# Designing a Successful Electronic Market in a Multi-Agent Environment

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Abstract-The important role of electronic markets in the realm of electronic commerce, for no one is unknown. The methods of determining the policies and rules of a market, in order to ensure its effective and optimum performance under different conditions, have attracted a lot of attentions these years. Our purpose in this paper is to clarify the existing tradeoffs through making decisions in the market on the way of achieving the targets and that how we can address these tradeoffs. These tradeoffs will be more tangible when the market is in competition with other markets and indeed in a multi-agent environment. The CAT or TAC Market Design Competition has been created as a platform for assessment of different market policies and for comparing various market strategies. In this paper, first we explain the CAT competition, and considering this platform, we will describe different parts of MySpecialist, our successful proposed market. Also conducting some experiments, we will show the remarkable performance of our market in comparison with some of the successful agents offered to previous CAT tournaments.

*Index Terms*—Electronic market, equilibrium price, extra-marginal traders, intra-marginal traders, multi-agent.

# I. INTRODUCTION

In recent years, there have been a lot of efforts in designing electronic commerce automated agents in order to do human tasks. Using these agents, human tasks will be done faster, with higher efficiency and with less difficulty. Moreover, further parallel works can be done simultaneously.

TAC Classic competitions analyzed the designing of optimal traders carrying out affairs related to their customers. But the other side, i.e. designing the optimal market in which the traders do their business, have been less discussed.

As is mentioned [1], under real conditions, a market do not operate in isolation, but its function is determined in comparison with other rivals. In this context, TAC Market Design competition or CAT [2] intends to further discussing and determining the design features of the markets in order to enhance their performance as a platform for traders to trade each other.

In this contest, participants play the role of markets in which a number of traders will trade. Each market should have clear policies in how and when the market will be cleared (Clearing Policy), the way the shouts of traders will be accepted (Accepting Policy), how to determine the fees of the market (Charging Policy) and how to determine the final transaction prices (Pricing Policy), and indeed, markets are distinguished regarding to their different policies.

Some traders from tournament organizers are introduced. The traders use various strategies for selecting the market each day; some use random selection, some remain static in some market during a day, and the rest of them see the market selection as a n-armed bandit problem and each day choose the best market available, according to the their interests in different markets during the days before, and the list of expenses provided by the markets for the current day. Also traders use four types of strategies for bidding. These four strategies are: ZIC [3], ZIP [4], GD [5] and RE [6]. Markets are not provided with the information about the distribution of these strategies among the traders.

Per day score of each market is obtained by three factors. Ratio of the number of the market's traders to the total number of traders, ratio of the number of shouts resulted in successful transactions to the total number of shouts in the market, and ratio of profit earned by the market to the profit earned by all markets as a whole. At the end of the game, the total values calculated over all days specify the ranking of the markets.

The effect of each sector of scoring on other sectors is significantly important. The sections cannot be seen independently, but they should be seen as a tradeoff which its goal is to improve overall performance of the market. In this paper, we first, in section II, review different parts of our proposed market and describe different strategies used in it and then in section III through some experiments we will show the desired and significant performance of our market in comparison with a number of successful markets presented in previous TAC Market Design games. In sections III.A and III.B we compare and evaluate different modes of using some subsidiary functions involved in market strategies, regarding market performance in each mode. Finally, in section VI, we conclude and also explain future works.

#### **II. STRATEGY DESCRIPTION**

We describe four policies of our market through section II.A to II.E. Fig. 1 shows our market internal structure.

## A. Accepting Policy

The importance of accepting policy is due to the fact that it causes the market to accept only shouts with high probability of success; this will result in higher TSR.

For shout assessment, we use a threshold that indeed is the market Equilibrium Price, its calculation method is explained in II.B. Conducting multiple tests and reviewing different solutions, we observed that this method more than others, brings us the desired results. Also placing a nonzero delta value, we can make this restriction looser and easier for traders, causing more satisfaction among them, and totally

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raising the TSR and also the share of the market. In this case only asks with a maximum price of Equilibrium Price + delta and bids with a minimum price of Equilibrium Price - delta will be accepted.

# B. Equilibrium Price Calculation

Reviewing the prices of previous transactions, we can achieve an Equilibrium Price, the point where supplies and demands come together. So far some of the markets took part in this competition have been used different methods to calculate the Equilibrium Price [7], but the point that exists in calculating this amount, and there should be more attention to it, is that the rate of fluctuations and changes in the values obtained for the Equilibrium Price should be low as much as possible, so that the transactions have been made for any reason, that their price is far away from the market equilibrium price, cannot change the Equilibrium Price and thus cause undesired shouts to come into the market. Therefore we calculate this value using a sliding window of length five for maintenance of last five transaction prices. In the beginning of each day when our sliding window still is not filled, we calculate Equilibrium Price as the average value over all sliding window's current values. But when the sliding window is filled until the end of the day, after arrival of each new price, each available price will be given a weight according to its distance to the current value of Equilibrium Price; i.e. the further the distance between any price in the sliding window and the Equilibrium Price, the less the price's weight, and vice versa. Multiplying the prices by respective weights and summarizing the values, the new value of Equilibrium Price will be obtained. As mentioned, it will lower the rate of fluctuations in the values calculated for the Equilibrium Price.

