Analyzing Prediction Market Prices and Their Ability to Forecast Election Results

By: Markus Anttinen

Aalto University School of Business, Department of Economics

Bachelor's Thesis 3.5.2017

Instructor: Pauli Murto

Opponent: Siiri Naumanen

Table of Contents

Abstract

This thesis discusses the use of prediction markets in event studies, more specifically what type of information can be extrapolated from prediction market prices and how can this information be used in order to forecast election results. The topic has been recently in the forefront of academic research of event studies as it has empirically been noted that prediction markets offer high predictive power and offer large sources of data in fields where data has been hard to come by.

The intention of this thesis is to outline previous research on the topic and study the question with the help of current market theory. The theoretical basis that is used in this analysis draws from Eugene Fama's efficient market hypothesis and Milgrom and Stokey's information and trade under common knowledge to name a few.

This thesis intends to critically examine whether or not there is any theoretical justification for using prediction markets as a support-tool for decision-making and what advantages and limitations there may be in deriving information from prediction market prices and in using it to forecast election results.

Introduction

The study of prediction markets has grown in recent years as prediction markets have found to be a rich source of empirical data with both theoretical and real-world value. Prediction markets are defined to be a marketplace where a trade contracts payoff is tied to a future event (Wolfres & Zietzewitz, 2006a). Prediction markets can be used to project corporate sales, predict economic indicators and forecast election results, the latter being the key focus of this paper.

Prediction markets have been a topical issue, as prices gathered from the market correspond with the probabilistic distribution of market expectations for a certain event of occurring (Wolfres and Zietzwitz). This aggregated market expectation has been found in certain cases to be more accurate than other forms of forecasting, which means that prediction markets have several applications. It can act as a support-tool for real-world decision-makers and for academic researchers who to study market behavior and expectations.

In the context of predicting election results, aggregated prediction market prices have historically been a better predictor for election results than opinion polls. The most famous prediction market for elections is the Iowa Electronics Market, which is a non-profit future market run for academic purposes and offers e.g. contracts on who will win an election and by what vote share (Wolfres and Zietzewitz, 2006a).

Prediction markets have grown significantly in volume in recent years. An internet betting exchange Betfair reported that in 2012 50 million USD was bet on the winner of the American presidential elections while in 2016 the corresponding figure was 130 million USD (Reuters, 2016). Betfair also reported that an aggregate of wagers worth 159 million USD had been put on the Brexit referendum, meaning that betting on political results is a worldwide phenomenon. It should further be noted that betting on political results is actually illegal in the United States, unless it is for academic purposes like in the case of the Iowa Electronics Market.

It is important to note that prediction markets are not the only relevant market for forecasting political elections. For instance, the value of the pound/dollar exchange rate fell months before the Brexit referendum as markets had ingrained some of the risk of an exit from the European Union into market prices. Furthermore, stock exchanges movement generally coincides with the direction of expected policy changes.

Therefore defining what a prediction market consists of can be conceptually difficult, if there are alternative and more profitable ways for rational agents to profit from political results than the

prediction market. This means that studying those market places can also give a good indication of expectations.

However, the strength in studying the prediction market is that it gives us a very good estimate for market-aggregated probabilities as prediction market contracts are well defined and thus, manages to isolate the exact phenomenon of interest which in this case is predicting election results. Prediction markets are also sizable enough to offer statistically relevant data.

Prediction markets are also relatively free of noise that will channel into other markets such as stock markets. Changes in economic outlook will effect both the stock market and the prospects of candidates getting elected, meaning that forecasting election results through stock market movements would be performed with the help of a statistically limited model.

In most cases, the odds of elections are calculated with pari-mutuel betting or "winner-takes-all" betting systems. In pari-mutuel betting, bets are pooled together and odds are calculated by comparing the amount of winning bets to the entire betting pool. Pari-mutuel betting is used in rank-order tournaments. Rank-order tournaments are situations where participants finish in a rank and candidates can be sorted from best to worst in a uniform way (Thaler & Ziemba 1988). However, other betting systems can also be employed and prediction markets often offer a myriad of contracts, not just on rank-order results. The advantage of pari-mutuel betting systems for researchers is simply that it quantifies probabilities of winning an election as odds.

Efficient Market Hypothesis and betting markets

According to Eugene Fama's (1970) seminal paper on efficient market prices, prices should "fully reflect" the available information. He further categorized markets into both weak and strong form efficiency: weak form market prices account all historical publically available information while strong form prices reflect all the information including private information. Wolfres and Zitzewitz (2006a) concluded that prediction markets seem to adhere to weak-form efficiency.

Efficient prices follow a random walk according to Fama, which in this case means that betting only on public knowledge should not yield profit opportunities as it is already reflected in the prices although as discussed further, there are still profit opportunities if information diffuses with a lag or if the market consistently over-reacts to information.

