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# Decision Support Markets: An Innovative Business Intelligence Tools

Areej M. Yassin
*University of South Florida*, ayassin@cona.usf.edu

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# Decision Support Markets: An Innovative Business Intelligence Tools

**Areej M. Yassin**
University of South Florida
ayassin@coba.usf.edu

## ABSTRACT

The spirit of business intelligence lies at the heart of information markets. This paper advocates the use of information markets as business intelligence tools for decision support. It highlights the market promising potentials, and the business need for collective intelligence in decision making. Market forecasts can reduce uncertainty surrounding business decisions and improve the quality of input into the decision making process, and thus allow managers to make better informed decisions. Further, this paper presents a heuristic for traders' forecasts of events probabilities. This heuristic extracts additional information from market transactions by incorporating posted, but not yet executed trades. Utilizing pending transactions is hypothesized to generate a more accurate representation of traders' beliefs than other commonly used measures. It might also boost decision makers' confidence in the market forecasts, and as a result, encourages them to embrace it, and make the best out of this invaluable tool.

## Keywords

Information markets, decision support, business intelligence, heuristics, information aggregation, forecasting.

## INTRODUCTION

Information markets are an emerging form of financial markets, whose primary purpose is to aggregate information rather than to raise capital, or transfer financial risk (Hanson, 1992). There are many types of information markets. Although they differ in many respects, such as market goal, design, and incentives structure (Chen and Plott, 2002; Spann and Skiera, 2003), they generally consist of one or more events for which you would like a reliable forecast. Traders in the market wager on virtual stock that yield payments based on the event outcomes. The result is a trading price that tracks the consensus opinion (Hanson, 1992), and can be interpreted as market-aggregated forecast of the event probability (Wolfers and Zitzewitz, 2007).

The incentive structure and the type of contracts used, can elicit the probability, mean or median value of an outcome (Wolfers and Zitzewitz, 2004). For example, a state-contingent contract, aka winner-takes-all, costs a certain amount and pays off, for instance, $1 if and only if the event occurs, and nothing otherwise. The price of state-contingent contract is constrained between 0-100, and can be interpreted as the event probability. The sum of the prices of the traded state-contingent contracts should be exactly equal to the payoff of the winning contract (Chen, Fine and Huberman, 2001).

The idea of using markets for decision support was first introduced by Hanson (Hanson, 1999), where he used the concept of decision or conditional markets to illustrate how market forecasts can be used to inform decisions about an event, given market predictions of another. Berg, Nelson and Rietz, (2008) provided an elaborate analysis of 1996 presidential election market and described how market prices can be used to support decisions, for example, republican voters could have supported a stronger candidate with a better chance of beating Clinton.

This paper advocates the use of information markets as decision support systems inside organizations. Information markets have at heart the basic functionality of a business intelligence tool. Their ability to aggregate desperate information scattered throughout the organization, and outside its boundaries, to forecast future events, holds great potential for business. The market aggregated forecasts can reduce uncertainty and improve the quality of input into the decision making process. Thus, allowing managers to make better informed decisions. This paper presents a heuristic for traders' beliefs about the outcomes' likelihood of occurrence based on their market transactions. This heuristic takes into account pending transactions in the market because, at different points in time, they might trap valuable information from being incorporated into the price. We hypothesize that the proposed heuristic will outperform other commonly used techniques such as maximum price, average price and others, and will be a more accurate representation of trader's beliefs. We also hypothesize that the availability of multiple predictive measures, such as the proposed heuristic, and other commonly used statistics, will boost decision makers' confidence in the market predictions and consequently, their willingness to incorporate them into their decisions.

The paper is organized as follows: the next section reviews current information aggregation and forecasting methods used in organizations along with their limitations. The use of information markets as business intelligence tools is advocated next. After that we review some successful applications of information markets in variety of domains. Our proposed heuristic and hypotheses are presented next. The conclusions and future directions section concludes this article.

## INFORMATION AGGREGATION METHODS

Organizations employ different methods to aggregate information held by group members. When the issues at hand are purely factual, statistical groups can be used by asking a large group of individuals and calculating the statistical mean or median of their answers (Sunstein, 2005). However, when the group is anchored by a misleading number or the group members are ignorant to the issue at hand, individuals are more likely to be wrong than right, and the likelihood that the group will decide correctly falls to zero as the size of the group increases (Sunstein, 2005).

