

**Volatility in Prediction Markets:
A Measure of Information Flow in Political Campaigns**

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Each presidential campaign has stories that seem to summarize the election in an anecdote, such as Clinton's campaign slogan, "It's the Economy, Stupid," and John Kennedy's performance in the televised debate against Nixon. However, some stories may seem to epitomize the campaign when they actually did not alter the outcome of the election or even relate to the underlying factors that did influence the outcome. How can we adjudicate between the events that mattered and those that did not? Building on work in the market microstructure literature in economics, this paper uses the volatility of prices of the 'Bush wins the popular vote' contract on the Tradesports prediction market as a measure of information flow. In the 2004 campaign, the events that added the most information to the campaign were John Kerry's nomination speech, the CBS story about Bush's National Guard service and its retraction, the *New York Times* story about the explosives that went missing in Iraq in 2003, and the presidential debates.

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Carlos Carvalho, researcher at the Institute of Statistics and Decision Sciences at Duke University, provided immense support with the estimation of the volatility measure. This paper is vastly better because of the help and suggestions of members of the Duke American Politics Dissertation Group. John Aldrich and Bob Nau, both at Duke, helped in the conceptualization of this project. Of course, all remaining errors are mine alone.

When asked to describe the pivotal moments of the 2004 campaign, Kerry strategist Mark Mellman first noted that analysts should be careful to:

Avoid what psychologists call fundamental attribution error. Fundamental attribution error consists, as some of you know, of overweighting the significance, the importance of individuals, of personalities, of events, and underweighting the significance, the salience of the structure of the situation of the underlying circumstances. (Jamieson 2006, 91)

He went on to outline the factors he believed to have been the most important: the decline of the Democratic plurality among voters, culture as the primary division in American politics as opposed to class, and the incumbency advantage. While he did list a number of events that the Kerry campaign viewed as important, his central message was that the campaign did the best it could and very well given the political situation in 2004. Matthew Dowd, a Bush strategist, also viewed the campaign as a series of relatively minor ups and downs with a largely expected outcome (Jamieson 2006). Yet when most people think back to the 2004 campaign, some events seem pivotal, such as the Swift Boat Veterans for Truth (SBVT) ads in August and Kerry's comment that he voted for spending \$87B before he voted against spending \$87B for emergency funds for troops and reconstruction in Iraq. Did those two events matter much in the final vote tally, or did they not really change the campaign as definitively as we might think?

Analysts look back at campaigns and identify defining moments—but, as Popkin (1994) notes, those anecdotes can just be the story that 'fits' our overall impression of the campaign as opposed to the events that actually affected the election outcome. How can we tell the difference between anecdotal explanations and the events that were actually important? By identifying which campaign events did, in fact, provide new information in a given election year, we can better understand the 'normal' dynamics of campaigns.

In order to investigate what kind of information and events have which kinds of effects on expectations' of a candidate's success, we need a continuous variable that reacts quickly to new information. Opinion polls give us a somewhat nuanced view of public opinion during campaigns,

but there is a practical problem with surveys: they are taken over several days. A poll taken the day before, the day of, and the day after a presidential debate does measure the effect of a candidate's performance in the debate on vote choice but it also registers the effects of events (e.g. candidate visits or speeches) that occur before and after the debate. If something shocking happened in a debate (would that debate-watchers could be so lucky!), the results from that standard three-day poll would partially reflect it, but we could only surmise what change in candidate preference occurred because of that gaffe and what change was caused by other events.

Prediction markets, like the Iowa Electronic Markets (IEM) and Tradesports, offer an attractive alternative to polls or academic panel studies for to answering this kind of question because they allow us to clearly analyze people's expectations of political outcomes and the fluctuation in those expectations given new information. The pricing of futures contracts in these markets provides a continuous measure of the probability of candidate winning the election. The immediacy of online futures markets lets us see exactly how information is incorporated, how quickly, and how expectations about political events stabilize.

This paper looks not at the price, or probability, of a candidate winning the election, but rather at the *volatility* of the price. It builds on theoretical developments in the economics literature, especially the market microstructure literature, that view the volatility of asset prices as being driven by information flow. The data analyzed are the prices of the 'Bush wins the popular vote' contract on Tradesports.com from July 1, 2004 to the close of the contract on Election Day. By looking at the volatility, which is defined as the standard deviation of the return on investment over time, we can see how information changes expectations about a candidate's success. Using a theoretically justified model of volatility as a measure of information flow will allow us to differentiate between the 'normal' campaign occurrences and the noteworthy, important events of particular campaigns. While the Swift Boat ads have become central to popular accounts of the 2004 presidential race, it

appears that Kerry's nomination speech and the debates, particularly the third one, imparted much more information. Other events that were particularly important in the campaign were the CBS story about Bush's National Guard service and the subsequent retraction, the report that explosives went missing in Iraq in late October, and, arguably, the release of the bin Laden tape a few days before the election.

POLITICAL PREDICTION MARKETS: Background

Prediction markets, which are also called "information markets," "idea futures," or "event futures," pay out returns based on whether or not a specified event occurs. Winner-take-all futures pay \$1 if event X occurs and \$0 if it does not. For example, at one point during the 2004 campaign, a person could buy a "Bush wins the popular vote" contract for \$0.55. If that person held onto that contract until November 2, then they would receive \$1, making a profit of \$0.45 cents per contract. Investors can resell or buy contracts at any point. For example, they could buy a Bush contract at \$0.55 and then sell it at \$0.58, for a profit of \$0.03 per contract. This paper examines winner-take-all futures markets, though there are several other types of contracts in prediction markets.¹

The Iowa Electronic Markets (IEM), run by the Tippie College of Business at the University of Iowa, are the most famous prediction markets. The IEM has had markets for each U.S. presidential election (including primaries) since 1988 as well as for elections in other countries. The IEM has also run futures markets on economic events. Other markets such as the Hollywood Stock Exchange run contracts based on box office sales or the winners at awards ceremonies. Tradesports (also called Intrade) has futures markets on many kinds of events, including political, financial, and sports events. The IEM has been used extensively for research on prediction markets and in

¹ Vote share contracts pay \$1 times a candidate's share of the votes. A third kind of futures contract is based on a combination of two events, like the vote share of the Republican candidate given that a specific Democrat wins the party's nomination.

classrooms and are not for profit. Other markets like Tradesports and Newsfutures are run as for-profit businesses.