Fama does not explicitly define what the necessary parameters for efficient market places are though he lays some sufficient conditions. For instance, having a frictionless market without transaction costs and, where investors agree on the implications of new information would be sufficient conditions according to Fama, but they are not requirements for efficient markets.

Markets could still be efficient with high transaction costs if traders take into account all of the available information, however efficiency would be broken if transaction costs inhibit traders and arbitrageurs to enter the market place and correct the misdirection of prices. Correspondingly, traders can have heterogeneous beliefs and differences of opinion. According to Fama prices will still be efficient as long as there are no traders that can consistently make better evaluations on public information that reflects into market prices.

Since prediction markets employ a zero-sum game, efficiency implies that the expected rate of return to bettors has an upper bound of zero. In reality, prediction markets yield on average negative returns for bettors as both the bookmakers and bettors cannot make a profit simultaneously. Even in a marketplace that does not have bookmakers or transaction costs, information acquisition is a cost that needs to be considered.

If prediction markets do indeed, yield on average expected negative returns then why would there be participators in the market? This question is not the focus of this paper, but will be briefly discussed. One proposed argument is that people and especially many bettors do not behave rationally. In the field of psychology and behavioral economics, irrational behavioral patterns are a hot topic. Several studies have been done to try to describe how bettors have ingrained biased heuristics that effect their decision making e.g. gamblers fallacy, gamblers ruin etc. (Croson & Sundali, 2005)

Even consistent losses may not deter agents away from the market because for most people who gamble for pleasure, the utility is gained from other sources than expected financial returns. This is in stark contrast to, for instance capital markets where capital firms have set expectations for the return on capital and the owners of such companies would punish consistent losses by investing elsewhere. Hence, companies behaving irrationally and making a consistent loss would eventually drop from the market place.

Kahneman and Tversky (1979) criticized the prominent expected utility theory, which states that under uncertainty individuals will choose the outcome that offers the highest expected return. Kahneman and Tversky point out that rather than choosing simply the highest expected return,

humans frame their projected gains and losses asymmetrically to a certain reference point, meaning that bettors asses their gains and losses in proportion to their current wealth.

According to Kahneman and Tversky in situations where both heavy losses and heavy gains are possible, experiments have shown that individuals behave in a more risk-seeking fashion: individuals choose the option that offers higher gains to compensate for the losses even if this would not offer the highest expected utility. Studying whether prediction market agents behave in a risk-loving fashion (as most gamblers do) or if they are risk averse (as most investors are), would be an interesting topic for further behavioral economic research.

However, whether or not all agents are informed and rational is not a requirement for market prices to be efficient. Efficient market prices can be reached by a small subset of informed agents whom may drive prediction market prices to their true value while a large number of agents remain uninformed and irrational (Hurley & McDonough, 1996). Irrationality in this context means that some agents base their predictions on irrelevant data. A finding of efficiency does not imply the absence of irrational behavior.

Market construction with rational agents

1. Common prior concordant beliefs

Milgrom and Stokey (1980) provided a model in which agents have access to public knowledge, all agents are rational and all agents are concordant e.g. everyone shares a common opinion of how certain information and its effects should be interpreted. Milgrom and Stokey focused their analysis on what happens to prices if new information, either private or public would be discovered. Private information refers to information accessed by only a small subgroup of the total population.

It is apt to assume that truly democratic elections' results are predicted generally with the help of publicly available information. Econometric predictive models are built using publically available figures such as economic growth, unemployment rates, tentative poll and estimations on voter turnout. Though there may be sources of private information that may influence elections, due to its' very nature private information is difficult to observe and the impact of private information is difficult to measure in truly democratic elections.

One could for instance hypothesize that the inner workings of party politics influences what type of visibility certain candidates receive. Hence, if one would possess intimate insider knowledge concerning the power relations within political parties this might give an unfair advantage to certain agents regarding the prediction markets. However in a concordant world with ex ante Pareto-optimal allocations, trade should still not occur according to Milgrom and Stokey.

The simple logic behind this theorem is that if the motive of an agent is to find an advantageous bet then for a trade to occur when all beliefs are concordant, a trade is acknowledgment of the fact that one party is submitting to a disadvantageous bet. The only way for a bet to occur is if one side has access to more information and even then, rational agents would not accept the bet as ex ante public knowledge has channeled into prices and any willingness to accept a different price would be a sign of private knowledge or irrationality. According to Milgrom and Stokey it is in fact a pre-existing condition that prediction markets require uninformed and irrational participants in order for the marketplace to exist.

