MODELLING THE COST OF COLLUSION IN THE CONSTRUCTION INDUSTRY: A CASE OF CHINA

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Within the construction industry, bidders tend to collude with each other to increase the probability of winning construction projects. To this end, they need to strike a trade-off between costs of collusion and potential benefits from collusion they adopted, to decide whether to participate in the collusion. In this process, the collusion cost and fine are important indicators for the colluder to decide whether to participate in the collusion. This study aims to develop two models, one model used to predict the collusion cost, and another is used to reveal the actual level of collusion fine. 103 collusion cases from China were collected to test the proposed models by regression analysis. It is found that the two models exhibit an upturned positive tendency with the winning bid price. The average of the ratio of collusion fine and collusion cost always remained the range of 0 to 0.5, and also showed the trend of first rising and then falling. The research findings reveal an important reason for the frequent occurrence of collusion, guide the construction unit to understand the negative impact of collusion and provide decision support for relevant government in supervision.

Keywords: collusion in bidding, collusion cost, fines, China

INTRODUCTION

The construction industry has been identified as the most collusion in the world (Chotibhongs and Arditi 2012). Recent decades have witnessed the proliferation of collusion in bidding (CiB) cases in many developed and developing countries. Such as, in examining the popularity of illegal competition in the construction context, the World Bank (2011) found that 14 out of 29 examined road projects competitions involved CiB. In Japan, the media reported that there was collusion in four major construction enterprises in the struggle for the Central Shinkansen Magnetic Levitation project and disclosed that the total contract size of CiB was about 80 billion USD (Xinhua net 2017). These reports have indicated an urgent situation of CiB in the construction industry.

CiB is mainly manifested in the fact that bidders cooperate covertly to win project competition by means of cooperation, information sharing, collective decision-making, and struggle against independent bidders (Zarkada-Fraser 2000). In practice, the key to CiB operation is that the leading conspirator pay fees to partners to ensure the stability of collusion, which fees called collusion cost. Nevertheless, CiB is risky.

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Wang, X, Liu, R, Ye, K and Tekka, R S (2020) Modelling the Cost of Collusion in the Construction Industry: A Case of China *In:* Scott, L and Neilson, C J (Eds) *Proceedings of the 36th Annual ARCOM Conference,* 7-8 September 2020, UK, Association of Researchers in Construction Management, 115-124

It may be discovered by owners and competitors and causes their partners to be disqualified for future project competition. If a bidder's collusion behaviour is discovered, the bidder's may be fined with administrative penalties (Marshall and Marx 2009). Therefore, conspirators make the decision carefully by taking account of payment of fees, risk of being identified, and the success rate of the project competition.

The willingness of bidders to join a collusion team depends on the magnitude of both collusion cost and fine. The more considerable the amount of the collusion cost, the stronger the willingness of bidders to attend, and the easier the establishment of a collusion team. However, an increase in either collusion cost or collusion fine confronts the leading conspirator with much more financial vulnerability. Therefore, the collusion cost and fine have to be gauged very cautiously before launching a CiB team. It seems that the collusion cost is a signal for the transaction between collusive members and a proxy for tracking illegal competition in the construction sector.

Due to collusion's complexities, dynamism and uncertainties, very few efforts have been made to quantify the collusion cost and the actual punishment faced by the collusive bidders. Consequently, this study aims to model the collusion cost and fine using data from China's construction industry. The proposed models were established by regression analysis. These models reveal the internal mechanism in organized collusion and provide a basis for subsequent research on the detection of collusion through bidding price.

LITERATURE REVIEW

CiB has many different forms. However, no unique test procedure can detect all collusive schemes (GUPTA, 2001). Many scholars claimed that the CiB is a form of corruption in which two or more market players reach agreements for a fraudulent purpose (Chotibhongs and Arditi 2012). In referring to game theory, Shi *et al.,* (2013) uncovered that two types of CiB cases. One is composed of the client's agents and bidders, while the other is a collusion between bidders only. The CiB undermines the foundation of market competition (Zarkada-Fraser, 2000), and it is one of the most severe violations of the Competition Law (Sichombo *et al.,* 2009). Besides, the CiB is conducive to corrode social welfare in the long run (Dorée 2004;). Perng and Chang (2004) found that collusion cost and fine are fundamental causatives leading to higher bid price from the collusive bidders. Hence, as proposed by many scholars, detection of collusion need to be analysed through bid price (Bajari and Ye 2003; Chotibhongs and Arditi 2012).

