Comparative Study of Several Kinds of Bidding Strategies in Transportation Service Market

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Abstract. In this paper, we studied the bidding strategy and the impact of the transport services market by the way of double auction. On the condition of single line transportation, ZIU, ZIC and K-ZI bidding strategies were contrasted, computer simulation experiment was implemented, then the trading volume and the income of shippers market were analyzed and contrasted respectively. It is found that the income of participants is smaller in ZIU strategy quotation, and the trading volume is stronger randomness in all strategies. The analysis of the conclusion will provide decision-making basis of auction design for participants in the transportation services market.

Introduction

With the rapid development of information technology, Transportation market’s online transactions have begun to rise rapidly in recent years. On the condition of electronic trading, some third party services are implemented through online platforms, but it is essentially a single item reverse auction. Now the research on the transportation services’ procurement based on auction is mostly focused on the reverse auction, it puts forward a high demand for the trader's computing power, and the double auction mechanism can effectively reduce the computational burden of traders.

Professor Friedman proposed the double auction[1] in 1956 and given its trading mechanism in 1993[2]. A large number of theoretical and experimental economics research found [3]-[5] that continuous double auction can quickly converge to a competitive equilibrium, effectively shorten the auction time, resulting in a high price discovery efficiency. And it has been widely used in stock market, monetary transaction and other commodity trade markets, but in the transportation services market, theoretical research on double auction was very limited. Considering there are many shippers and carriers in the transport services market, the double auction can effectively improve transaction efficiency and optimize the market allocation of resources, and the online trading platform create a very convenient condition for the implementation of double auction. Huang and Xu are concerned with the design of auction mechanism for the online road transportation market [6]. They firstly put forward to incorporate bilateral bidding into auction mechanism design for multi-unit transportation procurement in logistics e-marketplaces. Proposed mechanisms ensure incentive compatibility, individual rationality, budget balance and asymptotical efficiency. Huang and Xu [7] proposed a single line transportation service procurement double auction model which was led by the third party auctioneer, on the condition of the trader’s(the shipper’s and the carrier’s) truthful quotation , studied the optimal behavior and strategy of auctioneer. Fu Qiufang [8] et al studied transportation service pricing strategy of our country highway transportation market in the mode of transport agent through combinatorial double auction theory. Xu and Huang [9] proposed an effective resource allocation auction mechanism for distributed transportation procurement issues, and applied Ausubel auctions’ insights and primal dual optimization algorithm to the Dutch auction.

This paper is organized as follows. In Section 2, we describe the double auction market in transportation service market and the basic bidding strategy what we contrast. Section 3 provides the transaction rule and experimental parameters. The experimental results and corresponding analysis are presented In Section 4. Our conclusions and future research are given in Section 5.
The Model

Problem Description

In the e-commerce transportation service market, the shipper is an e-commerce platform by which a number of online orders between goods sellers and buyers are created and released to fulfillment, and the carriers are the third-party logistics providers (3PLs). The generated online orders are called trade orders and the 3PLs can fulfill the trade orders (see Fig. 1).

![Figure 1. The mode of online double auction in transportation service market.](image)

Base Bidding Strategy

Gode and Sunder [10] presented two versions of ZI traders: ZIC (zero-intelligence with constraint) and ZIU (zero-intelligence unconstraint). The mathematical description of ZIC and ZIU are as follows:

\[
B_i(zic) \sim [O_{\text{min}}, V_i] \quad \text{uniform distribution} \quad (1) \\
S_i(zic) \sim [C_i, O_{\text{max}}] \quad \text{uniform distribution} \quad (2) \\
B_i(ziu) \sim [O_{\text{min}}, O_{\text{max}}] \quad \text{uniform distribution} \quad (3) \\
S_i(ziu) \sim [O_{\text{min}}, O_{\text{max}}] \quad \text{uniform distribution} \quad (4)
\]

where \(B_i\) is the \(i\)th bidder’s random bid and \(V_i\) is his redemption value. \(S_i\) is the \(i\)th seller’s random ask and \(C_i\) is his cost. \(O_{\text{min}}\) and \(O_{\text{max}}\) are the highest and the lowest price in the market respectively.

By expanding the endowment range of redemption value and cost from \([O_{\text{min}}, O_{\text{max}}]\) to \((O_{\text{min}}, O_{\text{max}})\), Zhan presented a general ZIC model (k-ZI) in 2002 [11]. The k-ZI algorithm is described mathematically as follows:

\[
B_i \sim [k \cdot V_i, V_i] \quad \text{uniform distribution} \quad (5) \\
S_i \sim (C_i, O_{\text{max}} - k \cdot (O_{\text{max}} - C_i)) \quad \text{uniform distribution} \quad (6)
\]

where \(k \in [0, 1]\). \(B_i\) and \(V_i\) are the \(i\)th bidder’s random bid and redemption value respectively, and \(S_i\) and \(C_i\) are the \(i\)th seller’s random ask and cost respectively.

