Information Markets and Computational Improvements for Corporate Decision-Making

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Introduction

Today's executives, politicians, and lawmakers are increasingly fraught with decisions whose chief impediment lies within the aggregation of information. This trend has caused an upsurge in the demand for consultants, modeling software, and the training of analysts to use the structure that results from these processes. The nineties are known for the necessity for and implementation of models that "go beyond the hindsight view of regression", especially for cases in which predictions can be widely biased by subjective and unquantifiable information, leaving the question of how best to weigh differing facts and opinions on event probabilities unanswered.

In the formulation of the efficient markets hypothesis and arbitrage pricing theory, economist have posited that financial markets efficiently price assets through the incentive yielded by the sheer financial pressure to extract wealth. In following this ideal economists have followed suit in applying information markets in which formulating an exact weighting of input information remains challengingly dubious (Berg, et al, 2002). In 2002, Prof. Charles Plott conducted a series of experiments through the use of information markets to show the relative advantage that information markets could bring to predicting printer sales at Hewlett Packard over existing forecasting systems (Chen and Plott, 2002).

An Overview of Information Markets and Neural Networks

In the early 1950s, Economist and political philosophy Friedrich von Hayek supported this notion when he first posited the notion of the Free Price Theory which shares the same premises as the theory behind prediction markets, as well as and his support for a connectionist approach to decision making. However, information markets have several disadvantages that are present in any market: collusion, insider trading, market manipulation, arbitrage opportunities, imperfect liquidity, and flaws in design and implementation. Thus, Hayek was also an early proponent of exploiting the idea of simulating spontaneous order in the brain arising out of decentralized networks of neurons for the combination of information. In cognitive science, the idea of an artificial neural network is defined as an interconnected group of artificial neurons that uses a mathematical or computational model for information processing based on a connectionist approach to computation. Subsequent to the popularization of the concept, numerous developments in the field of neural networks, including the Cognitron, Hopfield's Network, and other elaborations upon the 1800s model of the Perceptron allowed the parallel distributed processing and back-propagation to surface as features that made neural networks technologically superior to linear regressions. Multiple Layer Perceptrons replaced multivariate linear regressions in time series applications where autocorrelations would cause some regressions to elicit much of the predictive effect of "driving by a gaze through the rearview mirror".

The information markets of today are increasingly approaching the status of financial markets, not only allowing traders to bet on the uncertainty of future events and their contingencies, but also serving as a mechanism for aggregating information and a means to determine the validity of decisions. This is possible because the pricing model, commensurate with the intuition of the aforementioned theories, causes the price, the monetary consensus of opinions to signify the probability that a binary event will actually occur. An example of these functionalities emerges upon consideration of whether there may be an attack such as that which occurred on 9/11 which was a candidate of the "Terrorist Futures Market" (Wolfers and Zitzewitz, 2004). In the case of a *winner takes all contract* for this event with a cost p between 0 and 1 with a payoff of \$1 for occurrence and \$0 for non-occurrence. A buyer of this contract makes the statement that he thinks it is a least *p*% likely that such an event will occur for the payoff to equal or exceed the cost of the contract, which would therefore provide profit. Because this is the consensus and the range of values lies between 0 and 1, the probability with which the event will occur at *p*%. The contracts displayed on most electronic markets are predominantly of this type, with the event associated with such a contract varying from movie release dates, winners of various cinema-related awards, the resignation of politicians, and other current events. All of these contracts are binary to simplify decisions, reaching equilibrium by the law of large numbers. The events in sports have proven to be the most popular target of information markets, with the online betting system replacing former book methods. The aggregation of opinions results in more rapidly adapting money lines—an up-to-date weighting of probabilities due to real-time consolidation of bets. In these cases where a plethora of information is made to the public on various the absence of players and different responses due to respective reaction of strategies based, it has be proven advantageous as opposed to only a group deliberation and consensus based on the opinion of a poll of experts, due not only the fact that the traders are able to volunteer greater amount of information in the face of uncertainty, but also the fact that their incentives are driven by the will for profit, causing them to aggregate information to formulate their individual beliefs to the fullest extent possible. The wagers on event outcomes are also not as prone to the politics and the biases that cause faulty predictions in opinion polls, typical research, or focus groups, simply because the market adapts to individual opinions efficiently enough to mitigate the effects of confirmation bias, mental accounting, and other factors affecting financial decisions.

Another structural advantage lies in the dynamic enforce by market makers. In group discussions, market makers sometimes bias the weight of their own opinions by eliminating controversy and causing greater adoption in group discussions, whereas in information markets the weight of their opinions is curbed by the willingness to spend a portion of their bankroll on betting on a certain contract. Thus information markets eliminate undue momentum and the biases and uncertainties that result from it.

However, several deficiencies surface in the philosophy and implementation of information markets, when considering not merely individual risk preferences, wealth, and distribution of opinions, but also their interaction with the mechanics of collusion, manipulations, and arbitrage that are incumbent in any market and which limit the power of information markets. It is these deficiencies that warrant endeavors to increase the effectiveness by means of clarifying and accelerating aggregation through the use of algorithms and computational optimization. A popular candidate for such a computation is neural networks, and this paper will explore the possibility of better aggregating opinions the prediction market by organizing trader insight into a neural network. According to Delvin D. Hawley, John D. Johnson, and Dijjotam Raina, the neural network may be able to better calibrate and insulate the information market from the aforementioned deficiencies by using available data from the information market, as well as past deviation in predictions from the actual outcome of a certain contract hypothesis, in order to train a system that can better store the probabilities associated with the occurrence of certain events with certain instances (1990).

Neural networks, on the mathematical level, is a representation of the probabilities with which certain conditions are associated with, and there may serve as predictors for, the outcome of an event. After training a neural network with sufficient data to establish the weights with which certain factors of input are represented, it is then able to retrace the discrete outcome of an event based on evaluating the linear combination of serial probabilities associated with different attributes supplied by an observation. By using neural networks, researchers can thus simulate decision making and adaptive learning for decision making. This paper will investigate these effects by first examining the features of information markets. Then it will proceed with a discussion on the application of information markets to corporate decision making. Next, it will present the details of the deficiencies that are associated with information markets in theory and practice. After, it will investigate the mathematical models of performance behind information markets. Finally, it will examine the computational improvements offered by neural networks and assess them when applied to information markets to make pertinent decisions.

Returning to the spirit endowed upon the concept of the Marketplace of Ideas, it is evident that markets yield better forecasts than individuals, since, by the efficient markets hypothesis, such markets would yield prices summarizing all available information pertinent to the value of a given security. Then, by the law of large numbers, the market price can serve as the ultimate and distinct collection of agents at play, yielding positive externalities for non-agents as well. For example, in the trading of company securities, all public information can be used as predictors of performance, including debt, financial allocations, public statements, pending legislation, industrial forecasts, and political forces. When faced with a shock in the supply of information, the price quickly readjusts. These dynamics are further explained by the Arbitrage Pricing Theory, which states that prices will adjust due to slight transactions in arbitrage when deviations in price from true value present profit opportunities to traders (Roll & Ross, 1980). The important observation is then made that immediate bidding of prices commensurate to true value under a comprehensive portfolio of available information, supply shocks must be the source of fluctuations in price. Predictions thus lie on the frontier of new and old information, and new information remains unaccounted for in the price of a contract, meaning that is inherently unpredictable.

In practice, a plethora of information is conceded in acquisition attempts made by one firm upon another. In 1981, it was shown in a study of cumulative abnormal return in a sample of 194 takeover attempts between that prices behaved erratically due to the incorporation of newly publicized information (Keown, 1981), ending with a stage in which prices experienced no further drift subsequent to the announcement date. The resulting prices in such scenarios, they posited, reflect the aggregation of new information into the value of such securities, with the amount of change equal to the profit yielded by the takeover for that given trading day.

The Efficient Markets Hypothesis has a number of forms, including the strong form, which states that security prices summarize all available information, regardless of agency membership within the public domain or as an insider.

