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WHY BETTING AND PREDICTION MARKETS WORK (NOT) WELL: AN INVENTORY OF OPEN QUESTIONS

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Discussion Paper No. 2007 – 178

March 2007

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http://www.cerge-ei.cz

Why Betting and Prediction Markets Work (Not) Well:

An Inventory of Open Questions*

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March, 2007

Abstract

Although it is well established that prediction and betting markets *can* generate accurate predictions of a variety of uncertain future events, it is not well understood *why* they outperform their alternatives. In this paper we review literature on prediction and betting markets and identify open questions that need to be answered to validate their use as a tool of information aggregation.

Keywords: prediction markets, information markets, betting markets, information aggregation

JEL classification: D82, G13, G14

*The author would like to thank Andreas Ortmann for many helpful comments. This work was supported by a CERGE-EI/World Bank Fellowship.

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1 Introduction

Trustworthiness of popular judgements and reliability of collective decision making have been of substantial interest for a long time. Charles Mackay, in a book first published in 1841 (Mackay, 2003), shows that the madness and confusion of crowds knows no bounds. A hundred years ago, British scientist Francis Galton attended a weight judging competition at Plymouth. Almost eight hundred townspeople estimated the weight of an ox. Some of the participants where experts at judging the weight of livestock (butchers, farmers) while others were guided only by their fancies with no insider knowledge of cattle. Surprisingly enough for Galton, the mean estimate, which can be interpreted as collective wisdom of the Plymouth crowd, was pretty accurate. Galton's experience, unlike that of Mackay, suggests that under some circumstances groups are remarkably intelligent and even smarter than the smartest people in them. Galton saw much more in this competition than just popular entertainment. He points out that the average competitor is probably as well fitted for making a just estimation of the ox, as "an average voter is of judging the merits of most political issues on which he votes" (Galton, 1907, p 450); could we continue "as an average employee of estimating the level of sales" or "as an average citizen of predicting the success of a certain public policy"?

Predicting the outcome of uncertain events like political or sporting events, sales forecasts, or macroeconomic indicators clearly requires that we have relevant and sufficient information with which to make our prediction as accurate as possible. Yet the information that is relevant typically is not concentrated in the hands of one person or even a few people. Instead, it is distributed among a lot of people, each of whom is likely to have a small bit of knowledge that is germane. An optimal solution would be to ask all these people to share what they know and to aggregate all the information they have.

In its simplest terms, information aggregation would look like this: Let's assume that we have six possible states of nature A, B, ..., F, all with the same initial probability of occurring. Five agents receive a private signal. The signal is drawn from an urn where the true state of nature (without loss of generality we assume it is A) is represented by five balls and the remaining five states (B to F) are represented by two balls. The probability of drawing the correct signal is therefore one third, while the probability of drawing the wrong signal is two thirds. Each agent draws (with replacement) three balls (i.e. three signals) with the following results:[1]

AAB	AEE	ABF	ACD	CDF
↓	↓	↓	↓	↓
A	E	?	?	?

The first agent thinks that the true state is A (and is right), the second thinks that the true state is likely to be E (and is wrong), and the remaining three agents receive a signal with almost no predicting power at all. The aggregated information (AAAAA, BB, CC, DD, EE and FF[2]), however, gives a much stronger signal about the true state of nature than does the private signal of any individual agent. Yet it is difficult, if not impossible, to find all those people who possess some relevant information and ask them about their signals. Moreover, people may not report their signals truthfully; for both reasons, we should find a mechanism which motivates people possessing some relevant information to reveal truthfully what they know. Prediction and betting markets seem to be such promising mechanisms.

Also known as information or decision markets, *prediction markets* are speculative markets created for the purpose of making predictions. In these markets, assets whose final cash value is tied to a particular event (e.g. will the next US president

[1] This example is based on Plott et al. (2003).

[2] Note that this particular realization of aggregation of information is the most likely outcome given the states' probabilities.

be a Republican) or parameter (e.g. total sales next quarter) are traded. The normalized current market price can then be interpreted as a prediction of the probability of the event or the expected value of the parameter. Evidence so far suggests that these markets are indeed surprisingly accurate in predicting election outcomes as well as completion dates of corporate projects. The reasons are manifold: First, they are often able to aggregate information that is dispersed (Chen and Plott, 2002); second, anonymous trading makes participants more likely to reveal what they really know (Berg, Nelson and Rietz, 2003); and, finally, well-constructed prediction markets are difficult to manipulate (Rhode and Strumpf, 2004).