Before proceeding to a discussion of the volatility of prices in political prediction markets and the evidence about campaign effects in the 2004 election, a few theoretical points about these kind of markets must be reviewed. In particular, I will discuss why prediction markets are able to aggregate information such that the final price of the futures contract is reflective of the event's true probability.

How do markets aggregate information? When a group of people are asked how many marbles are in a given large jar, very few of them will choose the correct answer. However, the average of the guesses is always correct or nearly correct. Similarly, few people can estimate the number of yards between point A and point B, but together the group 'finds' the true answer. This occurs even without discussion; opinions are polled privately and then aggregated to determine the distance. One person may be sure of the distance from point A to the flagpole and another may be sure of the distance from the flagpole to point B. Neither has the correct answer, but when the information that each person has is added together, the actual distance is discovered. This is the intuitive explanation of how a prediction market works. The theoretical explanation rests on the efficient market hypothesis and no arbitrage arguments.²

Prediction markets are likely to produce quality information because they “provide... 1) incentives to seek information; 2) incentives for truthful information revelation; 3) an algorithm for aggregating diverse opinions” (Wolfers and Zitzewitz 2004). These markets force people to “put their money where their mouths are,” so their expressed beliefs about a candidate's chances of

² No arbitrage arguments assume that a trader who has some information not already incorporated into the market will profit from the incorrectly priced futures contract. Assuming that enough traders are involved in trading such that arbitrage opportunities no longer exist (or are rare), the price will reflect the true value of the contract. That the equilibrium price perfectly reflects all information available can be proven using CAPM or APT models (Berg et. al. 2003). Somewhat more formally, “in a market where traders with CARA utility functions each received independent draws from a normal distribution about the true value of the asset, the market fully summarizes their information” (Wolfers and Zitzewitz 2005, 2).

success are not just cheap talk.³ It is important to note that the “average belief” of traders exhibited in the futures price is actually a weighted average, where people with more confidence in their assessment of a candidate’s success trade more so that their “opinions” count more in the price equilibrium. This can be viewed as an advantage over traditional polls: equilibrium prices take into account the strength of people’s beliefs about the candidate’s chance of electoral success.

Without discussing a candidate’s chance, the information held by people all over the country will be combined so that the market estimate of the candidate’s probability of winning is accurate. That is, a person who lives in Ohio might trade based on his impression of voters in his town and a person in North Carolina might trade on her impression of the local newspaper coverage. When added together with traders from around the country (and around the world), all the information is combined to produce the accurate value of the contract.⁴ This is easier to see in vote share markets. It is amazing how close IEM predictions of the Democratic vote share are in the week prior to the election (see below for more details). Because the market aggregation mechanism clearly works with the vote share market, we assume that it also works in the winner-take-all markets.

Bounded rationality & its implications for prediction markets

The economic theory behind prediction markets suggests that the prices of assets are accurate because people rationally and correctly understand and incorporate information into the market prices. However, behavioral research shows that people are limited information processors and are subject to biases due to their preferences. This is not a major problem because “all agents need not be informed for a market to be efficient... survey evidence documenting biased expectations does not necessarily imply that market prices will be similar biased” (Sauer 1998, 2027).

That market is efficient in the sense that it fully reflects all public information because of marginal

³ Some research suggests that prediction markets that do not use actual money, but instead use “virtual currency,” are also very accurate. For example, see Servan-Schreiber, Wolfers, Pennock, and Galebach 2004.

⁴ Erickson and Wlezien (2005) have noted that this is true only when a “naïve,” direct reading of the polling numbers is compared with the prediction markets. They then conduct a number of complicated regressions and produce a slight improvement over the However, this does not discount the fact that prediction markets are, in fact, very good predictors of election outcomes.

traders or market makers. In a market of sufficient size and with large enough payoffs to counter transaction costs, arbitrage in prices will occur until all traders, specialists as well as informed and uninformed investors, agree on the appropriate price (Andersen 1996). The IEM may not have enough volume, but Tradesports does have enough to alleviate this problem.

It is true that most traders are ‘biased’ much of the time. Berg (2005) notes that “traders are biased and mistake prone” and Forsythe et al. concur that “traders frequently leave money on the table through violations of arbitrage restrictions” (1999, 103). These conclusions are documented by surveys administered by the IEM to its traders. The surveys have consistently shown that traders are not in any way representative of the voting population. In particular, traders on the IEM are younger, more educated, more wealthy, and “more male” than the U.S. population and the voting population. Due to the incentives to seek information when trading, they are also probably more informed than the voting population.

Traders in the IEM tend to hold portfolios that are biased towards their preferred candidates (e.g. Forsythe, Nelson, Neumann, and Wright 1992). Forsythe et al. (1998) show that investors in the 1993 Canadian elections futures markets held unbalanced portfolios in ways consistent with their preferences. That is, supporters of a party were much more likely to hold more futures of that party than was the market as a whole. Forsythe et al. (1999) demonstrate that this bias also exists in the U.S. presidential prediction markets. The trading population of Tradesports is likely somewhat different than the trading population of the IEM due to its larger size and commercial aspect. However, there is good reason to believe that individual bettors in Tradesports markets are also biased.