Aggregation

Information markets are speculative markets created for the purpose of making forecasts, in which assets are created whose final payoff value is tied to a particular event or metric. At the most basic level, information markets serve as a method of aggregating information. In the case of pharmaceutical company Merck, for example, the fluctuation in Merck's stock price can indicate the availability of certain chemicals and distribution lines, the condition of pending approval from the FDA, announcements of investments in certain projects and drugs to be developed, whether Pfizer plans to acquire a smaller subsidiary, or whether Vioxx might be taken off the market by a certain date. By the law of large numbers and the definition of market equilibrium, For each individual, this is further enforced by the rational expectations theory of information propagation, which states that agents in a given market will maximize their respective expected utilities in the form of consumables and monetary equivalents. Therefore, the strong form of the Efficient Markets Hypothesis is fulfilled, because traders that hold private information will translate that abstract information to tangible asset to maximize their utility (Grossman, 1981). In the Merck case, supposing that a member of the clinical trials team who coincidentally traded shares of Merck knew that the trials were particularly "lenient", it would be irrational for such a person to hold the stock. Instead, he would probably short the stock or at least buy a put in case investigations actually swung in Merck's favor, allowing for the expectation of a number of future "lenient" trials.

In the simplest case, unless providing for alternative utility payoff functions, the mathematical model which captures this is:

$$p = \frac{\sum_{i=1}^{n} a_i q_i}{\sum_{i=1}^{n} q_i}$$

In this case, price p is given as a weighted sum of products, where a_i represents the speculative value and q_i is the quantity of asset purchased by individual i, and this sum is calibrated over total quantity purchased. Thus, one can see that in the mechanics of aggregation, those that purchase the asset at higher prices a_i will have a greater effect on the weighted average that computes p. It is this weighting that characterizes information markets' efficiency, since, returning to the rational expectations hypothesis, those with information will translate it, no matter at what quantity, to their decision to buy that quantity of asset at the price dictated by their own aggregate information.

Incentives and the Rational Expectations Hypothesis

Purchasing decisions made in this regard have a number of properties which further drive their efficiency. The first of these is the idea of incentives. By using a system of bankrolls, investment powers, and payoffs in a market, information markets give a structured incentive to make decisions and quantify the outcome of their actions. Whereas in other methods of forecasting and decision making the weighting, adoption (i.e. purchase), and even the volunteering of information are arbitrary, thus setting the precedent for irrational decisions, information markets provide structured payoffs, aggregation proportional to each agent's confidence in their assessment based on their knowledge. This makes the market properly attuned to fully utilizing the information held by its agents.

Risk Aversion and Wealth Considerations

The case of varying wealth levels also broaches the idea that different individuals may have different indices of risk aversion. In his paper, "Risk Aversion, Beliefs, and Prediction Market Equilibrium" however, Stephen Gjerstad showed that prediction market prices are typically very close to the mean belief of market participants if the distribution of beliefs is smooth (2004).

Money as Definitive measure of Utility

Incentives are further explored in the paper "Prediction Markets: Does Money Matter?" in which economists Servan-Schreiber, Wolfers, Pennock, and Galebach compare the relative accuracy of the respective predictions of real money information markets and play money information markets. The premise of the study is an extension of the observation above that the amount traders as willing to bet, as strong as their rational expectations may be, may ultimately be correlated with their wealth (2004). In addition, the uncertain events asset transactions into which initially self-select may also have a positive correlation with their confidence, which is also related to aspects of wealth or notions thereof. These are cases that would disestablish the assumptions the Gjerstad made above to exact a smooth belief distribution, therefore removing the advantages of the optimal weighting of opinions that information markets typically offer. In the study, the predictions made on real money sports gambling market Tradesports.com, and those made on play money events futures market Newsfutures.com. In the former, participants sign for accounts and import and amount of money which then serves as their bankroll, whereas in the latter, participants register and are allocated a small amount of play money when they fall under a certain net worth. Galebach, Pennock, Servan-Schreiber, and Wolfers then utilized a play money prediction market and compared it to its real money analog when making predictions about corresponding uncertain events in order to determine the loss of accuracy resulting from the play money market. Accordingly, play money market traders were rewarded with incentives that simulated those of their real money counterparts, by means of prizes, psychological satisfaction, and cash in place of real financial risk, eliminating wealth as a factor which might otherwise affect their ability to perform in their market. In addition, participants in play money markets accumulate wealth for habitual accuracy (2004), meaning that as opposed to the way they use their money to bet and influence the market, players in play money market these players are motivated by privileges of bidding on a number of expensive real prizes. With the speculations made on contract pertaining to the victory of certain sports teams, the economists compared the respective average percentage of each exchange's favorite games won with the average pre-game prices for each of the exchange's favorites, and the result was that across 208 NFL football game experiments, both information markets performed at the same rate of accuracy for predictability and neither performed systematically better than its counterpart.

The study also revealed that either prediction market outperformed the individual predictive abilities of individuals ranking sixth and eighth out of the top 1947 individuals over all 208 games, far beyond the average predictability of proven betting experts. With their conclusion that the community of "knowledgeable and motivated traders [seems to be the essential ingredient], and money is just one amount many practical ways of attracting them", one can infer that market designs must have a critical mass of informed traders, in addition to the incentivization that it inherently propels.

Enhancing Competition

In addition to the individual decision to buy or sell assets based on rational expectation is the idea that it enhances their ability to compete. Observations behooving the exploration of this effect include that only under limited circumstances do groups excel as good estimators for certain events attributable to the tendency for "groups performing tasks that involve solutions that are not easily demonstrable… to perform at the level of their average members" (Gigone & Hastie, 1997). In the proceeding of deliberations, the dominance of select group members' conveyance of relevant information may lowering the confidence of those who view their own information as less relevant, and effectively causing them to withhold disclosure of what might be pertinent information, or which might lead to pertinent considerations. Mathematically, this eliminates the hypothesis established by the rational expectations theory and assigns the weighting of expected utility extraction from potential contract asset sales to zero. In this way, the rationality of any organization relying upon group deliberations, though allowing for the volunteering of information held by minority voices, may depend on only a few opinions of those who hold sway over the discussions which compose them, which is most cases are contingent upon factors such as the verbosity, charisma, politics, demeanor, diplomacy, comprising the expression of delegated individuals engaging in discussion, all of which are subjective.

In the interest of time, discussions may be abbreviated, completely eliminating the fastness to which the marketplace of ideas is held, resulting in insufficient aggregation and non-optimal performance. Specific deficiencies arising from such dynamics were categorized by Sunstein as the "[error amplification], hidden profiles, cascade effects, and group polarization." (For the purposes of this paper, "hidden profiles" will be referred to as "obscured profiles" to reduce confusion with the terms "hidden motif" and "Hidden Markov Models". Information markets ameliorate these deficiencies by pooling information efficiently by the mathematical description above, enforced by the proper incentivization for maximum disclosure of information, notwithstanding subjective and personal skills and attributes of agents at play, and therefore regardless of by whom that information is held. To borrow from the principles of microeconomics, this is mathematically allowing for the integration of the demand curve, where instead the dimension of quantities is replaced by that of perceived relevance. Thus, the characteristic of anonymity inherent in information markets erects barriers to entry which make such a market profitable, which in turn reduces psychological forces from propagating irrational discussion or asymmetric information, serves to incorporate and disclose all information, and eliminating ulterior motives of participation from tainting the discussion at hand, which effectively enhances the ability of all participants to compete. In practice, examples arise such as the case of a democrat that votes for a republican candidate (redistribution of incentives and structurally motivated reallocations), people who make decisions which the perceive are in favor of the organization but not necessarily themselves, or to otherwise fulfill a leadership role (mental accounting, decision horizon perception, and time preference of investments), and under-promising and over-delivering (other personal agendas). In the network industry, sales divisions are commonly outsourced to other specialized providers as opposed to an internal department, and in negotiations for a contract, the representative of the provider may reframe hypotheses, limit discussion, and inflate the projection of obstacles in order to under-promise an offer, over-deliver on results, and ensure the agent's ability to "keep trading", in market terms, with the principal in subsequent years. In addition, this agent may have a better strategic alternative perceived by the other party and thus higher bargaining power, both of which are difficult to quantify by the principal. In the case of even the most modern forecasting methods, it is also possible that the agents that are hired traditional sales forecasters themselves bias the results, either by design or in reporting, in order to ensure that their services are demanded for the following period. Information markets eliminate this uncertainty by not only enhancing the productivity in information extraction achieved per unit time, but also eliminate the inefficiencies attributed to lack of incentive, obscurely strewn and relatively less salient considerations, structurally induced biases, by providing anonymity in one of the most optimal mechanisms for aggregating information on one metric: each agent's monetary willingness to compete.