If we expand private information to not only include literal private information as analyzed by Milgrom and Stokey, but to include knowledge and skills which are costly to acquire, such as an indepth understanding of statistical sciences or privately collected statistical information relevant to election results, the analysis becomes more complex.

However, according to Feldman (1987), rational, concordant agents would converge into a rational belief equilibrium either through market learning or by agents who consistently make a loss dropping from the market place. Therefore, the concluding result would be a market place where beliefs would become homogenous though this is likely not to be found in real-world prediction markets and current academic research allows for heterogeneous beliefs.

2. Heterogenous Beliefs

In the context of predicting election results, there are many underlying reasons why trades could still occur within the prediction market. As discussed prior, not all agents behave rationally. Secondly, assuming that all beliefs are concordant is a strict assumption and very likely does not reflect the real world. There may very easily be differences in opinion regarding what type of information is relevant to the overall result of truly democratic elections.

Morris (1994) argued that individuals might not hold a common prior understanding, as events have not occurred frequently enough to draw a universal conclusion. This could certainly apply to predicting elections, as elections occur infrequently and the theoretical framework of predicting elections is inconclusive.

Hong and Stein (1999) propose that information diffuses gradually within the market. This could likely be because information acquisition comes at a cost or because some data may not be available to everyone. Hence, market prices do not immediately reflect the "true" value and this leaves room for trading opportunities.

According to Banerjee, Kaniel and Kremer (2009), traders do not recognize what other traders know, as they can only observe some type of aggregate opinions through prices. Agents understand that other traders' opinions will influence prices but they disagree on the extent that new information will affect the behavior of other traders, hence this leaves the opportunity for new information to generate a drift in prices.

Grossman and Stiglitz (1976) argued that market prices could not truly be informative in conditions where information acquisition is costly. "If price systems were truly informative then there would be no differences in beliefs, if there were no differences in beliefs; there would be no trade; but then it appears that it is prices in markets where there is no trade which leads to uniformity of beliefs". Grossman and Stiglitz argued that costless information is a necessary condition for efficient market theory to hold and that it is not a realistic assumption in real world prediction markets.

However, Grossman and Stiglitz's analysis does not take into account that both price formation and information diffusion, as Hong and Stein noted, occurs relative to time. Therefore, if the acquisition of new information does not immediately reflect into the prices there are still possibilities for rational traders to profit from their information acquisition. This is especially true regarding information, which is accessed at first by only a few market participants.

They key question is then what exactly is meant by prices being efficient. As prediction market prices have been found to be weak form efficient, efficiency in this case implies that market prices reflect all publically available information immediately, the expected returns correspond with the level of riskiness the contract and no investment strategy based on historical technical data can

outperform the market in the long run. Efficient market prices do not require all beliefs to be concordant, but it requires that in the long-run investors cannot consistently profit from information that does not reflect into prices.

The famous favorite-longshot bias directly contradicts market efficiency, as it has been found on multiple occasions in betting markets that above expected returns have historically been gained by backing favorites to win while longshots i.e. those with smaller probabilities of winning, have statistically speaking overvalued odds (see Hurley and McDonough, 1996). The favorite-longshot anomaly occurs near the extreme ends of the probability spectrum.

One proposed explanation for the commonly found anomaly is that humans are poor at assessing the probabilities of very unlikely events (long shots) and poor at providing accurate estimates on probabilities with small incremental changes (favorites) (Kahneman & Tversky, 1979). As discussed previously, betting simply on technical price data should not yield above average returns and another offered explanation for this anomaly is proposed by Kahneman and Tversky who state that one-time larger gains may compensate for consistent smaller losses and provide additional utility through e.g. bragging rights.

Average Market Price

Because of the differences in beliefs and interpretations, the market would act as an aggregator of these varied beliefs. This line of thinking dates back to Friedrich A. Hayek (1945) whom argued that the main function of the price mechanism was to synchronize local knowledge and communicate it to others. The average price would in this line of thinking be a representation of the average belief of who bettors think would win.

However, Charles Manski (2004) showed quite controversially that in cases of binary options the aggregate price does not need to represent average belief, albeit it provides some useful information on the distribution of beliefs. Manski's model can also be expanded to pari-mutuel betting, which as previously described, is commonly used to determine the pay-off structure for election odds.

Manski's analysis, though controversial, holds if all agents are risk-neutral e.g. would be willing to wager their entire budget for an "underpriced" odd and if the budget and beliefs of agents are

uncorrelated. While Manski's results should not be understood as an absolute truth as both assumptions are very extreme and can easily be challenged, they still show how easy it is to construct a scenario where the aggregate market price does not reflect the mean belief.