These types of biases have been described as “wish fulfillment” in both the political science literature and the psychological literature. Granberg and Brent (1983) and Uhlaner and Grofman (1986) document the persistence and ubiquity of this phenomenon. Supporters of Carter in 1980

were much more likely to predict that Carter would win than were Reagan supporters (though a few of each candidate's supporters were less biased in their predictions). Whether due to the "false consensus effect," where supporters of a particular candidate see themselves as more representative of other voters than they actually are, or the "assimilation-contrast effect," where supporters of a candidate interpret news about that candidate much more positively (e.g. Uhlaner and Grofman 1986), most traders in the IEM exhibit this wishful thinking as evidenced in their portfolio holdings.

Efficiency of Prediction Markets

There is some evidence that most traders in the IEM are biased in their trading decisions (or at least likely to make mistakes) and it is likely that many, if not most, of the traders in Tradesports markets are similarly biased. However, that does not necessarily mean that the prices of candidate futures are incorrect. Though this paper specifically focuses on the effects of information on futures prices as opposed to the markets' predictive power, this section will briefly review the evidence of the accuracy of prices in prediction markets in order to show that analysis of prediction markets' prices is worthwhile. Many studies of the IEM show that prediction markets are as accurate as or more accurate than opinion polls, both in the week or days before the election and at longer time horizons.

Berg et. al. note that since 1988, the IEM political prediction markets (conducted in U.S. elections as well as in other countries such as Canada, Austria, and Turkey) have consistently outperformed polls and "in a few cases (the 1988 and 1992 U.S. Presidential Elections) the market dramatically outperformed polls" (Berg et. al. 2003, 4; also see Berg 2005). Not surprisingly, markets with a higher volume of contracts traded and markets with fewer candidates or parties are more successful. U.S. presidential election markets are the most accurate, though the overall market accuracy is also impressive: the average market error in vote-share contracts was 1.49% or 1.58% (depending on the exact measure used) whereas the average poll error was 1.91%. It is more difficult to judge the true probability of an event occurring, but in markets where a winner-take-all

contract and a vote-share contract are both traded, evidence suggests that the prices of the two contracts move together such that the probability expressed in the winner-take-all contract is similarly accurate.

The ability to predict the winner is intellectually interesting,⁵ though the accuracy of the election markets has been studied so extensively in part because other applications of idea futures markets rely on the markets' ability to accurately forecast events. Many people are investigating the predictive power of futures markets so that they can be used for decision-making in businesses (e.g. Wolfers and Zitzewitz 2005; for a particularly interesting potential application to government policy-making, see Hanson 2003). Contracts based on future earnings of companies on the IEM and contracts predicting box-office sales of movies on the Hollywood Stock Exchange have both proved effective at determining the actual outcome, suggesting that futures markets do aggregate information effectively.

If surveys of traders and findings from political science and psychology all show that people invested in the market are biased, how are market predictions themselves accurate? The apparent paradox has been resolved with the idea of the "marginal trader" (e.g. Forsythe, Nelson, Neumann and Wright 1992; Forsythe, Rietz, and Ross 1999). As Forsythe et. al. (1998) explain, "as long as there are some traders relatively free of such [wish fulfillment] biases and with deep enough pockets, they will take advantage of the biases of other traders and in the process bring prices to levels consistent with unbiased expectations." These less-biased investors serve as "market makers," which is to say that they will continue to trade until the price of each futures contract is correct.

Oliven and Rietz (2004) show that the average trader leaves money on the table, either due to bias or mistakes, but that the marginal trader takes advantage of those arbitrage opportunities and adjusts the prices. Other work has shown that market makers, the marginal traders, whose

⁵ It is also potentially financially rewarding to predict the outcome of elections. For example, see Den Hartog's and Monroe's analysis of the financial effects of the majority status of political parties in Congress.

portfolios and trades exhibit no bias, invest much more money than the average trader and are more active in trading (Forsythe et. al. 1992; Oliven and Rietz 2004). As a result, marginal traders “are able to drive prices to efficient levels while profiting from the mistakes of more error-prone traders” (Forsythe et. al. 1999).

Marginal traders’ behavior explains the accuracy of prediction markets, so our starting premise is correct: these markets are worth studying especially in regards to campaign and information effects. While it is true that the equilibrium price in a market with positive information and transaction costs does not summarize some small amount of the information, that fraction is negligible (Grossman and Stiglitz 1980). These findings suggest that the volatility and mean prices in the markets are, in fact, reasonable measures of the ‘true’ probabilities of a candidate’s success in that all information is rationally incorporated into prices, even if individual traders are not always (or even usually) rational.

THE VOLATILITY OF PRICES IN PREDICTION MARKETS

Studying the *changes* in the probability of a candidate winning an election is as important as studying the probability itself. In other words, the volatility, the standard deviation of the price around its mean, must also be considered in order to understand the dynamics of the campaign. In their study of presidential approval, Gronke and Brehm (2002) write:

No one would argue that a statistical distribution can be described solely by its central tendency; nor should our exploration of the patterns and causes of presidential approval look only at the mean. As important in many circumstances is the frequency and sharpness of shifts in public sentiment—volatility. (445)

Similarly, if we are interested in the question of what information during campaigns is seen as important or consequential (or at least potentially consequential), the volatility of futures prices matters. There may be a significant amount of action in a futures price when new information is acquired, though ultimately the price may settle back to the original equilibrium. An analysis of the mean price would hide that effect of political information.

In order to appropriately price a given asset in a financial market, the volatility, or standard deviation, of the asset's price must be determined. Volatility, the annualized standard deviation of the asset return, must be entered into asset pricing equations like the Black-Scholes model. It often enters into the equation as implied volatility, or the average deviation in prices from some previous time period. However, implied volatility is unsatisfactory because volatility changes over time. Economists, statisticians, and traders have developed extensive models to better describe it. ARCH (autoregressive conditional heteroskedasticity) models have been relatively successful though better approaches take into account the stochastic nature of the volatility with more complex estimation procedures.

