CRITICAL DRIVING FORCE FOR CONTRACTOR'S OPPORTUNISTIC BIDDING BEHAVIOR IN PUBLIC WORKS

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ABSTRACT : Contractor's opportunistic bidding behavior refers to contractor's deliberate low-bid, which cannot accord with the cost, and expectation for beyond-contractual reward (BCR), the compensation earned through cutting corners or claims after undertaking the construction project. This research applies System Dynamics to develop a model of contractor's pricing with consideration for dimensions of "cost", "market competition", and "BCR". Iterative computer simulations were performed to analyze the effects of contractor's pricing on the market price. The results were then examined by statistical analysis on data collected from 44 highway projects in Taiwan. It is found that the critical force driving the contractors to bid opportunistically is their excessive expectations in BCR under the current environment. Within the price competition mechanism, if the problem of BCR exists, even if the bidding system is further improved, contractors would still prefer opportunistic bidding behavior, and eventually make the whole construction industry operate ineffectively. Therefore, it is crucial to remedy the aforementioned BCR problem by more effective management policy.

Key words : construction industry, simulation, system dynamics, bid

1. INTORDUCTION

Under the competitive bidding system, fierce competition has long made the contractors to bid substantially low and sometimes even lower than their cost. Such abnormally low bids have been widely regarded as the main cause of poor quality in public project. In order to eliminate abnormal low-bids, government of Taiwan has adopted a number of policies, e.g., average-bid method [1], ceiling price method [2], and best value contracting method [3]. However, for the past few years, it was still common that the award price of the public projects is substantially lower than the budget. In some extreme cases, the awarded price was even 40% to 50% lower than the budget. According to the research conducted by Taiwan Construction Research Institute on construction companies in Taiwan, malignant competition for bid have become the utmost cause that affects the development of construction industry [4].

Previous studies have regarded the pricing of bidders as an optimum decision on account of cost and market competition level. Given constant cost factor, abnormal low-bids are attributed to insufficient market demand, excessive number of contractors, and unsound bidding system. However, it is noticed that when contractors begin the construction at an unfavorable price, they would adopt some strategies to cover the loss, such as cutting corners to lower the cost [5], and bringing up claims against the owner [6]. In this research, all the compensations gained beyond the contract are termed "beyond-contractual reward" (BCR).

Doyle and DeStephanis [7] warned that certain bidders extensively review the bid documents, noting mistakes, cataloging ambiguities, and looking for future change orders or claims. These bidders can lower their bid price with the knowledge that on subsequent change orders or claims they can recapture monies that were initially sacrificed for the award [8]. Ho and Liu [9] applied Game Theory to analyze the relationship between claims and contractors' bidding and concluded that contractors would lower the bid when they expect profits from claims.

In this research, contractors' opportunistic bidding behavior refers to contractors' deliberate low-bid, which cannot accord with the cost, and expectation for BCR. To be more specific, contractors expect to earn profit through cutting corners or claims after undertaking the construction, so they deliberately offer a low bid to win the award. Under normal circumstances, contractors reflect the cost on the bid price. When they anticipate a BCR, however, they would adjust the bid price accordingly. Therefore, focusing on the estimation of cost and markup cannot sufficiently explain the bid. The purpose of this study is to analyze in depth the contractors' opportunistic bidding behavior, and its effects on the overall price level of the construction market.

2. RESEARCH DESIGN

This research mainly consists of two parts. In the first part, a System Dynamics model with three dimensions of "cost", "market competition" and "BCR" is proposed to simulate contractors' pricing. Iterative computer simulations are performed to analyze the effects of two kinds of pricing on market price—"without consideration of BCR" and "with consideration of BCR". In the second part, 44 projects data collected from two major traffic construction project supervising agencies in Taiwan, National Expressway Engineering Bureau (NEEB) and Directorate General of Highways (DGH), as well as the questionnaire survey on contractors involved in these projects are analyzed to verify results obtained in the first part.

3. MODELING CONTRACTOR'S PRICING

This section discusses two kinds of pricing, i.e., "pricing without consideration of BCR" and "pricing with consideration of BCR". Market price and equilibrium pattern due to each pricing will be individually simulated and analyzed as well.

