# Work in Progress: Do They Really Mean It? Assessing Decision Market Outcomes

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**Abstract:** Decision markets are social media for decision making where the options to choose from are traded for (with real or play money) by the decision makers. The market equilibrium resulting from the competition between the options offered by sellers and sought for by buyers is interpreted as a collective consent and the relative market prices are interpreted as a ranking of the options. However, on decision markets like on financial markets market equilibrium prices may also arise out of mimicry resulting from either indecision or pure greed. The more the trading behavior is driven by indecision or greed, the less the equilibrium prices reflect genuine preferences. This article proposes a novel approach to decision making. It further describes to rely on artificial perturbations of a market's equilibrium for uncovering indecision or greed on decision markets. Based on the hypothesis that profit seeking is affected by psychological norms that can be activated by context cues and social interaction, an experimental evaluation is proposed that shifts a market's framing between a competitive individualistic and a collaborative communal setting. Social norms in the collaborative communal setting are expected to lessen greed and thus give ways to true preferences: The equilibria of markets with a collaborative communal setting are therefore expected to be less vulnerable to artificial pertubations than those with a competitive individualistic setting. This article describes in a principled manner first the market perturbations, second the experimental evaluation framework.

## 1 Introduction

On a single day, people make several decisions in private, public and corporate contexts. Decisions are made intuitively, trivially, spontaneously or routinely. Other decisions, which are likely to be more far-reaching, need more informational support, planning, the

involvement of other people or need to be made collectively. Methods for supporting such decisions can be subdivided into those based on the analysis and projection of historical data, e.g. time series analysis, and those based on the aggregation of individual knowledge such as surveys and polls of experts or people concerned, consensus based methods such as meetings of expert boards or voting based methods such as the Delphi method. With the advent of the Web 2.0 era, tools for participation of a large group of people for collaboratively creating content came into widespread use [DRH11]. Typically, wikis, blogs, social networking services or tagging services come to mind when thinking of these Web 2.0 tools. Recently, the ability of markets for aggregating information by their price mechanism is also gaining interest as another means for collaborative content creation. There, markets allow for aggregating dispersed individual knowledge from a large group of people into a shared understanding, tapping the so called "wisdom of crowds" [Sur05]. One may argue whether markets are some kind of social media at all. From the authors' point of view, markets reasonably can be counted among social media. Markets in general exhibit social characteristics, namely establishing contact between humans, enabling the exchange of goods and information and providing additional information by the pricing mechanism. Markets thereby utilize a form of human or social computation. There, market participants assess the information available and derive their trading actions accordingly. The pricing mechanism of the market then integrates the trading actions of all participants and produces an aggregated result, the price. In the past, the algorithmic calculations of the pricing mechanism were carried out by humans. The computerization of markets nowadays helps to enhance this aggregation of assessments by overcoming limitations such as language and geography and by providing supportive processing capabilities.

The origin of applying market principles for the primary goal of information aggregation dates back to the Iowa Electronic Markets (IEM) in 1988. Then, the organizers of IEM first employed so called "prediction markets" for forecasting presidential election results in the U.S. [FNNW92]. With prediction markets, the price mechanism is used to aggregate dispersed information into forecasts of uncertain future events [WZ04]. This is based on Hayek's hypothesis of markets being able to aggregate information by their price mechanism [Hay45]. Possible outcomes of an uncertain future event are represented as stocks on a market. Participants then trade shares of these stocks according to their assessment of the likelihood of the underlying outcome. The resulting prices are interpreted as the aggregated assessment of the participants on this likelihood. The payoff of participants is based on the accuracy of their individual forecasts. For every share of the occurred outcome they hold at market end they receive a payment, for every other share they leave empty-handed. Hanson and Berg both advocate the usage of markets as a means for aggregating information for their advantages in comparison to other information aggregation methods. Markets are decentralized and relatively egalitarian due to their availability over the Web and low entry barrier and allow for a continuous, direct and timely participation of people not found with other methods. They scale well in terms of number of users and stocks and they are fun to participate in due to their competitive nature [Han99] [BR03]. Recently, the ability of markets to aggregate information is more widely applied under the terms information aggregation markets, preference markets or decision markets for aggregating all kinds of information for purposes such as product innovation [DSS10], managing ideas [CGH$^+$10] [LBP07] [BAM09], research portfolios [Gas08] or even reviews of scientific

articles [Rob09]. Common to these markets is the fact that a future decision (e.g. which ideas to follow, or product to produce) is supported by the aggregated information. In this paper, we investigate all those markets that support or influence a future decision and we thus refer to these markets to as decision markets as a common denominator.