A parimutuel betting market, or simply *betting market*, as typically used in horse racing and other sports events, is based on a betting system in which all bets are put together and the payoff (odds) is determined by dividing the total amount of money invested by the amount bet on the winning horse.[3] Debnath et al. (2003) show that sports betting markets provide unbiased forecasts of game outcomes suggesting that apart from political (e.g. Berg et al., 2003a, 2003b) and corporate level predictions (e.g. Chen and Plott, 2002) markets can also do well in predicting sports events.[4]

Both prediction and betting markets generate predictions of outcomes of uncertain future events, the main differences between them can be summarized as follows:

- **insiders:** in a prediction market insiders are likely to enter the market first so that they can exploit profit opportunities.

  in a betting market, insiders tend to wait till the very last moment. This is so because the payoffs on betting market depend on the number of traders investing on particular market (market for state A, B, ... F). The higher the

[3] The amount of money available for distribution to the winners is usually lowered by the house charge.

[4] For more examples of prediction and betting markets see the Appendix.

number of traders the lower the payoff. Therefore insiders try not to reveal what they know, because it could attract more traders. In fact, they might invest on other markets first in order to make last minute investment into the relevant market more profitable.

- **payoff structure:** in a prediction market, expected payoff is known to trader at the moment of trade (it's the difference between the price and private belief about the true probability). The payoff does not depend on other traders' actions.

  in a betting market, the payoff will be known only at the end of the whole market. Only when market is closed final odds and therefore payoffs can be determined. Moreover, payoff per dollar bet on a winning horse is a *decreasing* function of the total bets placed on that horse.

- **price:** in a prediction market price of a contract is determined such that demand is equal to supply.

  in a betting market the price of a ticket is fixed and the supply is not limited. The final payoff is determined by the demand.

- **riskless portfolio:** in a prediction market it's possible to guarantee the sure profit. If trader holds one unit of each contract on the market he gets 1 currency unit for sure. If there is no arbitrage, sum of prices of all contracts is equal to 1, therefore trader's net profit is equal to 0.

  in a betting market there exists no riskless portfolio.

- **trading:** in a prediction market continuous trading is possible.

  in a betting market there is no possibility to resell the ticket once it is bought.

Although it is already well established that prediction and betting markets can be used to aggregate disseminated pieces of information and can generate accurate predictions of a variety of uncertain future events such as elections, project completion or sports events, it is not well understood why these markets perform so well. Notwithstanding a growing body of prediction and betting markets literature, theoretical questions concerning how traders learn information from the market price (odds) and how markets aggregate dispersed pieces of information remain unresolved. Plott et al. (2003) state that there is no clear theoretical reason why parimutuel systems should aggregate information at all. However, the implicit prices on their experimental markets are very close to the prices that would exist if all agents pooled their information and made decisions on the basis of the pooled data. This observation suggests that the information in their markets *does* aggregate. Relatedly, Roust and Plott (2006) raise the important question whether the odds that emerge from a betting process have the characteristics of the probability distribution over the possible states that results from the pooling of information held by all individuals. Plott et al. (2003) suggest, that the answer is positive except for the fact that the odds frequently overstate the probability of rare events and underestimate the probability of favorites.

The primary purpose of this paper, then, is to review relevant theoretical and experimental literature concerning examination of the process of information aggregation on prediction and betting markets. The secondary purpose is to identify open questions concerning prediction and betting markets which ought to be answered before the markets can be extensively used as a prediction and decision making tool.

2 Literature Review - Prediction Markets

2.1 Theoretical Literature

In Kyle's 1985 classic model of an information (i.e. prediction) market there are three kinds of traders of one risky asset: a single risk-neutral insider, random noise traders, and competitive risk-neutral market maker who observes quantities to be traded and sets the price such that the market clears. The insider reaps positive profits by exploiting his monopoly power in the market while noise traders make it difficult for the market maker to extract information about the insider's trading.

