

Game Theory Analysis of Bidding Rigging under Different Bidding Rules for Construction Projects

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Abstract

With the actual situation of bidding rigging in engineering construction areas, this article analyze the motivation of bidding rigging and use the game theory to discuss the possibility of the bidding rigging under different bidding rules; thus suggest the lowest price bid for simple construction projects and lower price bid+ comprehensive evaluation bid for complicated engineering cases. Finally, this article give suggests that establishing the credit evaluation mechanism, strengthening the information disclosure, introducing bidding supervision and report incentive mechanism can help to reduce the bidding riggings. From the angle of multi-period dynamic game theory, it also help to weaken the preference of bidding rigging and reverse the social atmosphere so that bidding system can play better for the role of effective allocation of social resources.

Key words: bidding rules; bidding rigging; dynamic game theory; report incentive

1. Introduction

Tendering and bidding has a wide range of applications in the transaction of current government procurement activities and large-scale construction projects. According to the provisions of Chinese tender and bid law, for projects achieving a certain scale of construction, it regulates to adopt the bidding method and process to determine the most appropriate contractor without special reasons. The bidding rules, which is the application of the principle and methods suitable to the bidding, regulates the provisions of bidding, including bidding time, bidding subjects, tender documents, process and way of bid evaluation, method of winning bid and other relative bidding information. Since first using tender form in our country, there have been about 200 years of history. At present, the commonly used bidding rules include the lowest price bidding method, the second lowest price bidding method, close to the base price bidding method, average price bidding method, the reasonable low price bidding, a combination of price bidding method and etc.

The positive significance of tendering and bidding is obvious, which has played a great role in country building. However, at the same time, some problems also emerge during the bidding process. Bidding rigging including surround-bidding, forging bidding and accompany bidding as the most widespread phenomenon of illegal, cause great influence and harm to society as well as the efficiency of resource allocation. Firstly, bidding rigging leads to the prices artificially high which cause the loss of the tenderer's interests. The second, it leads to the disorder of the allocation of social resources. Under such atmosphere, inferior enterprises expelling excellent enterprises easily happens which results in the following market confusion. The third, the trend of bidding rigging leads to abnormal development of the industry and company. Companies do not compete with excellent technology, mature experience and advantage of cost to win, but hack how to collude in bidding and win by commercial bribery. The Fourth, it leads to the growth of the social bad atmosphere and the increase of social corruption and is not conducive to social stability. The fifth, from long term view, the bidding rigging makes the bid become a mere formality. It destroys the creativity of the society and result in a large waste of social resources. From the view of participates, bidding rigging behavior can be classified into three types: the conspiracy between the tenderer and bidder, the collusion between bid invitation agency with the tenderer or bidders, and the surrounding collusion among the bidders.

And this paper will introduce the game theory to reveal the probability of bidding rigging under different bidding rules; from the point of curbing conspired bidding, get the conclusion that the lowest pricing bidding is applicable to simple engineering projects while the combination negotiation method for the lowest pricing + comprehensive evaluation applicable to complicated projects. Finally, the article put forward the control measures on how to curb the bidding rigging, from the aspects of law, economy and so on.

2. Bidding rigging and collusion phenomenon analysis and theoretical motivations

Bidding rigging and collusion appeared as the immature construction and engineering market developed to a certain stage. Bidding rigging is a kind of horizontal collusion which refers to a certain range of bidders run into a conspiracy and form a coalition of interests, by manipulating the bidding process to the exclusion of other bidders, so as to control the winning bidding price and the bidding results. Bidding collusion generally refers to the vertical collusion. Bidders, tenderers and tendering agents combine together by the interests and achieve the illegal purpose of winning the bid by a particular bidder, normally through the way of revealing bidding information in advance, revealing the bid, manipulating the quoting price, modifying the winning condition and other illegal methods to crowd out other bidders.