Incentives for participation in prediction markets are straightforward as people are rewarded based on the accuracy of their forecasts. That is, the more accurate and the earlier participants forecast the actual outcome the more they are rewarded. This reward may manifest itself as a monetary payoff as well as an increase in reputation for forecasting accuracy. Thus, the focus is typically on forecasting accuracy when evaluating the results of prediction markets [BNR03] [BNR08] [Luc08] [Gra09]. In the more general domain of decision markets, the goal of the market organizer is to aggregate the individual preferences of participants with respect to certain options of a decision. That is, participants reveal their consent or rejection by buying or selling shares of the respective options. Mostly, no external event exists at market end to evaluate the revealed preferences and the measure of accuracy cannot be consulted for rewarding participants. We thus distinguish between prediction markets and decision markets[1]. Prediction markets in this context are characterized by the existence of an external event, the determination of participants' payoffs based on the accuracy of their forecasts and the resulting incentive for participants to sincerely reveal their assessments with respect to the possible outcomes. Decision markets in contrast miss the existence of an external event and thus the determination of payoffs based on accuracy. Organizers of decision markets thus rely on rewarding participants based on their overall portfolio worth. Therefore, participants may have two different incentives for participation, one arising from the communication of their sincere preferences and one arising from the maximization of their portfolio worth. When buying one's favorite option is also the best strategy for portfolio maximization, these two categories of incentives might be translated into similar market behavior. But one cannot assume that this is always the case. As market organizers are interested in the aggregated preferences of participants they should be more interested in participants communicating their sincere preferences rather than in them maximizing their portfolio worth. In this paper, we propose a method for discerning prices resulting from portfolio maximization and from revealing sincere preferences. We further want to seek feedback from the social media community prior to executing an experimental evaluation.

The remainder of this paper is organized as follows. After this introduction on the overall functionality of decision markets we describe in the next section our approach for discerning different possible origins of a market's equilibrium by employing market perturbations. Then, we present the intended testing of the expected behavior from a psychological perspective. This is followed by a delineation of the experimental setting we devised for assessing the pertinence of the approach. We then describe the design of our market software and conclude this paper with a section on related work and future work in this area.

[1] Not all authors make this distinction. The denomination "decision market" is sometimes used in the literature in lieu of "prediction market".

## 2 Uncovering Equilibrium Origins with Price Perturbations

Among his six steps for market design, Hanson recommends choosing a jury who will eventually determine the actual outcome so that traders can be rewarded for the accuracy of their predictions [Han99]. In markets for aggregating preferences, however, consulting such a jury for benchmarking market results would end in the participants trying to predict the jury's assessment rather than revealing their sincere preferences. Thus, such external benchmarks cannot be consulted and no reward mechanism can be defined based on such a benchmark. Markets, however, depend on the existence of a reward that can be gained by competitively trading. Therefore, a common approach is to reward participants based on their overall portfolio worth in decision markets, as e.g. in [DSS10]. This portfolio worth is determined by summing up the virtual money in cash and the number of shares the respective participant holds multiplied by their current prices.

We identify for decision markets the existence of at least two different kinds of incentives for participation. First, participants maximize their portfolio worth, perform good in the leader board and get rewarded by a prize, additional money or reputation. For this maximization participants engage in what is called a beauty contest [Key36]. That is, they try to guess what the average participant will vote for and trade accordingly to exploit this. In this way the market prices will indicate what the average user thinks what the average user will think of the market stocks. Second, as is the interest of the market organizer, participants communicate their sincere preference regarding a given stock. That is, they buy shares of stocks they favor and sell shares of stocks they decline. In this way, participants aim to push forward their favored decision options. Participants may weigh the amount of preference communication and portfolio maximization, i.e. guessing of average thinking, from stock to stock, dependent on personal dedication and involvement with the underlying topic of the respective stock. Resulting from these different kinds of incentives for participation, a spectrum of different kinds of market equilibria should form on decision markets. At one end of the spectrum, the equilibrium results from trading mostly based on revealing sincere preferences with respect to the underlying topics and at the other end of the spectrum, the equilibrium results form trading mostly based on portfolio maximization. Market organizers employ decision markets for aggregating the sincere preferences of participants with respect to certain topics in order to get a joint preference for an outstanding decision. Thus, market organizers are likely to be interested in prices that result from trading predominantly based on sincere preferences rather than on portfolio maximization.

