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Research on Decision Market Model of Public Decision Problems in the Context of Big Data

CHANG Na[a],*

[a]School of Business Administration, South China University of Technology, Guangzhou, China.
*Corresponding author.

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Abstract

Decision markets are a method of community information gathering, so that market methods can be used to deal with public decision problems. The decision made by the decision makers can be shown as an equilibrium price. This thesis would design a Public Decision Markets model based on the principles of futures market. By using market principles to gather public decision preferences and use the equilibrium price to represent understandings. This model would be able to represent public intelligence level on public decision making. First transferring the binary decision market into a tradeable contract. Then make personal trading decisions under market environments. Finally, calculate the equilibrium price based on the total demand and total supply, providing a group consensus on the public decision issue. At the end of the thesis, it would provide cases where publicity tactics were decided upon the market acceptance. Proving this public decision model can effectively generate decision under big data context, while the tendency of group consensus was underestimated.

Key words: Public decision markets model; Collective intelligence; Big data; Preference group

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INTRODUCTION

Decision Market is a decision making tool designed to use market value as information, using equilibrium price to explain decision makers' expectations on the performance of a product. By set up a model futures market where allows the trade for the predicaments for future events under a certain set of principles. The final price of such contracts would provide a clear understanding on the opinion that a decision maker holds to that event. There are two major kinds of events that a market predicament could predicate: "true of false" event, which is a "binary" decision making problem, i.e. "candidate A would be the president". The liquidation price (1 when he wins, 0 when he loses) of such events is usually a fixed one based on the result (he wins the election or he loses.) In this event, the equilibrium price shows a public prediction on the possibility of such event. The other is "index" events, meaning the prediction is for an exact number, i.e. when "a CPU of 15G Hz" would come to the market. The final price of these events shows the public predicament of such event. This thesis would be the exact reverse of the market predication principles. Unlike the traditional market prediction model where the preferences of decision makers are shown by an equilibrium price. The decision support model this thesis would provide is to generate an equilibrium price and a group consensus when public preferences are known.

Public decision is a public of a society trying to influence the decision making process and the decisions that would be made, via due process or channel, in order to make such a decision fit in his own or a common interest. Public decision is different from the elite decision. Elite decision is to recruit a group of experts gathering different experience and knowledge they processed to make up the lack of personal intelligence or experience. Most of the social events in real life are decided via a public decision. i.e. the election of a president, box sales of a movie, the sales index of a new product. The public would vote on these issues by their choice. There are some aspects where public decision is different from everyday group decision: First of all, the decision group has influence

over such social event. Public decision is to make the prediction of future events and to make due decision on such matter. It would make do when such matter is a public on. For example, when predicting "when a CPU of 15G Hz" would be on the market, technology experts have their information gap over the general public, cutting the direct link between the general public and the result, making public decision useless in such case. Meanwhile, the decision group should be stakeholders of such events. Compared to the chaos results traditional poll takers would generate. The public decision model this thesis stands behinds is a market-oriented decision making process. The general public which involve in the deals would consider the result a matter of their interest, ensuring the truthfulness and effectiveness on the public opinion; at last, the decision group should not be part of interest groups, which would ensuring the effectiveness of such poll. In real life, decisions are usually followed up by interest reorganizations. Interest groups would lobby their way throughout the process. This is where the elite decision model is criticized for long. Public decision model can weaken the influence of interest groups via its mass base and simple base. With the ever-developing information technology, internet has become an effective channel for public to apply their opinions. This thesis would present a public decision model based on the theory which is used to predict the market. It would help reach group consensus when the preferences of such group are known. And should be effective given as stated advantages of such theory.

Group decision was first used in political science. It was used to study poll methods. Arrow's impossibility theorem of the 1960s had a fundamental impact on group decision studies. In the 1980s, Keeny set the goal for a group decision as to eliminate inequality between individuals. Post-WWII international policy making, especially technology policies is more and more influenced by technology experts, resulting in many studies on expert decision making. The "Government-Scientist" decision making relations has become the core of technology policy making. Since modern times, the public awareness and participation of democracy process have been greatly improved. The current political science studies related to this area are mostly focused on democracy connotations rather than public decision models. This thesis would use market prediction tools and theorize it and explain how such a model would be used in the practice of public decisions. Mainstream studies on market predicament used to take it as a futures market and conduct applicability analysis won which. This thesis would analyze so stated method and provide a public decision making method based on the market prediction principles. Where a gathering for group member's subjective judgments would provide an equilibrium price, which, provides a possibility or index prediction of such event.

