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PREDICTION MARKETS AS A TOOL FOR MANAGEMENT OF POLITICAL RISK

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Recently, several prediction markets for various events have been launched. The literature so far has focused on the predictive power of such markets. This paper considers such markets as tools for management of political risk. It outlines a model for use and pricing of such assets, and discusses the various benefits of a well-functioning, liquid prediction market for political decisions.

1 INTRODUCTION

Before the US presidential election in 1988, researchers at the University of Iowa designed and implemented the Iowa Presidential Stock Market (Forsythe *et al.*, 1992).[1] This market allowed agents to buy and sell contracts where payoff would depend on who won the presidential election. Hence, the market price of the contracts would also imply market opinions of each candidate's probability of winning the election. The experiment was in part inspired by von Hayek, 1945, and his argument about how market prices aggregate information. And indeed, the market information proved very successful in forecasting the outcome of the election (Forsythe *et al.*, 1992). Later, many more such markets have been launched, both by universities for research purposes and by exchanges and betting agencies for commercial purposes. While www.economicderivatives.com offers trade in future economic data, in some ways quite similar to traditional financial futures markets, numerous other market places offer trade in contracts based on for instance elections, other political events, sports events and movie box office numbers. These new markets have become the study object of a new branch of research,[2] primarily focusing on the information aspect of the markets, i.e., how well the markets predict outcomes, and how these markets' prices (and implied probabilities) could be used for forecasting and decision support. The literature by and large supports the initial findings; that such markets do a good job at predicting outcomes of future events.[3] Hence, it is not surprising that many larger corporations have created internal prediction markets to improve decisions, typically with "contracts" related to development time for new software, sales forecast for next year, cost estimates for new projects etc.[4]

At the same time, we see a growing awareness of political, social or macroeconomic factors as important risk sources for firms and individuals. One of the most obvious (and well-researched) areas for such risk is social security and pension benefits (Schnabel, 1998; McHale, 2001; and Shoven and Slavov, 2006). Industry surveys (e.g. Harwood *et al.*, 1999; Sonkilla, 2002; and Flaten *et al.*, 2005 for agriculture and Bergfjord, 2006 for aquaculture) also confirm the importance of such political risk factors. Such risk affects most firms in various ways, has potentially large consequences and is, unlike many other risk sources, difficult to insure against or hedge in existing financial markets. A solution is proposed by Shiller, 2003; Shiller, 2004 and Athanasoulis *et al.*, 1999 where such risk sources are discussed, and it is argued that new market solutions could shift some of this risk towards those better able to handle it.

Some attention should be paid to the challenges facing prediction markets in general and their role in risk management in particular. Cherry and Rogers, 2005 point out that legal issues so far have obstructed the rise of prediction markets. Such markets are often considered "gambling", and hence outlawed in many countries. Furthermore, most existing markets are limited small-scale experiments. To be useful for risk management purposes, markets must be much larger and more liquid. Finally, larger and more liquid markets with more money at stake would introduce more profitable opportunities for insider trading, manipulation etc. From different angles, these challenges all emphasize the need for structural, institutional and legal changes for such markets to work in a risk-management setting.

Even though such institutional changes will be crucial for prediction markets' success in risk management, we will largely ignore these challenges later in this paper. Instead, we will study pricing of contracts traded in prediction markets, and also how the rise of such markets might benefit society as a whole through more efficient political decisions.

To our knowledge, the innovative paper by Musto and Yilmaz (MY; 2003) is one of very few contributions studying prediction markets from a risk management perspective, and this will be an important reference throughout this paper. In brief, they study a prediction market based on a presidential election with two candidates with different policies on redistribution, and get the following main results:

- The existence of a market changes each candidate's probability to win, the amount of redistribution (taxation) and the timing of redistribution.
- If aggregate wealth depends on who wins, all voters will have more wealth post-trading if the "high aggregate wealth" candidate wins.