Alternatively, deliberation can be used to improve group decision making through discussions and debates, especially when the issues are normative rather than factual (Sunstein, 2005). Armstrong (Armstrong, 2006) presented the case against face-to-face meetings demonstrating how ineffective and inefficient traditional group meetings are at aggregating information. Groups often produce inaccurate outcomes because of informational and social influences that impair group judgment by emphasizing shared information, creating hidden profiles, cascade effects, and group polarization (Sunstein, 2005).

In addition, individual group members have limited information processing capabilities, and therefore rely on heuristics such as representativeness, availability, framing, anchoring and adjustment to reduce the cognitive load of predicting values or assessing probabilities (Tversky and Kahneman, 1974). The use of heuristics reduces complex tasks to much simpler judgmental tasks, creating biases and errors in individual judgments that are propagated and often amplified in group settings.

The Delphi method is utilized to diminish the informational and social influences of deliberative groups. The Delphi technique uses a self administered questionnaire and a system of controlled feedback, where a group of experts participate in anonymous rounds of estimates and feedback until the degree of convergence reach a desired threshold. Members are allowed to communicate their judgments and conclusions anonymously in a form of summary statistics, along with their justification and reasoning behind them. Experts can then respond to the forecasts and justifications of others, and revise their own based on the feedback they receive. Finally the individual judgments are statistically aggregated (Armstrong, 2001).

Rowe and Wright, (1999) reviewed 25 empirical studies that evaluated the effectiveness of the Delphi method in terms of forecasts accuracy and quality. Their review showed that Delphi outperformed both statistical and interactive groups roughly over 80% of the time. Although the Delphi technique proved to improve forecasting and decision making, it has its own limitations. In addition to the possible difficultly of recruiting experts in any area of interest, Delphi does not have an incentive structure to motivate experts to reveal their true beliefs. Also Delphi does not allow incorporation of additional information into the forecasts because it offers results only at a certain point in time.

## MARKETS AS BUSINESS INTELLIGENCE TOOLS

The key to any business intelligence tool is the ability to aggregate information from many sources, summarize it into meaningful measures, and display it appropriately in terms of form, and level of granularity. Perhaps the capabilities of business intelligence tools have changed dramatically since the term was first coined by Luhn in his 1958 seminal piece, but the main objective of BI tools is, and will always be, to inform decisions.

Business Intelligence tools can uncover trends or patterns that were previously unknown, and improve the quality of inputs to the decision making process (Negash, 2004). They can also forecast future events such as product sales, market trends and project delivery dates, and provide managers with a realistic view of current conditions to improve management understanding of current situations, or help managers form more realistic expectations of performance.

The spirit of business intelligence lies at the heart of information markets. Much of the enthusiasm for using information markets as a method for eliciting forecasts, and aggregating information held by individual members of an organization, came from the strong-held belief in the power of collective intelligence to overcome the limitations of the various aforementioned methods of forecasting and information aggregation.

Teams and individuals of an organization oftentimes feel they do not have enough information, or insight to inform business decisions, such those related to demand forecasting, market assessment, and production planning. Information markets can be used to transfer information and intelligence from those who have it, to those who need it to make decisions (Hopman, 2007).

The ability of markets to aggregate information dispersed among individuals can be traced back to Adam Smith and his invisible hand theory (1976). The invisible hand process works via free markets and division of labor where outcomes are produced in a decentralized way, with no explicit agreements between thousands of independent, utility maximizing agents, whose aims are neither coordinated nor identical with the actual outcome, yet bringing wealth to their nations.

This vision of decentralized planning of economies that secures the best use of knowledge in society is what Hayek (Hayek, 1945) believed can be maintained only through the free markets price system. Thus, in a society where individuals, spatially separated from each other (decentralized), each has only partial local knowledge, and their thoughts and believes are diverse and independent, it does not matter if only few knew about a certain circumstance, as long as they all act and think independently seeking their self interest, free markets can collect, coordinate and ensure cooperation where the whole act as one bringing about a collective wisdom purified from cognitive problems of those few (Surowiecki, 2004).