Volatility can often be categorized as “price jiggling” (Working 1958), where the price moves up and down slightly producing a negative first order serial correlation (Patell and Wolfson 1984). However, when new information such as earnings reports becomes public, stock and futures prices often move more dramatically. Many economists have studied the effects of earnings reports and news releases on volatility (e.g. Jennings and Starks 1985; Brown and Hartzell 2001; Patell and Wolfson 1984; Chan 2003). Though “the influence of information arrival is one of the most challenging problems in modeling market behavior” (Patell and Wolfson 1984), researchers have found that information is incorporated into the market very quickly, that the level of informativeness of an announcement affects the characteristics of the volatility of the stock price, and that people respond differently to new information depending on whether it is negative or positive.

The idea of volatility has also been explored in political science, though often not with that terminology. When developing a better ARCH model for volatility in political science, Maestas and

Preuhs (2000) point out that Jacobson (1987) and Schlesinger (1991) both:

see volatility, the degree to which the aggregate vote is predictable from one election to the next, as a function of changing political conditions. Likewise, they believe that vote volatility has important effects on the behavior of candidates and parties. (96)

Gronke and Brehm (2002) explicitly discuss the need to study the volatility of public opinion. They argue that studying the ways the public has responded to presidents over time has changed, so high levels of support in the present period no longer mean that he will enjoy high support in the future. This can impact the ways that other politicians react to the president's initiatives and informs our understanding of the effects of declining partisanship.

TYPES OF VOLATILITY

Volatility can be described with three characteristics: level, duration, and whether the period of volatility results in a new mean price. Increased volatility tells us what information affects people's expectations whereas the time period of spikes in volatility gives us insight into what kinds of effects are caused by which kinds of information. Volatility over a longer period of time would suggest that the effect of some new piece of information is not clearly known (perhaps news of a developing scandal); traders are not sure about how the event affects a candidate's chances of winning the election. In contrast, high volatility for a shorter period of time would suggest that the effect of some kind of information was more quickly used to forecast a candidate's viability (perhaps a bad debate performance). The third dimension of volatility, whether or not the mean price settles back to its starting equilibrium price or moves to a new one, is also crucial to understanding the effects of different campaign information. Information that causes volatility but ultimately results in no change in the mean price suggests that the information was not significant in the long term.

The three ways that volatility can vary can be combined into a typology:

Volatility in Futures Pricing		Volatility		
		Low	High- Short Time	High- Longer Time
Mean Price	Change	1	3a	4a
	No Change	2	3b	4b

Table 1 illustrates the kinds of events that may cause futures prices to move in these specific ways.

Table 1. Potential Causes of Price Changes in Prediction Markets

1	Gradual change in price over time	The ‘normal’ view, where one candidate is improving in the polls slowly without any major new development.
2	No change	This is probably not likely in a presidential campaign. Perhaps a House race with no serious challenger might look like this. (Sufficient data on such races does not exist on Tradesports.)
3a	High volatility for a short period resulting in a new equilibrium price	Some startling, negative revelation about a candidate which clearly alters his chances of winning—like Gary Hart’s “Monkey Business” scandal.
3b	High volatility for a short period of time, no ultimate change in probability	A small gaffe, widely reported and discussed by political elites, momentarily changes some traders’ beliefs, but it is viewed as unimportant to voters so the price returns to equilibrium.
4a	High volatility for a longer period of time with a change in price	A more complicated story may be found by reporters but not understood by the public for some time, or until it reaches saturation point; a campaign fundraising allegation that finally “sticks.”
4b	High volatility for a long period of time with no ultimate change in probability	Some news is coming out slowly or is complicated, perhaps caused by a developing scandal like Whitewater, so the effects of the event are more uncertain. It may also be the result of a close election—increased spending and close polls, where the probability of a candidate winning is unclear.

This paper is part of a larger project that will investigate each type of volatility described above, though this paper will only look at the level of volatility (increased or not) and the duration of periods of high volatility. This paper will be purely descriptive with some limited conjectures about the events driving the changes in volatility.

VOLATILITY AS AN INFORMATION FLOW

Volatility can be conceptualized as a measure of the information flow into a market. In the market microstructure literature in economics, the Mixture of Distribution Hypothesis “posits a joint dependence of returns and volume on an underlying latent event or information flow variable” (Andersen 1996, 170). While the theory describes the “informativeness of market prices, the presence of liquidity traders in the market and the manner in which news is disseminated” as factors influencing both volatility and volume, it “points to the rate of information arrival to the market as the primary variable of interest” (Fleming et. al. 2006, 1555). The volatility, or the change in prices, is “primarily [caused] by the arrival of new information and the process that incorporates this information into market prices” (Andersen 1996, 170).

Information flows into the market and affects both the prices of the assets and the volume of the assets that are traded. When this trading occurs, the price of the asset reaches an equilibrium state. Andersen (1996) explains:

An important finding is that over the course of a (short) period, the sequence of trades reveals the pricing implications of the private signals and subsequently—until new private information arrives—all market participants agree on the value of the traded asset. Thus, private information arrivals induce a dynamic learning process that results in prices fully revealing the content of the private information through the sequence of trades and transaction prices. (172)

It is new information that starts this process. When new information about the campaign—whether polling numbers, a larger ad buy in a battleground state, or an endorsement—becomes known, the price of the candidate’s futures contract adjusts accordingly. Volatility is low despite some new information when rational anticipation of that future event was already incorporated into the price. In contrast, high volatility occurs when unexpected information enters the market.