The MY paper focuses on a political election, and the political consequences of such a market. This paper, on the other hand, is more concerned about the financial and social implications.

The rest of the paper is hence structured as follows: First, a simple model is outlined, where the pricing of prediction market contracts and risk shifting effects for individual agents are studied. This model is in many ways similar to the MY model, but with another case, to study some effects not treated by MY. Then the implications and effects of better risk distribution on political decision making are studied, before we conclude and propose further research.

2 MODEL

We assume a static asset pricing model with Arrow-Debreu contingent securities and discrete states.

Assume n agents, $A_1 \dots A_n$. A_n is risk neutral, the other agents have unknown utility functions $u_1 \dots u_{n-1}$. (I.e., at least one agent must be risk neutral).[5] This is not unreasonable. Any one state claim traded in a prediction market is likely to be small enough for at least one investor to pursue a risk neutral behaviour in its trading. However, this is an important deviation from the MY paper. In their model, the agents are individuals (consumers and voters), and are all assumed to be risk averse. In our model, we are not concerned with voting, but primarily concerned with the market for contracts. Agents are not necessarily individuals, and hence, it is easy to imagine large and important agents trading without significant risk aversion related to the outcome of this particular event, for instance hedge funds.

At time t_1, there are m different possible states, $1 \dots m$, each occurring with probabilities $p_1 \dots p_m$, $\sum_1^m p = 1$ and all agents agreeing about the probabilities. These states will give agent n a wealth of W_n^m.

Assuming agreement about the probabilities might be unrealistic. Ottaviani and Sørensen, 2007 provide one central argument for this: Prediction markets usually deal with unique or at least rare events. Traders have limited experience with relevant events, and can hence not be assumed to have homogeneous prior beliefs.

Nevertheless, we assume homogeneous beliefs to focus on the risk-shifting effects of trading. Even if initial beliefs are very different among traders, they are likely to converge somewhat during the trading period, as market prices, polls etc are published. Furthermore, differences in beliefs would not change our main conclusions. Our model is thus different from for instance Wolfers and Zitzewitz, 2006, where the Kyle framework (Kyle, 1985) implies that some traders are informed, and hence assign other probabilities to the different states. For a more general treatment of risk-sharing with heterogeneous beliefs, see for instance Gollier, 2006. One of his main points is that if beliefs are heterogeneous, the agent who carries the most risk will influence the price (collective belief) the most.

It can then be shown (see e.g. Eeckhoudt and Gollier, 1995, ch.13) that the (Pareto efficient) equilibrium price P of the contingent claim of 1 in state m equals the actuarial value of the claim, i.e., the probability of the state occurring.

$$(1) \qquad P = \Pi_m = p(m)$$

Prices and utility functions imply that all risk averse agents would maximize utility by trading in such a market until fully insured, i.e., so that every risk averse agent gets the same wealth and utility in every state.[6] This in turn implies that the risk neutral agent(s) bear(s) all the risk, and that the risk neutral agent(s) not necessarily will be indifferent between the different states. In terms of utility, the risk neutral agent(s) will be equally well off, but all risk averse agents will be better off compared to a situation without a market for such claims.

The risk sharing effect in our case can be illustrated with a simple example: Assume two risk averse agents A_1 and A_2 with the simple utility functions $u_1(W) = u_2(W) = \sqrt{W}$, one risk neutral agent A_3; and two equally likely states 1 and 2. Here, we assume that these states are the results "NO" and "YES" in a vote whether a country should join the European Union (EU). We assume the following pre-trade endowments W_i:

$$W_1^1 = 100$$
$$W_1^2 = 150$$
$$W_2^1 = 100$$
$$W_2^2 = 0$$
$$W_3^1 = 100$$
$$W_3^2 = 100$$

We now assume trade in a prediction market in contracts yielding 1 if state 1 is realized, and zero otherwise. States 1 and 2 are mutually exclusive, so effectively, contracts yielding gains if state 2 is realized can be obtained by issuing the existing contract. The equilibrium price P would be $\Pi_1 = p(1) = 0.5$. A_1 has a smaller pre-trade payoff in state 1, and hence wants to buy claims with a payoff if state 1 is realized. A_2 has the opposite position, and hence wants to short (issue) such contracts to be hedged against the election outcome. A_3 is risk neutral and not exposed to the election, but will buy and sell contracts opportunistically.