Also the obtained values for Equilibrium Price are daily reset because each day, our market has different traders with private value ranges different from the previous day.

Of course, in III.B through experiments, we will compare the results of resetting or not resetting the values obtained for the Equilibrium Price at the end of each day and show which method is more effective.



Fig. 1. Internal structure of MySpecialist agent.

# C. Clearing Policy

In the case of market clearing, two issues are important. First when and second how to clear the market. Regarding the time, there are two dominant views. One is CDA in which each shout will match immediately after finding a suitable shout for it. Another view is CH in which market is cleared at certain times. Clearing the market at specific times causes higher profits for the market because of the fact that the traders, while reaching the defined time, regularly improve their shouts. On the other hand, CH makes more transactions comparing to CDA. We clear the market at the end of each round of a day, taking advantages of both methods.

About how to clear the market, we use a policy similar to what has been used by IAMWildCAT agent [8]. Our policy is based on the knowledge that at the early rounds of a day, mainly Intra Marginal Traders are trading and in other words the shouts are more competitive. In these rounds we use ME or Equilibrium Matching method for clearing in which the best bids will match with the best asks with the purpose of raising traders' profit. But in the next rounds, as the competitiveness of shouts is lessen, we use MV or Max Volume Matching method in which the best bids will match with the worst asks to increase the number of transactions. Thus, at the first rounds we gain more profit and also more satisfaction among Intra Marginal Traders. Also at the next rounds, when due to the fact that the shouts are not so competitive the traders' profit is less important, changing the method of clearing, we will increase the TSR and beside that satisfaction among Extra Marginal Traders who do not have so much hope for their shouts to be succeeded. Presence of this type of traders in the market helps to boost market share.

We chose the time threshold when the way the market is cleared is changed, 0.4 so that after spending 0.4 of the day and when the shouts become less competitive, market clearing policy will be changed.

At the end of each round, a number of shouts may remain unmatched. These shouts are asks lower and bids higher than Equilibrium Price which have not been matched, or asks higher and bids lower than Equilibrium Price that regarding the non-zero value of delta, have entered the market, or they are shouts that at the beginning of the day, when the Equilibrium Price still is not determined, have found a way to the market. We remove these shouts at the end of each round. Keeping these shouts in the market can be rational with respect to the logic that most of these have been good enough to satisfy the limits of our accepting policy and, with high probability in the next rounds and especially with the use of policy MV, will result in successful transactions. But another approach is that to remove these shouts at the end of the rounds will increase the performance because removing these shouts, allows the traders to improve their shouts. However, in III.A a comparison between the results of these two views will be done and we will see how removing the unmatched shouts from the market will result in improved market performance.

#### D. Pricing Policy

The importance of pricing policy is due to the amount of satisfaction it creates among the traders. The traders pay attention to the benefit market allocates them, and indeed to the market justice. Hence our market determines the value calculated as the Equilibrium Price (which the shouts have entered the market, have been selected according to the same value) as the price of transactions. At the beginning of each round, the current value of Equilibrium Price is given to the Pricing Unit that this value remains constant in this unit until the end of the round and is used for determining the transaction prices in the current round.

Determining the transaction price as the Equilibrium Price, the traders offer more competitive shouts, earn more benefit.

At the beginning of each day, when the Equilibrium Price has not determined yet, our market determines the price of a transaction as the average of bid and ask participant in the transaction. Since at this part of the day, shouts are so competitive and also clearing method is ME, often the values obtained are around the middle point of the range from which the private values of the traders have been selected (range 50 to 150); In other words, the values obtained are close to the theoretical Equilibrium Price. For this reason, the final prices that also will be used to calculate the initial value of the Equilibrium Price each day are appropriate values as criteria for deciding on acceptance of shouts.

Some shout may result in the transaction in which the final price (the Equilibrium Price) is outside the range of ask and bid. These shouts may have been entered in the early day when the Equilibrium Price has not determined yet, or regarding the non-zero amount of delta, they may have found a way to the market. Since these are not competitive shouts, the final transaction price in these cases, has little effect on traders' satisfaction. Our market in these cases sets the final price as the middle point between bid and ask.

After spending early rounds of the day, when the shouts become less competitive and the traders' satisfaction is of less importance, our market changes the pricing policy to Side-Biased Pricing [9] in which each side of a transaction (buyer or seller) that totally has less number of shouts in the market, earns more profit. This makes the market balanced in terms of the number of buyers and sellers and eventually cause increased market share and TSR.

#### E. Charging Policy

Price list of each market includes five types of fees: registration fee that each trader pays to register for the market, information fee paid for giving information from the market, shout fee that each trader pays for announcing each shout, transaction fee which traders pay after every successful transaction, and profit fee or some percentage of both parties' benefit in a successful transaction. Charging policy is directly effective both in market share and income. Through the tests we did, we observed if we have some non-zero costs to be determined in the market, these costs decrease substantially the market share, even if the amount of these costs is low. Also it's shown that increasing multiple costs will cause severe loss of market share [10]. For these reasons in our market, our primary focus is on profit fee and other expenses will be changed only if necessary.

