PREDICTION MARKETS: A NEW INVESTMENT TOOL

By Gregory Mark Ovenden

ABSTRACT

Prediction Markets are trading exchanges for event driven binary options i.e. options that pay out a fixed amount if a strike condition is met. The event in question might be anything from an equity index being above some level at some time, to a future CPI release being above a certain level, or a candidate winning a political election. Because the payoffs of the options in a Prediction Market are of known size and not unbounded as is the case with vanilla options, it is possible through a system of trust accounts and immediate margining of trades for the Prediction Market exchange to bear no risk at all. Research shows that Prediction Market-generated forecasts typically perform well. In the case of Prediction Market contracts which have as underlying a financial instrument it is possible to use a pricing formula for binary options derived from the Black-Scholes framework; however there are some problems and caveats in respect of the usage of these formulae. Apart from speculative bets, Prediction Markets may be used for hedging and arbitrage. Interesting inferences can be made from families of contracts on the same underlying but with differing strikes or expiries. A South African Prediction Market under the auspices of the Bond Exchange of South Africa has been launched offering contracts based on equity, bond and commodity prices, econometric data and MPC interest rate decisions. It is intended that the data from this market will be freely available to any interested party.

KEYWORDS

Prediction markets; forecasting; binary option; trading exchange; finance; financial arbitrage; financial hedging

CONTACT DETAILS

GM Ovenden, Ovenden Investments (Pty) Ltd, PO Box 2609 Houghton 2041. Tel: 011 484 8124. Cell: 083 256 0832 Fax: 086 615 0612. Email: ovenden@mweb.co.za.

1. INTRODUCTION

Prediction Markets are trading exchanges for event driven binary options. A Prediction Market contract is a ‘bet’ that some clearly defined event or situation will occur at some specified date in the future. Such contracts pay out a fixed amount if the strike condition is met at expiry (for the purposes of this paper we will always assume that this payout is R100) and nothing if the strike condition is not met at expiry. All currently traded Prediction Market contracts are European in style. The event in question might be anything from an equity index being above some level at some time, to a future CPI

release being above a certain level, or a candidate winning a political election. There is evidence that prediction Markets are surprisingly accurate in their predictions. Apart from speculative bets, Prediction Markets may be used for hedging and arbitrage. We will be particularly concerned in this paper with financial contracts which can be used in asset management or to hedge risk. It is possible to infer various underlying implications from the prices of a series of Prediction Market contracts with the same underlying.

2. HISTORY AND PREVALANCE

The Iowa Electronic Market[1] (IEM), run by the University of Iowa since 1988, is one of the oldest prediction markets. The IEM focused initially on US presidential election outcomes, but now includes contracts on other political and economic events. The University of Iowa's electronic market has correctly called every presidential race since its inception in 1988 and come within one point of guessing the total percentage of votes received by the winner on every occasion. Since 1993 the IEM has offered contracts based on economic indicators and earnings and returns of equities.

The Chicago Board of Trade (CBOT) offers well-traded binary options on the Fed Funds rate as set at meetings of the Federal Open Markets Committee.

InTrade[2] based in Ireland trades political, weather, financial, commodity and forex contracts. InTrade has been operational since 2001, has a total of 82 000 registered participants and had processed nearly 400 million trades.

To date, contracts on sporting events represent most of the volume in prediction markets. Hedge Street Prediction Market has contracts on currencies and commodities. The Ideosphere Prediction Market has contracts focusing on scientific and technological advances.

Recently some large firms have begun experimenting with internal prediction markets within their organizations. The function of these markets is to generate predictions which efficiently aggregate many employees' views to produce forecasts of sales and other significant business variables. Google, Yahoo, Microsoft, Hewlett Packard and Siemens are among those who have successfully conducted such experiments (Arrow, KJ *et al* 2008).