This price adjustment process, as evidenced in the estimated volatility, can be used to characterize information and events. Jennings and Starks (1985) study the effects of high-content earnings announcements as compared with low-content announcements and find that high-content ones induce more volatility for longer periods of time. Studies like that one take the information

content as fixed and study the effects on the market, whereas this paper looks at the effects on the market and attempts to make statements about the information content contained in different campaign events. This is done by first estimating both a continuous measure of volatility and a discrete measure of a state of high or low volatility. These volatility measures are estimated from both returns and volume because both are driven by the latent information flow. Estimating the dependent variable, informativeness of event, fact, or observation, using volume and returns allows an investigation of the campaign that will document key events. While this approach presents some hurdles in terms of making assertions about causality, by allowing the market to judge the consequential events, we better understand the role of information, campaign events, and other factors on election outcomes.

The model estimated in this paper is a direct extension of Andersen (1996), where the volatility is determined by a Markov-switching stochastic model that allows for occasional shifts in the parameter determining the level of volatility. The incorporation of structural changes in the model solves the problem of overestimation of the persistency of volatility in high-frequency data while providing a straightforward way to identify clusters of high and low information flows in the market. In Andersen's model, returns and trading volume follow a mutually and serially independent bivariate distribution, conditional on the number of information arrivals, where information arrivals are modeled as a stochastic volatility process. This is an empirical representation of a well defined market microstructure model in which both informed and liquidity traders participate in determining prices in the market and where the volatility process is inferred simultaneously from returns and trading volume.

Let R_t represent the logarithm of returns, V_t represent the trading volume, and I_t represent

the flow of information, all at time t . The model takes the following form:

$$R_t = I_t^{1/2} u_t \quad u_t \sim N(0, 1)$$

$$V_t \sim \text{Po}(m_0 + m_1 I_t)$$

$$\log I_t = \alpha S_t + \beta \log I_{t-1} + \varepsilon_t \quad \varepsilon_t \sim N(0, \sigma^2)$$

with the information state S_t following a 2-stage first order Markov process.

These equations represent a complex, dynamic non-linear system with two latent (non-observable) states, the information flow I_t and the information state S_t . We estimate the above model by posterior simulation of parameters and latent states through a Markov chain Monte Carlo algorithm that combines the methods proposed by Watanabe (2000) with the methods proposed So, Lam and Li (1998) algorithm for stochastic volatility models with multiple regimes.

The data were acquired from Tradesports. They include all transactions made on the Tradesports 'Bush wins the popular vote' contract from July 1 to Election Day. The transactions were grouped into 3 hour time periods. Observations of the price of the contract at the close of the three hour period and the volume traded in the period were recorded at 3am, 6am, 9am, noon, 3pm, 6pm, 9pm, and 11:59pm.

CAMPAIGN EFFECTS IN 2004

The varying levels of volatility in the Tradesports data indicate that the flow of information from the campaigns was not static. Volatility rose significantly at many points during the campaign, though it remained low for much (but not all) of July, August, and September. The duration of increased volatility also varied. Spikes in volatility were often accompanied by longer stretches of a state of high volatility, indicating greater uncertainty about the effect of new information. However, on many occasions, the volatility increased to a high state and then quickly fell back to the normal level, indicating that the effects of some new information were easily understood and incorporated into the probability of Bush's electoral success.

(Figure 1 and Table 2 about here)

Figure 1 shows the volatility over the length of the campaign. Table 2 lists the time periods of the highest volatility in the continuous measure I_t shown in Figure 1. All of the periods occur in October or November. This makes sense: October is clearly the time when an immense amount of information is making its way into public knowledge via the media. The number of contracts traded increases drastically in the last month of the campaign. People who are extremely interested in the campaign traded before October, resulting in a number of periods of increased volatility. However, the number of people participating increases significantly as the campaign becomes more salient to the general public.

The day of the third debate exhibited very high volatility and the hours and the day after the debate exhibited even higher volatility. The third debate evidently caused the market to adjust and readjust the probability of Bush winning. Interestingly, Bush's performance in the first debate, viewed by many as a poor one, did not appear to add much new information. This does not necessarily mean that his performance didn't matter, but rather that it was *expected* that he would do poorly in comparison to Kerry, such that Bush's probability of winning already had that information incorporated into the price.

There are a few hypotheses about why the third debate affected the information flow so significantly. First, it may be that the debate itself included significant information. People believed the Bush shored up his base with several comments about domestic policy and Kerry made the ill-advised comment about Cheney's lesbian daughter, perhaps reinforcing his image as somewhat awkward. Second, it may be that that Bush exceeded expectations in the debate, especially after his performance in the first debate. Third, it may be that the debates matter as a whole—that the public viewed them as essentially one event. Matthew Dowd explained that “one debate by itself wasn't

[important]. It was the totality that was important” (Jamieson 2006, 87). At this point in the analysis, it is not clear which of those explanations is most appropriate.

A few other periods of high volatility deserve mention. On October 6, the Duelfer report was released concluding that Saddam Hussein did not have the ability or concrete plans to create weapons of mass destruction. Early that morning, volatility spiked, most likely because the report’s contents were known before it was released. October 25 and 26 brought the story about the explosives that went missing in Iraq in 2003 to light. In addition to these spikes, the level of volatility remained high for a significant amount of time after those revelations. Lastly, the tape of Osama bin Laden that was first played on Al Jazeera on October 29 also increased the volatility.

Table 2 shows the instances of the highest volatility. An additional parameter, the information state (S_t), was also estimated. The states of volatility over the length of the campaign are shown in Figure 2. The volatility was in a high state for about 25% of the three hour time periods. On many occasions, the volatility spiked to its high state for a few time periods but settled back to its normal level relatively quickly. This implies that the effects of some information were clear and that the market was easily able to adjust the price. However, on a number of occasions, the volatility remained in its elevated state for more than one day. These instances are listed in Table 3.

(Figure 2 and Table 3 about here)

On September 8, CBS News aired a story on “60 Minutes” that Bush had not properly reported for duty while he was in the National Guard. The story developed over 12 days, with conservative bloggers immediately questioning the story and the documents and investigating the print on 1970s typewriters. From the period when the story aired to Dan Rather’s retraction on September 20, there were two extended periods of time when the volatility remained in a high state.