Market Makers vs. Expert Opinion

The third mechanistic attribute of information market is accelerating convergence to an estimate of the ideal decision. With proper communication of structured payoffs, ability to preserve competitive ideas, and market empowerment, traders can be properly incentivized beyond expert research or group discussion. This being further enforced by anonymity, convergence to the optimal group decision in a given scenario is supported by the contribution of the most informed traders. Whereas the participation of these traders would otherwise only serve to polarize group thought, Lichtenstein, Kaufmann, and Bhagat posit that their presence in information markets *increases* the markets ability to perform by sending market signals and driving the market to mine its agents' resources for greater depths of information (1999). In correcting against the over-weighing of expert opinion exhibited in some group discussions, one might infer that an information market at times, might overcompensate. However, although it is the case that several information markets are centered on popular discussions and vehemently debated issues might imply that low-level traders (people who are *least* appropriately defined by the term "expert") are allocated inappropriately high levels of weight in market pooling, but on the contrary, the information market also corrects for this potential inconsistency. Wolfers and Zitzewitz further bolster this argument with their depiction of the Tradesports.com Saddam Security, a contract which yielded $100 upon Hussein being ejected by a given end of a given month or $0 otherwise. In the example depicted (Figure 1), the price traced heavily two other explanatory variables: an expert journalist's estimate of United States declaring war on Iraq, and oil prices. Thus, if information markets are more efficient at predicting events, they must exhibit a systematic means of calibrating the relevance of expert opinion, a fallible variable in both systems in consideration. This calibration is further impeded by irrational choices such as those made by people based on salience of certain ideas in the media. Wolfers and Zitzewitz give the example of decisions based on the sheer exposure given by commentary on the activity of a favorite team or political candidate which has no bearing on actual performance or which gives irrelevant information toward determining the prediction in question (2004). The information market serves to mitigate the weight of these irrational players by the activity of *market makers*. As aforementioned experts carrying the greatest amount of information, these traders have the attribute of investing twice as much volume, had a higher incident of trading, were rewarded with higher returns, made one-sixth as many errors, and were on average, unbiased. Market makers are characterized by making offers accepted by others rather than accepting those others offered. In a paper by Forsythe, Rietz, and Ross, a survey determined that these traders tend to be more highly educated (1992) and experienced at trading (1999). Because of their influence in both contributing information and competitively driving the rational purchase of assets, market makers are able to drive and accelerate the adoption of an accurate prediction even in markets in which traders are few and in which a survey would otherwise potential yield a statistically insignificant result due to the law of large numbers. In an information market, however, the hypothesis to the law of large numbers can be assumed because instead of using people's guesses as static observations, the market is using the transactions yielded by its participants to determine an unbiased estimate of the prediction objective. Therefore this is not only advantageous in that fewer participants are necessary for the market to reach an accurate consensus, but also in that it allows for the possibility of an accurate market even if a small percentage of traders have good information. The Iowa Prediction Markets are a prime example. In these markets, 85% of participants have statistically poor judgment, exhibited by their tendency to hold shares for long periods of time or their acceptance of others' offering price. Thus, the mere 15% of the market drive the prediction by their amount of knowledge, higher rate of acquisition and refinement of information, and willingness to bet, are designated with the title *market makers*. By this dynamic, information markets are more accurate than opinion polls and other competing institutions due to the disproportionate influence of a small percentage of highly rational, proactive, and experienced traders have on the majority. In addition, when small information markets fail, it is easier, though not necessarily quantifiable, to isolate certain bets that influenced the market to make a wrong decision among the few participants involved. One final observation that contributes to fully aggregating information is that when an offer is made in this auction layout, the buyer will act competitively to mine his sources of information in order to make the best buyer decision, including his own obscure notions, which is then put to the test and either becomes a source of income for the buyer or the market serves to compete it away (Plott, 2000). It is this dynamic of offers and acceptances that drives the extraction of obscure information and makes unbiased estimators of the ask prices, yielding a several advantages in the employment of information markets over group deliberations.

Corporate Applications and Foundations of Performance

By examining the features of information markets discussed above, one can surmise that information markets' advantages make them a very viable choice for forecasting for corporate decision-making. A sample of the extent to which market implementation can be used to effect accurate results in a corporate setting is illustrated in the studies briefly mentioned above conducted by Charles L. Plott of Caltech. Referring to the overall function of information markets first stated in this paper, Plott dubs the information market an *Information Aggregation Mechanism*. To test the accuracy of the IAM in aggregating dispersed information predicting the outcome of uncertain events, Plott prepared laboratory experiments demonstrating the prospective for information markets to collect and aggregate information into a cohesive, weighted summary. To this end, in a paper called "Markets as

Information Gathering Tools" (2000), Plott defined two states of the world X and Y in which an asset paid 400*u* and 200*u* respectively. Traders in the market were given income in each period of trading. The experiment proceeded, allowing for information about the state to be distributed, and based on this exchange, trading was permitted to take place until the true state of the world was revealed. At the end of each trading period, securities were irrevocably exchanged for dividends in the values as described above. The probabilities of the two complementary events were 0.75 and 0.25, respectively.

Prior to each trading session, a piece of paper which was either blank or had written upon it the true state of the world was distributed to each participant, in order to simulate insider information. There was a 50% chance that insider information would be disseminated. In the case of no insider information, each participant would receive a blank piece of paper and be oblivious to whether or not any insiders (fellow participants with information on the true state of the world) truly existed. In the case that extant insider information *was* dictated by the random event, then a select number of participants would be endowed with the information as denoted on their piece of paper, and only those select few would not only be aware of the existence of insider information, but also know the true state of the world.

Intuitively, without the existence of insiders and a complete understanding by all participants that insider knowledge did not exist, the price of the security would be:

$$E(p) = P(X)V(X) + P(Y)V(Y) = (0.25)(400) + (0.75)(200) = 250$$

If public knowledge was that X was the true state of the world, the price of the security would be 400. If public knowledge was that Y was the true state of the world, the price of the security would instead be 200. The experiment was done over twelve periods with the price hovering around 250, with the exception of Round 11, during which the price of the security quickly approached 400, the equilibrium price in the case that all participants held the belief that insiders existed and also believed the true state of the world to be X. However, in this case, there were actually no insiders; participants only adopted the belief, without true knowledge, that insiders existed, meaning that after 11 rounds of aggregation, the market failed to make the right prediction. The exploration demonstrates the ability of the IAM to not only collect, but also broadcast even the slightest unfounded notions comprising individual information (such as the hypothesis that there might be insiders who know the true state of the world to be X) or the results of traders "probing" others (Plott, 2000). As attributed above, the presence of uninformed traders do not necessarily adversely affect the ability of the market to perform, since they also assess the perception of market signals given by any existing market-making entity and help the market converge to the true consensus, but it does illustrate some of the imperfections incumbent in the application of information markets in corporate settings, providing for the possibility of errors, insufficient broadcasting, and possibly renewed confusion, if not properly analyzed. Information markets, as with most tools and mechanisms, are not infallible as blatantly depicted in the final periods of the experiment, shown in Figure 2.

In 1991, Camerer and Weigelt hypothesized and confirmed that certain situations exist in which, devoid of insider information, traders adopted behavioral patterns in their purchases similar to those exhibited by traders that perceive the existence of information, simply due to the fact that some traders acted upon the vague notion that other traders were behaving like insiders, resulting in a cascade effect. They refer to their paper on combinatorial iterated dominance (Camerer and Weigelt, 1982) to further explain this.

Therefore, it is not indispensable for the movement of asset prices to be contingent solely upon insider initiative. Shyam Sundar further examines the phenomena exhibited in the final periods of Plott's experiment and determined that the critical convergence to a biased value by a mere three traders, given Plott's experimental design, would cause the market to fail in its prediction of the true state of the world (1988).

Another application of information markets was implemented by the Defense Advanced Research Projects Agency (DARPA), a government think tank under the jurisdiction of the Department of Defense (DOD), wanted to use information markets to analyze, evaluate, and ultimately predict future event upon which several public policy plans remained contingent. To this end, their proposal for this employment of prediction markets involved the creation of a Public Policy Analysis Market allowing traders to bet on a number of outcomes for uncertain events tied to the policy of the United States' economic health indices, international relations, healthcare policy, environmental issues, military plans, and other relevant futures contracts. Included in the motions for proposal were the prospects of trading on terrorist acts, and in response a number of objections were stated, including not only the trivialization of and the lack of due regard given to the gravity of the prospect of such an event happening, but also the idea that it would be setting a dangerous precedent for *mis*information: first, terrorists could be broadcast market signals, effectively informing the government of its countermeasures, and therefore heightening the likelihood of a pre-emptive attack by the terrorists; and second, terrorist would be able to use their own insider knowledge to engage in arbitrage, market manipulation, and collusion, the last of which would in effect lower the barriers to entry for newly formed terrorist groups to attack the United States.