3.1 Pricing without Consideration of BCR

This section explores contractors' pricing when BCR is not taken into account, but only cost and competition in the market are concerned.

3.1.1 Explanation of the Pricing Logic

As shown in Figure 1, contractors' bidding price (BP) is influenced by variables from two dimensions of "cost" and "market competition". Each dimension further consists of a number of variables that vary with time. Since the "cost" only reflects contractors' bottom line in pricing, dimension of "market competition" becomes the main consideration in pricing. Definitions and relationships of variables in Figure 1 will be explained as follows.

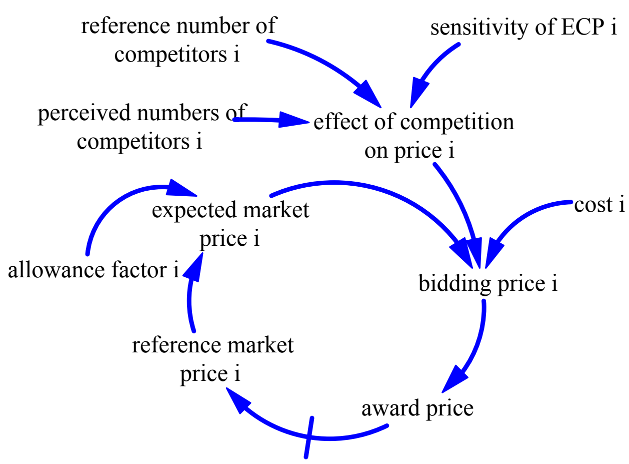

Figure 1. Pricing without consideration of BCR

Assume contractors aim to obtain maximum profit, and the goal of pricing is to look for a price which is "minimally" lower than that of any other competitors. To achieve this goal, bidders need to assess and predict prices that their competitors may offer before they determine their own price. In this case, the award prices of previous projects become an important reference. In order to win the bid, contractors would set their price lower than that of previous projects, termed "reference market price" (RMP).

In addition, Carr [10] proposed that, "as the number of competitors varies from project to project, contractors typically adjust their markups to reflect increases and decreases in competition". The factor is termed "level of competition" in this paper.

Consequently, "reference market price" and "level of competition" become the most fundamental considerations in the dimension of market competition.

1.Effect of *RMP* on contractor's pricing

As mentioned earlier, contractors decide on the bidding price after they predict possible prices of their competitors on the basis of reference market price, RMP, so as to win the bid with a lower price. Following the rule of "First-order linear negative feedback system" introduced by [11]. RMP is designed as a variable that varies with time and depends on the contractor's previous experience. Contractors constantly update and adjust their new RMP based on the discrepancy between previous RMP and award price. By doing so, the RMP will approach the reasonable lowest price of all competitors. Assume that the number of competitors in the market is n, the RMP perceived by each competitor i differs with different timing and range of adjustment. Therefore, in Figure 1, RMP for each competitor is represented by "reference market price i", where i ranges from 1 to n. The same concept applies to other variables labeled with i. With RMP taken into account, the price adjusted lower by a contractor with regard to RMP is called "expected market price"(EMP). The easiest adjustment is making a discount on RMP, which can be expressed as in Equation (1):

EMPi = RMPi * allowance factori ($) …………...……(1)

where "allowance factor" represents the discount coefficient of market price. The lower the discount coefficient is, the more eager the contractor is to win the bid.

2.Effect of Competition Level on contractor's pricing

De et al. [12] has verified that the larger number of competitors is, the lower profit the winner gains. Accordingly, contractors would adjust their expected profit based on the level of competition before they determine the bidding price. There have been numerous studies on bidding strategies, e.g., Friderman [13], Gates [14], Carr [15], Drew et al. [16]; and they vary with respect to the criteria for measurement on competition level. This research applies "number of competitors" that is most frequently used to represent competition level. The more bidders there are in for a project, the more competitive the project is.

This research applies "effect of competition on price" (ECP) to indicate the effect of competition level on the bidding price. ECP is a function of three variables, "reference number of competitors" (RNC), "perceived number of competitors" (PNC), and "sensitivity of ECP" (SECP).