First, we see that state 1 maximizes the social endowment ($\Sigma W_i^1 = 300$, $\Sigma W_i^2 = 250$). Hence, this will throughout the paper be referred to as the "socially efficient decision". Both risk averse agents will trade to get a safe, state-independent payoff, and the risk neutral agent will buy and sell opportunistically. Given the probability of 0.5, and agent i buying contracts, post-trade payoffs Y_i^θ will be

$$(2) \qquad Y_i^1 = W_i^1 + (1 - \Pi)q_i$$

$$(3) \qquad Y_i^2 = W_i^2 - \Pi q_i$$

In our example, this means that the risk averse agents will get a state-independent payoff, while the risk neutral agent A_3 will get different payoffs in the two states, and will be 50 better off in state 1 than in state 2.

$$Y_1^1 = Y_1^2 = 125$$
$$Y_2^1 = Y_2^2 = 50$$
$$Y_3^1 = 125$$
$$Y_3^2 = 75$$

Even if the literature is mixed in terms of whether prices in fact have mimicked probabilities in existing prediction markets (see e.g., Gjerstad, 2005; Manski, 2004, and Wolfers and Zitzewitz, 2005), such an equilibrium is in line with traditional financial theory (e.g., Borch, 1962). However, more than in many other markets, it here seems reasonable to believe that the existence of a market and the resulting hedging itself has the potential to influence the probabilities, complicating the analysis. This contrasts standard financial theory, where it is usually assumed that agents cannot influence probabilities. Furthermore, as we have a continuous market, the changes of prices and probabilities will be a dynamic process, not just with "before" and "after" prices. If we return to the example above, all gains from a socially efficient decision will be collected by A_3, but he will also suffer all losses from an inefficient decision. With the other agents perfectly hedged, there should be no reason for the decision-maker to make the inefficient decision.[7,8] All agents knowing this, the probability (and state claim price) would no longer be 0.5. Via some (hard-to-model) dynamic process, the price would increase, as $p(1)$ is more than 0.5. On the other hand, it will not be 1, indicating a 0 probability of the inefficient decision. (If the efficient decision were certain, A_2 would not be interested in paying anything to get insured against the consequences of state 2). Table 1 shows payoffs and certainty equivalents for the agents under different assumptions. The increased probability of the efficient decision is also found by MY in their model; however, they go on to focus on how this increases the importance of ideology for voting.

First, we see that the trade increases the CE of agent 1 and 2. Agent 3 is risk neutral and gets the same expected value in both scenarios, and is hence unaffected. Furthermore, we see that a post-trade belief adjustment changes the situation in several ways. This belief adjustment makes agent 1 worse off, agent 2 better off and agent 3 worse off. The agent who originally gained from the socially efficient outcome is gaining as the probability of this outcome is increased. The risk neutral agent has the same incentives to promote state 1, the only difference is that his payoff distribution has changed with the higher probability of state 1. We note that no matter how the belief adjusts, both risk averse agents will be perfectly hedged. This is due to the assumption about a risk neutral agent. Any change in probability will be exactly matched by a change in price, so the sum of the initial endowment and the market value of the contracts will always be the same in the two states. If we assume rational agents with the ability to foresee this, the whole, very complicated dynamic game is reduced to a single decision.