In this work, we assume a market outcome to be of good quality from the perspective of the market organizer if the equilibrium price is the result of mostly sincere trading of participants. We assume a market outcome might be of poor quality if the equilibrium price is based mostly not on sincere trading but on other motivations such a portfolio maximization. Indeed, meaningful decisions are taken by a board, i.e. the traders, only if the board members express what they really mean! We therefore develop a method for assessing this quality of market outcomes. This method is based on the assumption that different traders react differently to price changes due to differences in their attitude towards the underlying decision option of the respective stock. We expect participants who

sincerely favor a decision option to react differently than participants who trade only in that option for portfolio maximization. In particular, we expect sincere traders to endorse their revealed preferences even in the face of possible losses in portfolio worth. That is, they hold their already bought shares or even buy additional shares in that stock. We expect portfolio maximizing traders to sell stocks earlier with decreasing prices. The general approach of our method is therefore to influence market prices and observe the resulting trading behavior of participants.

If market prices change, traders will re-assess the new market situation. That is, they will see if their current holdings still best serve for reaching their respective goal, namely revealing sincere preferences or maximizing their portfolio worth. Traders will then choose the according trading actions, based on their assessment of the new market situation. Portfolio maximizers will check their overall portfolio worth and determine the need of selling certain holdings due to price decreases and for emerging possibilities of further increasing the portfolio worth. If the portfolio worth decreased due to others selling the same shares portfolio maximizers will assess whether they will also sell in order to limit losses. A sincere trader on the contrary will check whether his favored decision option is still being represented by the market situation and whether he needs to trade for achieving a better representation. If his favored decision is still being represented by the market a sincere trader may choose either to keep the current holdings or to buy additional shares to further endorse the representation of his favored decision option. In case the favored decision option is not represented by the market any more, a sincere trader is assumed to try to achieve this representation again by buying the respective shares.

**Market perturbations** For realizing the aforementioned method we propose an approach with market perturbations. There, artificial perturbations are introduced to the market, which could be based on changing the stock prices, the available money or tradable stocks. In this paper, we focus on the perturbation of stock prices. Our goal is to change certain stock prices by introducing artificial sells or buys that the real traders cannot recognize as such and observe the reactions of traders to these changes. Basically, any stock of the market could be chosen for perturbation. For discerning trading based on sincere preferences and maximization of portfolio worth, however, particularly high or low prices, or prices with high volatility should show great promise. In this paper, we focus on lowering high stock prices in order to illustrate the approach of market perturbations. We employ artificial traders for influencing the prices of stocks by their trading actions. That is, these artificial traders participate in the market just like other real traders but their trading actions are controlled by a market perturbation system with the goal of influencing stock prices. The artificial traders are not discernible to the real traders, i.e., the traders have information only on their own portfolio and on the market prices. They do not know how many other traders are involved and they cannot consult the portfolio of other traders. Admittedly, real traders could ask each other whether a trading seriously affecting the market prices has been performed by one of them. We assume, however, that the traders explicitly accepted not to discuss such market related issues, but only their preferences. This assumption is reasonable: The traders form a decision board from which a responsible handling is expected. The decision board is assumed to have decided to use

the decision market, not to unwillingly use and therefore possibly misuse it.

We first wish to determine whether market perturbations overall stimulate additional trading. This is the basis for further analysis. So, our first hypothesis is:

**H1:** Market perturbations stimulate market activity after prices reached equilibrium.

This hypothesis will be tested by comparing the number of trades that are executed before a market perturbation is introduced to the market with the number of trades after the introduction.

We also wish to test whether market perturbations can help identify different origins of equilibrium prices. We argue that greedy traders, or speculators, are more likely to change their portfolio composition, as they are more profit seeking. That is, they should be more sensitive to stock price changes.

**H2:** Market perturbations can lead to changes in portfolio composition.

The changes in portfolio composition during the market lifetime will be analyzed for testing this hypothesis.

Market participants who stated sincere preferences, that is traders not speculating, for a certain decision option should stay with that option even if the price of that stock gets perturbated. Market participants who did not state sincere preferences for a certain decision option are expected to abandon that stock, thus selling their shares of that stock.