Kyle's simple and sufficiently realistic model provides a solid base for further theoretical research on the prediction market and possibly also on process of aggregating information in the market. Wolfers and Zitzewitz (2006), for instance, include transaction costs into Kyle's model and therefore provide a useful generalization of the basic model. An additional extension could aim at determining an optimal role of a market maker. A market maker in Kyle's model sets a price to clear the market and earns zero profit but this concept of a competitive market maker can lead to market inefficiencies. If the profit of insiders is not high enough (the spread between ask and bid price is too small, or there are not enough noise traders) they do not have an incentive to trade and therefore not all the information is reflected in the market price. In such a case a "sharp" market maker could set the price off its competitive level in order to extract all the information, even at the cost of his own loss.

The predictive power of the prediction markets comes from the fact that the price in a properly designed market reflects the aggregation of all the information traders have about some future event. A duly normalized current market price of a contract is naturally interpreted as the market probability of corresponding event. Manski

(2004), being aware of the empirical success of prediction markets, points out that nevertheless there is no formal theoretical analysis of aggregation of information in prediction markets supporting such an interpretation. He strengthens his critique by citing a special case of a market in which risk-neutral traders are willing to risk the same amount of money in the market and they invest all their money whenever the current market price differs from their subjective expectation of the true probability of the event. Under these specific assumptions, the market price does not correspond to the market probability. Ottaviani and Sorensen (2006a) claim that the arithmetic average of beliefs, used in Manski as the equivalent of the market probability, is not necessarily the most appropriate benchmark since it fails to give greater weight to more extreme beliefs. Although Manski's critique itself is based on the questionable assumption that traders invest all their money in the market, he calls attention to the limitations of interpretation of the prices in some cases, and his article inspired economists to pay more attention to the theoretical justification for treating market prices as probabilities.

Manski's further critique of prediction markets is based on the fact that while in a survey (which is a standard counterpart of a prediction market) expectations of randomly selected individuals are revealed, a prediction market aggregates only the expectations of persons who self-selected themselves to trade in the market. The resulting bias should be controlled for, especially in small-scale corporate level markets, because the market price reflects only a central tendency of beliefs rather than an objective mean expectation. At the same time, self-selection affects the process of aggregation of information and therefore should be kept in the decision maker's mind.

Wolfers and Zitzewitz (2005) claim that the problem presented by Manski (2004) follows from the extreme assumptions that traders are risk-neutral and invest their entire wealth in the market which leads to extreme results. The authors show that for log utility of traders the market price corresponds exactly to the mean expectation of traders on the market. Moreover, they generalize this result to other utilities and show that even if the market price does not coincide with the mean expectation anymore, it is close enough and provides a useful estimate for practical purposes. In their model, Wolfers and Zitzewitz eliminate Manski's implausible assumption by endogenizing the decision about the amount of money to be invested, and their results indicate that the market price indeed corresponds to the market probability.

Ottaviani and Sorensen (2006a) model trade and price formation in a prediction market with risk-averse individuals having heterogenous prior beliefs, heterogenous private information, and heterogenous attitudes toward risk. The authors posit that the market is in a fully-revealing rational expectations equilibrium, i.e. traders make correct inferences from the prices, given common knowledge of the information structure and the prior beliefs. In other words, the authors assume that prior beliefs, signal distribution and rationality of all traders are common knowledge therefore they in fact assume that information does aggregate and do not model it explicitly.

In Hahn and Tetlock (2006), the authors summarize up-to-date knowledge of prediction markets and provide a comprehensive analysis of their potential to improve both public policy and private decision-making. The chapters of the book address necessary conditions for markets to work well and lay out the areas for further research.

Leynard (in Hahn and Tetlock, 2006, pp 37-66) identifies the limits of policy prediction markets and presents some design issues which can improve their functioning. He tries to identify the optimal predition market design, however, he notes that several theoretical assumptions (e.g. price taking) needed for prediction markets to work well may not be accomplished in real markets. Leynard proposes a marketscoring rule which performs better than standard markets. His main interest lies in policy markets in what case he points out the tradeoff between the number of markets and value of information.

Sunstein (in Hahn and Tetlock, 2006, pp 67-100) deals with possible ways to aggregate information in small groups; deliberation and prediction markets being the most promising ones. He emphasizes the advantages of prediction markets over deliberation in which people tend not to reveal what they really know. The author states that there are several sources of potential deliberative failures such as informational influence, social pressure, or informational and reputational cascades. Sunstein notices the potential of prediction markets to provide the right incentives to disclose the information and to correct rather than amplify individual judgment errors. To keep his analysis balanced Sunstein looks at potential failures of prediction markets as well and as the most important ones he identifies manipulation, bias or bubbles.