Although the emergence of CiB cases is attributable to many reasons, a key factor is the excessive business competition that contractors have been aware of in the construction industry (Shi *et al.,* 2013). Fonseca and Normann (2014) consider that the decision to establish collusion should foremost depend on the gains and costs from cartelization. The collusion cost is determined by some external factors such as competition intensity and economic cycle, suggesting that its prediction is overwhelming. Given the predictability of collusion cost, collusive members would be able to determine bid prices regarding key determinants (Porter and Zona, 2008), and control loss in case that they lose project competition (Kenny 2009). But in fact, a precise calculation of the collusion cost improves the transparency of project competition, which aids both government and the clients to explore practical ways to inhibit collusion (Foster and Méndez 2009; Goel and Nelson 2011).

Owing to CiB is a secret conspiracy, its detection requires extensive police investigation in the form of a collection of legal evidence such as recordings of meetings between collusive bidders and witness testimonies (Bajari and Summers 2002). As an economic measure, fine is often adopted by governments to warn those bidders breaching the law of bidding competition (Allain *et al.,* 2015). Exposure to potential administrative punishment weakens bidders' willingness to make collusion. Therefore, CiB may be less if the administrative penalty increases to the extent to which bidders feel the enormous risks of collusion ahead (Tabish and Jha 2012) Roux (2015) looked at the potential of punishment to inhibit collusion and found that punishment benchmarking cannot mitigate collusion from the construction market. Zhang *et al.,* (2017) argued that CiB cases would be less if legal penalties are adequate. Goel and Nelson (2011) disclosed that bidders could find it easier to collude if the fine is not that much. These works of literature reveal that the study of the current actual fine imposed is of considerable significance to the supervision of collusive behaviour.

METHODS

Data Collection

Data collected from the justice system report facilitate the calculation of collusion cost and improve the accuracy of the measurement (Della Porta 2001) as well as reveal more important collusion details. Uytse (2018) mentions in the study of artificial intelligence algorithm technology and pricing strategy that, the cost of collusion can be estimated through existing legal instruments. While referring to the above theory, the data used in this study was collected from China Judgment Online as a website established by the Supreme People's Court of China. Since 2014, the network has published on the Internet a unified website for the valid judgment documents of people's courts at all levels. In this paper, 103 CiB cases collected using the site's advanced search function.

These cases distributed in different provinces of China, including five types of projects, namely, building construction (52%), municipal engineering (21%), water conservancy and hydropower engineering (9%), highway engineering (8%) and others engineering (11%). Collusion cases release times are mainly distributed between 2014 and 2018. In attaining the objective of this study, a total of three sets of data namely, winning bid price, collusion cost and fine were collected from these cases. A detailed description of the data is shown in table 1.

Table 1: Profile of the samples

Variable	Cost			Standard deviation
	min.	max.	average	
Winning bid price	150.85	68936.18	6121.67	9097.18
Collusion cost	4.12	1720.00	194.20	299.99
Collusion fine	1.14	270.00	24.57	35.21

Note: The unit of 10,000 yuan (about 1405.13USD)

Regression Analysis

Regression analysis is a statistical method used for estimations or prediction of an examined subject (Powers and Xie 2008). It was used to provide the relationship between two or more variables which have a cause-effect relationship as well as the estimations of unknown facts from known findings (Akcay *et al.,* 2018). As presented above, the relationships between collusion cost with winning bid price and collusion fine with winning bid price were computed using regression analysis, the ordinary least squares (OLS) approach was adopted for parameters estimation. R^2 was used to determine the explanatory power of the model, T-test was employed to determine the correlation between the coefficients and F-test was used to monitor whether the linear relationship between dependent variables and independent variables significant.

DATA ANALYSIS

Statistical Packages for Social Sciences SPSS 25.0 software was used to draw the scatter plot used to show the relationship between winning bid price and collusion cost (see Figure 1). In figure 1, the independent variable is winning bid price, and the dependent variable is collusion cost. It can be seen from figure 1 that the data show a skewed distribution, which means that they cannot be computed straight for regression analysis. Hence, the logarithmic transformation is required. The data were converted by using the natural logarithm of winning bid price and collusion cost. The results fit the requirement of distribution, and it minimizes the impact of sample outliers on regression estimates. Using the new variables ln (winning bid price) and ln (collusion cost) are re-scattered and added the fitting line in figure 2. As can be seen from figure 2, a positive direction of the relationship between ln (winning bid price) and ln (collusion cost). Moreover, the equation on the line in the diagrams was obtained using the ordinary least square (see Table 2).