**H3:** Profit seeking traders will sell more shares than sincere traders.

This hypothesis will be tested by comparing traders' behavior in terms of their selling actions and their a priori stated preferences. These preferences will be surveyed from participants before market start.

**Perturbation steps** In the following, we give a description of the single steps of a market perturbation. We thereby discern between a perturbation and a perturbation action. A perturbation encompasses one or more perturbation actions which serve to achieve the goal of the perturbation. It may be necessary to perform more than one perturbation action to induce reactions of traders. Furthermore, we wish to design the perturbation actions as naturally looking as possible and it would be possibly suspicious to perform one single disproportionately large trade. For the perturbation process, we define an equilibrium phase to start after the execution of a trade and to last as long as the price changes only in the decimal place. The average price of the stock during this phase is then the equilibrium price pertaining to this equilibrium phase. The exact figures of the perturbation parameters will be adjusted by a pilot study prior to the actual experiment. The single steps are as follows.

**Stock selection** A market perturbation starts with the selection of a suitable stock. Initially, all stocks of a given market are potential candidates for being perturbated.

We select the stock with the highest current price that remained in its equilibrium price for a duration at least as long as the average duration of the previous equilibrium phases of this price.

**Determination of perturbation action** The next step is the determination of the parameters of the perturbation action. This includes the number of shares to be traded as well as the artificial traders for actually performing the trade. We determine the magnitude of the perturbation action, i.e. the number of shares to be traded, depending on current market prices. That is, the artificial trader will sell so many shares that the price being perturbated is lowered by a fraction of the average price of all stocks in the market. For this fraction, we assessed a fraction of 10% to be a good starting point. The number of artificial traders is determined by the number of real traders in the market setting. In a small setting with around 5 participants, one artificial trader should be enough for generating price movement while at the same time not being suspicious. In larger settings, additional artificial traders may be necessary to generate enough price movements. The actual artificial traders for performing the trade are determined by the perturbation system according to the available cash of the artificial traders of the market.

**Execution of perturbation action** The perturbation action is actually executed by the appointed artificial traders.

**Repetition of perturbation action** Subsequently, it is determined from the reactions of the real traders whether another perturbation action will be necessary. We plan to repeat this perturbation action until the perturbated stock reaches the price equilibrium that existed prior to the perturbation or until a certain time elapsed. We determine this time by the average duration of the previous equilibrium phases of this stock.

## 3 Testing the Expected Behavior from a Psychological Perspective

As mentioned above, two categories of incentives can be differentiated in decision markets: portfolio-maximization and expression of sincere preferences. Since market behavior that is (predominantly) driven by the motivation for portfolio-maximization might spoil the validity of the market outcome, the market organizer should be interested to both *measure* the magnitude of portfolio-maximizing trading and to *influence* the magnitude of portfolio-maximizing trading.

**Theoretical framework** The market perturbation method proposed in this paper aims to measure this magnitude of portfolio-maximizing trading. The validity of this approach relies on certain assumptions on motives and on how these motives translate into market behavior. To strengthen the empirical support for the market perturbation method, these psychological assumptions should be tested by social research methods, as outlined in this chapter.

To establish a theoretical framework form which testable hypotheses can be deduced, one needs to conceptualize the psychological states of "portfolio-maximizing" and "sincere-preference-expression". We therefore adopt the Unified Theory of Social Relations by Fiske [Fis92]. According to Fiske, human social interactions are shaped by four basic social norms, called relational orientations: Communal Sharing, Authority Ranking, Equality Matching and Market Pricing. We focus on the two orientations most relevant to our work: Communal Sharing and Market Pricing. Communal Sharing can be described as a norm to share your resources without restrictions and to contribute them to the welfare of the relevant group. In contrast, a Market Pricing orientation demands precise price determination by market processes and trading for one's self-interest. People differ by the extent they "use" these orientations in social interactions across situations, but also different situations activate specific norms.

Clearly, the Market Pricing orientation seems to resemble the norms of a market. The more the Market Pricing orientation is active in a decision situation, due to personal traits of the trader or situational cues, the more these norms advise profit-orientated and calculative behavior. The implications of the Communal Sharing orientation in a market context is less obvious. We hypothesize, that a strong Communal Sharing orientation should foster sincere trading, but only if the other participants are perceived as a relevant group. Together, both orientations seem relevant to our context. To limit the complexity of the first experiment, we propose to focus on the Market Pricing orientation for hypothesis testing and experimental manipulation, measuring the Communal Sharing orientation as a variable for exploration.