Abramowicz (in Hahn and Tetlock, 2006, pp 101-125) points out that prediction markets are not primarily designed to stimulate information revelation and suggests that better incentive system could lead to more efficient market generating more accurate predictions. He claims that the structure of markets needs to be changed in order to deliver reasonable predictions in small group settings. Further Abramowicz notes that new market structure should give traders incentive to sway other participants and his noteworthy proposed solution is to base rewards on the later value of predictions. In other words the author tries to bring the deliberation process into the prediction markets especially to those of little public interest and calls for experimental testing of these theoretical findings.

Hanson (in Hahn and Tetlock, 2006, pp 126-141) devotes his chapter to discussion of various forms of foul play (manipulation, sabotage) as potential failures of prediction markets and suggests new approaches to deal with them. Manipulation on public policy prediction markets occurs if losses from foul trades made to change prices and ultimately policy are outweighed by gains from the desired policy. Hanson claims that bringing estimating parameters closer to the decision parameters of interest can mitigate this problem. Further the author states that sabotage is unlikely to occur on prediction markets as they are usually thin and tied to large economic aggregates thus difficult to be influenced by individuals. Sabotage can be more of an issue in case of small scale corporate level markets were the individuals can substantially influence the estimated parameter. Here Hanson suggests that the amount of stakes and hence maximum achievable profit should be limited what would prevent employees to sabotage the project. This is undoubtedly a correct point, however, this rule can harm the accuracy of predictions as insiders can not drive the wrong price to its true value because of these limits.

Berg and Rietz (in Hahn and Tetlock, 2006, pp 142-169) argue that prediction markets can provide alternative or complementary method to traditional forecasting techniques and they summarize the performance of the Iowa Electronic Markets. According to further identified stylized facts about prediction markets, traders are biased and are not a random sample of the population and prices respond to news quickly and can be moved by large trades. Finally, Berg and Rietz present open issues that need to be addressed in the future research including a theoretical model of the prediction markets consistent with observed trader behavior and the development of methods to detect and limit price manipulation.

Hahn and Tetlock (2006) in their concluding chapter present an interesting idea to combine information markets with pay-for-performance system. This "performance-based policy" presents the attempt to design a new approach to economic development. The authors note potential difficulties of this market design. For example, if some policy is not very likely to be implemented traders will not trade contracts whose payoff is conditional on this policy and therefore information about potential effect of this policy will never be revealed. If this little trading activity problem can be overcome, performance-based policies can lead to more transparent and efficient support of economic development coming from foundations and nongovernmental organizations.

2.2 Experimental Literature

Chen and Plott (2002) report on the results of an experimental prediction market inside the Using a known mechanism of information aggregation in a real business environment, Chen and Plott provide a promising methodology for the implementation of prediction markets on a corporate level. The HP prediction market was run for the purpose of making sales forecasts. The authors provide evidence that prediction markets' predictions are more accurate than other prediction methods used within HP. Moreover, prediction markets provide the whole distribution of probabilities of all possible outcomes, not only point predictions provided by traditional HP methods.

Berlemann and Nelson (2005) show that there is a wide range of possibilities to implement prediction markets as a forecasting tool. Their experimental inflation forecasting market consistently outperformed a variety of inflation indicators and forecasts. Berleman and Nelson argue, however, that extensive use of prediction markets is unlikely in the near future and therefore they propose running small-scale markets.

Motivated by the success of the pilot experiments reported in Berlemann and Nelson (2005), Berlemann, Dimitrova, and Nenovsky (2005) designed and implemented a similar market for Bulgaria. That particular prediction market - apparently the first ever for a transition economy - was meant to forecast inflation expectations and exchange rate movements. Unfortunately, "the forecasting success of the Bulgarian markets was not overwhelming" (Berlemann, Dimitrova, and Nenovsky, 2005, p.17). Specifically, the inflation markets failed to deliver consistently accurate predictions; the exchange rate markets did somewhat better. The failure of these prediction markets is, however, the rare exception. All the evidence strongly supports the fundamental viability of prediction markets for inflation expectations and exchange rate movements. The results of the Bulgarian pilot experiments suggest some important design and implementation issues (an insufficient number of traders, problematic selection of traders and insufficient incentive system, problematic market setup, the sorry state of data availability in Bulgaria, etc.), all of which warrant careful (re)examination.