Table 2 The calculated equations

Model	Mathematical equation	R^2
1	ln (collusion cost) = 0.76 × ln (winning bid price) − 1.54	0.691
2	ln (collusion fine) = 0. 6 × ln (winning bid price) − 2.04	0.642

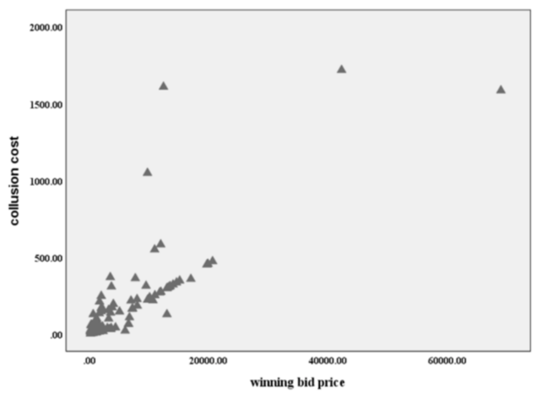

Figure 1: Relationship between winning bid price and collusion cost

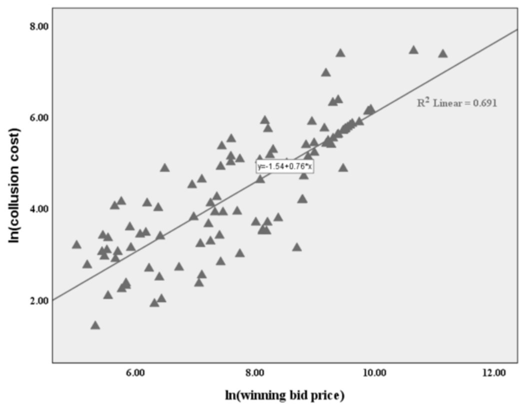

Figure 2: Relationship between ln (winning bid price) and ln (collusion cost)

The procedure of modelling the relationship between winning bid price and collusion cost is repeated to detect the relationship between winning bid price and collusion fine. For simplicity, steps for this modelling process are not described here. The scatter plot is shown in figure 3 and figure 4 and the collusion fine prediction equation in table 2.

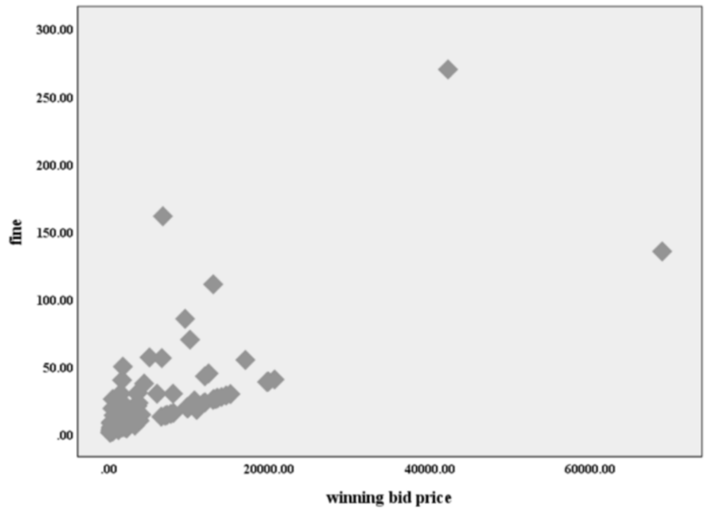

Figure 3: Relationship between winning bid price and collusion fine

Figure 2 and figure 4 all exhibit a positive upturned tendency relationship. In table 3 and table 4, given that the probability value for the T- and F-test statistics have a value less than 0.05 for both evaluation parameters, this led to the rejection of the null hypothesis, which states that the coefficient for the cost of these parameters is zero, and hence this result says that the model is statistically significant at the 95% confidence level. As indicated by the coefficients of R^2 per model, 69% of the variance is explained for the collusion cost (Model 1), and 64% of the variance for the collusion fine (Model 2).