1. PUBLIC DECISION BUILDING BASED ON MARKET PREDICTION MODEL.

1.1 Variable Definitions

J: The sum of decision makers, standardized as 1

R_j: The capital in j's procession.

π_i: Result: the contract price is i. $\pi_i \in (0,1), i = m,n$, m means the result is true. n means the result is false.

p_i: Result: the liquidation price is i.

x_{ij}: Decision maker j subjectively judges that the possible of i is $x_{ij} \in (0,1)$, $\sum_{i=m}^{n} x_{ij} = 1$.

x_i: Gathering J Subjective judgment probability. The probability density function is $f(x_i)$. Distribution function is $F(x_i)$.

θ_{ij}: The proportion of j's investment in contract i.

d_{ij}: Decision maker j's need to the contract i.

One of the most valuable aspects of market prediction as a tool to market public decision is that it could review the groups' opinion by an equilibrium price. A marketed decision making process takes two steps. In the first step, individual expresses his ideal. Assuming everyone in the market is an' rational man', the decision maker makes his demand upon market price and his subjective judgement. The second is to summarize a total demand relying on individual demands, and even the total demand and total supply via market system. Providing an equilibrium price. The total demand must by in even with the total supply to ensure the stable of the equilibrium price.

1.2 Analyze on Individual Behaviors

The individual buying behavior is based on his subjective judgement and the current market price. Set the utility of a decision maker as $U_j=u(x)$, the predicted revenue of each contract as $x_{ij}u(p_{ij}-\pi_i)$. Assuming θ_{ij} percent of a decision maker's sum R_j is used to buy contract i. Then the expected utility of a decision maker j would be:

$$E_j = \sum_{i=m}^{n} \frac{\theta_{ij} R_j}{\pi_i} x_{ij} u\left(p_{ij} - \pi_i\right). \quad (1)$$

Since m and n are symmetrical. Take m and θ_{mj} to expand the so stated formula with, $\sum_{i=m}^{n} \theta_{ij} = 1$ it would be:

$$E_j = \frac{R_j}{\pi_n} x_{nj} u\left(p_{nj} - \pi_n\right) + \theta_{mj} R_j \left[\frac{1}{\pi_m} x_{mj} u\left(p_{mj} - \pi_m\right) - \frac{1}{\pi_n} x_{nj} u\left(p_{nj} - \pi_n\right)\right],$$

in which, $\frac{1}{\pi_{ij}} x_{ij} u\left(p_{ij}-\pi_i\right)$ stands for the expected utility of unit currency of contract. Set $e_{ij}=\frac{1}{\pi_i} x_{ij} u\left(p_{ij}-\pi_i\right)$, an educated guess could be made that if

$$\frac{1}{\pi_m} x_{mj} u\left(p_{mj}-\pi_m\right)-\frac{1}{\pi_n} x_{nj} u\left(p_{nj}-\pi_n\right)>0,$$

then, when θ_{mj}=1, a decision maker j would achieve at maximum expected utility. Meaning his best strategy is to invest all his capital in contract m. Resulting in:

$$d_{mj}=\begin{cases}\frac{R_j}{\pi_m}, e_m>e_n\\ 0, e_m\le e_n\end{cases}. \tag{2}$$

At which time

$$E_j=\begin{cases}\frac{R_j}{\pi_m} x_{mj} u\left(p_{mj}-\pi_m\right), e_m>e_n\\ 0, \quad \text{Other}\end{cases}. \tag{3}$$

Theorem 1: In the case when x_{ij} constant, $e_{ij}=\frac{1}{\pi_i} x_{ij} u\left(p_{ij}-\pi_i\right)$ is the monotonic decreasing function of π_i

Theorem 2: In the case when e_{mj}=e_{nj} decision maker j's decision on whether or not he would buy m would make no difference in the demand.

The theorem 1 shows that when personal subjective judgement is constant, while he judges the possibility is higher than the market price, and the demand to the contract still exists, when decision maker group's demand to this contract is relatively high, the market demand would exceed the supply, increasing the market price. While the market price raises, personal exception on the utility of unit currency at the result of contract i would decrease, until the condition of theorem 2 is met. Which is when decision maker j would exit the market dealing the contract i.

1.3 Group Preferences Gathering

Assumption 1: The number of contracts and the initial price of the market place were set by the market setter. Set the number of contracts as S and the initial price as π_0. The sum of S is relevant to the activity of the market place and the evaluation made by the setter.