Bid rigging is a kind of speculation driven by interests. Under the current prosperous engineering and construction markets, the great profit can be obtained through conspired bidding to monopoly the bidding price. At the same time, bidding rigging has the characteristic of strong concealment and, cannot easily be found through investigation. High profit combined with low risk becomes one of the strong motivations for bidding rigging. But the root cause is the lack of social integrity and credibility system in engineering construction field and even in the whole society. Without the healthy and sound credit system to block the conspired bidding, the illegal bidders often get a big success by collusion behavior. Gradually, other bidders will imitate and affect the integrity of the industry and then the whole society, while the lack of social credit in turn makes the bidding rigging phenomenon intensified. The third of the reason is the connivance of the relevant laws and regulations to bidding collusion. The illegal bidders win the bid by high price but low quality while the punishment is weak even the conspired behavior being discovered and seized. The largest punishment is the fine or cancel of bid qualification, offenders can start again easily by changing a place. The weak penalties in a certain extent have been pampering the bidding rigging; Fourthly, the offender can take advantage of the bidding mechanism by seizing the loophole, defects or some unreasonable detail rules and regulations, such as defects of bidding rules, design changes, weak on-site visa control, the casual selection of bidding agencies and etc. There are the following forms of bidding rings in construction engineering project:

- 1) The tenderer regulated the bidding conditions in accordance with a particular bidder
- 2) The tenderer, bidding agency, bidders collude with each other and reveal the bid to the bidders
- 3) The bidder win the bidding with the lowest price first, and then collude with the owners to get high compensation by using design changes, on-site visa and other illegal means.
- 4) The tenderer or bidding agency get the information of bidders in advance and collude with certain bidders before the bidding, manipulate the quoting price by driving it up or down and decide the winning bidder internally.
- 5) The bidders surround the bidding and make commitment to win the bid in turns to reach common rigging of different projects
- 6) Construction enterprises, outsourcing team and the owners collude together; outsourcing team affiliate to the construction corporation and conspired; construction enterprises and bidding agencies collude and make illegal operations

3. Game theory and bidding rigging

According to rational economic man hypothesis, people are selfish and unscrupulous in pursuit of material interests. During the process of bidding, in order to pursue the largest interests, the bidder is possible to surround the bidding with other bidders or collude with the bidding agency vertically to obtain the successful bid. Of course, bidders can also win the bid through low profit quotation and high quality supply in accordance with the law of marginal cost. So what choice will the bidders make? Under what situations they will make bidding rigging? In a limited number of repeated prisoner's dilemma game, incomplete information can lead to the cooperation among prisoners. With the current market information asymmetry, the weak investigation and technical means, the lack of data and credit system provides the breeding of the warm bed to bidding rigging.

On the one hand, the bidding rigging and colluding can increase sources of information and drive up prices. On the other hand, it also can create false information and cause the deterrent to other bidders so as to make the bidder to achieve the maximization of their own interests. In this case, as long as the cost paid by the bidder by collusion is lower than its earnings, as a rational economic person, the bidders will choose bidding rigging. This paper introduced reporting and supervision mechanism in the evaluation process. In this process the accompanying party has two choices: the first is that he participate in bidding rigging and get the accompanying pay but has large possibility to be discovered and get a big fine; the second choice is to report colluding initiator to obtain the incentive bonus and possibly get the bid as a normal bidder. For the bidding rigging process, the bidding initiator launches a signal for the intentions of conspiracy activities, other bidders or tenderer (tendering agency is also regarded as the representative of tenderers) receive the signal and choose whether to respond the bidding rigging or report the initiator, while bid evaluation system decide the bid according to the bidding rules which determines the success or not of the bidding rigging activities. The whole process is regarded as an incomplete information dynamic game process. In this process, the accompany parties are pulled into the game board. In the game, players have a sequence of choices, and the actors behind can learn the choice of ahead, while the accompanying parties know the choice of the initiators and evaluation system (including supervision mechanism) can also know the tenderer's choice (price and quality). In this case of dynamic game, rigging initiator and participating parties are similarly put into the prisoner's dilemma. And game theory under the dynamic environment is added time dimension and the information asymmetry, which study when the action subject take measures, how it affect the other players and the countermeasures taken by other players and the equilibrium problems.

4. Game theory model of bidding rigging

For the real bidding activities, generally there are two kind of bidding rigging behaviors: (1) horizontal collusion among the bidders; (2) vertical collusion among the tenderee and bidder or bidding agency. Following we analyze these two bidding rigging behaviors under different bidding rules. First of all we assume the tenderer, bidders are rational economic people who pursue their own interest maximization and will accept bidding rigging if situation allows

If the number of bidders is n the cost is c , the normal price is b , if choosing bid rigging the offer is b' , the horizontal accompanying relative fee is b'' and the vertical collusion fee is b''' , the extra income is e for bidding rigging. Normal bid acceptance probability is P , while the probability is $P1$ for surround-bidding and $P2$ for vertical bidding collusion, the probability of being investigated is p' and the fine is f . If being reported successfully by conspirators, the fine is f' and the reporting probability is p'' and the fine of f' to the prosecutor. All bidders, tenderer and accompanying bidders are neutral people and choose the prior probability of bid rigging was 0.5