Wolfres and Zietzewitz conversely concluded that market prices are a highly informative description of mean belief, and any divergence from the mean is only a small absolute error. Wolfres and Zieztwiz commented Manski's findings by stating that extreme assumptions yield extreme implications, referring to Manski's assumption of risk-neutrality. Wolfres and Zietzewitz's models does not require risk neutrality but rather assumes the logarithmic utility function. The logarithmic utility function is consistent with Kahneman and Tversky's prospect theory, in that the marginal utility of gains decreases when referenced to a starting budget.

It has now been postulated that bettors in the prediction market do not behave fully rationally and that market prices do not convey all the relevant information nor do they necessarily have to even convey the aggregate average beliefs of bettors. The question that then remains to be answered is: what information can be garnered from prediction market prices and how can this information be used to determine election results?

[i] Theoretical justification of Charles Manskis model

Information Transmitted Through Prediction Market Prices

Betting market prices give insight on the probabilities which bettors give candidates to win elections. The prices reflect the direct opinions of the bettors of who they think will win. Even if the beliefs of bettors are biased, the general assumption is that the market prices are not biased as they are aggregated from a large pool of information sources and account for all available public information thus providing an accurate estimate for the true probabilities.

Kou and Sobel (2004) argued that whether or not prices are efficient in themselves, does not necessarily reflect whether prices offer a good power of predictability. Efficient market prices are an indication that the market is fair with limited opportunities of arbitrage and speculation, but it is entirely possible that market prices are well risk-adjusted. This could still mean that there is considerable risk i.e. that the confidence intervals of probabilities relative to their outcomes is notable, diminishing the predictive power of market prices. It would simply mean that the

riskiness of the product would be accounted for in the prices, not that the risk itself wouldn't exist.

Why should the prediction market provide improved analysis on the understanding of the current political climate? Gruca and Berg (2007) stated that there is a substantial, directional bias in the information that is publicly available i.e. the public overreacts to news that has very little influence on voter behavior and irrelevant news may influence market prices as a form of noise. Since there are monetary rewards for traders who are able to detect the informational bias relative to market prices, it is in the traders' best interest to correct these biases by buying or selling, thus moving prices in the direction that reflects the "true" probabilities.

Traders in prediction markets also use a myriad of tools to analyze probabilities. As there are financial incentives to map out the probabilities correctly, it could be assumed that rational traders would be incentivized to conduct thorough analysis with the help of econometric and statistical modelling rather than use only their subjective understanding to predict election outcomes, even if this would mean incurring some costs. These incentives could mean that prediction markets could yield more accurate results than other alternative methods.

In theory, rational investors in election markets should be capable of ignoring short-term shifts in public opinions, such as spikes in popularity that occur after party conventions (Erikson & Wlezien, 2008), but which eventually disappear come Election Day. Election traders have limited opportunity to profitably speculate off short term noise: if any noise would be transmitted into prices it would be at the expense of those misinterpreting the signals.

Because prediction market contracts have a set expiration date (i.e. Election Date), attempts to artificially inflate market prices or try and engage in other forms of price speculation should not succeed. At least they should not succeed without having to take considerable risk by purchasing a significant amount of contracts above their true market value. (see Erikson and Wlezien)

Tetlock (2004) estimated that there might exist a small degree of negative serial correlation between returns, meaning that there are bettors who consistently misevaluate the probabilities of a candidate's victory. This could be because of non-monetary motivation such as partisanship and political stance. It could also be a finding of irrationality where participants base their wagers on irrelevant data. Those bettors would exert pressure on prices to deviate from their true values; however, informed traders would still cause the prices to converge to their true values.

An instructive example of how naively interpreting prediction market prices as objective truths is flawed was shown by Wolfres and Zietzewitz while studying the 2004 US Presidential elections. Wolfres and Zietzewitz studied contracts that paid one penny for each percentage point of the two-party vote share won by the Democrats, conditional on the trader also correctly picking the winner of the Democratic nomination race.

Wolfres and Zietzewitz reported based on these contracts that the favorite to win the Democratic candidacy: John Kerry was estimated to have a probability of 50% for winning the General Election against the republican nominee while John Edwards who trailed John Kerry by 15% was given a probability of 55%. (2006b)

Hence naively assuming that Democrats should maximize their respective candidates presidency by electing John Edwards is flawed since bettors had taken into account, that in order to secure the democratic nomination Senator Edwards would require the popular votes of the Democrats to shift in his favor by a successful marketing campaign, which would resonate with the voters. Such a dramatic shift in public sympathies would result in his improved chances of winning the general elections thus justifying the higher probability.

Such scenarios give birth the opportunity of arbitrage if one were to find a contract where:

P (A)*(B)> P (B|A) P (A),

For instance in the previous example:

P(Edwards wins dem. nomination)*P(Edwards wins the general election)>P(Edwards wins the general election on the condition that he is nominated)

Thaler and Ziemba (1988) studied horse tracks, found that in general, betting markets were efficient, and provided very few arbitrage opportunities but there were a few anomalies (i.e. Favorite Long shot bias). There are financial gains for markets to correct such anomalies, meaning that they usually exist only for a brief window in time. Tetlock (2004), who studied prediction markets and sports betting markets, has also replicated these findings.