Table 1
Payoff Before and After Trade

	State 1		State 2		Certainty equivalent
	Payoff	Utility	Payoff	Utility	
Without trade					
Agent 1	100.00	10.00	150.00	12.25	123.76
Agent 2	100.00	10.00	0.00	0.00	25.00
Agent 3	100.00		100.00		
After initial trade, p = 0.5					
Agent 1	125.00	11.18	125.00	11.18	125.00
Agent 2	50.00	7.07	50.00	7.07	50.00
Agent 3	125.00		75.00		
After initial trade / belief adjustment, p = 0.6					
Agent 1	120.00	10.95	120.00	10.95	120.00
Agent 2	60.00	7.75	60.00	7.75	60.00
Agent 3	120.00		70.00		

At first sight, it looks difficult to say something specific about the pricing of the asset. Each agent will be able to hedge away all his risk, no matter how likely the different outcomes are perceived to be. Fundamentally, each agent will only use contracts if this makes the *ex ante* expected utility higher than remaining unhedged. In this example, the "inequality" to be hedged requires 100 contracts to be traded (1 unit per contract). Furthermore, if contracts are used, it is always optimal to hedge completely. That is, it is never optimal for an agent to buy for instance 26 contracts, so if contracts are used, all 100 contracts will be traded. (50 issued by agent 1, 50 by the risk neutral agent). Hence, we get the following pre-requisites for each agent to trade:

$$(4)\quad p\sqrt{100}+(1-p)\sqrt{150}\leq p\left(\sqrt{100+50-50P}\right)+(1-p)\sqrt{150\ -50P}$$

$$(5)\quad p\sqrt{100}+(1-p)\sqrt{0}\leq p\left(\sqrt{100-100+100P}\right)+(1-p)\sqrt{100P}$$

The left hand side of the inequalities expresses the utility without hedging, while the right hand side expresses the utility after trade, i.e., when the agent is perfectly hedged. The payoff difference compared to the unhedged situation can be calculated using equation (2) and (3):

Agent 1, state 1: 50-50*P* (buys 50 contracts, receives 50)
Agent 1, state 2: -50*P* (buys 50 contracts, receives nothing)

Agent 2, state 1: $100P$-100 (sells 100 contracts, must pay 100)
Agent 2, state 2: $100P$ (sells 100 contracts, must pay nothing)

The risk neutral agent is not considered here, as we assume that he will buy/sell at any price in the market reflecting the probability. Of course, both risk averse agents will always gain from hedging. Any price/probability will thus be an equilibrium; although a high probability will give agent 1 (and the risk neutral agent) a lower utility to the benefit of agent 2, while a low probability will benefit agent 1. Different utility functions will not affect the main results, but they will affect how much each agent gains from hedging. Knowledge about the agents' utility functions is hence useful for the exchange when determining whether such a contract should be launched. If the potential gains, based on perceived (pre-trade) probabilities (from polls, bookmakers etc) and agents' utility functions are large, the contract is more likely to become liquid and successful. If the utility functions are clearly different on the two sides (for instance, contracts issuers are on average much more risk averse than contract buyers), this would of course also influence the pricing of the contracts.

As we have seen, the equilibrium price is not easy to determine. For our example, it could be a function of the following type:

(6) $$P = \Pi = F(p_0, u, l, x)$$

p_0 equals the initial (pre-trading) probability for the outcome. Everything else equal, the final equilibrium price will increase in p_0.

u is a measure of the utility functions of agents, i.e., the degree of risk aversion. The presence of a risk neutral agent will remove all risk from the risk averse agents. If there were no risk neutral agent, the agents would divide the risk according to the mutuality principle, thus all post-trade gain from the efficient decision, indicating a lower price than in the case with a risk neutral agent. On the other hand, fully hedged agents would have no incentives to lobby (or even vote) for the efficient decision. The risk neutral agent would have large sums of money to lobby with if necessary, but in democratic processes (like our example), small incentives for all agents could be more powerful than large incentives for one.[9] This would in turn make the efficient outcome post trade more likely. Hence, it is not obvious in which direction the presence of a risk neutral agent would move post-trade prices. The agents' utility functions would also determine how much more attractive a hedged position would be compared to the unhedged position, and hence influence which transaction costs etc agents could tolerate to actually participate in the market.