<u>Market Manipulation</u>

To the contrary, however, the uproar caused by the DARPA terrorist proposal may have been rather tenuous due to the fact that by the tendency for markets to achieve information symmetry, there are inferior incentives for terrorist to manipulate the market in their favor, and that since the project would not yield a great deal of benefits, as summarized in the following treatment. Also, due to limited information and paltry informed participants, the market would likely not be liquid enough to make accurate predictions. Therefore, DARPA would probably have rejected the idea of using contracts. The prospect of market manipulation is highly correlated with their scale (Wolfers and Zitzewitz, 2004). One further comment is that in the Terrorist Futures Market, there would be two separate parties of insiders, which would provide for a polarized distribution of insider information, and since it would be in the best interest of each respective "trading faction" to collude with allied participants, manipulate the market, and send false market signals, the social value perceived by both "trading factions" in the implementation of this market would most likely outweigh any monetary benefit, making the rational expectations theory inapplicable to this case and likely prevent the prediction from actually communication the true consensus, rendering the entire market ineffectual. Therefore, because there exist thick markets already for responding to terrorist attacks, this yields additional disincentive for terrorist participation, and less incentive overall for participation for all parties given the demands for cost in implementing such a project. Economists Wolfers and Leigh found evidence of political candidates betting on themselves to create a buzz, which would lead to other parties identifying them as targets for research. With a sufficiently thin market, such a buzz could consume that market into making poor judgments (2002), much to the same effect of the idea that students taking multiple choice reading comprehension tests may answer questions poorly by selecting answers with buzzwords or which are true, but have nothing to do with answering the question asked. Economist Robin Hanson, however, disagrees on some levels, asserting that "noise traders" may improve the accuracy of market predictions, since the mere presence of a few informed traders driving the value of certain outcome probabilities would dwarf the effect of the small volume of noise trading by their ability to inform the other traders in question with their larger scale market signals. In this way, market manipulators could induce motivation through their noise signals to be more inclined to resolve a debate, and therefore ameliorating the problem of noise trading by inciting controversy, which should be resolved since this would provide a greater volume of transactions, which would in turn fulfill the requirements of the Law of Large Numbers.

Arbitrage Opportunities

Arbitrage is another vital consideration in the mechanistic validity of information markets. This includes predictive movements in the swing of prices as they reach convergences, and the idea that because securities are based on what can be though of as binary events, and there may not be a sufficient number of traders, arbitrageurs may be able to act on arbitrage across contracts or those across different markets predicting the same event with different pools of participants with different rational expectations distributions and risk aversion indices. Wolfers and Zitzewitz, however, discovered that the pricing of securities whose outcomes are similar or related, tend to be internally consistent (2004), by studying the co-movement of the 2003 Gubernatorial election. They found that these securities on Tradesports.com absorbed information markets with the reflection of what some economists refer to as simultaneous *time preferencing* (Venkatesh, 1997). In their study, Wolfers and Zitzewitz found that the time series of prices in these markets still followed a relatively random walk as opposed to a predetermined path and that there were no real cases exploited by arbitrageurs based on deviations in correlation that actually led to profit. Figure 3 was included in their study, where the prices were collected every four hours, showing that the movement of the price in the two securities across two markets moved sufficiently closely together, virtually eliminating opportunities for arbitrage.

Prediction markets are useful, however, in their prediction of events with less life-threatening consequences, such as is the case with most of the contracts on Tradesports.com (whose contracts were originally primarily sporting events), Hollywood Stock Exchange (prediction of the winner of various awards such as the Oscars), and Newsfutures.com (whose contracts were originally primarily current events). Some markets, though, due to discrepancies and differing convergence rates, still yield larger opportunities for arbitrage. In 2001, Pennock, Lawrence, Giles, and Nielson demonstrated that the Hollywood Stock Exchange rivaled a panel of professional forecasters in their arbitrarily accurate closeness to the predictions made as well as the actual outcome. Run in part by economist Servan-Schreiber, Newsfutures.com now serves as a consulting company by implementing interfacing with information markets to solve for the deficit of information aggregation incumbent in most firms. Companies such as Hewlett Packard, Eli Lilly, and not surprisingly, Google now employ information market as a crucial source in prediction through the pricing of futures based on certain metrics of their company (2002). Most commonly these include the demand for product features and combinations, coupled with Hedonic processes. Other candidates for prediction include revenue and the sales forecasts that support them, events pertaining to industrial considerations such as suppliers, new entrants, and existing rivals. But the most powerful application of these processes include incorporating strategic decisions, including new product design, mergers and acquisitions, resignation and removal of executives, company expansions, and the allocation of finances to projects (Servan Schreiber, et al), allowing for a more complete extraction of insight for at least reaching the assumptions behind the decisions normally made by a hierarchy of leaders, if not the decisions themselves.

The aggregation mechanism described above is a source of competitive advantage for businesses that require intelligence on not only forecasting, but also a wide variety of corporate decisions such as the inclusion of new product features, areas of operations research, financial strategy, key industrial moves such as mergers, acquisitions, outsourcing, buyer and supplier behavior, competitive moves by rivals, entrants, and competing products. The problem with several corporations is that there is no formalized method of aggregating—collecting and weighing—information, so that business leaders can make the most informed decisions. Take the example of Carly Fiorina at HP. The decision to take of Compaq could have very well have been arbitrary. One might ask, "How accurate of a prediction was made with respect to the losses that HP would incur as a result of a less than ideal acquisition? How much monetary benefit does eliminating Compaq as a perceived rival afford HP? Due to the outlay of cash required for such a move, what is the calculated opportunity cost of other projects this acquisition would be replacing?" These are all questions that would lead to key assumptions for making such a business decision, and though this information is very private, it is vital that all these issues are explored and contingent success factors determined so that certain corporate decisions are not made on irrational premises. Commonly, individuals with extreme proximity to key business processes have developed an intuition and other subjective expectation factors that allow them to arrive at the most rationally developed conclusions for decision-making. This limited information is key to the activity of market makers stated above, but unless it is used in the market, might yield a consistent bias that affects all corporate decisions to which these individuals contribute. Because of the time- and resource-intensive nature of business development, the implementation of surveys, polls, focus groups, and deliberations are seriously constrained and therefore limited on their competitive advantage. Furthermore, such implementation is cumbersome, inconclusive due to inconsistent aggregation methods, and fraught with biases from factors affecting informants that are immeasurable even by statistics gleaned from a group of people. From an operations research point of view, the actual optimization such an implementation is making, is a weighted sum of participants' geographies, personal disposition and incentives, and a plethora of subjective information that causes expert opinion and group deliberations to be an inefficient and therefore non-optimal choice, which in turn are influenced by other constraints, much less the company's own convenience and money. A good example of this is a case where a director of sales who chooses to understate the sales force's performance estimates for the last trimester of his wife's, and then subsequently over-delivers on those estimates.

Another example is the ad hoc committee assembled by Governor Pataki, in an attempt to rebuild the World Trade Center after the 9/11 attack, to bolster Pataki's own political agenda, which has accomplished next to nothing because of improper weighing potential initiatives and the satisfaction it would yield all parties involved. Similarly, appointments and elections for executive positions is a common issue encountered in the field of corporate governance. As recruiting firms will attest to, selecting a new CEO, or any executive is a daunting task, mainly because they are maximizing a monetary, objective metric—revenue or market capitalization—with subjective measures, like the candidate's integrity, ability to motivate the marketing team, or chemistry with the incumbent CFO.

Economists argue that utilizing markets to make or prepare for decisions will allow for the board of directors in such a case to obtain their goal, or at least provide for a path to obtain it. Robin Hanson then gives the example of creating a market with two securities, each with a one-dollar payoff linked to the election of a certain candidate (given the premise of the decision). Mathematically, the share of stock tied to the security of a certain candidate would be priced at its value weighted by the probability of that candidate being employed for the executive position in question. The ratio of the stock option, then, yields the value (effective larger scale payoff) of the company's stock if such a candidate is selected. By the rational expectations theory and the auction structure posited at the beginning of this article, each candidate's money option would sell for a price proportional to speculation, from a rational market, that that respective candidate will be selected for the position.