Researchers have tried to isolate prediction market expectations and establish a causal relationship between other commodities. For instance, Roberts (1990) studied movements in prediction market prices during Ronald Reagan's re-election and movements in stocks of defense firms implying that re-electing Ronald Reagan would increase defense spending. He found that defense stocks responded to the shifts in the perceived probability of Ronald Reagan's re-election during the election cycle.

Tetlock criticized current theoretical frameworks on prediction markets because they try to explain market-pricing behavior through financial theory even though the financial markets and betting markets are not analogous: inefficiencies in betting market do not translate to inefficiencies in financial markets and vice versa.

The markets are different in both their market construction and participants' behavior. Betting markets consists of some risk-loving participants, whom may use non-monetary reasons for trade while risk-averse traders in financial market generally base their investment decisions on rational models. Second, the markets themselves differ in that prediction markets have lower volumes and higher transaction costs implying that there may exist impediments to markets correcting their prices through arbitrage.

Therefore, Tetlock recommends heeding with caution before drawing conclusions between financial markets and betting markets. Understanding which type of market inefficiencies influence the prediction markets and understanding the nature of the market participants has room for further empirical study.

Comparing Polls with Market Prices

Polls that measure simply whom a particular voter intends to vote provides only a small snapshot of time. Opinion polls provide the average response from statistically significant sample groups but polls provide a narrow scope as they measure only the intention of a voter. However, they are often corrected with more complex models such as the trial-heat model, which takes into account e.g. the state of the economy (Campbell, 1996). Aggregated averages of polls are these days more preferable in order to improve their reliability.

This intention is subject to change and the act of polling is subject to several biases. Inherently, opinion polls have flaws that skew their accuracy and restrict the unbiased, scientific knowledge that could be derived from their results in order to forecast the election results. Polls also have a tendency to overreact to short term stimuli which evaporates by Election Day, thus hindering their forecasting value.

First, in order to have a credible result, poll-makers should be able to randomly select the people who submit a reply to the poll. This is clearly not the case as online surveys, phone surveys,

written questioners etc. are well documented of having issues with randomizing their respective repliers possibly skewing the results and miring the validity of the results. The same could be said for prediction markets as participation in these markets is distorted and prices have some component of higher order expectations ingrained in them meaning that they reflect whom the voters think other voters think will win rather than who they themselves think actually will win. (Rothschild, 2008)

Second of all the answers gained from polling are inconclusive as they measure intent to vote, not actions. Polls are highly susceptible to time. Whether or not a voter will turn up on Election Day and vote or whether he will change his opinion during the election-cycle, will affect the quality of results gained from polling. Using a large sample size in polling does not reduce this inherent uncertainty present at predicting election results through poll responses.

The aforementioned issue is one major reason why it is seen preferable to use prediction market prices to predict election results as opposed to the use of scientific opinion polls. As Wolfres and Zietzewitz have put it "Markets aggregate opinions and, by requiring a trader to put your money where your mouth is" e.g. the key advantage of prediction markets over alternative approaches is that it provides the truthful revelation of probabilities that agents give for election results (2006a).

Using the idea of truthful revelation of beliefs, Wolfres et al. find that opinion polls that measure who a voter expects to win rather than who he himself will vote for, give a more accurate forecast than polls that measure voter intent. This could be attributed to the fact that voters would draw from a larger pool of information through their respective social networks and their understanding of public information thus conveying more information to the pollster in a similar fashion of how a marketplace would operate. (Rothschild & Wolfres, 2011)

Furthermore another issue with opinion polling is that the polls are conducted, aggregated and published through a slight lag and due to the expenses incurred by collecting the opinions of thousands, polling is conducted infrequently by individual polling stations. This means that individual polls do not necessary portray an up-to-date snapshot of current voter intention, rather public sympathies may fluctuate in any given direction. However the impact of this error can be diminished by aggregating different polling stations, thereby offering snapshots through different time-periods and accessing a larger pool of voters, diminishing the effects that one skewed poll may have on the results.

The sensitivity of polls relative to time is not an earth-shattering revelation and so it begs the question should polls be used as such to forecast elections that happen long in the future or is the

practical value of polls in understanding what the current preferences of voters are on a set date, which polls are a good indicator of. Shouldn't the inherent practical and theoretical use of polls therefore include but not be limited to furthering the understanding of how political changes influence voter behavior?