RNC is the predicted number of bidders based on previous bids (for example, the average number of bidders in previous projects); and PNC is the number of bidders known before the bid. If the PNC equals the RNC preset by a contractor, after deciding the bidding price based on the RMP, the contractor does not need to make further adjustment in accordance with competition level; In this case, ECP equals 0. If the PNC is larger than RNC, the competition is keener and ECP will be negative. Therefore, bidders will lower their price to win the bid. On the contrary, if the PNC is smaller than RNC, the bid is less competitive and ECP will be positive. In this case, bidders may raise their bidding price. And "sensitivity of ECP" (SECP) represents the weight of this decision logic, where the value of SECP ranges from 0 to 1. The higher the SECP is, the more weight the contractor gives to the competition level in pricing, and the larger the range of adjustment. If a contractor's SECP equals 0, that means the contractor takes no consideration for competition level of the project at all.

To summarize, the contractor's decision function for the determination of bidding price is as follows:

BPi = (EMPi + Ci * ECPi) …………………....………….(2)

where BP indicates contractor's bidding price, C indicates cost, and the bidding price is adjusted with regard to competition level by C * ECP.

Since contractors will not perform the construction at a sacrifice, if the estimated price is lower than cost, they will not lower the price but stay at the cost. Therefore, a more comprehensive decision function for pricing of each individual contractor has been shown as Equation (3) where the contractors choose a maximum value among the estimated price and cost:

MAX [($EMP_i + C_i * ECP_i$), C_i] …….....................……(3)

where MAX indicates the maximum value adopted.

4.1.2 Simulation of Market Price

In this section, a simulation is conducted on the price trends when BCR is not taken into consideration by the contractor. The computer program used in this research is ithink® Analyst 6.0.1.

Assume the initial budget estimated by the owner is Bx, and the cost is 90% of estimated budget, i.e., 0.9Bx. Due to improvements in management and production techniques, the cost will decrease with time for most contractors. According to the 44 sample projects collected in this research, the number of bidders ranges from 3 to 13, and the average is 7. Therefore, in the model, the RNC is set as 7; the PNC is set between 3 and 13, which is defined as RANDOM (3, 13) in order to conform to a random variable with even distribution.

The price trend obtained by computer simulation is shown in Figure 2. The X-axis indicates time, and the unit is month. The Y-axis indicates market price, and the unit is dollar. "RMP" curve represents the tendency of market price that varies with time, "cost" curve represents the cost of the contractor with the best cost advantage, "cost 2" curve represents the average cost, and "cost 3" curve represents the cost that never changes.

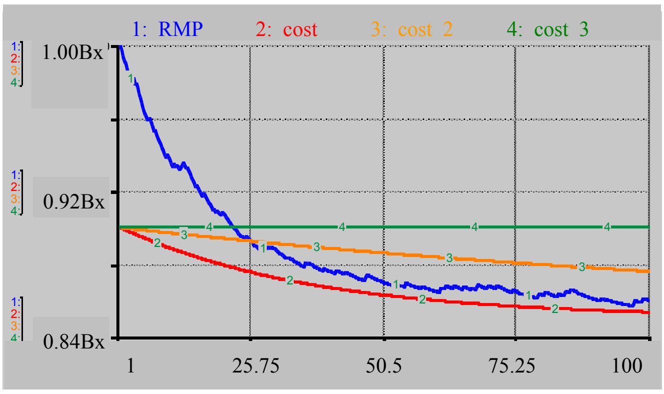

Figure 2. Market price trends without account of BCR

It is shown that, under the competitive bidding system, the starting point of the market price, i.e., the budget estimated by the owner, reduces with time and level of competition, until it gets very close to the cost and the equilibrium price level. Besides, since the number of competitors varies at different points of time, the market price fluctuates.

Throughout the process of competition, the market price lowers with the price offered by the contractor with the lowest cost. If a certain contractor does not follow the general pace of cost reduction, or does not reduce at its cost at all, in the long run, this contractor will surely lose its competitiveness.

4.2 Pricing with Consideration of BCR

This section explicates the contractors' pricing with consideration of "cost", "market competition", and "BCR".

4.2.1 Explanation of the pricing logic

Since BCR is taken into account, contractors expect on the BCR as the room for price adjustment and lower the bidding price to win the bid. Therefore, the pricing with only consideration of "cost" and "market competition" of Figure 1 is expanded to that of Figure 3.