The pricing of such prediction market is adjusted mainly by an electronic system based on the supply-demand relations. Equilibrium price is when the total demand is equal to the total supply. The public decision making model this thesis stands behind based on the price when total demand is equal to the total supply to find out the final equilibrium price, which is the public decision consensus.

Set $P(e_m>e_n)$ as the total number of people buy contract m. When $e_m>e_n$, an individual would invest all his capital on m. Thus the group preference needs to be distributed according to personal preferences. To figure out the exact percentage of people what would buy contract m:

$$P\left(e_m>e_n\right)=P\left[x_{mj}>\frac{\pi_m u\left[p_{nj}-\left(1-\pi_m\right)\right]}{\left(1-\pi_m\right)u\left(p_{mj}-\pi_m\right)+\pi_m u\left[p_{nj}-\left(1-\pi_m\right)\right]}\right], \tag{4}$$

$$\text{Set}\,\eta\left(\pi_m\right)=\frac{\pi_m u\left[p_{nj}-\left(1-\pi_m\right)\right]}{\left(1-\pi_m\right)u\left(p_{mj}-\pi_m\right)+\pi_m u\left[p_{nj}-\left(1-\pi_m\right)\right]}. \tag{5}$$

Similarly: $P\left(e_m\le e_n\right)=F\left(x\right)\Big|_0^{\eta(\pi_m)}$, function graph goes:

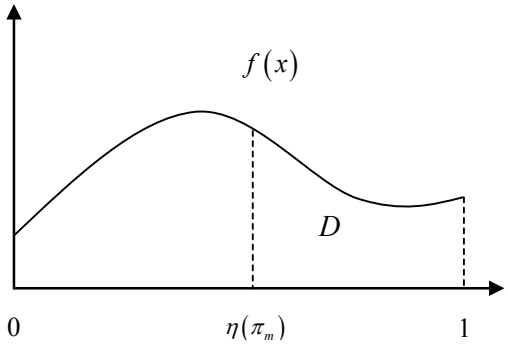

Figure 1
The Distribution of Decision Makers' Subjective Preferences

Set x_{ij}'s distribution density function as y=$f(x)$, the total capital of each decision maker in this coordinate system would be R_j=$z(x_{ij}, y)$, then the total sum invested on m would be $\iint_D z\left(x_{ij},y\right)\mathrm{d}\sigma$. Which is the volume of cylinder with a bottom of $F\left(x\right)\Big|_0^{\eta(\pi_m)}$ and with the top of such cylindrical surface being R_j=$z(x_{ij}, y)$.

Set total market demand equal to total market supply, then:

$$S=\frac{\iint_D z\left(x_{ij},y\right)\mathrm{d}\sigma}{\pi_m}. \tag{6}$$

At any given time the market equilibrium price must meet the conditions of the stated formula. Thus we can generate an equilibrium price that adjusts accordingly to the subjective judgements of decision makers and total capital sum.

1.4 Model Parameter Analysis

To understand the relationship between the independent variable and the dependent variable, we need to control the irrelevant variable. At the following sessions, when one variable is discussed, other variable are considered to be irrelevant variable and are to be set to its simplest form, which are: Decision maker's subjective distribution is to be evenly distrusted according (0, 1); every and each decision maker has an same amount of capital R; and their risk preference type is neutral.

To analyze the equilibrium price among an evenly distribution situation. Set decision maker's subjective distribution is to be evenly distrusted according (0, 1) . The sum of consumers who buys the contract would be:

$$P\left(e_m > e_n\right) = D = P\left[x_{mj} > \eta\left(\pi_m\right)\right] = \int_{\eta(\pi_m)}^{1} f\left(x\right) = F\left(x\right)\Big|_{\eta(\pi_m)}^{1} = 1-\eta\left(\pi_m\right) = \frac{1-\pi_m}{1-2\pi_m}$$

the total market demand to this contract is

$$\frac{\iint_D R\mathrm{d}\sigma}{\pi_m} = \frac{R\cdot D}{\pi_m} = \frac{R\left(1-\pi_m\right)}{\pi_m\left(1-2\pi_m\right)}.$$

Equalize total demand with total supply then:

$$2S\pi_m^2 - \left(S+R\right)\pi_m + R = 0 . \tag{7}$$

The equilibrium price would be

$$\pi_m = \frac{S+R-\sqrt{\left(S+R\right)^2-8SR}}{4S} , \tag{8}$$

or

$$\pi_m = \frac{S+R+\sqrt{\left(S+R\right)^2-8SR}}{4S} = \frac{\left(S+R\right)\left[1+\sqrt{1-\dfrac{8SR}{\left(S+R\right)^2}}\right]}{4S} . \tag{9}$$

And ensures $\Delta = \left(S+R\right)^2 - 8SR \geq 0$. (10)

Theorem 3: Unless the sum of contracts meet the condition: $S \geq \left(3+2\sqrt{2}\right)R$, otherwise no reasonable equilibrium price would be generated.