Both polling and prediction markets are susceptible to the fact that by simply gathering information on the different probabilities of winning and by distributing this information to the public, the results of the elections may change. This new information can change the general perception of the public and in extreme cases influence voter turnout during the Election Day.

The extreme opposites of public perception influencing voter behavior are known as the bandwagon effect and underdog effect. The bandwagon effect means that voters will vote for the candidate who is perceived to be on top. This is proposed to be the result conformity or "herd behavior" and another alternative explanation for the phenomenon is that humans prefer to back winners and want to be associated with success (Ansolabehere & Iyengar 1994).

The bandwagon effect may also manifest itself as a strategic consideration when a voter perceives that his or her preferred candidate has "no chance" of winning the election based on current polls or prediction market information. Therefore the voter will change his or her respective vote in favor of his second most preferred candidate to try and ensure that his least preferred candidate does not get elected. (Sher, 2011)

The opposite effect is known as the underdog effect, where the public decides to vote for the candidate perceived to be trailing. There are also some descriptive psychological explanations for the underdog effect mainly attributing it to the human ability to sympathize with the underdogs and thereby influencing voter behavior. How the underdog effect manifested itself in elections is when the supporters of the candidate who is favorite to win fail to show up during Election Day as they perceive their candidate's victory to be a certainty because of e.g. recent poll results (Sher, 2011). The committed supporters of the underdog experience thus a relatively higher voter turnout and this causes a deviation in the actual elections results and polled results and in extreme cases, reverses the fortunes of the two candidates.

A unique detriment to prediction markets is that wagering money on election results gives an incentive for market participants to try to manipulate the outcome of the election itself. While this is likely not such a big issue in largescale elections such as the American presidential election, where voter turnout is in the millions, it is still and issue that needs to be considered and has

historically been a cause for concern (Rhode & Strumpf, 2004) It is also the main reason why betting on political events is illegal in the United States.

Forsythe et al. (1992) concluded that market prices do not follow poll results rather market price fluctuations predate changes in polls and may predict changes in poll results. The key question that Forsythe asked is what new information do polls provide? Is the information of a small, biased sample group relevant at predicting election results? If market prices are on average both in the short and long run better at estimating election results then should not an informed bettor use market prices rather than polls to correct his or her beliefs. However, these results have been challenged by other researches (see Kou and Sobel, 2004).

It should be underlined that prediction markets do not dispense the need for opinion polling. Scientific polling can be used as a tool in tandem with prediction markets. One assumption is that the results from scientific polls can also influence the prices of prediction markets as the new information gained from such extensive polls provides some relative insight of the probabilistic boundaries of voter behavior. It could be assumed that bettors would use trial-heat polls as a tool for their decision-making.

It should also be noted that other more sophisticated models of forecasting have emerged in recent years generated by political scientists and contemporary literature acknowledges the shortcomings of opinion polls. These advanced models likewise offer better predictive power than opinion polls, but have their accuracy has yet to be tested in regard to market prices according to my understanding.

However, intuitively if these models would provide a better understanding of the phenomenon, then rational traders would update their beliefs and start incorporating these models so that market prices would begin to mimic their results. This would lead to a convergence in prediction market prices and in the results that such models would yield.

Market Accuracy in Respect of Time

While several studies have been conducted, proving the short-term accuracy of prediction markets (see Rothscild et al.) the long-term accuracy of prediction market contracts is not as clear-cut though most recent empirical studies agree that prediction markets are still better than alternative possible methods at predicting election results long-term.

Asch, Malkiel and Quandt (1982), while talking about pari-mutuel betting in general suggest that informed bettors should wait for the last possible moment before making a bet. This is mainly because of two reasons. Firstly, early in the betting cycle as transaction volumes are smaller, even a modest wager can influx the odds. Furthermore as election-cycles progress more information is revealed about the probabilities of the candidates. While this information could potentially help all bettors, it lowers the variance of expected returns for rational, informed agents.

Thirdly Asch, Malkiel and Quandt point out: those agents with some private knowledge should wait for the last possible moment to reveal their information in order to avoid the bandwagon effect which in this case would mean that other bettors adjust their beliefs through the true market prices. Once private knowledge would be revealed through market prices it would gradually become public knowledge thus limiting the ability of one holding such information to profit. In fact by waiting for the last possible moment rational bettors can gain from the knowledge that has already been revealed in prices by others.

Page and Clement (2013) also studied the influence that the time-dimension has on prediction market prices and noted that traders with time discounting preferences receive no interest for the funds committed to their prediction market contracts. Therefore, the incentive to trade grows the closer one is to the contract expiration date e.g. Election Day. This is especially true for those bettors, whose beliefs are very close to the true market prices and therefore, would stand to make only a small profit in the first place.