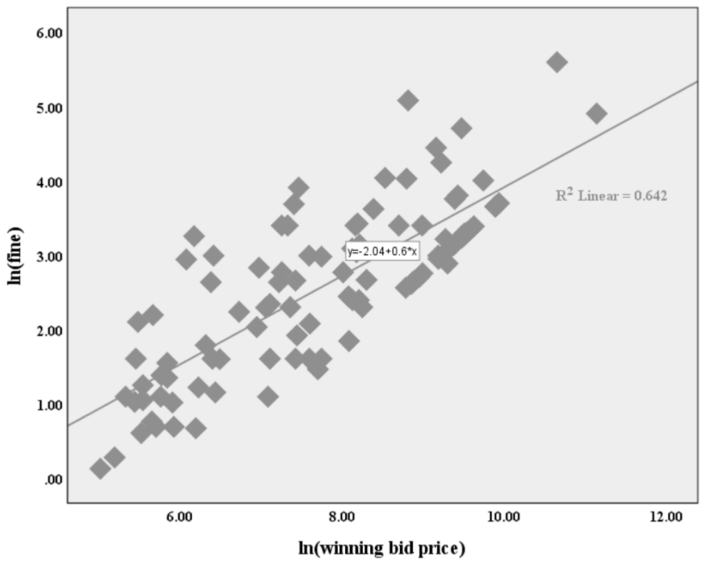

Figure 4: Relationship between ln (winning bid price) and ln (collusion fine)

Table 3: Model regression analysis

Model	R	Adjusted R^2	Standard error	R^2 variation	F variation	Significant change in F
1	0.831[a]	0.688	0.765	0.691	225.533	0.000
2	0.801[a]	0.639	0.666	0.642	181.252	0.000

Table 4: Variables coefficients

Model	Coefficient	standard error	t	Significance
1	constant	0.404	-3.808	0.000
	ln (winning bid price)	0.051	15.018	0.000
2	constant	0.352	-5.811	0.000
	ln (winning bid price)	0.044	13.463	0.000

The relationship between fine and collusion cost is explored using a box plot (Figure.5). First, ln (winning bid price) is divided into five intervals of 5-6, 6-7, 7-8, 8-9, 9-10 from small to large respectively. Second, the ratio of collusion fine and collusion cost is calculated using the mathematical method. Finally, a box diagram is drawn (Figure.5) whereby "×" in each box represents the average of each set of data.

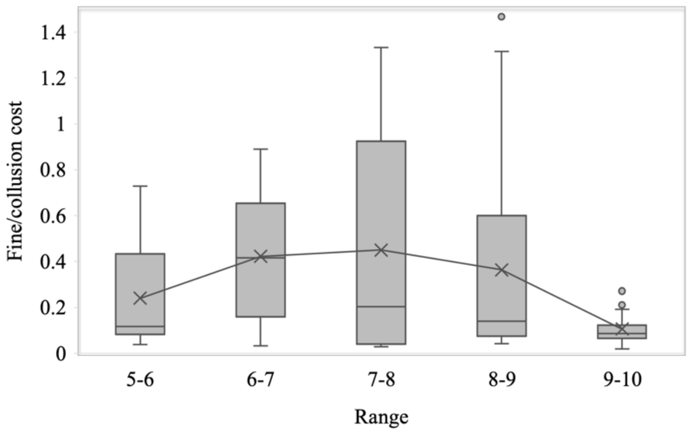

Figure 5: The ratio of collusion fine and collusion cost

FINDINGS

Trends of Collusion Cost

Quantitative analysis of collusion cost and winning bid price was carried out according to the principle of parameter estimation of OLS. It can be seen from figure 2 that, as the winning bid price increases, the collusion cost shows a trend change in the model 1 (Table 2), that is, the collusion cost increases as the winning bid price. The reason is the government will more strictly regulate the project as the project scale increases, and the more likely the conspirators will be found, so the leading conspirators must pay more collusion cost to reach the collusive alliance. Meanwhile, another important reason is the project may bring more benefits as the project scale increases, and the number of enterprises participating in the bidding will also increase accordingly. Therefore, if the leading conspirators want to succeed in the conspiracy, they must ally with more bidders, which will also lead to an increase in the collusion cost.

It is calculated that the adjusted goodness of model 1 is R2=0.69, which means the interpretation degree of the model reaches 69% accuracy. In table 3 and table 4, the t value and F value of model 1 are both less than 0.05, which means that the model passes the test. That is, combined with the above model 1, and the winning bid price can predict the collusion cost. However, if the model is used to predict the collusion cost, the degree of interpretation of the model should be considered to make a correct judgment.

Goel and Nelson (2011) mentioning that the assessment of collusion cost is critical to the development of anti-collusion strategies. Uytse (2018) found that accurate prediction of collusion cost can contribute to predicting the price of the conspirators' bids. This study is an extension of the above research, the first to analyze the collusion cost from a quantitative perspective. The result was providing a more scientific basis for industry and follow-up research. Besides, the collusion cost development law can give government departments and owners a deeper understanding of the formation mechanism.