Green, Armstrong and Graefe, (2007) discussed how information markets can avoid the drawbacks of existing methods such as Delphi. For example, participants self select to participate in the market if they believe their private information is not yet incorporated in the market price. Also the market provides continuous forecast as more information get incorporated in the price, and offers continuous incentives for true revelation of beliefs, where traders can benefit financially by buying and selling according to their beliefs.

## MARKETS SUCCESS STORIES

While research on information markets has witnessed an exponential growth in the number of published articles in the last ten years (Tziralis and Tatsiopoulos, 2007), information markets have been around for a long time. Betting on political outcomes has a long tradition in the United States, with large and formal markets, such as the New York betting market, operating for over three-quarters of a century. These markets had a remarkable predictive accuracy and had an astonishingly large volume of activity, which at times dominated stock exchange transactions on Wall Street (Rhode and Strumpf, 2004).

Today, Iowa Electronic Markets (IEM), the most well known application of information markets, is offering markets in which traders can bet on a wide variety of events ranging from the outcomes of presidential elections to the periodic interest rate decisions of the Federal Reserve's Open Market Committee (Hahn and Tetlock, 2006). Since 1988, prices on the IEM have proved more accurate than traditional polls in forecasting elections more than 75 percent of the time (Forsythe, Nelson, Neumann and Wright, 1992; Hahn and Tetlock, 2006).

The Hollywood Stock Exchange (HSX) is another successful application of information markets. Traders in the HSX buy and sell shares of their favorite actors or movies causing securities' prices to rise or fall. Prices of securities are used to predict Oscar, Emmy, and Grammy award winners and movie box office returns and they prove to be highly correlated with actual award outcomes. According to the most recent HSX press release, players correctly predicted 29 of 37 Oscar nominees for the 81st Annual Academy Awards, with a 78.4% success rate, bringing HSX' 11 year average to an impressive 82.1%.

There is a large and growing number of Web-based information markets designed to aggregate information and forecast events in a number of areas, including sports, politics, finance, law, entertainment, and even the weather. Some examples include NewsFutures, Intrade, TradeSports, Inkling Markets, Goldman Sachs and the Foresight Exchange. Other examples of regulated derivative markets are HedgeStreet and the Chicago Mercantile Exchange.

In 2006, over 25 companies in the United States had started to experiment with information markets, including Yahoo, Google, Microsoft, GE and HP (King, 2006), to forecast sales, predict which products will be successful, and to help make business decisions. For example, Chen and Plott (2002) described series of experiments conducted at Hewlett-Packard laboratories for the purpose of forecasting sales resulting in the market outperforming HP forecasts 75% of the time.

Ortner (1997, 1998) ran an experiment using information markets at Siemens Austria to explore the potential use of such markets to support project management decisions. The experiment was designed to forecast delays and reveal information about the project progress resulting in market prices anticipating delays long before the official release of information. These results demonstrated a satisfactory forecasting potential of these markets in supporting project management decisions.

Intel integrated an information market designed to forecast demand into the company's standard forecasting processes. The results of early experiments showed that market forecasts are stable, responded well to demand fluctuations, and at least as accurate as the official forecasts, with 75% of market forecasts falling within 2.7% of actual sales (Hopman, 2007). In addition to using the market to generate forecasts, Cowgill, Wolfers and Zitzewitz (2008), analyzed Google's internal prediction market and showed how the market can be used to track information flow within the organization and how it responds to external events.

**HEURISTIC FOR BELIEFS**

Information markets indeed avoid the bulk of drawbacks of other methods (Sunstein, 2005; Green et al., 2007), and the aforementioned experiments demonstrate the feasibility of using information markets in a business environment.

However, it is important to note that the market efficacy should not be measured based on the price predictive accuracy. The market itself does not predict the future, traders do. The market merely aggregates what the traders know. In other words, it is possible to have an inaccurate price forecast that is highly reflective of the mean belief. Thus, regardless of whether the price is an accurate forecast of an event probability or not, as long as the market aggregates information and the price reflects the market's mean belief, the market is considered a success.