3 Literature Review - Betting Markets

3.1 Theoretical Literature

Ottaviani and Sorensen (2006b) formulate a simple theoretical model of parimutuel betting that provides an information explanation for the occurrence of the favorite-longshot bias and its reverse.[5] In their model, the authors let bettors decide simultaneously whether and on which of several outcomes to bet a fixed and indivisible amount. The authors point out the relationship between the amount of information present and favorite-longshot bias. If signals contain little information

[5]Reverse favorite-longshot bias occurs when the distribution of probabilities derived from the market prices is more extreme than the distribution of beliefs, i.e. the market assigns higher than the objective probability to favorite.

or if there is aggregate uncertainty about the final distribution of bets due to noise, reverse favorite-longshot bias results. If population of informed traders is large and private information sufficiently precise, favorite-longshot bias occurs.

Ottaviani and Sorensen (2006c) focus on explaining three empirical regularities: a sizeable fraction of bets is placed early, late bets are more informative than early bets, and proportionally too many bets are placed on longshots. Generally, traders who have inside information prefer to bet late not to reveal their private signal. The authors show, that when insiders are large and share the same information among them, they have an incentive to bet early to prevent competitors from unfavorably changing the odds. The main contribution of this paper is that the authors point out the similarities between parimutuel betting system and Cournot model of competition what allows for a new analysis of information aggregation process.

3.2 Experimental Literature

Plott et al. (2003) present several theoretical measures of information aggregation on parimutuel markets. Further, they experimentally test the ability of parimutuel markets to work as an information aggregation device. The authors run a series of experiments and claim that in their experimental parimutuel betting markets information aggregation occurs; since the market prices implicitly determined from the market odds (implicit prices - IP) are reasonably close to the aggregated information available (the distribution derived from the pooling of all observations). In fact, IP are closer to the aggregated information available (AIA) than the prediction of several models mentioned in their work (Decision Theory Private Information - DTPI, Competitive Equilibrium Private Information - CEPI) and the statistics called Average Opinion (the average of individual beliefs before the market opens); only the Best Opinion statistics performs better than implicit market prices (i.e. there exist bettor(s) who have more accurate beliefs before betting than does the market after the period is over).

This result constitutes an interesting paradox: Information aggregation does occur and traders are involved in strategic behavior, but at the same time the Decision Theory Private Information model - which assumes no aggregation whatsoever and also no strategic behavior - fits the implicit market prices data the best. Such a paradox could be explained by the prior private information distribution of traders, but to do so a detailed inspection of the experimental data is necessary. An alternative explanation of this paradox could be based on inaccurate predictions of all models and implicit prices. Consider six possible states of nature and a market with six corresponding assets with the following predictions of their probabilities:

AIA: $\{0.5, 0.1, 0.1, 0.1, 0.1, 0.1\}$

IP: $\{0.1, 0.18, 0.18, 0.18, 0.18, 0.18\}$

DTPI: $\{0.05, 0.25, 0.1, 0.1, 0.25, 0.25\}$

CEPI: $\{0.01, 0.35, 0.05, 0.05, 0.35, 0.19\}$

Following Plott et al. (2003), the Würtz criterion[6] implies the following results:

	IP	DTPI	CEPI
W	0.4	0.45	0.59

where W is the Würtz measure of the distance of the probability distribution from the AIA distribution. Hence, in this example, implicit prices are closer to the

[6]If the discrete distributions are described by their probability density functions p_i and q_i then the measure proposed by Würtz (as cited in Plott et al., 2003) can be writen as $W(p,q) = 0.5 \sum |p_i - q_i|$.

AIA than the prediction of two remaining models and we can conclude that the information does aggregate and traders are involved in a strategic behavior.

Similarly,

	DTPI	CEPI	AIA
W	0.21	0.35	0.4

where W is the Würtz measure of distance of model predictions from implicit prices. From this table it follows that Decision theory private information model describes the traders' behavior the best.