Plott and Hewlett Packard Revisited

These dynamics are further explained by the experiment conducted by Charles L. Plott from the California Institute of Technology on his concept of the *Information Aggregation Mechanism* (IAM) in conjunction with Kay-Yut Chen of Hewlett Packard Laboratories. The objective of the experiment was to compare of information markets and traditional survey approaches to make printer sales forecasts. They identified pay-off structure, anonymity, and market design as crucial influences on the incentives of the participants to make more accurate and surpass the accuracy of official corporate predictions (Sunder, 1992), and then proceeded to design an information aggregation mechanism for Hewlett Packard Corporation with the aim of predicting these sales, thus testing whether the capacity of any competitive processes could be harnessed and developed into an information aggregation tool for the purposes of business management. The study focused on the participation of

10-15 participants selected from the three divisions over the two departments of marketing and financing departments, to participate in competing to make accurate predictions for monthly sales three months into the future. These participants were selected because of a smaller hypothesis that these divisions had "different patterns" of information about the *target event* (2002), but also the most relevant patterns of information, including market intelligence, client information, pricing strategies, and other non-numerical data which would lend itself to an information aggregation mechanism. The information on their wagers was collected on a weekly basis over a server located at Caltech, with the market being opened at lunch and in the evenings. The laboratory experiments implied that a small number of uninformed participants provided for both market liquidity and what was described as "'consistency' to the market through a process of 'readying' and 'interpreting' the actions of others", much to the effect of the dynamics of a game of poker. Thus five additional subjects were recruited from Hewlett Packard Laboratories, each carrying little or no information, to participate in the experiment (correlating with the presence of non-market makers). The subjects were geographically dispersed throughout California and no public summaries of information were made available for participants during the operation of the prediction market, nor were the official forecasts made known until the prediction market closed, therefore making the information aggregation mechanism the primary form of collecting information, from the "reading" and "interpreting" described above. The individuals were each given a portfolio of shares in markets and cash, a small amount of cash to alleviate the constraints imposed by the opportunity cost to which each individual was subject due to their participation, and a 15-20 minute instruction sessions explicated the structure of incentives, the market mechanism, and the web interface, along with the goals of the experiment and the importance of their participation to Hewlett Packard's business development. Anonymity was enforced to the extent of providing each participant with an identification number, causing transaction information being made public only through these identification numbers. Plott and Chen inferred that taken together in addition to anonymity, the prospect of monetary profit from the experiment, motivation on the organizational level, and compensation for opportunity cost, these were sufficient measures to ensure each participant was properly incentivized to actively engage in trading. Referencing Forsythe and Lundholm, they assumed that their primary choice of a single compound security, paying a dividend in proportion to the level of the item of prediction (in this case, sales), in multiple state contingent contracts, would be a reliable choice for a market asset (1990). They then partitioned the range of possible outcomes. Upon realization of an outcome associated with a given partition, the security tied to that partition would pay off the fixed amount. For example, the interval 0-100 would thus be associated with a security named 0-100 that traded in a market named 0-100, if the final outcome fell between 0 and 100, the corresponding security would pay, say, one dollar per share at the end of the experiment. All other securities would pay nothing (2002). Therefore, upon examination of the prices assigned across all shares assigned to each of the 10 intervals partitioned for the study, one could assign a probability to any combination of outcomes, and to a degree, the distribution of expectations, which yielded not only a more detailed depiction of the information landscape, but also a display of the data numerically—a accurate representation of which would otherwise be difficult to produce with any other method, most notably, the standard survey. So, given the pricing of assets associated to, and thus probabilities of the outcomes of sales a printer unit in intervals between 20,000–30,000 as well as 30,000–40,000 for example, they could predict the probability of sales falling in the combined interval, or that which is associated with sales falling grossly below that interval, and therefore act to close down or activate production lines, or design a new product. The results indicated that the IAM was around 3% more accurate than the official Hewlett Packard forecasts in predicting the actual sales figures, implying that the IAM was more efficient. The event summaries and forecast data from the study are shown in Figures 5 and 6, respectively. In six out of the eight events available from Hewlett Packard official forecasts, the IAM forecasts were more comparatively more accurate.

Another observation is that sell offers tended to exceed buy offers in the duration of the experiment, which is widely interpreted as an indication of impetus toward convergence at a consensus. Intuitively, Plott and Chen note, the early stages are those in which little information is revealed and so prices during these periods equilibriate around the same levels in all possible outcomes. As the market progressed and aggregated more information, prices associated with most outcomes (except the few likely ones) decrease. They observed more sell offers than buy offers because prices associated with most of the outcomes were decreasing (2002) with the progression of the exchange. So, as more information was distributed and acquired by the market participants, expectations became more developed and eliminated the value of outcomes perceived as unlikely to occur, and rationally attempted to sell the assets attached to them. One last note is that the enforcement of anonymity inherent in the methodology made it more flexible, scalable, and incentive compatible (2002) with its ability to limit to a great extent, if not eliminate completely, the strict hiding of insider information, information that was misrepresentative of true value due to biases, or the idea that information or the request thereof might be simply ignored. The incentives, therefore, were able to affect the market fully, enforcing the participation of traders to provide and acquire information based on inferences, and thus employ information in executing their market trades as more rational expectations than they might have otherwise done.

Such accuracy behooved Hewlett Packard to create its own economics laboratory. Several other companies have followed suit, either by outsourcing the task to consulting firms like Common Knowledge Markets, Newsfutures.com, or Consensus Point, or starting their own departments in-house, such as in the case of Google.

From the Plott experiments at Hewlett Packard, one can observe and expound upon the proper implementation of information markets. First, incentives were enforced by allotting a certain amount of cash to participants to alleviate opportunity cost. Second, potential reward payoffs generated active participation and liquidity by those participating. Since the active exchange of a critical number of traders is crucial to the success of any market, this is a primary consideration, since even in the best of implementations, the market will fail, making poor judgments such as those exhibited in the last round of the first Plott experiment mentioned in this paper. Thus the information markets with superior information, such as those involving securities of widely discussed events are more likely to converge at an unbiased consensus estimate than those involving obscure events. The reason for this is that most interested participants will self-select into or out of participation. If participants were selected from the pool of unemployed citizens in the United States were asked to optionally participate in a market on the fate of Sudanese refugees, with insufficient incentive, for example, their lack of interest in comparison to finding a job might cause the market to fail. In addition, if a market implemented shortly after the incident of 9/11 would to predict the probability of such a thing occurring on 9/12, the tremendous comparative social pressure to actually help the victims of 9/11 would likely outweigh the incentives offered by most markets. Hollywood Stock Exchange survives because though trivial, provides a great amount of entertainment value to those participating, in addition to the prospect of reward for information derived from activities in which participation has low barriers to entry. Uncertain and unpopular events, therefore, suffer from insufficient liquidity due to the fewer number of buy and sell offers, and summarily tend to fail due to withholding of information by insider traders; insiders are not given enough incentive to make market signals that benefit the market as a whole. Another premise of necessity is the element of flexibility and scalability in terms of clarity of information given through, terms agreed upon in, and enforceability of contracts. Since deficiencies in any of these would by design impeded the making of rational choices, each of these criteria, as well as the dynamics of designed incentives, is a principal concern in market design an implementation.

Returning to comments by Servan Schreiber and Newsfutures.com consulting, an outline for the procedure of implementing a prediction market is as follows. First, the outcomes for the event in question are partitioned into a range of estimates in which binary predictions can be pigeonholed. The company then invites or selects personnel with pertinent knowledge to participate in a virtual stock exchange based on their confident in each outcome over a certain number of periods. As alluded to above, the aggregate decisions made by the market yield a weighted, consensus opinion as opposed to the average opinion and hence gives due credence to greater monetary confidence. The market is implemented with an online interface in order to lower "barriers to entry" for the user and ensure that the action of and incentives behind trading is not decreased by interior emotional design, and so that it does not interfere with trade actions that make the market decision optimal. This also allows for a large number of geographically dispersed participants, increasing competition of the market, which in turn makes better informed, more rational, and more competitive decisions.