Many online prediction markets have been established by Internet entrepreneurs. Some are cash-based, while others operate in virtual or play money. To date, contracts on sporting events represent most of the volume in prediction markets. A huge industry has grown up around Prediction Markets: there is a Journal of Prediction Markets[3], a Prediction Markets Industry Association (PMIA)[4], software to run a Prediction Market is

[1] http://www.biz.uiowa.edu/iem/
[2] http://www.intrade.com/
[3] http://www.predictionmarketjournal.com/
[4] http://www.pmindustry.org/

available and there are several Blogs relating to Prediction Markets, perhaps the best known of which is the MIDAS Oracle[5]

Prediction Markets have aroused academic interest and a large body of research now exists dealing with various aspects of prediction markets.[6]

3. MECHANICS OF A PREDICTION MARKET EXCHANGE

Prediction Markets are today almost always implemented as automated Internet applications. Because the payoffs of the options in a Prediction Market are of predetermined and fixed size, and not unbounded as is the case with vanilla options, it is possible through a system of client trust accounts and immediate full margining of trades for the Prediction Market exchange to bear no risk at all (other than the collapse of the institution holding the trust funds). In this model an individual who wishes to be active in the Prediction Markets will place an amount of cash in a trust account then once this deposit is cleared he or she may enter into contracts. The mechanism that matches buyers to sellers is a continuous double auction, with buyers submitting bids and sellers submitting asking prices, and with the system executing a trade whenever the two sides of the market reach a mutually agreeable price.

Let us consider a simple example to make this clearer:

> Robert wishes to trade on the Have_a_Punt Internet Prediction Market Exchange. He registers with the Exchange, provides FICA documentation and deposits R500 in his trust account. He is convinced that Gold will be trading below $750 at the close on 31 December 2008. The current offer in this contract is R57. He purchases two contracts. If Gold does finish below or at $750 at close on 31 December 2008 each contract will pay out R100 he will gain a profit of R200 – 2 x R57 = R86 plus some interest on his funds. The most he can lose is 2 x R57 = R114 if Gold finishes above $750 at close on 31 December 2008 and the contract then pays out nothing. The exchange will therefore earmark R114 as full margin for his trades and he will now only have R500 – R114 = R386, less any transcation fee, left to trade with. Notice how important it is here that it should be clear what happens if Gold finishes at $750 on 31 December 2008. Generally the originators of Prediction Market contracts nust specify the payoff critearia very precisely and unambiguously and those proposing to take positions in such contracts must make certain they understand exactly the terms of the contract.

---

[5] http://www.midasoracle.org/

[6] Tziralis, G and Tatsiopoulos, I. Prediction Markets: An Extended Literature Review. Sector of Industrial Management and Operational Research School of Mechanical Engineering National Technical University of Athens.
(http://gtziralis.googlepages.com/PredictionMarkets_AnExtendedLiteratureReview_TziralisTatsiopoulos.pdf

The Prediction Market makes money for the entrepreneur in two ways. Firstly a small transaction fee is charged to the aggressor (i.e. whoever initiates the trade) in any trade. Secondly a client's trust fund deposit earns interest and it is common for the Prediction Market to impose a haircut of a percent or so on the interest earnings to cover costs. Notice that the fact that the client earns slightly less than a money market rate on his trust account has the effect of making the acheivement of some hurdle rate of return more feasible than would be the case if no interest was earned on trust funds or margin.

The usual problems of insider trading and manipulation also exist for Prediction Markets. In the case where the underlying is a share or a commodity measures exist in the underlying markets to counter such malfeasance. One assumes that Macroeconomic data releases are immune to 'leaks'. However in the case of pure event driven contracts such as 'Jacob Zuma will be the next president of SA' use of insider knowledge such as that held by, for example, a person typing Judge Nicholson's recent judgement is harder to prevent and detect.

4. ACCURACY OF PREDICTION MARKETS FORECASTS – HOW EFFICIENT ARE PREDICTION MARKETS?

Research shows that Prediction Market-generated forecasts typically perform well (Berg, Nelson & Rietz 2008). Numerous recent empirical studies that examine whether the likelihood of a binary prediction market contract paying off is equal to its price, i.e. whether the price can be interpreted as a probability, have in general concluded that this is the case - furthermore prediction market prices are usually close to the mean beliefs of the participating traders[7]. (Williams 2005)

In a recent review article, Wolfers and Zitzewitz (2004) wrote (p. 108): "In a truly efficient prediction market, the market price will be the best predictor of the event, and no combination of available polls or other information can be used to improve on the market-generated forecast." The expression "efficient prediction market" refers to the strong form of the efficient markets hypothesis (EMH), which posits that price is a sufficient statistic for all private information held by traders. However, the EMH is only a hypothesis that may hold in some settings; it is not a universal truth. In particular Prediction Markets can have too little liquidity and/or too few participants to aggregate a sufficiently wide spectrum of views and hence reach equilibrium in reasonable time.