1) For the normal offer, the expected return of the bidder i

$$E(ui) = (bi - ci) \times P \tag{1}$$

2) If bidder i choose to surround the bid and the total surround-bidding numbers is m ,

$$E'(ui) = (b'i - ci) \times P1 - b''i - f \times p' - f' \times p'' \tag{2}$$

3) The expected return of accompanying bidder k if he agrees to accompany the bidding

$$E'(uk) = \frac{b''}{m} \times P1 \tag{3}$$

4) The expected return of accompanying bidder k if he report i and provide normal offers

$$E(uk) = (bk - ck) \times P + f'' \times p'' \tag{4}$$

5) The expected return of the bidder i if he choose vertical bidding collusion

$$E''(ui) = (bi - ci) \times P2 - b'''i + ei - f \times p' - f' \times p'' \tag{5}$$

6) The expected return of the tendering agency / tenderers if all bidders offer normally

$$E(uz) = 0 \tag{6}$$

7) The expected return of the tendering agency / tenderer if bidder i choose vertical bidding collusion

$$E'(uz) = b''' - f \times p' - f' \times p'' \tag{7}$$

8) Surround-bidding model: if participate is P, not participate is NP

		Accompanying bidders	
		P	NP
bidders	P	$E'(ui), E'(uk)$	$E'(ui), E(uk)$
	NP	$E(ui), E(uk)$	$E(ui), E(uk)$

Vertical bidding rigging model: if participate is P, not participate is NP

		tenderer	
		P	NP
bidders	P	$E''(ui), E'(uz)$	$E(ui), E(uz)$
	NP	$E(ui), E'(uz)$	$E(ui), E(uz)$

9) Bidders decides to initiate surround-biding based on the expected income of the rigging has to be greater than or equal to the expected income of not-rigging and investigation / being reported probability is low, that is, $E'(ui) \geq E(ui)$, so the formular is

$$(b'i - ci) \times P1 - b''i - f \times p' - f' \times p'' \geq (bi - ci) \times P \tag{8}$$

10) Accompany bidder decides to participate in surround-bidding based on the expected income of the rigging has to be greater than or equal to the expected income of not-rigging and investigation / being reported probability is low, that is, $E'(uk) \geq E(uk)$, so the formular is

$$\frac{b''}{m} \times P1 \geq (bk - ck) \times P + f' \times p'' \tag{9}$$

11) Bidders decides to collude based on the expected income of the rigging has to be greater than or equal to the expected income of not-rigging and investigation / being reported probability is low, that is, $E''(ui) \geq E(ui)$, so the formular is

$$(b''i - ci) \times P2 + ei - b'''i - f \times p' - f' \times p'' \geq (bi - ci) \times P \tag{10}$$

12) The bidding agency decides to collude based on low probability of being investigated and getting string income

$$b''' - f \times p' - f' \times p'' \geq 0 \tag{11}$$

5. Game theory analysis of bidding rigging under different bidding rules

Due to space limitations, these articles just discuss several representative bidding rules.

5.1 Lowest price sealed bid

Bidding rules: The lowest prices win the bid

$$P1 = \frac{1}{n - m + 1}$$

1) For surround-bidding, $\frac{1}{n - m + 1}$, the number of m is bigger, the probability of being investigated is bigger. When increasing the number of n, the probability of winning bid is lower. All in all, if n is large enough; the collusion probability is very small. For the accompanying parties, if the accompanying income with low probability of winning bid is less than the prosecuting income, they will not choose to participate in the bidding rigging as a rational economic man.

2) With rules of lowest price sealed bidding, $P2 = P$, and the winning price should be lower enough, that is $b''i = bi$, so the equation is:

$$ei - b'''i - f \times p' - f' \times p'' \geq 0 \tag{12}$$

If bidder collude with the tenderer to win the bid with lowest price and claim high compensation later, the amount of should be large enough, otherwise bidders take abnormally low bid is not worth.

Thus it can be observed in lowest price sealed bid that when the number of bidders is large enough (or unable to confirm the number of bidders on online bidding) or some people do not agree with rigging, the probability of winning bid by bidding rigging is low. For vertical collusion, e_i amount has to be large enough. When getting bid with normal price and then colluding with the tenderer to obtain additional e_i , it depends on the control of e_i amount and the investigation degree.