Case Study: Neural Network Improvements

With these considerations, we can outline the ability for neural networks to improve upon information markets as aggregation mechanisms. The methods involved will focus on three main aspects of improving upon the strengths and compensating for the weaknesses of information markets. The first investigation of methodologies is providing an interpretation of whether or not traders are properly incentivized. Incentives being the core driving force of markets, this is a primary consideration because it allows the information market to cater to the risk aversion and information pool of each group of participants (Fayyad, 2002) as opposed to only relying on taking the monetary signals at face value.

The second investigation takes advantage of the idea that a small minority of investors serve as market makers. A neural network is implemented to identify motifs of insider trading activity that leaders to certain traders be, and identify those who bet accordingly, subsequently defining a hierarchy of bettors. The idea behind this is that the non-market makers will behave much in the same way as a market maker once they adopt the insight held by market makers, and behave similarly, with varying degrees of adaptation subject to their own preferences (Safer, 2003). This may exacerbate the effect of the majority of good decisions or that of minority of bad decisions that market makers make, both of which lead to large swings in predictions from which market may not be able to recover.

The third investigation is using this information to identify liquidity and promote consistency within the information market by adding virtual participants that have betting behavior that are consistent to the outwardly observed dynamics (Geyer-Schulz, et al, 2002) exhibited by the market in order to identify the predictors for its success or failure.

The idea for these improvements is not necessarily to combine the two methods, since that would detract from the advantages posed by information markets in the first place (since a simple comparison of their performance in parallel is a relatively trivial investigation), but instead, create a supplementary support system for decisions. A deficiency of both systems of forecasting is the aspect of learning. Neither of these tools offer an underlying structure (Groth, 2003) to the predictions made and therefore further hypotheses must be made in order to test other underlying assumptions. The purpose of these neural networks is thus to take advantage of the way information markets take on the burden of aggregating the information, while the neural network simply provides a dynamic case analysis system (Roiger, 2003) to suggest reasons for why markets succeed or fail. All data was taken from contracts on Tradesports.com and extracted by a third party.

To engage in the first application, we implement a Multiple Layer Perceptron on the measures of time each bet occurred during the day in the individual's time zone, sequential time of the bet with respect to others, time of placement of their five most recent bets, wealth of the individual as determined by their bankroll at time of bettering, and total volume of betting amounts on the compound contract to date. This in turn served to predict the risk aversion and consistency in incentives for each individual.

The first set of results provided by the neural network, the form of weights, is that there is that for select individuals, there is a lower resulting weight placed on some individuals within the amounts that they bet and the frequency with which they bet with respect to the time that they bet. For a select few of these individuals, however, these frequencies increase with time, as suggested by a higher weight value for those two metrics. However, for a last category of individuals, the weight is *negative*, meaning that they were less engaged in betting after a certain period of time (See Figure 6).

The second set of results showed volume of bets according to current wealth and other commitments. As expected, the weights assigned to current wealth were positive and those assigned to amount committed to other contracts was a small negative number.

To engage in the second application, we used the sequential data obtained from the first neural network to implement another Multiple Layer Perceptron on the volume of the five sell offers by other participants occurring before and after the bet in question within the entire market of related contracts, along with the price at which that offer was made, and binary variables indicating which member of the market made those offers. As explained above with the idea of market manipulations, this is an attempt to capitalize on Hanson's claim that controversy will accelerate the aggregation of information on traders and provide a greater number of contract transactions, leading to a convergence that is as accurate as, if not more accurate than, the market consensus prior to the introduction of manipulative market actions. The incidences of these binary variables were then re-routed into another layer to evaluate the probabilities that an effect by specific offer could have influenced the market in such a way that caused other participants to act in a similar or a different manner. In addition, the Perceptron also incorporated many of the measures that are used to identify insider trading for use in the third investigation (See Figures 7 – 9).

The initial results of this investigation were determined by allocating probabilities to intervals defined on the proportion of individuals they would likely lead and follow in making offers. Then, the window of sell offers before and after the incident offer was expanded to ten offers, and participants were partitioned into three categories according to the proportion of the market that would follow them probabilistically, labeled *market makers, fast followers,* and *laggards*. To engage in the third application required using information from the second step to test how well a computerized version of the traders defined computationally in the second investigation to determine how well neural networks trained to adhere rationally to the rules inferred by trading activity, if only given information on certain numbers, would perform in the market. A random stratified sample of the buying behavior of market makers, fast followers, and laggards were introduced to the information gleaned from the market environment, having been trained on 3 months worth of data to test whether or not their market actions might be superior to actual human beings. The neural networks for market makers were also trained by the information exhibiting insider trading activity in order to exploit the potential that insider traders could have to benefit the market as a whole.

The results of this investigation were that the predictive ability of the neural networks did not substantially increase the accuracy of information markets when the original random stratified sample was introduced in addition to the original market. In almost all instances where it did, however, the fluctuations in the market converged around the actual result much faster than the information market did by itself (See Figures 10 and 11).

Discussion

From the results of these investigations, one can make a number of inferences upon the dynamics of markets. From the first study, the beginnings of divergence in incentives can be inferred. Because there are people who start making offers and purchases in larger amounts and in more frequent actions, those buyers are likely to be driven by higher incentives than those who make neither of these competitive moves later in the time period. Also, wealth, though determined to be actual money in an account by the structure of Tradesports.com, also had very high weighting. The weights attributed to monetary participation in other contracts, however, was near zero and non-conclusive. This may be due to the fact that some of these contracts may have been related to the contract in question, or they may have been totally unrelated. This would be reflective of the idea that an individual is better able to diversify their portfolio around a set of related contracts, but nothing can be said about that correlation without finding out what exact other contracts that are superficially unrelated to the contract in question. If the distribution of other contracts a given participant were relatively independent of the contract in question, one could conclude that the volume dedicated to those other contracts may not have an effect on purchasing and offering behavior in the contract at hand. In this second study, an accurate hierarchy could not be readily established upon viewing the weights of the information, besides a brief and likely inaccurate ranking on the probability that a certain participant influenced the "valuation direction" of the traders that made the moves subsequent to the offer. This may be a factor that determined the success of the third study, in which the addition of neural participants, with merely their own reactions to the market information (and no reaction from the market itself), caused greater accuracy in less than 5% of the periods in question. However, regardless of their interactive performance, their addition is undoubtedly correlated to speeding up the market's convergence onto the consensus value much more quickly than it had been from the actual sample itself.

Though this investigation as a whole has given some credence to expounding upon the incentives of individuals, a more thorough treatment remains to be performed in investigating improving and the effectiveness with which incentives influence rational decisions. For example, a hypothesis that a remains to be tested is whether the incentives such as those offered by play money markets actually incentivize participants for long periods of time, or whether eventually the prize of privilege offered in markets such as

Newsfutures.com lose their luster after a certain period of time due to the fact that payoff structures are different between markets such as Newsfutures.com and Tradesports.com. Furthermore, this topic broaches other aspects of information markets, such as methods of measuring liquidity and consistency based on not only the number of participants and their behavior, but also the mechanics of liquidity that are actually offered, and out participants' perception of it might influence their choices differently than in the Hewlett Packard studies with Plott, in which Plott and Chen determined a certain number of players to provide adequate liquidity for a certain scenario. Another aspect to explore, which also may have caused a deficiency in this study, is the idea that some markets are not completely anonymous, and that participants putting more weight on information based on identifying another rational actor that is outperforming them and following their actions might instigate information aggregation, but might also cause the market to "lock up" on limited pieces of information. In this study, a small but substantial weight determined the purchasing and offering behavior or the neural participants, and perhaps given that there was little information otherwise, may have played too great of a role in the market's decisions, and therefore eliminated the benefit of potentially making the market more accurate. Through statistical analysis, one might be able to test determine a measure of risk aversion based on the factors included in the first Multiple Layer Perceptron such as wealth, co-participation in other contracts, and time and volume trading, and such a index might be used to refine the calibration of categorization exhibited in the second stage of this study (Babanov, 2003). Because of this study may not have categorized or simulated traders correctly and as a result only established insignificant results in the performance of the market due to the addition of various classes of participants define by those categories (Bearson, 1999), the results on whether adding more artificial participants that are market makers, or even typical fast followers to "read and interpret" information yielded by such market makers and validity of constructing a ranking or priority queue-like hierarchy of traders remains inconclusive.