**Testing the assumptions** The first critical assumption for the validity of the perturbation method is that market participants differ in the extent they respond to the incentives of profit maximization and expression of sincere preferences. To test this assumption, we measure the strength of the actual state and the personal trait of the Market Pricing orientation of each trader in the decision market by survey methods before the market has started.

> **H4a:** The surveyed Market Pricing orientation on market level exhibits a significant variance.

The second assumption is, that traders sell more of the perturbated option because of their self-interest, i.e. portfolio maximization effort. Since traders that consider the market a (strong) Market Pricing situation should trade in their self-interest, they aim to maximize their portfolio; these traders should therefore react by selling the perturbated option, if the assumption is true. In contrast, traders which do not consider the market as a Market Pricing situation should not sell the perturbated option. This assumption should be tested by two methods: A correlational and an experimental. To test the second assumption correlationally we will simply compare the surveyed relational orientation with the selling behavior after the perturbation. We then expect:

> **H4b:** Traders that consider the market a Market Pricing situation will sell more perturbated shares than traders that do not consider the market a Market Pricing situation.

While, if Hypothesis 4b is supported, it seems plausible that the traders sell the perturbated option because of their self-interest orientation, one cannot exclude alternative explanations of this relationship, due to the correlational nature of the data. To validate the assumption of causality we propose an experimental manipulation (so called framing) which activates two different types of relation orientations - market pricing versus collaboration. The framing refers to the sum of situational cues and instructions individuals are exposed to before and during participating in the market. These signals should at least co-determine how the participants perceive (or frame) the situation, and thus, the extent to which particular relational orientations are made salient to the individual. In this study we design the experimental instructions in two variants: In the Market Pricing - high - condition the situation will be framed as a profit seeking market task. In the Market Pricing - low - condition the situation will be framed as a collaborative task. Manipulating the active relation orientation by framing has already been shown to successfully activate either profit seeking or collaborative behavior in economic decision making tasks [KRB10]. If the selling behavior of the perturbated option is caused by self-interest, albeit a strong Market Pricing orientation, the effect of the perturbation should be greater in the Market Pricing - high - condition than in the Market Pricing - low - condition.

**H4c:** In the Market Pricing condition, traders sell more of the perturbated option than in the Communal Sharing condition.

If the hypotheses H4a, H4b and especially H4c are supported, there is strong evidence that the proposed perturbation method is a valid tool for measuring the amount of self-interest in a decision market. Furthermore, if H4c is supported, one can consider the framing manipulation a first hint how to design and introduce decision markets to enhance the amount of sincere trading.

## 4 Assessing the Pertinence of the Approach

For exploring the impact of the approach of market perturbations we plan to conduct both a pilot study and an experiment. The pilot study will be executed with a small sample of around 30 participants in order to investigate the mode of operation of the approach, to record the emerging usage patterns of the participants and to incorporate these findings into the modeling of the hypotheses as well as the adjustment of the market perturbation approach. However, conclusions on correlation or causation cannot be drawn from a small pilot study. Therefore, we plan to also conduct market experiments. The effects we want to observe occur at the market level. For an inferential statistical evaluation of the results we need a sufficient number of observations at the market level for both the control group and the treatment group. In the following, alpha error probability is the probability of falsely observing a difference when in truth there is none. Testing power denotes the probability of a statistical test to detect an effect of a certain size. If we define an alpha error probability of 0.05 and a minimum testing power of 0.9, we need at least 20 independent observations to identify big effects [Coh92] [FELB07]. Therefore, we plan for 20 market sessions each for the treatment group and the control group. In each market session one market will be

performed with 4–6 participants and one artificial trader. Market participants will not be informed of the presence of an artificial trader and they will communicate - if at all - their preferences but not market-related analyses to each other. We plan to execute the market experiment as a laboratory experiment. The advantage of a laboratory experiment is to be in control of all the variables that are relevant to the experiment. In the laboratory the experimenter can reliably segment participants into two groups which are comparable in their attributes with no systematic differences with respect to the dependent variables of the experiment. The experimenter then introduces a variation in the independent variable and observes the resulting changes in the dependent variables. At the same time the experimenter can control other variables at fixed levels thus eliminating their influence on the dependent variables. The independent variables describe the treatments. For them the effects should be evaluated from the study. The independent variable of interest in this study is the application of market perturbations. It can take two values: no perturbation and a perturbation of lowering high equilibrium prices. The dependent variables are as follows. The number of trades measures the overall trades that have been executed in a decision market. The portfolio change measures the degree of portfolio changes a participant realizes. The number of sells measures the number of selling trades that the participants performed in the decision market.