Experimental Setup

Considering the particularity of the transport services market, which not only meets the optimal price constraints of both sides, but also maximize the volume of bilateral transactions, this experiment set up an experimental framework of three phase, to simulate the transaction process of the transportation market. Experimental framework is set as follows:

The first stage, according to the quota from both sides, to match the highest shippers’ quota with the lowest carriers’ quota ‘to match the second high price shipper with the second high price carrier and so on, until all the remaining shippers’ transportation price are higher than the carriers’ offer, and to reject the volume have been traded this round. The second stage, according to the volume, in this round of matching, to match the shipper of the largest remaining required freight volume with the carrier of the largest remaining carrying volume, the shipper of the second largest remaining required freight volume with the carries of second largest remaining carrying volume and so on, until all the remaining shippers’ transportation price are higher than the carriers’ offer, and to reject the volume...
have been traded this round. The third stage, according to the valuation and cost, making a rank of the shipper and the carrier of the unit price in descending order and ascending order respectively, to match the shipper with carrier according to the rank, in this round of matching, the condition of constraint is that the transaction price of per pair is less than the matched shipper party unit valuation and greater than the matched carrier unit freight costs. the transaction price of above round is set as the mean value of the matched shipper's offer and carrier's offer, the trading volume is set as the traffic volume of the smaller one between the matched shipper's volume and the carrier's volume, then repeat the third stage until all the shipper's valuation is higher than carrier's cost in the market have been matched, then experimental end. Experimental framework sketch is set as follows (see Fig. 2)

![Experimental framework sketch](image)

**Figure 2. Experimental framework sketch.**

We choose 36 buyers and 36 sellers on each side of the continuous double auction market. The buyers and sellers are ZIU ZIC and K-ZI traders who make their offers according to their algorithms with the same endowment and volumes. The endowments of buyers’ redemption value and seller’s cost are uniformly distributed between 0 and 100. Because of the random offers in each experiment the volume, trading price and trading quota are also randomly distributed. All the experiments were conducted by MATLAB software.

**Experimental Results**

We repeat the experiment for 100 times, and calculate the total income, the average income and trade volume of every strategy. Due to the market with equal the number of people of every strategy, and the initial volume is distributed by computer. We only consider the shipper's market.

**The Total Income**

The total income is defined as:

\[ \text{the total income} = \sum (\text{valuation} - \text{the trading price}) \times \text{the trading volume} \]

![Figure 3. The total income of every strategy in shippers market.](image)
Table 1. The mean of each total income.

<table>
<thead>
<tr>
<th></th>
<th>ZIU</th>
<th>ZIC</th>
<th>K-ZI</th>
</tr>
</thead>
<tbody>
<tr>
<td>mean of each total income</td>
<td>395.7258</td>
<td>783.6923</td>
<td>689.3623</td>
</tr>
</tbody>
</table>

We can see the total income of ZIU, ZIC and K-ZI strategy from Fig.3. and the mean of each total income from table 1. Table 1 shows that the total income of ZIU is far less than that of ZIC and K-ZI and the total income of K-ZI is a little less than that of ZIC. It may because ZIU bidding strategy simulates the irrational individual of the market. And the parameter k is representative of the greedy of participants, the more k is close to 1, the more quotation of participant is close to the true, so it may be that the excessive pursuit of trade ratio incurs the traders get a lower income. In figure 3, we can see that the amplitude of swing of ZIU is far greater than that of the other two strategies, even it may be less than 0, this may also be caused by irrational quotes.

The Average of Income

The average of income is defined as:

\[
\text{the average of income} = \frac{\text{the total income}}{\sum \text{the trading volume}}.
\]

Figure 4. The average income of every strategy in shippers market.

Table 2. The mean of each average income.

<table>
<thead>
<tr>
<th></th>
<th>ZIU</th>
<th>ZIC</th>
<th>K-ZI</th>
</tr>
</thead>
<tbody>
<tr>
<td>mean of each average income</td>
<td>7.56353</td>
<td>20.02612</td>
<td>16.68564</td>
</tr>
</tbody>
</table>

We can see the average income of ZIU, ZIC and K-ZI strategy from Fig. 4 and the mean of each average income from Table 2. Fig. 3 shows that the average income of ZIU is far less than that of ZIC and K-ZI and the average income of K-ZI is a little less than that of ZIC. It may because ZIU bidding strategy simulates the irrational individual of the market. And the parameter k is representative of the greedy of participants, the more k is close to 1, the more quotation of participant is close to the true, So it may be that the excessive pursuit of trade ratio incurs the traders get a lower income. In figure 3, we can see that the amplitude of swing of ZIU is far greater than that of the other two strategies, even it may be less than 0, this may also be caused by irrational quotes.

The Trading Volume

Figure 5. The trading volume of each strategy.

We can see the trading volume of ZIU, ZIC and K-ZI strategy from Fig. 5. We can find that there is stronger randomness of trading volume in all strategies from figure 5, we think although that the number of participants is equal, the freight volume of participants required (or could carry) is randomly reported, resulting in a different supply and demand market.
Conclusion

In this paper, we study the trading strategy and the impact of the transport services market in the way of double auction. On the condition of single line transportation, we simulated the traders' bidding randomly by computer experiment, and made a comparison of the participants' total income, average income and their respective trading volume in bidding strategies of ZIU, ZIC and K-ZI. It is found that the income of participants who use the ZIU quotation is smaller. We analyze the reason of the result. The trading volume are stronger randomness in all strategies, the reason may be that although the number of participants is equal, the freight volume of participants required (or could carry) is random, resulting in a different supply and demand market. So, we will study the impact of the supply and demand imbalance on the bidding strategy of the two sides of the market in the next stage.

Acknowledgement

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References