About charging policy, our market acts such that until the middle of the game, the fees will be determined as less than the lowest current fees among all other markets, in order to preserve and enhance the share. In other words each day when the whole list of all market charges was announced, our market in each type of cost (profit fee, registration fee, information fee, shout fee and transaction fee), selects the lowest value among all markets, if this value was more than a predefined constant value, the respective fee in our market will be determined as the difference between this lowest fee and the constant value. If the markets' lowest cost was less than the constant value, the respective fee in our market will be determined as zero. This method makes our market attract traders by maintaining the lowest costs among all competitors, moreover, not neglecting of earning profit, it makes our market gain income and profit as much as possible.

From the middle of the game onwards, when the rate of changes in market shares is low and each market has found a relatively constant share, in order to increase profits and taking advantages of the existing traders in the market, we suddenly increase the profit fee and keep it at this level until the end of the game. Thus, although due to rising costs, until the end of the game, we will lose some share, but regarding the tradeoff we face, with earning high profits and maximum use of existing traders, we try to improve market performance and gain more points.

#### III. EXPERIMENTS AND COMPARISONS

In order to test the performance of the proposed market, we conducted some experiments under JCAT Platform [11] and in an environment prepared similar to that of CAT competition. In these experiments, we used 320 traders, consisting of 120 ZIP traders, 120 RE traders, 40 ZIC traders and 40 GD traders. This population was divided equally into buyers and sellers. Tests carried out on 500-day periods, each day consisting of 10 rounds and we used five other agents, all from well-known participants of previous CAT tournaments. These agents include IAMWildCAT ranked first in 2007, PersianCAT ranked first in 2008, Mertacor, UMTAC and cestlavie.

Under conditions similar to that of CAT competition and the number of 50 repeats to ensure the accuracy of results, our market with strategies mentioned above totally achieved the first rank among these competitors. Average of the total results and average score of each market in each day, through all repeats, are shown in Table I and Fig. 2. As you see, our proposed market, has gained outstanding results in terms of both TSR and profit, excelled among all markets examined, and only in terms of share, its point is less than some other markets. One of its reasons, as previously noted, is to increase profit fee in order to raise the score at the middle of the game.

TABLE I: THE AVERAGE OF TOTAL RESULTS

Market Name	Market Share	Profit	TSR	Score
IAMWildCAT	0.17	0.11	83.9%	162.275
Mertacor	0.25	0.17	73.54%	173.013
MySpecialist	0.17	0.24	91.65%	199.554
PersianCAT	0.15	0.23	67.6%	154.693
UMTAC	0.16	0.11	67.17%	136.929
Cestlavie	0.15	0.16	71.49%	151.302

# A. Clearing vs. Not Clearing Unmatched Shouts

Removing or not removing the shouts that remain unmatched after clearing of the market, each has its own benefits that were explained in II.C. To compare market performance in every case, two test series were conducted, each with 30 repetitions. In the first series, we kept the unmatched shouts after each time market was cleared and in the second, we removed them. The results of these tests are shown in Fig. 3. Notable increase of TSR through using the second method shows that removing the unmatched shouts from the market, helps improving the functionality of the market.



Fig. 2. The average of each market's score per day.



# B. Resetting vs. Not Resetting the Equilibrium Price

Resetting the value obtained for Equilibrium Price, at the end of each day, is rational in the way that the traders of the market each day, are different from the previous days. The opposite method, i.e. maintaining the value of the previous day and using it also makes sense since it makes the market apply a restriction on shouts even at the beginning of the day. To compare these two perspectives, keeping other parts unchanged and only changing this part, two series of experiments was performed and each series was repeated 30 times. In the first series, we did not reset the obtained value for the Equilibrium Price at the end of each day and in the second we did. The results of these tests are shown in Fig. 4.

Tangible improvement of TSR through using the second method, in comparison with the first one, shows that resetting the Equilibrium Price at the end of each day brings us better results.



# IV. CONCLUSION AND FUTURE WORK

In this paper, we described strategies used by MySpecialist agent, designed to participate in CAT competition. The market should provide its own policies in four different areas as Accepting, Pricing, Charging and Clearing which we described them through section II.A to II.E. Also in section III we evaluated our agent by simulation of competition environment and concluded that our market features brilliant performance in competition with some of the best agents presented to this competition before.

Next in sections III.A and III.B we compared some elaborations involved in market strategies and measuring the performance of the market, we evaluated different modes of strategies and details involved in them.

As future work, it seems that even though our market, as a whole, acts well and effective in the term of the tradeoff among different scoring parts and their relations, in trader attraction, separately, there could be seen some weaknesses that in the future, we should try to overcome the deficiencies and reform the market in order to optimize performance in all three scoring sections.

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