A single market experiment session in the laboratory then proceeds as follows. Participants get an introductory tutorial explaining the overall idea of assessing decision options by employing a market mechanism, the layout and functionality of the market, the buying and selling of shares and the subsequent increase or decrease of stock prices, the market maker mechanism as a trading intermediary and the reward and how they can achieve it. Furthermore, the remainder of the experiment is presented. Participants also get a printed manual. Participants then trade in a test market for 5–15 minutes to get acquainted with the market software. Stocks and money are separate to the experimental market and not transferable. Play money will be used in both the test market and the experimental market. This play money will not be redeemable to real money. After the test market, participants are presented the decision options of the actual experiment market. Before the experiment market starts, participants fill out a computerized survey asking them for their individual preferences of the decision options. Then, the experiment market is conducted with the actual decision options and will run for an hour. For a decision market this should be sufficient according to [DSS10], as no new information gets available during the execution. In the treatment group the market perturbation will be introduced. After the trading period, the market will end automatically, that is, trading actions will not be accepted any more by the system. We devised the scenario of designing a degree program curriculum for the decision market experiment. The decision in this market will be the question: “what topics would you want to be included in a future degree program?” The profession of the program will be adjusted to the available students in the experiment.

## 5 Design of the Market Software

In the following, we describe the design of our market system for testing the market perturbations detailed above. To ensure accessibility, acceptance and compatibility, we implement the market system as a web based system. This way the system will be accessible from any computer with a normal web browser with no need for any local installation routine. A three tier approach typical for web applications is applied consisting of a presentation layer, business logic layer and persistence layer. This three tier architecture follows the Model-View-Controller pattern for separating concerns in an application. The presentation layer is responsible for displaying all relevant information dependent on the respective user and the selected view. The business logic layer offers both common decision market functionality and functionality specific to market perturbations. We segment the business logic of the market system into user management, order management and perturbation management. The user management subsystem is responsible for authentication and authorization of the respective users. It provides for login and logout procedures to the system and for user details management. The order management handles the overall transactions, i.e. checking for available cash, transferring cash and shares and updating all relevant details. The perturbation management system deals with the management of market perturbations and perturbation actions, i.e. providing means for configuration, execution and monitoring. The persistence layer serves as the persistent storage of all market data. This includes data of all users, topics, prices, transactions and perturbations. We chose to implement our own prototype to get a system that meets our needs in terms of functionality. Based on the Seam Framework[2], we implemented a market prototype and successfully tested its overall functionality. Figure 1 shows the dashboard view of the market system, including information on available cash, total portfolio worth, current holdings of shares and the most recent transactions of the current and all participants, respectively. Figure 2 illustrates the details view for a selected decision option. This includes the title, description, the respective participant's current holdings and a chart of the price development as well as links for buying or selling shares of this decision option.

Two main approaches have emerged today for realizing actual pricing in a prediction or decision market. With the continuous double auction (CDA) mechanism traders directly interact with one another with the trades being recorded in an order book and matched according to the highest bid and lowest ask. However, in markets with many stocks and few traders, so called thin markets, trading often does not occur as matching counterparts are missing. The market maker approach sets to remedy this problem [Han07]. In a market maker setting, the market system provides a centralized trading entity, the so called market maker. Participants do not trade directly with one another but only via the market maker acting as an intermediary. The market maker quotes buy and sell prices at which he is willing to trade with the participants. Dependent on supply and demand, the market maker adjusts the quoted prices. Stocks with high demand will typically get more expensive while those with high supply will get cheaper. Traders can thereby buy as many shares from the market maker as they can afford or sell as many shares as they own. The market maker acts as an "always there" counterpart. Therefore, he secures liquidity even in thin

[2] http://www.seamframework.org


Figure 1: Dashboard view

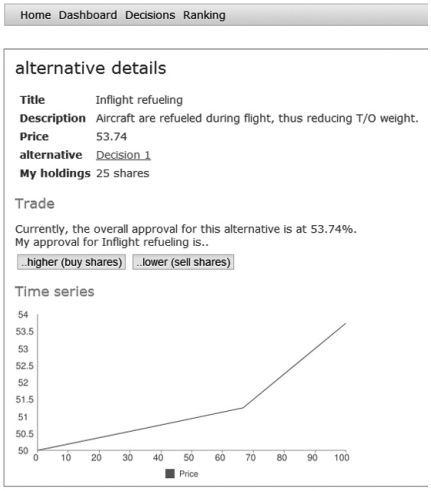


Figure 2: Details view

markets. Moreover the market maker can always quote a price which it not possible with the CDA mechanism if there is no matching trade or a large bid-ask spread.