Prove:

$$\Delta = \left(S+R\right)^2 - 8SR \geq 0 ,$$

$$S \leq \frac{6R-\sqrt{36R^2-4R^2}}{2} = \left(3-2\sqrt{2}\right)R \quad \text{(Unreasonable)},$$

$$S \geq \frac{6R+\sqrt{36R^2-4R^2}}{2} = \left(3+2\sqrt{2}\right)R .$$

In order to get the relationship between the amount of contract set by setters, the equilibrium price and the amount of capital processed by decision maker, the following chart was made. As the chart shows, in the case of a fixed capital, the equilibrium price increases with the contract amount to infinitely close to 0.5; in the case of a fixed contract, the equilibrium price decreases gradually from infinitely close to 0.5, while the smaller the number of contracts drops to, the faster the price declines We know under evenly distribution, the average value, the mode and median is 0.5. Thus the closer an equilibrium price is 0.5, the more accurate the public opinion is expressed. As we may easily find form the chart, the smaller amount of capital each decision maker holds (the found is dispersed), the more contract that were provided (active market), the more accurate that equilibrium price (public consensus) would be. Via this analysis, we found the decision making model this thesis stands behind has a tendency to underestimate group consensus.

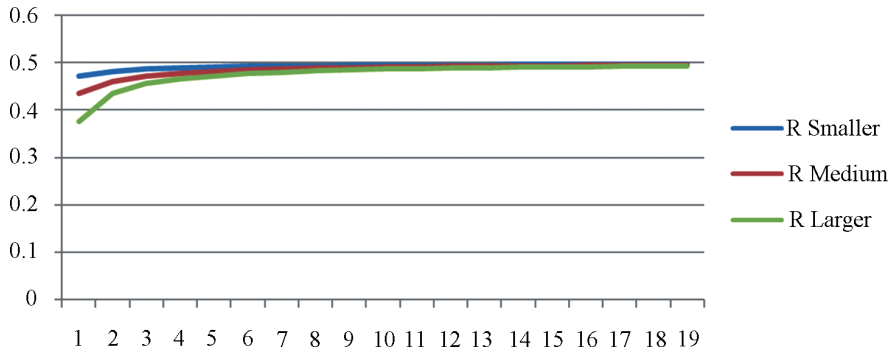

Figure 2
How Quilibrium Price Changes With the Number of Contract

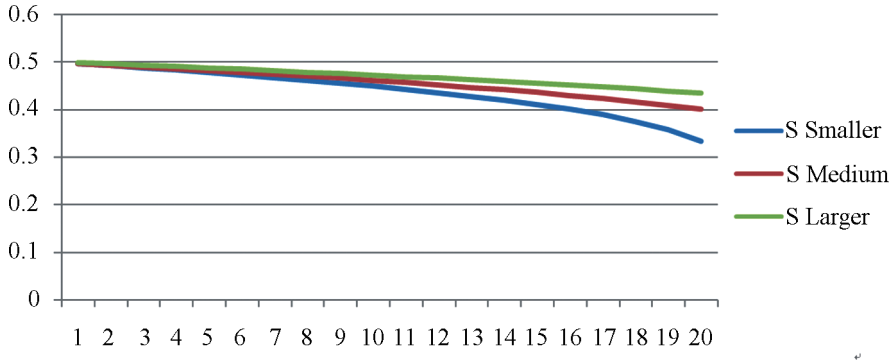

Figure 3
How Equilibrium Price Varies With the Amount of Capital a Decision Maker Processes

2. CAST ANALYZE

There's a suitable range for every kind of group decision method. The effectiveness of market predicament is that the people who influence the events are the people who took part in the poll. Thus such method can only be applied when the target pool can be polled, and it must be a general event. We use the case, the market acceptance of a new product, and put our model into it.