This example illustrates a paradox. Since all predictions are inaccurate (both models and implicit prices fail to even identify the winning state) it can happen that from all distant predictions the implicit prices are closest to the AIA. It is questionable, however, if this is the result of traders' strategic behavior.

Thus, while Plott et al. (2003) present an interesting paradox, the support for their results is not very convincing. While trying to show that the DTPI model fits the data the best, the authors compare implicit prices to only three private information models and AIA. With at most 15 traders the size of the market is probably not sufficient to result in AIA prices hence it is not surprising that AIA is not close to IP. And since all three remaining models are based on private information the result is not startling at all.

Roust and Plott (2005) focus their attention on fighting well documented problems with information aggregation in parimutuel betting markets (late betting, bubbles). Their experiments show that a special "two-stage" parimutuel mechanism has the potential to speed up the process through which information is revealed and to reduce deceptive behavior[7] and incorrect aggregation (informational cascades). In the first stage, similar to a simple lottery for a fixed prize, participants are endowed with a certain amount of money which they can bet on their preferred outcome. This money has no alternative use and therefore traders have incentive to spend all of their budget and thus reveal all information they possess. Furthermore, only the aggregated amount of money bet on each outcome is observed at the end of the first period, not the individual bets, hence participants have no incentive for any kind of deceptive behavior. The second stage is a parimutuel betting system with increasing price of tickets to prevent waiting strategies. This two-stage parimutuel mechanism preserves the ability of betting market to aggregate information and reduces the number and intensity of bubbles. Moreover, after the first stage participants learn the strength of the signal. If the aggregated information is poor, participants are more likely to rely on their own information which prevents the formation of bubbles and lead to more reliable aggregation of information.

4 Open Questions and Future Research

In this section we pose ten open questions concerning prediction and betting markets which should be answered before these markets can be extensively used as prediction and decision making tool. These open questions include theoretical challenges as well as design issues.

[7]Strategic behavior based on investing against one's beliefs in order to mislead other traders and therefore affect market odds in a desirable direction.

1-5. Open Questions by Wolfers and Zitzewitz

Wolfers and Zitzewitz (2006) idenfity five open questions. The first one is that of attracting uniformed traders to motivate informed groups to participate (that could presumably be solved by paying to subsidize the market to induce participation). The second problem is how to write issues of interest into contracts. The third question concerns how to limit market manipulation, the forth one is calibration of low probability events and the last one is separating correlation from causation. The latter can be done, as the authors demonstrate, by using instrumental variable technique if an appropriate instrumental variable can be identified. All these relevant open questions clearly need to be answered to validate using prediction and betting markets as a prediction tool.

6. Process of Information Aggregation

As mentioned before, the review of resources illustrated that is not clear why prediction and betting markets aggregate information better than their alternatives. Further, Berg and Rietz (in Hahn and Tetlock, 2006, pp 142-169) present open issues that need to be addressed in the future research including a theoretical model of the prediction markets consistent with observed trader behavior.

Berlemann and Nelson (2005) also present an interesting open theoretical question concerning the way in which traders learn information from the market price. This question is a key problem in understanding the process of aggregating information on prediction markets, because the market price is not a simple average of all traders' prior expectations. As traders enter the market they learn the expectations of other participants at least to some extent and can update their subjective predictions. This problem can be of major importance especially in the case of small-scale prediction markets implemented within a firm where the actions of one trader have a relatively big impact on the market price. A full understanding of the process of aggregating information in the market is of great importance for the decision maker who can regulate the liquidity and the exchange of information in the market in order to enhance its effectiveness. In other words, aggregation of information in prediction markets is closely related to the optimal role of the market maker.

Ottaviani and Sorensen (2006) show that aggregation of information can not be easily separated from aggregation of beliefs.[8] The authors' results suggest that the process of information aggregation can be modelled assuming common prior beliefs and heterogenous private information about the probability of each outcome.

7. Role of the Market Maker

In all existing models of prediction markets a market maker observes quantities to be traded and sets the market price such that the market clears. However, in some markets this kind of competitive behavior might not be optimal. In small-scale markets (where insufficient liquidity is often of an issue), a "sharp" market maker who sets the market price off its equilibrium value may enhance liquidity resulting in better aggregation of information and hence more reliable predictions.