Logically this preference to wait for the end of the betting period before submitting a bet can be observed through market volumes. As market volumes are smaller, the prices are less likely to contain all the possible, relevant information. It is only natural to assume that the prices would converge to their true values once all of the market participants submit their information. Hence, long-term contracts are unsurprisingly less informative than their short-term market prices (Berg et al, 2001).

For instance Erikson and Wlezien (2008) noted that using prediction market prices to predict the US election in 2008 6 months prior to the election would have resulted in an average error of 5%. Similar results were gained by Berg et al. (2001), who concluded that the average standard error of prediction markets 84 days prior to the Election Day for U.S presidential elections from 19882000 was about 2,5%.

Conclusions

Prediction markets offer a novel way of forecasting elections and offer a rich source of data that can be used to understand changes in voter expectations in response to political changes. Prediction markets have grown in their market size in recent years which theoretically would improve their predicting power. Furthermore prediction markets isolate the exact phenomenon of interest and offer a novel way of accessing information thus justifying its appeal for researchers and decisionmakers alike.

In general betting market prices have been found to be efficient with a few exceptions, however understanding that efficiency does not describe the quality of information which markets base their decisions on nor does it guarantee the accuracy of the forecasts derived from prediction market prices is paramount to interpreting the results. Efficiency is an indication of fair markets and prediction markets have been found to be weak-from efficient.

Furthermore as pointed out by Tetlock, a shortcoming of the current theoretical framework is that it attempts to explain prediction markets by using modern financial theory even though the markets are not identical in their construction or in their agents' behavior. Whether participants are riskaverse as capital market agents are, risk-loving similar to gamblers or risk-neutral has implications on what information prediction market prices convey. Manski and Wolfres & Zietzewitz provided conflicting models on whether market prices provided an aggregated belief or not and their models depend on the participants attitude towards risk.

Prediction markets offer financial incentives for participants to correct the over-reaction and outside noise. Therefore prediction markets theoretically encourage for a truthful revelation of beliefs thus being in many ways superior to other forms as forecast such as opinion polls. All public information should in theory channel into prediction market prices however one should heed with caution when drawing conclusions from the market prices as was demonstrated by Wolfres and Zietzewitz. Finally, the accuracy of prediction markets improves over time and this was in part due to the discounting preferences and low volumes of traders at the start of the election cycle.

It can be stated that further research is necessary in understanding the behavior of prediction market participants and understanding the construction of the market. This is vital, should one wish to understand how intelligent are the markets at gathering all of the relevant data and what type of information can be derived from prediction market prices. Though prediction markets offer a lot of promise in the field of event studies, naively believing in the superiority of markets over other sources of information is misguided as understanding the complexities of election recycles

requires a comprehensive understanding of the field. Other tools such as opinion polling can and should be used in tandem with prediction markets.

Sources

Ansolabehere, S. & Iyengar S. (1994), *Of horseshoes and horseraces: Experimental studies of the impact of poll results on electoral behavior*, Political Communication, 11, 413-430.

Banerjee Snehal, Ron Kaniel Ilan Kremer (2009) Price Drift as an Outcome of Differences in Higher-Order Beliefs, Review of Financial Studies, forthcoming

Berg, Joyce E. Forsythe, R., Nelson, F., & Rietz, T. A. (2001). *Results from a dozen years of election futures markets research*, Handbook of Experimental Economic Results, 1, 486515

Campbell, James E. (1996). *Polls and Votes: The Trial-Heat Presidential Election Forecasting Model, Certainty, and Political Campaigns*, American Politics Quarterly 24:408–33.

Croson, Rachel, James Sundali, (2005) *The Gambler's Fallacy and the Hot Hand: Empirical Data from Casinos*, The Journal of Risk and Uncertainty, 30:3; 195–209

Erikson Robert, Christopher Wlezien, (2008) *Are Political Markets Really Superior to Polls as Election Predictors?* Public Opinion Quarterly, Vol. 72, No. 2, Summer 2008, p. 190–215

Fama Eugene, (1970) *Efficient Capital Markets: A Review of Theory and Empirical Work*, Journal of Finance. VOL.25, No.23, p. 83–417

Feldman Mark D. (1987), *An Example of Convergance to Rational Expectations with Heterogenous Beliefs*, International Economic Review, Vol. 28, p. 635-650

Forsythe Robert, Nelson Forrest, George R Neumann and Jack Wright, (1992) *Anatomy of an Experimental Political Stock Market* ,The American Economic Review Vol. 82, No. 5 (Dec., 1992), p. 1142-1161

Grossman Sanford, Joseph E. Stiglitz (1976) *Information and Competitive Price Systems* The American Economic Review *Vol. 66, No.2 (May 1976), p. 246-253*

Gruca, Thomas S., Joyce E. Berg (2007). *Public information bias and prediction market accuracy. The Journal of Prediction Markets*, 1(3), 219-231.