If these methodologies were established, however, one could then investigate the how robust information markets would be, with proper supplementary neural networks, in the face of simulated insider trading, collusion, market manipulation, and attempts at arbitrage (Wang, et al, 2002), which could then be used to test against other market anomalies that are incumbent in group deliberations, such as hidden profiles, cascade effects, and group polarization, to see exactly how the hierarchy of market makers, fast followers, and laggards is traced in eliminating the dynamics that would regularly hinder a group deliberation and allow for insight for determining how to run meetings more effectively.

Conclusion

The predictive power of information markets are centered on the incentives studied in the above investigation and in addition, though attempts to establish a further structure for improvement of information markets proved to be inconclusive, the study still demonstrates the ability for that structure to be determined and evaluated in order to capitalize on the motivations that the information market enforces toward making all parties extract the greatest amount of information for themselves, and aggregating and broadcasting such information by the realization of the rational expectations theory in order to achieve the consensus estimate, removing the deficiencies that are exhibited in group deliberations, and in turn preserving the candor and validity of information transacted. The object of this was to determine a greater number of structural insights that could be gleaned by calculating specific metrics that are made readily apparent in the market's behavior into the activity of its constituents, by capitalizing on the candor afforded by anonymous markets which have been established as one of the most efficient mechanisms of collecting and aggregating information, and to identify those cases in which they will fail in an effort provide for a support structure to compensate for that possibility, thereby enhancing the ability for prediction markets to determine why people make the decisions they would make when using information markets for corporate decisions. The potential of wielding such amounts of information is a valuable source of insight for corporations in how to direct their inquiries and group deliberations. For example, if this study were to prove the validity of methods with which to identify market makers and fast followers, perhaps a corporation could form a committee based around a group of such people, or question the assumptions of those who are not considered as savvy in a certain field, to improve the basic communication that occurs in business settings. In addition, information markets could also be used to improve the portfolio of corporate projects, just as real futures markets are used to hedge against current price changes. Hahn and Tetlock explored this with an example pertaining to public policy in the household that, if a parent was concern and more confident than not that his or her child's education quality would decline as a result of a policy initiative, that parent could bet against the policy's success on a prediction market so that he or she would later have the money to send their child to a private school of invest in a private tutor. Similarly, a corporation producing drugs that are used to effect abortions might be interested in betting in favor of the appointment of Samuel Alito as Supreme Court Justice in order to have money to invest in other projects or hire an assassin. The liquidity that this offers corporations only serves to make the adoption and divestment of projects more efficient. If this were perfected and established as common practice, then we as a society could make better contingency plans and hedge against major disasters such as the recent disasters in New Orleans and the impending ones in Florida and some parts of Africa, and plan for preventative measures instead of investing in capital that may expire unused. Better security can be formulated to finance higher priority measures such as the future of education and health care. Information markets, if properly dissected for pertinent information, could then be used to improve the application of neural networks and other artificial intelligence. Smaller information markets can then be erected on the microeconomic functions of organizations, such as an information market to support neural network decisions in determining whether a patient has cancer and allowing doctors to consider a variety of options for patient care. By improving information markets for corporate practice, one can provide for a safer precedent for making corporate decisions, but also enable organizations in general and the economy at large to make the most rational decision possible by alleviating the constraint of information and providing liquidity to hedge against the concerns. This, in turn has tremendous implications for the principal-agent problem, as well as corporate culture as a whole. Andrew S. Grove once outlined the idea that the most developed ways of corporate execution is that of an established ecosystem of ideas so that corporations as a group can consolidate their information into tangible results. By raising the standards by which information is handled and providing for a the premise of consistent rational choices, information markets can serve as the driving nexus which unites all people in participating in that large organization we call our society.

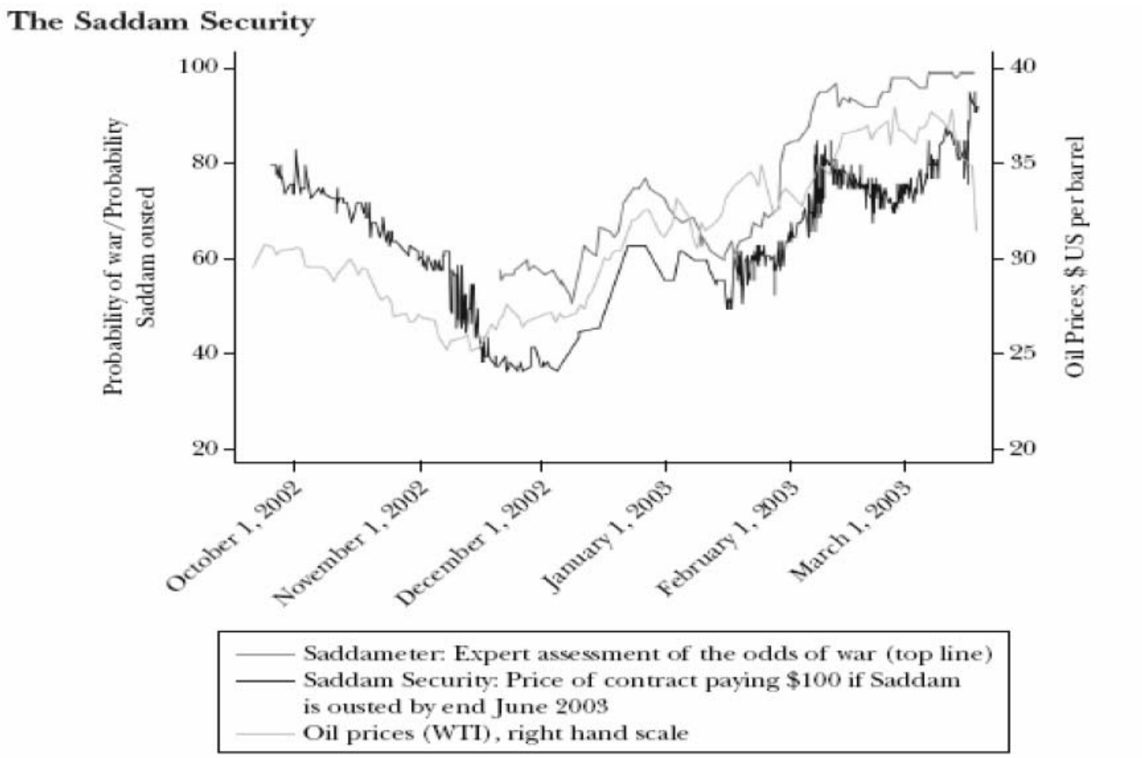

Figure 1: The Saddam Security
(Source: Wolfers and Zitzewitz, 2004)

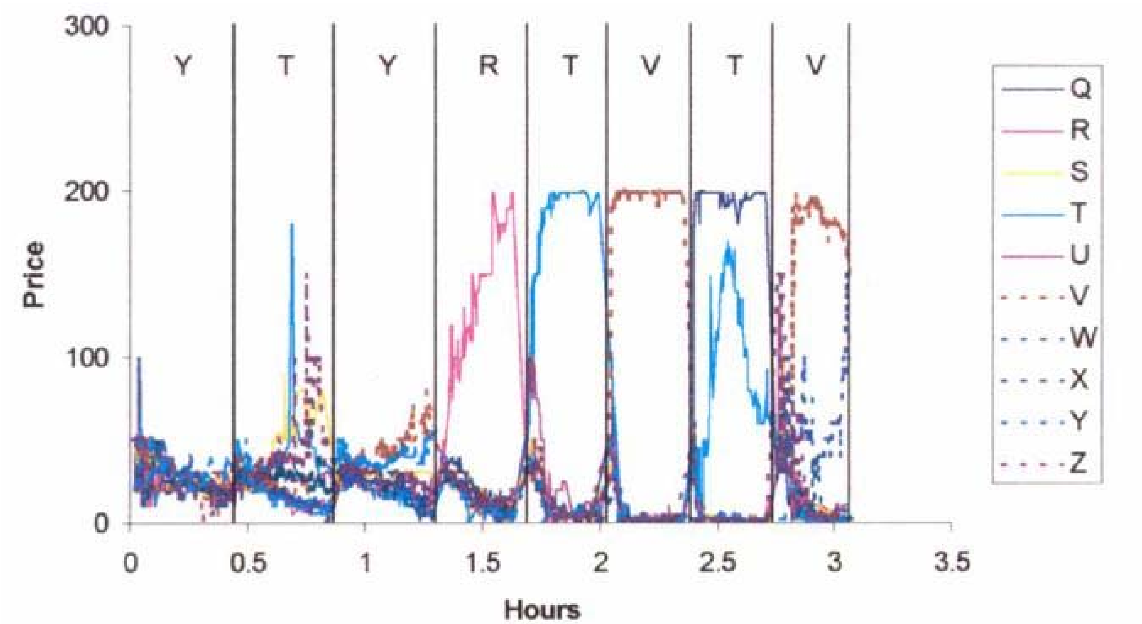

Figure 2: The Market of the Actual State Emerges Quickly with the Highest Price.
(Source: Plott, 2000)

