research and development outcomes, success of new products, and regulatory outcomes. In the public sector, the Pentagon attempted to use markets designed to predict geopolitical risks, although negative publicity stopped the project (Hanson, 2005). An intriguing attempt to apply prediction markets to forecasting influenza outbreaks is detailed in Nelson, Polgreen and Neumann (2006). Rhode and Strumpf (2004) have detailed the existence of large-scale election betting as far back as the election of Washington.

Prediction market contracts have been traded in a variety of market designs, including continuous double auctions (both with and without market-makers), pari-mutuel pools, bookmaker mediated betting markets, or implemented as market-scoring rules.

Prediction Markets in Theory: Information Aggregation

The claim that prediction markets can efficiently aggregate information is based on the Efficient Market Hypothesis. In certain cases, existing theoretical results regarding efficient capital markets can be applied directly. Grossman (1976) documents a set of sufficient conditions for the equilibrium price of index futures to summarize private information perfectly: In a market where traders with CARA utility functions each receive independent draws from a normal distribution about the true value of the asset, the market price fully summarizes their information.

Manski (2004) noted that much of the analysis of the price of binary options had simply assumed that these revealed a market-based probability estimate, but that appropriate theoretical results were lacking. He illustrates the importance of this issue by way of an example where prediction market prices fail to aggregate information appropriately. In his model all traders are willing to risk exactly \$100. Thus if a contract paying \$1 if an event occurs, is selling for \$0.667, then buyers each purchase 150 contracts, while sellers can afford to sell 300 contracts (at a price of \$0.333). This can only be an equilibrium if there are twice as many buyers as sellers, implying that the market price must fall at the 33rd percentile of the belief distribution, rather than the mean. The same logic suggests that a prediction market price of π implies that *1-π%* of the population believes that the event has less than a π% chance of occurring. Clearly the driving force in this example is the assumption that all traders are willing to risk a fixed amount.

Wolfers and Zitzewitz (2005a) provide sufficient conditions under which prediction market prices coincide with average beliefs among traders (and hence aggregate all information in the Grossman setup). They consider individuals with log utility and initial wealth, y, who must choose how many prediction market securities, x, to purchase at a price, π, given that they believe that the probability of winning their bet is q:

$$\underset{\{x\}}{Max}\ EU_j = q_j Log[y + x_j(1-\pi)] + (1-q_j)Log[y - x_j\pi]$$

$$yielding: \quad x_j^* = y\frac{q_j - \pi}{\pi(1-\pi)}$$

The prediction market is in equilibrium when supply equal demand:

$$\int_{-\infty}^{\pi} y\frac{q-\pi}{\pi(1-\pi)}f(q)dq = \int_{\pi}^{\infty} y\frac{\pi - q}{\pi(1-\pi)}f(q)dq$$

If beliefs (q) and wealth (y) are independent, then this implies:

$$\pi = \int_{-\infty}^{\infty} qf(q)dq = \overline{q}\ .$$

Thus under log utility, the prediction market price equals the mean belief among traders. If wealth is correlated with beliefs, then the prediction market price is equal to a wealth-weighted average belief. This finding is general in the sense that no assumptions are required about the distribution of beliefs, but it is also quite specific, in that it holds only under log utility. Experimenting with a range of alternative utility functions and distributions of beliefs typically yields prediction market prices that diverge from the mean of beliefs by only a small amount.

Both the Manski and Wolfers-Zitzewitz models are silent as to the sources of the different beliefs across traders, which allows them to sidestep the theoretical difficulty posed by Milgrom and Stokey (1982): that under common beliefs, no trade will occur. The logic of the "no trade theorem" is simply that each trader should always be wary that anyone seeking to trade with them possesses an information advantage, and hence should moderate their beliefs accordingly. Explaining why there is any trade in prediction markets remains an important open theoretical question. Wolfers and Zitzewitz (2006) provide a simple adaptation of the Kyle model in which trade is driven by uninformed outsiders with either hedging- or entertainment-driven demand for the prediction security, or by manipulators attempting to influence market prices.

Another important role of prediction markets is that potential trading profits provide an incentive for *information discovery*. Grossman and Stiglitz (1976) consider the case where information is expensive to garner. They point to the impossibility of prices being fully efficient: if prices fully reflect information, then there is no incentive for any trader to gather that information. Instead, they construct a model in which prices never fully reflect all of the information possessed by informed traders; in equilibrium the inefficiency in pricing is just sufficient to induce a proportion of traders to become informed.

Another key advantage of prediction markets over alternative approaches to information aggregation is that they provide incentives for *truthful revelation* of beliefs. If prediction markets are to be used as inputs into future decisions, this may provide a countervailing incentive to trade dishonestly to manipulate prices. While such manipulation would typically lead the manipulator to lose money, Hanson and Oprea (2005) have shown that these losses increase the rewards for informed trading, which may ultimately increase the accuracy of prediction market prices.

Prediction Markets in Practice

While we are still accumulating evidence on the behavior of prediction markets in different contexts, there are already a few generalizations that can be drawn from existing, albeit piecemeal evidence.

First, market prices tend to respond rapidly to new information. Figure 1 draws an interesting example from Snowberg, Wolfers and Zitzewitz (2006): movements in the price of the Tradesports contract on the re-election of President Bush, around election