This indicates that traders reacted to the increased flow of developing information over several days and that there was a significant level of uncertainty about the potential implications of the story.

Other events that increased the volatility over an extended period of time were the October 26 *New York Times* report about the explosives that went missing in Iraq in 2003, the vice presidential debate and the lead-up to the second presidential debate, and Kerry's nomination speech. Not surprisingly, the last few days of the campaign show a high state of volatility. At that point, the race was perceived as close, especially in battleground states like Ohio. On Election Day, the release of early exit polls contributed to high volatility and extreme price fluctuation.

These findings describe the patterns of information flow during the campaign. I have tried to match these periods of high volatility with events that occurred during the campaign. Further work will be done to systematically analyze the causes of the increased volatility. I will also combine the volatility and the probability of Bush winning the popular vote (i.e. the mean price) to further untangle the events that cause people to adjust their expectations of the election's outcome.

CONCLUDING REMARKS

By estimating a modified version of Andersen's Mixture of Distribution model using a more complex, better suited stochastic volatility approach (as opposed to a GARCH model), I use the information flow parameter as a dependent variable to investigate what kinds of information and which events affected people's expectations of the election outcome. The Swift Boat Veterans for Truth ads that questioned John Kerry's service in Vietnam and his anti-war behavior once he returned home are a central part of the narrative of the 2004 presidential campaign. However, by looking at volatility as a measure of information flow, it appears that the impression that the ads were central in Kerry's defeat may be flawed. Instead, it was the presidential debates, Kerry's nomination speech, the CBS News story about Bush's National Guard service, and the Osama bin

Laden tape three days before the election all contributed more new information than did the SBVT ads.

While those ads and other information like Bush's poor performance in the first debate do, in a sense, 'matter' when thinking about which campaign events move voters' preferences and opinions, it is the *unexpected* bits of information that the market views as revealing previously private information. Once this private information turns public, a price discovery phase—in this case a probability discovery phase—occurs and the new information is added to the market. Whether and how this price adjustment process occurs can tell us much about the effects of various kinds of information in campaigns.

Bibliography

- Andersen, Torben G. 1996. "Return Volatility and Trading Volume: An Information Flow Interpretation of Stochastic Volatility." *The Journal of Finance* Vol. 51 No. 1.
- Berg, Joyce. 2005. "The Iowa Electronic Market: Lessons Learned and Answers Yearned." Forthcoming in *Information Markets: A New Way of Making Decisions in the Public and Private Sectors*, Paul Tetlock and Robert Litan (eds.). AEI-Brookings Joint Center, Washington, DC.
- Berg, Joyce, Robert Forsythe, Forrest Nelson, and Thomas Rietz. 2003. "Results from a Dozen Years of Markets Research." In *The Handbook of Experimental Economics Results*, eds. CR Plott and VL Smith.
- Berg, Joyce and Thomas A. Rietz. 2002. "Longshots, Overconfidence and Efficiency on the Iowa Electronic Market." Working paper.
- Berg, Joyce, Forrest Nelson, and Thomas Rietz. 2003. "Accuracy and Standard Error of Prediction Markets," working draft.
- Brown, Gregory W. and Jay C Hartzell. 2001. "Market Reaction to Public Information: The Atypical Case of the Boston Celtics." *Journal of Financial Economics* Vol. 60.
- Camerer, Colin. 1998. "Can Asset Markets be Manipulated? A Field Experiment with Racetrack Betting." *Journal of Political Economy*, 106:3, 457-82.
- Chan, Wesley. 2003. "Stock Price Reaction to News and No-News: Drift and Reversal after Headlines." *Journal of Financial Economics*.
- Den Hartog, Chris and Nathan W. Monroe. "The Value of Majority Status: The Effect of Jeffords's Switch on Asset Prices of Republican and Democratic Firms." Working paper, University of California-San Diego.
- Erikson, Robert S. and Christopher Wlezian. 2005. "Are Political Markets Really Superior to Polls as Election Predictors?" Presented at the Annual Meeting of the World Association of Public Opinion Research, Cannes.
- Fleming, Jeff, Chris Kirby, and Barbara Ostdiek. 2006. "Stochastic Volatility, Trading Volume, and the Daily Flow of Information." *The Journal of Business* Vol 79 No 3.
- Forsythe, Robert, Murray Frank, Vasu Krishnamurthy, and Thomas W. Ross. 1998. "Markets as Predictors of Election Outcomes: Campaign Events and Judgment Bias in the 1993 UBC Election Stock Market." *Canadian Public Policy*, Vol. 24 No. 3.
- Forsythe, Robert., Forrest Nelson, George Neumann, and J. Wright. 1992. "Anatomy of a Political Stock Market," *American Economic Review*, 82:1142-1161.
- Forsythe, Robert, Thomas A. Rietz, and Thomas W. Ross. 1999. "Wishes, Expectations and Actions: A Survey on Price Formation in Election Stock Markets." *Journal of Economic Behavior and Organization*, 39:832-110.
- Gelman, Andrew and Gary King. 1993. "Why Are American Presidential Election Campaign Polls So Variable When Votes are So Predictable?" *British Journal of Political Science*, Vol. 23, No. 1.
- Granberg, Donald and Edward Brent. 1983. "When Prophecy Bends: the Preference-Expectation Link in U.S. Presidential Elections, 1952-1980." *Journal of Personality and Social Psychology*, 45:477-491.
- Gronke, Paul and John Brehm. 2002. "History, Heterogeneity, and Presidential Approval: A Modified ARCH approach." *Electoral Studies* 21.
- Grossman, S. and J. Stiglitz. 1980. "On the Impossibility of Informationally Efficient Markets." *American Economic Review* Vol. 70.
- Hanson, Robin. 2003. "Shall We Vote on Values, but Bet on Beliefs?" Working paper.
- Jacobson, Gary. 1987. "Running Scared: Elections and Congressional Politics in the 1980s." In McCubbins, Mathew and Terry Sullivan (Eds.), *Congress: Structure and Policy*. Cambridge: Cambridge University Press.
- Jennings, Robert and Laura Starks. 1985. "Information Content and the Speed of Stock Price Adjustments." *Journal of Accounting Research* Vol. 23 No. 1.
- Maestas, Cherie and Robert Preuhs. 2000. "Modeling Volatility in Political Time Series." *Electoral Studies* 19.