l is a measure of the (perceived) lobbying power of those agents with a post-trade interest in the outcome. Initially, all agents of course have incentives to influence the decision so as to improve their own bargaining position. After the contracts are traded, however, only some agents have incentives; in our example, only the risk neutral agent has incentives. l can also be viewed as a measure of trust in the decision maker to make the efficient decision. High lobbying power/high trust in the decision would increase the final equilibrium price.

x is a measure of all other factors able to influence prices. Examples could be altruistic voting, or non-financial effects of the different outcomes. This is an important aspect of the MY paper; they study how the introduction of a market increases the importance of ideology (relative to financial self-interest) for voting; as well as how presidential candidates could change their ideological position based on this to attract votes.

3 IMPLICATIONS

Risk shifting, and thus increased utility as explained above, is only one of the benefits from such a market. Additionally, such a market would provide "positive externalities" by providing information about the likely outcome also for those not themselves involved in the market. This is the classical prediction market argument. Equally important; it should provide information about the total financial consequences of the decision. For large decisions, it is impossible for any central planner to know the precise consequences for all affected agents; even making a reasonably good estimate is hard. By studying the pricing process in such a market (and in particular the post-trade lobbying), decision makers would get additional information about the total financial consequences any decision would lead to. Nevertheless, most important is probably the potential to influence decisions. As outlined above, the contract prices and implied probabilities will depend on a number of factors. However, the price will always be such that the probability of a socially efficient outcome is increased compared to the situation without trade. No one will post-trade have any incentives to promote the inefficient outcome, but all agents with post-trade interests will have incentives to promote the socially efficient decision. This contradicts the situation without such markets. Although the total incentives to lobby by definition are larger for the "socially efficient side" also without such market, traditional lobbying introduces several problems solved by risk-shifting markets. First, lobbying is costly. Without a market, one might imagine 10 agents lobbying for the socially efficient decision and 8 against it. With risk-shifting, most agents would be hedged, leaving only the marginal 2 agents with incentives to lobby for the efficient decision. This would significantly reduce the total costs of lobbying. Also, 2 campaigns for the "efficient" side and 0 for "inefficient" is probably better for the "efficient" decision than 10 campaigns for "efficient" and 8 for "inefficient." It seems unlikely that lobbying should be an activity with increasing marginal returns, so the difference in effect between 2 and 0 should be larger than between 10 and 8. Furthermore, as concluded by Persson and Tabellini,, 2002, ch 7.3,

> "suboptimal policies are enacted only because of incomplete participation in lobbying."

In a setting where only a small group has an interest in the outcome, there will no longer be a large group with a weak interest in the outcome, yet not enough interest to lobby.

The second problem with lobbying is that often, a few agents have very large incentives to lobby against the efficient decision, whereas the gains from the efficient decision are spread among many agents, who all have too small incentives to invest in lobbying. Hence, traditional lobbying usually is considered to benefit some minority's interest, on the expense of the society at large.[10] Because agents with smaller amounts at stake would have smaller incentives to trade in the market too, a market would not solve this problem completely. Nevertheless, it is worth noting that with all risk avers agents fully hedged, all the risk would be carried by (a few?) risk neutral agents, who definitely should have large enough incentives to lobby.

An interesting possible implication is the effect on democracy itself. As discussed by MY, once the market is there, everybody should use it, but some might still be worse off than before the market was introduced. Hypothetically, this could be a large group of poor people, while the winners could be a few rich people. Without a market, the larger group would win the election, while the market eliminates their advantage of being many. Another effect is that with a fully hedged market and no incentives for risk averse agents to even vote, the only agents with (financial) incentives will be the risk neutral ones. If these for instance are large, international funds, some might argue that it is unreasonable that these should have so strong incentives to "interfere with politics." Thus, the introduction of markets should increase the total wealth, but maybe at the expense of less power to democratic organs. Whether this trade-off is viewed as beneficial will of course depend on both the details of the specific market in question, as well as political and ideological preferences.