## 6 Related Work

Several research projects deal with the application of market mechanisms to support decision making. LaComb et. al. investigate the applicability of markets to idea management by employing a commercial prediction markets software and find them suitable for the generation and ranking of ideas [LBP07]. Bothos et. al. devise a custom market platform especially targeted at idea generation, idea enhancement and idea evaluation [BAM09]. The selection of features for future products by employing markets is researched by Dahan et. al. [DSS10]. In these applications of markets, equilibrium prices are interpreted as the joint consent of participants and are also compared to the results of expert boards. However, they do not address the problem of possibly different origins of price equilibria.

The term *manipulation* basically describes a *behavior that influences someone or controls something in a clever or dishonest way*, according to Macmillan Dictionary [Mac]. In prediction markets, the goal of manipulation is typically to increase one's portfolio worth and thus to gain greater influence on the market outcome. Rhode and Strumpf analyze manipulative attacks in three markets: the Iowa Electronic Market in 2000, the historical Wall Street betting markets, and the 2004 TradeSports market for presidency [RS08]. The results of their investigations indicate that it is very expensive to manipulate such markets over a longer period as the manipulator has to trade against the assessment of all other participants and would therefore require a great amount of money. Thus, Rhode and Strumpf identified that prices returned close to their previous levels after a certain transition period,

presumably due to the limited budgets of manipulators. Our approach of market perturbations differs in two ways from such manipulations in prediction markets. First, our purpose differs from that of market manipulations. We are not interested in gaining profit from employed market actions but rather want to derive information on price formation in markets. Second, our proposed method is employed in the area of decision markets which, in contrast to prediction markets, do not have an external event for judgement of results.

Harmon et. al. investigate the discovery of price movements caused by uncertainty for real stock markets [HdAC+11]. Their goal is to detect market bubbles and subsequent crises that are not caused by changes in fundamental values but by self-organized panic reactions of traders. For this, Harmon et. al. define a measure of co-movements of stock prices as an indicator for detecting the beginning of self-organized crises. This is based on the observation that in market bubbles a significant number of stocks move in the same direction over a certain period of time prior to subsequent market crises. In prediction markets as well as in decision markets however such co-movements do not occur for stock prices.

Markets have been investigated from a mathematical viewpoint as well, mostly with the aim of demonstrating the pertinence of the equilibrium prices they produce and their formation - where "pertinence" is understood in different manners. Amongst others, such mathematical investigations of markets include game theoretical investigations. We do not refer in detail to such studies because their relevance for the novel approach proposed here is not yet fully clear. Indeed, the core concept of the approach proposed here, that of market perturbations artificially introduced so as to assure that an equilibrium price reached on a decision market expresses what the decision makers really mean, cannot be solely investigated based on the assumptions mathematical market studies so far rely upon.

## 7 Conclusion and Future Research

In this paper, we described the possible existence of different origins of a decision market's equilibrium and introduced a novel approach for discerning these possibly different origins. The general idea is thereby to capitalize on the traders' different incentives of sincere preference revelation and others such as portfolio maximization or uncertainty. We proposed to employ market perturbations to equilibrium prices and observe the resulting trading behavior of market participants. The perturbations are carried out by artificial traders in our approach. These are traders that are controlled by the market system in order to create these perturbations by trading. We further envisage a pilot study for investigating the principle mode of action of market perturbations and an experimental setting for testing the approach of market perturbations. We also described the market software that we developed for this effort.

As a next step we plan to actually execute the pilot study and the experiment in a laboratory setting for investigating the aforementioned perturbation method while considering the feedback of the professional community. Further experiments will be needed for fine tuning the perturbation parameters, possibly depending on different decision making con-

texts. In this paper, we presented only one possible market perturbation method in more detail. Other prospective means of perturbations include money granting schemes, offering and delisting of stocks as well as other price perturbation means such as a decay mechanism. For future research we plan to investigate these means for their suitability of generating market perturbations and gaining meaningful insights on traders and market outcomes.

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