Trends of Collusion Fine

The data of winning bid price and collusion fine are analyzed having the same data processing method above to give the result. Fig 4 indicated that, as the winning bid price increases, the collusion fine shows a change in the development trend of the model 2, that is, the collusion fine increases with winning bid price increases.

In the study of anti-collusion competition, a large number of scholars propose to reduce collusion by increase fine (Brown and Loosemore 2015; Oke *et al.,* 2017; Tabish and Jha 2012; Zhang *et al.,* 2017). However, none of the above studies systematically studied the intensity of fine from a quantitative perspective. Although it is possible to deduce the scope of the fine by the winning bid price through the punitive measures of the collusion in the bidding law formulated by the government department, the scope can't reflect the actual punishment of the government for CiB. This study used the collusion fine and winning bid price data in the court judgment paper and conducted a quantitative analysis of the relationship between the two. The assessment model 2 (Table 2) and the law of change (Figure 4) are between winning bid price and collusion fine, which can provide a more reliable basis for government departments, provide a reference for them when formulating punitive measures, and realize the transition from theoretical research to practical research.

Trends of the Ratio of Collusion Fine and Collusion Cost

The collusion fine represents the cost that the collusion violates in a certain social system environment, reflecting a social attitude. The relationship between ln (winning bid price) and the ratio of collusion fine and collusion cost is explored above using a box plot (Figure 5). It can be seen from figure 5 that as ln (winning bid price) increases, the average of the ratio of collusion fine and collusion cost increase first and then decrease, but it always remained the range of 0 to 0.5. Meanwhile, when ln (winning bid price) reaches 9-10, the average of the ratio of collusion fine and collusion cost is only 0.1059, which indicates that the collusion fine only accounts for about 0.1 times the collusion cost.

In the collusive process, the conspirators will be subject to a fine only when the collusion is discovered. However, conspirators are negotiated in secret, and it isn't easy to find. Therefore, when the supervision is not stronger before the conspirators make decisions, the first consideration is the size of the collusion cost. From a psychological point of view, if the conspirators are willing to pay the collusion cost, and if the regulatory authorities discover the collusion in the later period, they only need to pay a lower fine and the probability of being found is extremely low. More bidders are willing to participate in the collusion. From figure 5, the penalty is only 0-0.5 times the collusion cost, so when the supervision is not strict, more bidders are more inclined to participate in collusion. This study believes that the fines at this stage are lower and do not reach the deterrent effect.

The relationship between collusion fine and collusion cost was discussed using 103 CiB cases. It can be judged that the ratio will fluctuate with the changes in the institutional environment and the stage of economic construction, but the overall is maintained at a level. When considering the broader or more national institutional environment and economical construction stage, it can be estimated that the ratio of the collusion fine and the collusion cost varies. Still, the overall level will remain at a certain level. The main reason is that society always has standards for specific violations or behaviours. Another reason is that collusion fine and collusion cost are positively related to the winning bid price. Therefore, this requires policymakers to pay attention to creating an excellent institutional environment, paying attention to the issue of penalty intensity standards when the punishment for collusion. This research was filling the latest evidence for the study of the relationship between the collusion fine and collusion cost.

CONCLUSION

This research attempts to explore the models of collusion cost and collusion fine in bidding. Regression analysis results show that as the winning bid price increased, the collusion cost and fine continued to increase, and the predictability of collusion cost and fine were given. When discussing the relationship between winning bid price and the ratio of collusion fine and collusion cost, it was found that the average of the ratio was always between 0 and 0.5, which means that the fines at this stage are lower and do not reach the deterrent effect.

The research findings contribute to providing a new perspective on the construction industry towards collusion cost and fine's linear analysis. Meanwhile, the research findings reveal the changing rules of collusion cost and collusion fine, it guides the construction industry to understand the negative impact of collusion fully and also provide decision support for relevant government departments in bidding supervision, formulating anti-collusion strategies and related punishment measures. In addition, the ratio of collusion fine and collusion cost can be used as a research benchmark, which will help to later study the collusion cost and the intensity of punishment in the anti-collusion behaviours.

Despite these contributions, this study has its limitation. This research gives the prediction models of collusion costs and fines from the perspective of economics. However, these models cannot be directly applied to collusion monitoring, and can only provide a theoretical foundation for subsequent collusion research.

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