4 CONCLUSIONS AND FURTHER RESEARCH

As outlined above, a well-functioning market place for claims on political decisions could lead to large potential gains for both individuals, firms, decision makers and the society. Individuals and firms could reduce their risks and get valuable information about the probability of different outcomes, decision makers could get useful information about the perceived aggregate consequences of their decisions, and society could get more efficient decisions on average.

However, many challenges remain. The arguments above are purely theoretical, and it remains to be seen for instance how many would use such a market, and how individuals would be able to affect prices (and probabilities) in markets of different sizes.

More fundamental is the lack of any current markets of the scale needed for risk-shifting. A real market is needed to test how well this model describes what happens in the market and the proposed benefits from a market. Yet, some might say that the lack of relevant markets can be interpreted as a lack of demand for such risk shifting, e.g., that the benefits must be smaller than described in this paper.

This leads us to one important area for further research – to further examine the perceptions of (and potential hedging needs for) such political risk. If a larger body of literature suggests that such markets in fact could be useful, this would serve both as good marketing for organizer/exchanges, as well as put pressure on governments to introduce necessary regulatory changes. On the other hand, if further research suggests that the benefits described here are overrated, or that such markets would introduce negative side effects, or that the risk is perceived to be manageable without new markets, further research on pricing, institutions etc would seem irrelevant.

Given the need for markets, the next step would be to study the institutional requirements for such markets, and then for governments to adjust regulations accordingly. Finally, the financial industry would have to create markets and contracts and promote these to get sufficient liquidity. This process should be accompanied by the kind of research we see in existing, more mature financial markets, for instance development and formal analysis of pricing models and trading strategies.

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NOTES

1. For a thorough discussion of earlier betting markets base don presidential elections; see Rhode and Strumpf, 2004.
2. See e.g. Wolfers and Zitzewitz, 2004 or Tziralis and Tatsiopoulos, 2006 for surveys of different markets and their efficiency.
3. See e.g. Berg *et al.,* 2003 and Forsythe *et al.*, 1999.
4. Providers of such services include, among others, www.predicorp.com, www.mercury-rac.com, www.predicom.com, www.nosco.dk, and www.predimark.no.
5. The assumption about a risk neutral agent may be relaxed here too. If all agents are risk averse, they will all carry some risk, depending on their utility functions. Eeckhoudt and Gollier, 1995, ch.13 give pricing formulas for scenarios where individuals have quadratic and negative exponential utility functions.
6. We here assume, like MY, that utility over wealth is separable from utility over ideology, and we ignore the latter. One could imagine people "over-hedging," i.e., buying contracts such that the financial payoff would be larger in one state – the state they dislike from ideological or other reasons – to maximize overall utility. The importance of this "betting against your favourite team" strategy would be difficult to evaluate, and is also discussed by MY.
7. In the case without a risk neutral agent, all agents would carry some risk, depending on their utility functions. However, in equilibrium, they would all gain from the socially efficient decision, and there would still be no rational reason for the inefficient decision. (The sizes of their gains would depend on their utility functions).
8. If, for some (irrational) reason, there was still a chance of an inefficient outcome, A3 could use some of his gains from the efficient decision to influence the decision, via lobbyism or other less legal ways.

This possible cost would, however, influence the price of the claim, and hence the post-trade distribution of the payoffs.

9. Most textbooks in political economy, e.g. Persson and Tabellini, 2002, give thorough and formal analyses of lobbying. This is also discussed by MY.
10. Again, the political economy litterature as described by Persson and Tabellini, 2002 analyses lobbyism and bribery in detail.

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