Company A is going to decide whether to increase its publicity effort based on the reaction of audience. So they introduced the appearance, function and pricing information in the market prediction, then issued the contract. If the sales number exceeds 100,000, then the result is true. They put out 10,000 shares, and gave each decision maker 100 unit currency. All decision maker's risk preference is neuter, the utility function for that is $u(x)=x$, and the subjective judgement is (0,1), which means it distributes evenly according (0,1). The liquidation price chart:

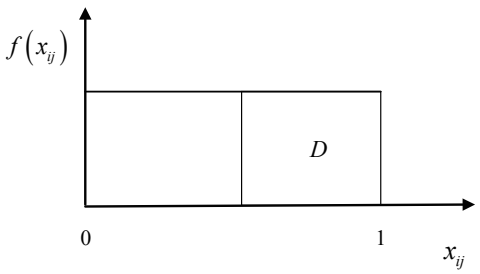

Figure 4
Subjective Judgment Evenly Distributed

Table 1
The Relationship Between the Transaction Results and the Liquidation Price

Result	100,000 within 3 month	failed
Liquidation price	1	0

The demand for the contractor is:

$$d_j = \begin{cases} \dfrac{100}{\pi_m}, e_m > e_n \\ 0, \text{Other} \end{cases}$$

Total amount of people bought the contract:

$$D = P(e_m > e_n) = \int_{\eta(\pi_m)}^{1} f(x)dx = 1 - \eta(\pi_m) = 1 - \frac{\pi_m(\pi_m - 1)}{(1-\pi_m)^2 + \pi_m(\pi_m - 1)}$$

Total amount of money spent in the deal:

$$\iint_D 100 d\sigma = 100D = 100\left[1 - \frac{\pi_m(\pi_m - 1)}{(1-\pi_m)^2 + \pi_m(\pi_m - 1)}\right].$$

When the total market demand is equal to the total market supply:

$$\frac{\iint_D 100 d\sigma}{\pi_m} = 10000 \quad .$$

The final equilibrium price would be π_m=0.01(unreasonable) or 0.495, which means when subjective judgement is evenly distributed, group tends to believe that there are 49.5% of chance when the sales index exceeds 100,000 in time. That was the simplest even distributed case, which explains the equilibrium price being so close to 0.5.

CONCLUSION

What matters is, the real life market prediction is the reverse of our model. The market prediction predicts the subjective judgement according to the equilibrium price. While this model generates equilibrium price with known distribution. In the process of market prediction, the equilibrium price is concluded by market self-adjustment, we can only get a result, and to predicate decision maker's mindset and market reactions via that. The bullet point of this thesis, however, is to develop a decision making system upon the market prediction theory, which, not only make the best use of market prediction system, but also generates a group consensus on the known public preference. We might conclude:

First of all, the equilibrium price is not relevant to issue price. The issue price is relevant to setter's final revenue. However, at any given active market, as long as the issue price is not so high that no one's willing to buy in any issues, then the final equilibrium price must have nothing to do with the issue price. This thesis's market and contract only sets the condition for "true", making it a zero sum game among setter and decision makers. If the event is "true", then setter would pay contract holder one unit of currency per contract. If the event is "false", then all contract became worthless, setter win all.

Second, when decision's subjective adjustment is evenly distributed, and the total sum of capital remains the same, then the equilibrium price would increase with the total amount of contracts, and the smaller decision maker's capital amount goes, the higher equilibrium price raises.

Third, when the decision maker's subjective adjustment is evenly distributed, as long as the total sum of contract remains the same, the equilibrium price would drop according to the total capital, and the smaller the total amount of contracts goes, the faster the equilibrium price drops.

Last, the group subjective adjustment pattern this thesis adept to gather public opinion has a tendency to underestimate the group consensus.

As a neo prediction and decision making system, market prediction is not only effective at market rates, but also links the general public directly before the decision was made, providing direct assistance in the prediction process. In real life, general public decides whether they like a new candidate, movie or product or not. But whether or not to put these products in front of the public is decided by a political party, a producer or a business manager. General public was not involved when these decisions were made. If the general public could take part in the decision making process, then a single vote could review their opinion. The truth is in the hands of a few, perhaps market prediction method wouldn't provide the best product, movie or the most dedicated president, but it would generate the most loved ones.

There's a wild range of use for market prediction, most public opinion gathering can practice this system. E-commerce and electronic Internet platforms both provide soil a fertile soil for this method. Especially when both fields have a community of public decision maker who can be a direct sample or platform for the method to be tried out. In costumer-orientated development of E-commerce, there's an important tendency to focus on online community's public opinions. Compared to current methods like grandstanding and so, this system can handle the force of the market more effectively, generating an effective market price, instead of traditional unilateral pricing according solely on the cost side. At this democracy society which is taking people's opinions to a more and more important place, E-government is a great platform to practice the market prediction method. E.g. one government can issue a prediction contract on "to build metro or not", and predicates the need for the public on the final price of such stated contract.

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