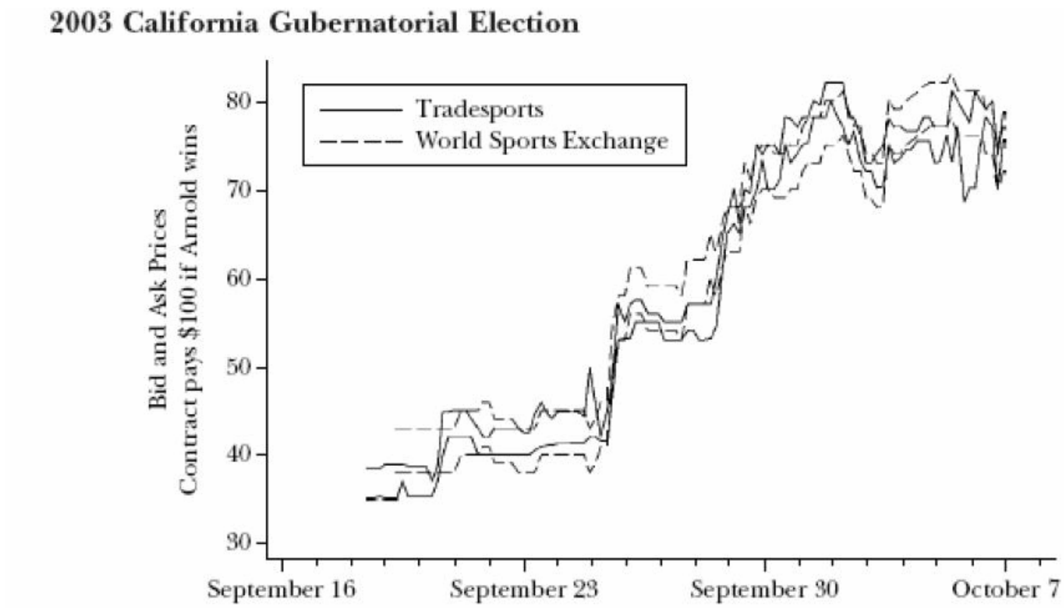

Figure 3: 2003 California Gubernatorial Election
(Source: Wolfers and Zitzewitz, 2002)

	Event to be predicted	Number of active participants	Date [time] of experiment	Experiment Duration	Number of Markets
1	Profit sharing percentage to be announced by upper management	16	10/96 [11:00 AM-1:00 PM; 4:30 PM-8:00AM]	1 week	8
2	Next month sales (in $) of product A	26	11/96 [11:00 AM-1:00 PM; 4:30 PM-8:00AM]	1 week	9
3	Next month sales (in units) of Product B	20	01/97 [11:00 AM-1:00 PM; 4:30 PM-8:00AM]	1 week	9
4	Quarter ahead monthly sales (in units) of product C	21	05/97 [11:00 AM-1:00 PM; 4:30 PM-8:00AM]	1 week	10
5	Quarter ahead monthly sales (in units) of product D	21	05/97 [11:00 AM-1:00 PM; 4:30 PM-8:00AM]	1 week	10
6	Quarter ahead monthly sales (in units) of product B	21	05/97 [11:00 AM-1:00 PM; 4:30 PM-8:00AM]	1 week	10
7	Quarter ahead monthly sales (in units) of product C	24	06/97 [11:00 AM-1:00 PM; 4:30 PM-8:00AM]	1 week	10
8	Quarter ahead monthly sales (in units) of product D	24	06/97 [11:00 AM-1:00 PM; 4:30 PM-8:00AM]	1 week	10
9	Quarter ahead monthly sales (in units) of product E	24	06/97 [11:00 AM-1:00 PM; 4:30 PM-8:00AM]	1 week	10
10	Quarter ahead monthly sales (in units) of product F	12	04/99 [11:00 AM-1:00 PM; 4:30 PM-8:00AM]	1 week	8
11	Quarter ahead monthly sales (in units) of product G	12	04/99 [11:00 AM-1:00 PM; 4:30 PM-8:00AM]	1 week	8
12	Quarter ahead monthly sales (in units) of product H	7	05/99 [11:00 AM-1:00 PM; 4:30 PM-8:00AM]	1 week	8

Figure 4: Summary of Events in Plott Hewlett Packard Experiment
(Source: Chen & Plott, 2002)

Event				IAM Predictions Last Trade	Average Last 60% Trade	Average Last 50% Trade	Average Last 40% Trade
1	Outcome	8.770	IAM Prediction	9.619	9.092	9.259	9.369
	HP Forecast	None	Tail Prob Truncated	0.040	0.038	0.043	0.041
	% error	None	% error	9.683	3.672	5.571	6.829
2	Outcome	220.000	IAM Prediction	234.065	230.136	230.059	230.294
	HP Forecast	249.000	Tail Prob Truncated	0.009	0.008	0.009	0.009
	% error	13.182	% error	6.393	4.607	4.572	4.679
3	Outcome	1152.000	IAM Prediction	1766.399	1814.155	1793.875	1781.017
	HP Forecast	1838.000	Tail Prob Truncated	0.010	0.008	0.008	0.008
	% error	59.549	% error	53.333	57.479	55.718	54.602
4	Outcome	1840.000	IAM Prediction	1612.891	1695.796	1690.102	1683.273
	HP Forecast	1681.000	Tail Prob Truncated	0.008	0.011	0.011	0.011
	% error	-8.641	% error	-12.343	-7.837	-8.147	-8.518
5	Outcome	2210.000	IAM Prediction	1429.839	1526.466	1512.397	1506.579
	HP Forecast	1501.000	Tail Prob Truncated	0.024	0.011	0.011	0.012
	% error	-32.081	% error	-35.301	-30.929	-31.566	-31.829
6	Outcome	128.000	IAM Prediction	91.801	96.985	96.592	95.619
	HP Forecast	90.000	Tail Prob Truncated	0.007	0.010	0.010	0.010
	% error	-29.688	% error	-28.280	-24.231	-24.538	-25.297
7	Outcome	2002.000	IAM Prediction	1828.000	1855.320	1861.382	1867.697
	HP Forecast	2084.000	Tail Prob Truncated	0.008	0.017	0.018	0.019
	% error	4.096	% error	-8.691	-7.327	-7.024	-6.708
8	Outcome	1788.000	IAM Prediction	1728.600	1752.300	1746.033	1755.340
	HP Forecast	1786.000	Tail Prob Truncated	0.008	0.026	0.028	0.021
	% error	-0.112	% error	-3.322	-1.997	-2.347	-1.827
9	Outcome	166.000	IAM Prediction	134.886	126.401	124.748	125.515
	HP Forecast	119.000	Tail Prob Truncated	0.027	0.061	0.073	0.076
	% error	-28.313	% error	-18.743	-23.855	-24.850	-24.389
10	Outcome	30.000	IAM Prediction	15.178	15.017	15.245	15.150
	HP Forecast	None	Tail Prob Truncated	0.148	0.092	0.073	0.072
	% error	None	% error	-49.407	-49.944	-49.184	-49.498
11	Outcome	10.000	IAM Prediction	15.158	15.170	15.308	15.337
	HP Forecast	None	Tail Prob Truncated	0.083	0.082	0.081	0.085
	% error	None	% error	51.583	51.705	53.082	53.368
12	Outcome	17.000	IAM Prediction	15.708	14.991	15.281	15.366
	HP Forecast	None	Tail Prob Truncated	0.085	0.054	0.061	0.064
	% error	None	% error	-7.602	-11.818	-10.112	-9.612

Figure 5: Errors for Hewlett Packard Experiement
(Source: Chen & Plott, 2002)

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