- Oliven, K. and Thomas Rietz. 2004. "Suckers are born but markets are made: Individual rationality, arbitrage and market efficiency on an electronic futures market." *Management Science*, 50:3.
- Patell, James M. and Mark A Wolfson. 1984. "The Intraday Speed of Adjustment of Stock Prices to Earnings and Dividend Announcements." *Journal of Financial Economics* Vol. 13.
- Popkin, Samuel. 1991. *The Reasoning Voter: Communication and Persuasion in Presidential Campaigns*. Chicago: University of Chicago Press.
- Rhode, Paul W. and Koleman S. Strumpf. 2004. "Historical Presidential Betting Markets." *Journal of Economic Perspectives*, Vol. 18, No. 2.
- Sauer, Raymond D. 1998. "The Economics of Wagering Markets." *Journal of Economic Perspectives*, Vol. 36.
- Schlesinger, J.A. 1991. *Political Parties and the Winning of Office*. Ann Arbor: University of Michigan Press.
- So, Mike, K. Lam and W. Li. 1998. "A Stochastic Volatility with Markov Switching." *Journal of Business and Economic Statistics*.
- Uhlener, Carole Jean and Bernard Grofman. 1986. "The Race May be Close but My Horse is Going to Win: Wish Fulfillment in the 1980 Presidential Election." *Political Behavior*, Vol. 8 No. 2.
- Watanabe, Toshiaki. 2000. "Bayesian Analysis of Dynamic Bivariate Mixture Models: Can they explain the behavior of returns and trading volume?" *Journal of Business & Economic Statistics*.
- Wolfers, Justin. 2004. "Pricing Political Risks with Prediction Markets." Policy Brief, Stanford Institute for Economic Research.
- Wolfers, Justin and Eric Zitzewitz. 2004. "Interpreting Prediction Market Prices as Probabilities." Working paper.
- Wolfers, Justin and Eric Zitzewitz. 2005. "Prediction Markets in Theory in Practice." In *The New Palgrave Dictionary of Economics*, ed. L. Blume and S. Durlauf, forthcoming.
- Working, Holbrook. 1958. "A theory of anticipatory prices." *American Economics Review* Vol. 48.

Table 2. Periods of Highest Volatility^a

Date	Time	Event
October 14	All day	Day following final debate
October 13	All day	Day of final debate
October 28	Morning	Polls: Bush leading in FL, PN, Kerry leading in Ohio Candidates discuss missing explosives in Iraq
November 2	Morning	Election day
October 15	Afternoon- Evening	Two days after final debate
October 12	Morning- Night	The day before the final debate
October 6	Early morning	Duelfer report released
October 26	Afternoon- Evening	Questions about the <i>New York Times</i> story on missing explosives in Iraq
October 31	Morning, Night	Candidates tied in the polls
October 27	Morning, Night	<i>NYT</i> Missing explosives story
November 1	Morning	Day before election
October 29	Night	Osama bin Laden tape shown on Al Jazeera

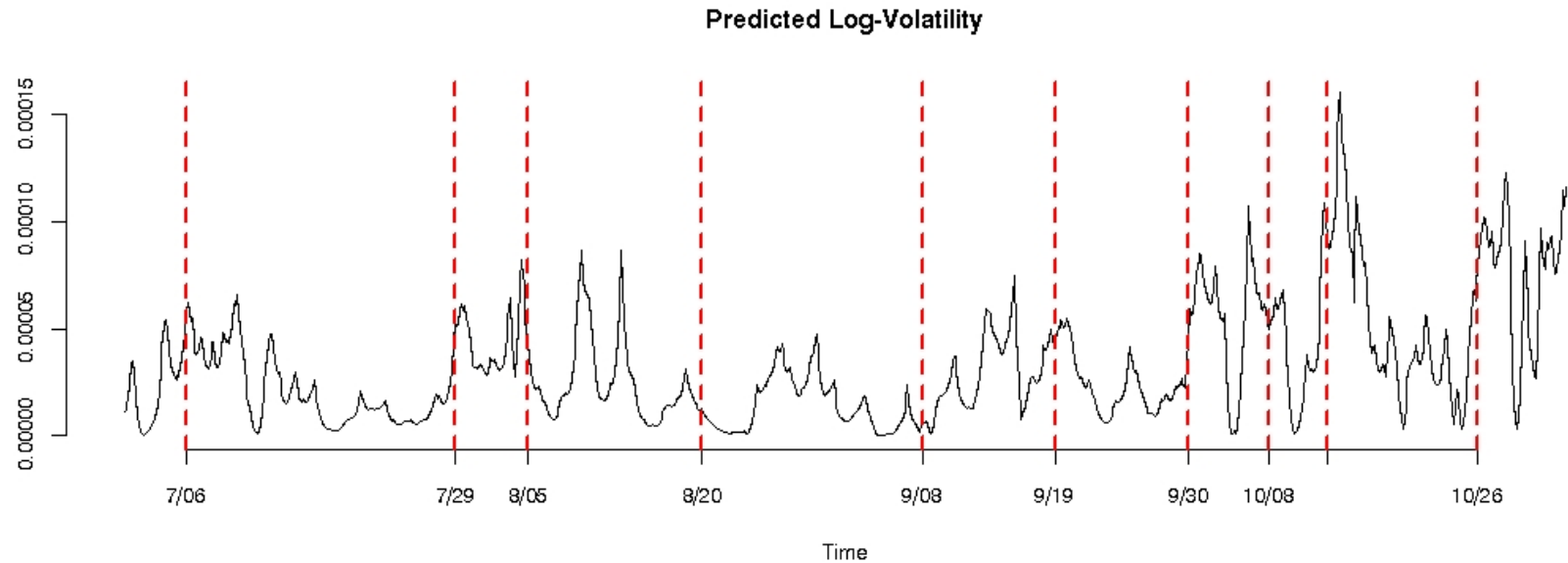
^a These dates have the highest level of information flow I_t .