It is a point not often noted that not only can one not beat a strongly efficient market and make a consistent profit but one cannot also make a consistent loss since all contracts are always correctly priced. The presence of clear winners and losers makes it unlikely that Prediction Markets are strongly efficient

Arrow *et al* state that "Prediction markets have already been used in a variety of contexts with remarkable success. For example, prices of economic derivatives predict economic variables better than professional economists; prices in Iowa political markets are

[7] J Wolfers, E Zitzewitz (2006) Interpreting Prediction Market Prices as Probabilities. bpp.wharton.upenn.edu

typically more accurate than the polls in forecasting elections; and prediction markets at Hewlett-Packard Labs beat official forecasts of printer sales most of the time." [8] The paper from which the quote is taken was an appeal by a large group of respected economists for the US Regulatory authorities to facilitate the growth of the Prediction Market Industry as they believed that it would improve the efficiency of the economy as a whole. The group asserts that "U.S. regulators should lower barriers to the creation and design of prediction markets by creating a safe harbor . . . .. We believe our proposed change has the potential to stimulate innovation in the design and use of prediction markets throughout the economy, and in the process to provide information that will benefit the private sector and government alike".

According to Surowiecki (2005), aggregate predictions of Prediction Markets have been shown to be more reliable than the output of conventional forecasting methods. Surowiecki's book contains many case studies supporting the idea that Prediction Markets can be extraordinarly accurate and efficient. Surowiecki relates the story of how Francis Dalton observed that the crowd at a cattle show very accurately guessed the weight of an ox when the mean of all their estimates was taken.

The significance of prediction markets as forecasting tools is that they are "market-based" as opposed to "expert- or survey-based." They can also serve as a powerful mechanism for price discovery for variables which have no explicit "market" - such as weather phenomena.

There is every reason to believe that Prediction Markets may also be subject to speculative bubbles and market manipulation just as conventional financial markets are.

5. TREATMENT OF CONTRACTS WITH FINANCIAL UNDERLYINGS AS BINARY OPTIONS

In the case of Prediction Market contracts which have as underlying a financial instrument it is possible to use the pricing formulae for binary options derived from the Black-Scholes framework. See, for example, (Hull 2005). The difference between a binary and a standard ('vanilla') option is in the payout profile. A binary option pays out a fixed amount, while a standard vanilla option pays out a potentially unlimited amount. Both options can expire worthless or "out of the money." If the underlying instrument ends "in the money", a binary call will pay a fixed amount, say R100, while a vanilla call will pay anywhere from R0 to infinity depending on how far above the strike price the underlying instrument trades at expiration.

[8] Arrow, Kenneth J., Sunder, Shyam, Forsythe, Robert, Litan, Robert E., Zitzewitz, Eric, Gorham, Michael, Hahn, Robert W., Hanson, Robin, Kahneman, Daniel, Ledyard, John O., Levmore, Saul, Milgrom, Paul R., Nelson, Forrest D., Neumann , George R., Ottaviani, Marco, Plott, Charles R., Schelling, Thomas C., Shiller, Robert J., Smith, Vernon L., Snowberg, Erik C., Sunstein, Cass R., Tetlock, Paul C., Tetlock, Philip E., Varian, Hal R. & Wolfers, Justin, Statement on Prediction Markets(May 2007). AEI-Brookings Joint Center Related Publication No. 07-11 Available at SSRN: http://ssrn.com/abstract=984584

In the Black-Scholes model, the price of the option can be found by the formulas below. Here *S* is the initial stock price, *K* denotes the strike price, *T* is the time to maturity, *q* is the dividend yield, *r* is the risk-free interest rate and σ is the volatility. Φ denotes the cumulative distribution function of the normal distribution,

$$\Phi(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{x} e^{-\frac{1}{2}z^2} dz.$$

and,

$$d_1 = \frac{\ln \frac{S}{K} + (r - q + \sigma^2/2)T}{\sigma\sqrt{T}}, \; d_2 = d_1 - \sigma\sqrt{T}.$$

Binary Call

This contract pays one unit of cash if the underlying of the contract is above the strike level at expiry:

$$C = e^{-rT}\Phi(d_2).$$

Binary Put

This contract pays one unit of cash if the underlying of the contract is below the strike level at expiry:

$$P = e^{-rT}\Phi(-d_2).$$

In the standard Black-Scholes model, one can interpret the premium of the binary option in the risk-neutral world as the expected value, i.e. the probability of being in-the-money discounted to the present value.