5.2 Close to the base price bidding

Bidding rules: the price the most close to the set price D winning the bid

Under such situations, the bidders only know the set price D , that is, only if $b_i = D$, then $P = 100\%$, as shown in formula (13).

$$(b_i - D) + e_i - b_i - f \times p - f' \times p' \geq (b_i - D) \times P \quad (13)$$

Thus it can be observed that collusion is easily happened under this bidding rule. The bidder can win the bid if they know the “ D ” which is set by the tenderer. Only if strengthening investigation degree and increasing the prosecution and incentive measures, the collusion behavior can be controlled.

5.3 Average price bidding

Bidding rules: Take all the average price of M , the more close to the lower of the average price of M , the more easily to win the bid

$$M = \sum_{i=1}^n b_i / n, |M - b_i| < |M - b_j|, 1 \leq i \leq n, i \neq j, \text{ then } P = 100\%, \text{ otherwise } , P = 0 \quad (14) \quad \text{As the}$$

winning probability depending on M , as long as $n/2$ or more bidders form the coalition of interests, then M can be included in the quotation of these $n/2$ bidders, and the successful rate was 100%. Under this situation, if the punishment and investigation degree is weak, the possibility of rigging was 100%.

5.4 Comprehensive evaluation bidding

Bidding rules: mark m respectively to p_i (price bid) and q_i (quality bid, including performance, delivery, comprehensive strength, etc.) and determine the final scores according to a certain percentage. The highest score wins the bid.

$$m(p_i) \times x + m(q_i) \times (1-x) > m(p_j) \times x + m(q_j) \times (1-x), 1 \leq i \leq n, i \neq j, P = 100\% \quad (15)$$

As there are many subjective factors in $m(q_i)$, if corrective mechanism is not perfect and the supervision mechanism is weak, collusion easily happens.

5.5 Composite bidding

Bidding rules: The first round adopts sealed bidding and chooses a few lowest prices. The second round use the comprehensive evaluation method and the one with highest scores win the bid.

Game theory Analysis: theoretically, this composite bidding method can choose the good bidders. But it still inevitably avoids bidding rigging phenomenon. If bidder i has the intention to collude, in the first round he surround the bidding to enter the second round, while in the second round exists some soft targets, there are also the probabilities to make collusion.

6. Some conclusions and suggestions on bidding and tendering

In summary, all bidding rules cannot completely eliminate bidding rigging behaviors, especially colluding to claim high compensation is unavoidable when the investigation is weak. Relatively speaking, the lowest price sealed bidding method can effectively cut down the price and minimize bid rigging. The composite bidding, lowest price sealed bidding+ comprehensive evaluation method, can choose a relatively excellent bidder. These two bidding methods are respectively suitable for the bidding with low technical requirements and high technical requirements. In view of the above points, the proposal for the bid is as follows

- 1) The loss of social credit and weak external supervision and punishment is the fundamental reason of frequent bidding rigging behaviors. This article suggests reducing the probabilities of bidding rigging through the establishment of project credit evaluation mechanism, introducing national bidding supervision institutions in the evaluation process, increase of rigging reporting & incentive system, strengthening the information disclosure and adding rigging expenses.

- 2) From the view of multi-period incomplete information dynamic game theory, these measures will weaken the bidding rigging and collusion preference and reverse the social atmosphere, so that bidding work can play a better role on the effective allocation of social resources
- 3) The lowest price bidding method is an effective method in bid with simple technical requirements, which has large probability to block the bid rigging conspiracy behaviors. But the high compensation claim is unavoidable which caused by the excessive price competition. Therefore, the strict control of the after-bid compensation is the necessary measure to promote the price back to the reasonable level and exert the lowest price bidding advantages.
- 4) Close to base price and average price biddings are two of the bidding rules that bid rigging players can operate easily. These should be avoided unless there is a huge price difference or in some special biddings
- 5) The composite bidding method will increase the bidding cost, but the sealed bid + comprehensive evaluation method is still a way to find bidders with excellent performance. Although there are still bidding rigging behaviors, but it can control the price in a relatively reasonable range and to find relatively high quality suppliers.
- 6) the implementation of online bidding is an effective approach to barrier the meeting of the bidders so that to avoid the formation of colluding.
- 7) It is necessary to strengthen the law of bidding and make the rules for the tender and bidding more complete and more specific, so that the bidding activities has laws to go by and the laws must to be observed and enforced.

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