This paper introduces a heuristic for traders' beliefs about events probabilities. This heuristic is based on their trading behavior as demonstrated by their executed and pending transactions in various outcomes in the market. Drawing from our knowledge base, it is assumed, according to the efficient market hypothesis and rational expectations theory, that efficient markets aggregate all available information driving the price to a rational expectations equilibrium, which theoretically should reflect the mean belief. Empirically, markets are not perfect information transmission and aggregation systems, and hence the price does not always reflect all the information in the market (Grossman and Stiglitz 1976; Noeth, Camerer, Plott, and Webber, 1999; Plott, 2000). As a matter of fact, the degree to which markets aggregate information, and prices accurately reflect the mean belief, is still an open question.

Prices do leave unaggregated information in the form of pending transactions in the market. Traders submit orders based on their beliefs, and their beliefs will not get incorporated into the price unless their orders get executed, and due to liquidity issues, market thinness, or homogeneity of beliefs, this may never happen. Our hypothesis is that an aggregated measure that takes pending transactions into account, is a more accurate representation of traders' beliefs, and may generate more accurate predictions of actual outcomes, than other commonly used measures such as the last trade price, maximum price, average price and volume-averaged transaction price.

For each trader *(T_i)* in the market, calculate her/his belief in each outcome probability of occurrence using the following heuristic:

$$P_i(S_j) = \frac{\text{Money invested (MI) in } S_j + \text{Money willing to invest (MW) in } S_j}{B}$$

Where the amount of money invested *(MI)* in an outcome *(S_j)* equals the number of shares bought in the outcome times the price paid for each (e.g. 2@10 =$20). The amount of money the trader is willing to invest *(MW)* in an outcome *(S_j)* equals the number of shares s/he is trying to buy (pending transactions) times the price s/he is willing to pay for each. *B* is the trader's bank in the market. All traders start with an equal endowment of credits or money in their banks at the beginning of each trading period.

For each trader *(T_i)*:

$$\text{(MI in } S_1 + \text{MW in } S_1) + \text{(MI in } S_2 + \text{MW in } S_2) + \dots + \text{(MI in } S_j + \text{MW in } S_j) <= B$$

And

$$P_i(S_1) + P_i(S_2) + \dots + P_i(S_j) <= 1$$

Traders' beliefs calculated using the above heuristic will be updated automatically whenever new bids are posted.

The issue of price proximity to the market mean belief, is also directly related to an important open question in information markets; how to limit manipulation (Wolfers and Zitzewitz, 2006). What makes markets vulnerable to manipulation is our reliance on the last trade price as a forecast of an event probability, where all it takes is a group of traders acting collusively to influence the price (Hansen, Schmidt and Strobel, 2004; Hanson, Oprea and Porter, 2006; Rhode and Strumpf, 2006).

While it is hard to prevent manipulation, it is still possible to detect it. Having an alternative measure of traders beliefs available to decision makers, along with the last trade price, can significantly reduce their anxiety about the possibility of having an abnormally inflated or deflated price. Thus, the availability of this aggregated measure, in addition to the price, can serve as an assurance method to the price representativeness of beliefs. It is conjectured that this measure will boost decision markers confidence in the market price, and as a result, their willingness to base their decision on it will also increase.

**CONCLUSIONS AND FUTURE DIRECTIONS**

This paper contributes to the information systems literature by advocating the use of information markets as a business intelligence tool for managerial decision support. It highlights the market great potentials and the business need for collective intelligence in decision making. It also proposes a new heuristic for traders' beliefs that attempts to extract additional information from pending market transactions. To our knowledge, our proposed heuristic is the first to utilize posted but not yet executed market transactions.

This paper is the first step in a long term research project that aims to identify ways of making this innovative business intelligence tool more useful to managers. As part of a larger study, we intend to test the effectiveness of the proposed heuristic in predicting the actual outcomes compared to other techniques such as last trade price, maximum price, average price and volume-averaged transaction price. We also intend to test the impact of the availability of multiple predictive statistics, such as the proposed heuristic, last trade prices and other measures, on decision makers' confidence in market predictions, and on their willingness to incorporate them into the decision making process. We hypothesize that the availability of multiple measures will boost decision makers' confidence in the market predictions and will help clear or confirm doubts on whether or not it has been manipulated. We also hypothesize that the proposed heuristic will outperform other commonly used measures of traders' beliefs such as average price, maximum price and others.

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