8. Prediction versus Betting Markets

This section is focused on the optimal design and implementation of prediction markets. Some design issues are already well documented in prediction markets literature. Problems with insufficient number of traders and their selection or

[8]Beliefs are assumed to be completely uninformative, i.e. not correlated with the actual outcome at all. Information, on the other hand is an informative signal, i.e. correlated with the outcome.

insufficient incentive system are shown to worsen the ability of prediction markets to generate reliable predictions (Berlemann, Dimitrova, and Nenovsky, 2005). However, somewhat surprisingly, no study concerning the appropriate choice of the market structure (prediction or parimutuel betting market) has been conducted yet.

Both prediction and betting markets seem to aggregate information and deliver reasonably accurate predictions in real as well as experimental markets.[9] When designing a market, apart from determining for instance the optimal number of traders or type of contracts, market organizer has to make a choice between prediction and parimutuel betting market as well. So far there does not exist any analysis which would specify what market concept is appropriate in various decision problems.

9. How to Make Traders Sway Others?

Abramowicz (in Hahn and Tetlock, 2006, pp 101-125) notes that market structure should give traders incentive to sway other participants and his noteworthy proposed solution is to base rewards on the later value of predictions. In other words the author tries to bring the deliberation process into the prediction markets especially to those of little public interest and calls for experimental testing of these theoretical findings.

10. Limiting Sources of Prediction Markets' Failures

Sunstein (in Hahn and Tetlock, 2006, pp 67-100) states that there are several sources of potential deliberative failures such as informational influence, social pressure, or informational and reputational cascades. As the most important sources he identifies

[9] See e.g. Plott (2003) for experimental parimutuel market results or Berg et al. (2003) for prediction markets accuracy.

manipulation, bias and bubbles. Similarly, as it was already mentioned, Hanson (in Hahn and Tetlock, 2006, pp 126-14) devotes his article to various forms of foul play (manipulation, sabotage) and Wolfers and Zitzewitz (2006) present limiting market manipulation as one of their five open questions.

5 Conclusion

In this paper we reviewed theoretical and experimental literature concerning prediction and betting markets. The analysis of literature leads to several open questions that need to be answered before prediction and betting markets can be extensively used as a prediction and decision making tool. The most relevant open problems seem to be the following: understanding the process of information aggregation; determining the optimal role of the market maker; preventing manipulation; and the appropriate choice of market structure. These questions require further theoretical analysis as well as experimental testing.

Appendix

List of real/potential prediction markets[10]

- Political events
  - next president, election outcomes (general, senate, governor), next party leader, new EU members, resignation (Iowa political prediction market is analyzed in Berg et al. 2003a, 2003b)
- Financial bets
  - house prices, interest rates, indices (Dow Jones, FTSE, DAX,...), currencies (exchange rates), macroeconomic indicators (inflation), commodities (gold, oil), tax futures, GDP, CPI, international trade balance (Two inflation prediction markets are reported in Berlemann & Nelson, 2005 and Berlemann et al., 2005)
- Social events
  - Osama bin Laden capture, US air strike against Iran, Hamas recognition of Israel, Bird flu, terrorist attacks
- Public policies
  - is it worthy to introduce new vaccination program? benefit-costs analysis of policies
- Sporting events (There exists a large body of empirical literature analyzing the data sets from sports betting markets)
- Movie and TV industry

[10]Main sources: www.betfair.com, www.tradesports.com, www.hedgestreet.com

  - movie sales, box office returns, next TV competition winner, Emmy and Grammy awards

- Corporate level indicators

  - sales forecasts, project time schedule, generating new ideas (E.g. Chen & Plott, 2002; Ortner, 1997, 1998)

- Weather forecast (hurricane), locating a lost submarine, what drugs will be successful

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Individual researchers, as well as the on-line and printed versions of the CERGE-EI Discussion Papers (including their dissemination) were supported from the following institutional grants:

- Economic Aspects of EU and EMU Entry [Ekonomické aspekty vstupu do Evropské unie a Evropské měnové unie], No. AVOZ70850503, (2005-2010);
- Economic Impact of European Integration on the Czech Republic [Ekonomické dopady evropské integrace na ČR], No. MSM0021620846, (2005-2011).

Specific research support and/or other grants the researchers/publications benefited from are acknowledged at the beginning of the Paper.