Hayek Friedrich, The Use of Knowledge in Society (1945), *American Economic Review*, 35, 519-530.

Hong, Harrison and Jeremy C. Stein. (1999) *A Unified Theory Of Underreaction, Momentum Trading, And Overreaction In Asset Markets*, Journal of Finance, vol 54, Dec 6, 2143-2184

Hurley Willliam, Lawrence McDonough (1996), *The favourite-longshot bias in parimutuel betting: A clarification of the explanation that bettors like to bet longshots* Economic Letters vol. 52, issue 3, pages 275-278

Kahneman Daniel, Amos Tversky, (1979) *Prospect theory: an analysis of decision under risk*, Econometrica, vol. 47, pp. 263–91.

Kou S.G, Michael E. Sobel, (2004) *Forecasting the Vote: A Theoretical Comparison of Election Markets and Public Opinion Polls Political Analysis*, Vol 12, p.277–295

Manski Charles, (2006) *Interpreting the predictions of prediction markets*, Economics Letters, vol. 91(3), p 425–9.

Milgrom Paul, Nancy Stokey (1982) *Information, Trade and Common Knowledge*, Journal of Economic Theory, Vol. 26, No. 1, February 1982

Morris Stephen, (1995) *Trade With Heterogenous Prior Beliefs and Asymmetric Information*, Econometrica, 62, p.1327-1348

Page, Lionel, Robert T Clement, (2013) *Do Prediction Markets Produce Well Calibrated Forecasts?*, The Economic Journal, 123 2013 (May), 491–513

Rhode, Paul, Koleman S. Strumpf, (2004) *Historical Presidential Betting Market*, Journal of Economic Perspectives, Vol 18, No 2, Spring 2004, Pages 127–142

Roberts, Brian, (1990) *Political Institutions, Policy Expectations, and the 1980 Election: A Financial Market Perspective*, American Journal of Political Science, 34(2), 289-310

Rothschild, David, (2009) *Comparing Prediction Markets, Polls, and Their Biases*, Public Opinion Quarterly, Vol. 73, No. 5, p. 895–916

Rothschild, David, Justin Wolfres, (2011) *Forecasting Elections: Voter Intentions versus Expectations*, working paper

Sher, Chien-Yuan (2011), Distinguishing Strategic Voting from Bandwagon Effects – How did Voters' Subjective Expectations Affect Results, working paper

Tennery Amy, *Betting Sites See Record Wagering on U.S. Presidential Election*, Reuters, 7.11.2016, retrieved from www.reuters.com

Tetlock, Paul. (2004). How efficient are information markets? Evidence from an online exchange, Yale University, working paper.

Thaler Richard H, William Ziemba (1988) *Anomalies Parimutuel Betting Markets: Racetrack and Lotteries* Journal of Economic Perspectives Vol. 2, No.2 Spring 1988

Wolfres Justin, Eric Zitzewitz (2006a) *Prediction Markets in Theory and Practice,* The New Palgrave Dictionary of Economics, 2nd edition, 2006 p. 877-890

Wolfers, Justin, Eric Zitzewitz (2006b). *Five open questions about prediction markets,* Information Markets: A New Way of Making Decisions in the Public and Private Sectors, Aei Press (April 27, 2006) p. 150-200

Appendix

i

Consider a market offering all-or-nothing contracts. Let the prices of these contracts be π_m and π_n. Suppose that a population J with heterogeneous beliefs participates in this market. Each person $j \in J$ has a fixed trading budget of y_j dollars and a subjective probability q_{jm} that event m will occur; thus, $q_{jn} = 1 - q_{jm}$. Let $P(q_m, y)$ denote the cross-sectional distribution of beliefs and budgets. Assume that the distribution of beliefs is continuous and that budgets are statistically independent of beliefs. Finally, assume that persons are price takers and maximize the subjective expected value of their contracts.

(1) $\pi_m = P(q_m > \pi_m)$. | $\pi_n = 1 - \pi_m$.

(2) $E(q_m) \in (\pi_m^2, 2\pi_m - \pi_m^2)$.

(3) $E(y) = (1/\pi_m) \cdot E\{y \cdot 1[q_m > \pi_m]\} = (1/\pi_n) \cdot E\{y \cdot 1[q_m < \pi_m]\}$.

If y and q_m are statistically independent, then $E\{y \cdot 1[q_m > \pi_m]\} = E(y) \cdot P(q_m > \pi_m)$ and $E\{y \cdot 1[q_m < \pi_m]\}$
Hence, equation (3) reduces to

(4a) $\pi_m = P(q_m > \pi_m)$,

(4b) $\pi_n = P(q_m < \pi_m)$.