Table 3. Periods of High State Volatility

Date	Number of Periods ^a	Event
October 12-16	35	Day before final debate to three days after, when first poll numbers post-debate were released
October 5-9	32	The night of the VP debate to just after the 2 nd presidential debate
October 25-28	30	Story about the missing explosives
October 1- 4	25	Night of the first debate to three days after first debate
October 31- November 2	20	The last hours of the campaign
August 9-10	13	4 days after the Swift Boat Veterans ads; <i>Unfit for Command</i> reviewed by <i>New York Post</i> ; Porter Goss announced as nominee for CIA director
September 19-20	12	CBS describes Bush National Guard story as “a mistake” in the <i>Washington Post</i>
July 29- 30	11	Kerry’s nomination speech
September 13-14	9	Questions about National Guard story being discussed widely

^a A period lasts three hours. Volatility estimated from data include volume and price at 3am, 6am, 9am, noon, 3pm, 6pm, 9pm, and 11:59pm.

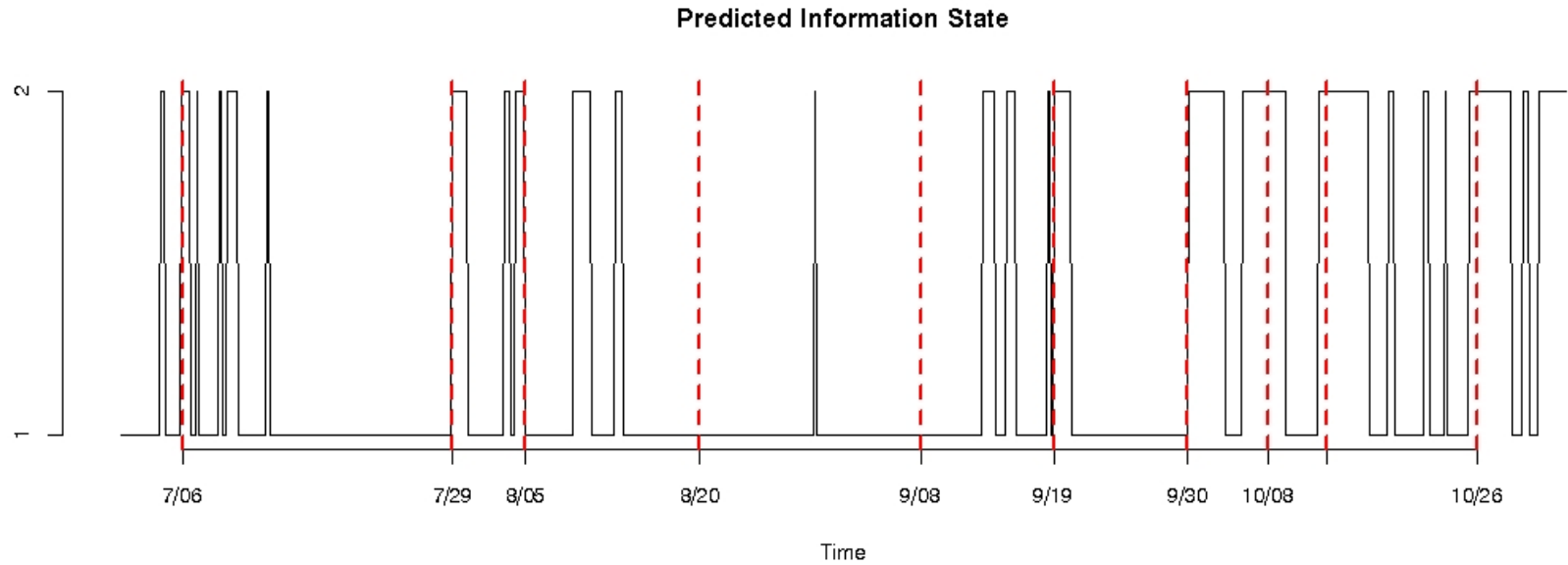
Figure 1. Volatility in the 2004 Campaign



Key Dates:

- July 6 Kerry picks Edwards as VP
- July 29 Kerry's nomination speech
- August 5 First Swift Boat Veterans for Truth advertisement airs
- August 20 Second SBVT ad airs
- September 8 Bush's National Guard service questioned in CBS story
- September 19 CBS retracts the National Guard story and Dan Rather releases statement
- September 30 First debate—Bush performs poorly
- October 8 Second debate
- October 13 Third debate—Kerry makes comment about Cheney's daughter
- October 26 Story about missing explosives in Iraq in 2003

Figure 2. Volatility in the 2004 Campaign: Information States



Key Dates:

- July 6 Kerry picks Edwards as VP
- July 29 Kerry's nomination speech
- August 5 First Swift Boat Veterans for Truth advertisement airs
- August 20 Second SBVT ad airs
- September 8 Bush's National Guard service questioned in CBS story
- September 19 CBS retracts the National Guard story and Dan Rather releases statement
- September 30 First debate—Bush performs poorly
- October 8 Second debate
- October 13 Third debate—Kerry makes comment about Cheney's daughter
- October 26 Story about missing explosives in Iraq in 2003