Unfortunately, the standard Black-Scholes assumption of log-normal returns and constant volatility significantly misvalues binary options. To take volatility skew into account, a more sophisticated analysis based on call spreads can be used (see e.g. Taleb 1997) – this adjustment tends to make calls more expensive.

However there are some problems and caveats in respect of the usage of these formulae. It is clearly necessary in the case of contracts based on single stocks to treat the dividend as a single discrete event rather than to use a dividend yield model. One would expect a stock trading at price S which pays a dividend of D to then trade at S – D, however in

South African Markets experience indicates that the new price will be S – kD where k is a little less than 1. It may be better to use a formula analogous to the Black formula for options on futures and to input a future price which has built into it the effects of the risk free rate and any dividend payouts in the time to expiry. To obtain such a formula one simply sets *r* and *q* equal to zero and replaces the current price *S* with the future price *F* at the expiry date.

In the case of foreign exchange based contracts it is a simple matter to regard the dividend yield as the interest rate applying to the foreign currency.

Similarly storage costs and convenience yields for commodities can be combined and treated as a dividend yield.

6. HEDGING USING PREDICTION MARKET CONTRACTS

Prediction markets can in theory be used in avariety of ways to hedge existing assets or positions in the financial, currency and commodity markets. For example, suppose an investor who has an exposure to the YEN through investments in Japanese equities feels that the ZAR (South African Rand) will gain ground against the YEN. She wants to hedge her risk and try to protect her Japanese investment from dropping in value in ZAR terms. She may do this by buying binary call contracts on a prediction market, which have as their expiry event "ZAR/YEN rate will be above 13.50" by 4:00 PM ET in three days time. If her analysis is correct and the ZAR gains ground over the YEN, rising above 13.50, the binary contracts will expire in-the-money, yielding a total payout of which can offset the losses her investments incur in ZAR terms as a result of the YEN's weakness. However, if the ZAR/YEN rate did not end above 13.50, the binary contracts will expire out-of-the-money. In this case, the trader would lose her initial investment on the binaries, but would be compensated by the retention in value of her Japanese investments. So the purchase cost of the binary calls would be a kind of insurance premium.

A General Insurer which keeps a high portion of its funds in liquid short-term instruments whose return is linked to the Reserve Bank repo rate and whose claims and running costs are both somewhat sensitive to inflation and hence, given the current inflation-targeting central bank policies prevalent worldwide, by proxy, sensitive to rises in the Reserve Bank repo rate, could neutralise some of this risk by by purchasing contracts predicting that the Reserve Bank repo rate will rise at the next MPC meeting.

There is no particular reason why Prediction Market contracts cannot be based on credit events or longevity measures or property indices and, indeed, it can only be a matter of time before such Predictin Market derivatives evolve since there is an obvious market for them (see, for instance Blake *et al* 2006).

Prediction market contracts have been proposed and, indeed, in some cases traded, for political events such as terrorist attacks and natural phenomena such as extreme weather

events or earthquakes. Such contracts could provide useful estimates and even hedging possibilities for general insurers.

7. ARBITRAGE ARISING FROM PREDICTION MARKET CONTRACTS

Suppose a Prediction Market has a contract for an event which has a yes/no outcome which will be determined later. Further suppose that the current trading price for Yes is R45 and for No is R40. In this case we can achieve arbitrage by buying a share of both (costing R85). When the outcome is decided, we will get R100 (regardless of the outcome) and thus have made a profit of R15.

Similarly, suppose the current trading price for Yes is R60 and for No is R50. In this case, we can achieve arbitrage by shorting both shares (which gives R110). After the outcome is decided, we will receive a payout of R100 for a net R10 profit[9].

The above are very simple and obvious arbitrage opportunities. All these arbitrage opportunities require that the Prediction Market should have reasonable liquidity and, hence, tight spreads in the relevant contract. There are obviously also many more complex arbitrage opportunities arising, for instance, from the combined universe of a stock, single stock options on that stock, listed warrants on that stock and Prediction Market contracts with that stock as underlying.

