psychological and behavioral factors that appear to influence job performance also influence trading performance. In this study, IEM traders complete surveys that are traditionally used in job performance research. Traders’ personality profiles are then compared to trading performance. The study is still in progress and has not yet reported results.

Conclusion

What do we know about prediction markets? They appear to “work.” Prices seem intertemporally efficient and forecast well both just before an event and well in advance of the event, both in absolute and relative terms. Prices respond extremely quickly to news. But, exactly how prediction markets become efficient is something of a mystery. Traders are biased and mistake-prone and are a non-representative sample of the population. Some traders are not even human - they are robots that trade according to what must be technical rules. Price
efficiency seems to be driven by marginal, somehow more rational than average, traders, but identifying such traders in advance is problematic.

Our state of knowledge today leaves many open questions about prediction markets and when they are likely to be most accurate. To date, no theoretical model exists that incorporates the features of the IEM that seem to be crucial to its accuracy and also is consistent with observed trader behavior in these markets. While we do not see strong evidence of manipulation, and the efficiency of prices argues against widespread long-run manipulation, we cannot rule it out. It seems difficult to detect in context. Nevertheless, as the use of prediction markets becomes more widespread, especially in the formulation of policy, whether prediction markets can be manipulated and how manipulation can be detected become important questions. We also think a more systematic investigation of accuracy is needed as prediction markets are used for wider ranges of applications. In particular, while marginal traders appear to drive results in IEM election markets, will they continue to do so in smaller markets?

In summary, the IEM markets continue to provide a rich institutional and informational environment in which to study the behavior of prediction markets. Understanding these markets has benefited by both theory and laboratory experiments. Future theory and experiments will undoubtedly benefit by information learned in the IEM. This paper has investigated the general lessons learned from IEM research and explored areas that demand future research.