8. INFORMATION EMBEDDED IN A SERIES OF PREDICTION MARKET CONTRACTS

Interesting inferences can be made from families of contracts on the same underlying but with differing strikes or expiries. From a series of contracts with the same expiry date but differing strikes one should be able to infer a volatility smile or skew by numerically solving for the implied volatility in the binary option formulas given a price at which they are trading. (Rubenstein 1995). Soft Arbitrage opportunities could thus be uncovered between Prediction Market Options and vanilla options traded on other exchanges.

The price of Prediction Market contracts can be regarded as probabilities. For instance a price of R40 on a contract with a R100 payoff implies that the aggregate market estimation of the probability of the event occurring is 0.4. Were a Prediction Market to offer a series of contracts of differing expiries based on the occurrence of default or bankruptcy events for a specific equity one would be able to infer a time structure of credit spreads from the market prices obtaining for the series of Prediction Market contracts.

9. BEHAVIORAL ASPECTS OF PREDICTION MARKET TRADING

Behavioural aspects of markets are also examined in the literature. Trader behavioural types are assessed and categorized. There is substantial evidence from psychology and

[9] This and the preceding arbitrage could also take place across two different Prediction Markets offering similar contracts.

economics suggesting that people tend to overvalue small probabilities and undervalue near certainties. For example, there is a well-known "favorite–long shot bias" in horse races which also appears to be prevalent in Prediction Markets (Vaughan Williams 2005). The "favorite–long shot bias" implies if one invokes the binary option pricing formulae a "volatility smile". The "volatility smile" in options refers to a related pattern in financial markets (Rubenstein, 1994), which involves overpricing of strongly out-of-the-money options and underpricing of strongly in-the-money options (relative to their future values or their ex-ante values from the Black-Scholes option pricing formula).

10. A SOUTH AFRICAN PREDICTION MARKET

A South African Prediction Market under the auspices of the Bond Exchange of South Africa has recently been launched trading under the name 'Justrade'[10] and offering contracts based on equity, bond and commodity prices, econometric data (e.g. CPIX) and MPC interest rate decisions. At this stage the Financial Services Board has declined permission for 'political' contracts (e.g. 'Jacob Zuma becomes the next SA President') although indications are that they may not be opposed to the introduction of such contracts once the exchange is firmly established).[11] It is intended that detailed data from this market will be freely available to any interested party.

[10] www.justrade.com

[11] The alternative route of establishing a market under gambling legislation, as opposed to an exchange-based FSB regulated approach, failed in 2001 because, among other things, it is a little known fact that gambling losses are legally unenforceable.

ACKNOWLEDGEMENTS

The author would like to than Rory Mackay of Prediction Markets (Pty) Ltd for many useful discussions and the provision of a comprehensive bibliography.

REFERENCES

Wolfers J & Zitzewitz E, (2004). Prediction Markets. Journal of Economic Perspectives, vol. 18 (2), pp 107-26.

Arrow, KJ, Forsythe R, Gorham M, Hahn R, Hanson R, Ledyard JO, Levmore S, Litan R, Milgrom P, Nelson FD, Neumann GR, Ottaviani M, Schelling TC, Shiller RJ,. Smith VL, Snowberg E, Sunstein CR, Tetlock PE, Varian HR, Wolfers J & Zitzewitz E. (May 2008). The Promise of Prediction Markets. Science 16: Vol. 320. no. 5878, pp. 877 – 878

Suroweicki, J. (2005). The Wisdom of Crowds. Anchor Books. NewYork

Berg JE, Nelson FD. & Rietz TA. (April-June 2008). Prediction Market Accuracy in the Long Run. International Journal of Forecasting Volume 24, Issue 2, Pages 283-298

Williams LV (Ed), (2005). Information efficiency in financial and betting markets. Published by Cambridge University Press, ISBN 0521816033, 9780521816038

Hull, JC. (2005). Options, Futures and Other Derivatives. Prentice Hall ISBN 0131499084

Taleb, NN (1997). Dynamic Hedging: Managing Vanilla and Exotic Options. Wiley Finance. ISBN 0471152803.

Blake, D., A.J.G. Cairns and K. Dowd. 2006. “Living with mortality: longevity bonds and other mortality-linked securities.” Presented to the Institute of Actuaries in London, Feb 27, 2006 (http://www.actuaries.org.uk/files/pdf/sessional/fac_sm20060116.pdf.)

Rubenstein, M. (1994). “Implied Binomial Trees.” Journal of Finance. 49:3, pp. 771–818.