This research assumes that "expected beyond-contractual reward" (EBCR) is the jetton on which contractors rely to lower the bidding price. Therefore, the decision function of contractors' pricing transforms from the equation of MAX [(EMPi + Ci * ECPi), Ci] into that of Equation (4).

{ MAX [(EMPi + Ci * ECPi), Ci] – EBCRi } ………..(4)

Contractors who follow regular course of business do not expect BCR, so EBCR equals 0; yet from Equation (4) it can be understood that in competitive bidding system, contractors who consider EBCR might enjoy larger market share.

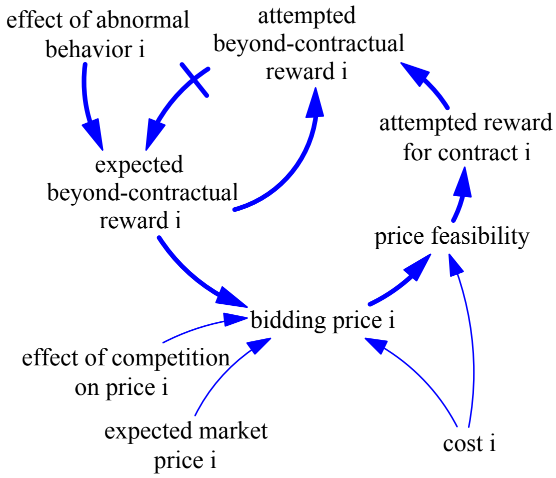

Figure 3. Pricing with consideration of BCR

In Figure 3, the variable "attempted beyond-contractual reward" (ABCR) represents the BCR that the contractors attempt to obtain. There are two sources of the variable; the first is "attempted reward for contract" (ARC) conducted by contractors to make up the sacrificing rewards in the tender stage. Criterion for contractors' conducting abnormal behavior for ARC is "price feasibility" (PF), which is defined as: PF = BP/C. ARC is a function of PF. If BP/C < 1, then it means that the contractor is faced with loss, forcing them to pursuit BCR to make up the loss. The lower the value of BP/C is, the higher the ARC of contractors. If BP/C > 1, then it means the bidding price covers part of the contractor's profit, so the contractor doesn't look for ARC.

The second source of ABCR is the contractor's "degree of inertia" (DOI) for EBCR, which is refers to the fact that, when the contractors have experienced obtaining BCRs in the past, they tend to repeat the same behavior in order to gain the maximum profit. Since the contractors are expecting BCRs, whether the award price is reasonable or not, they attempt to apply the tactic that they once used to gain BCR.

Besides, ABCR is the BCR that the contractors attempt to obtain. In fact, since owners have control over the project performance, contractors' ABCR is not completely feasible. Under different strictness of construction management on the project, even all contractors intend to gain BCR, there should be a difference among BCRs actually obtained. To describe this situation, this research configures an impact factor "effect of abnormal behavior" (EOAB) on contractors' ABCR, where EOAB ranges from 0 to 1. BCR actually gained by the contractor is ABCR * EOAB. When EOAB equals 1, it means that BCR gained by contractors equals ABCR; in other words, the owner's construction management doesn't work at all. And the lower EOAB is, the stricter the construction management of the owner is.

Both contractors' "expected beyond-contractual reward" (EBCR) and "reference market price" (RMP) described in previous section are variables that constantly change with previous experiences and time. The EBCR are directly influenced by previous BCR; and contractors make adjustments by the discrepancy between the EBCR and BCR actually earned after each project. Therefore, this research similarly applies the "First-order linear negative feedback system" to model EBCR.

4.2.2 Simulation of Market Price

As the computer simulation afore-mentioned, it is assumed that 70% of contractors who attempt to gain compensation eventually obtain the rewards (EOAB equals 0.7). Then, even though the market price trends in the computer simulation still feature effects of market competition, obviously, the market price has become lower than the contractors' cost (see Figure 4.). This would force contractors, who don't pursuit BCR, to offer similar price lose their competence for market competition. For contractors who have considered BCR for pricing, even though the market price seems lower than the cost, the total reward calculated by "market price+ expected BCR" still substantially covers the cost and profit. It can be hereby inferred that the opportunistic bidding behavior of "win the bid with low price and then look for BCR" by contractors under competitive bidding system grounds in rational decision strategies.

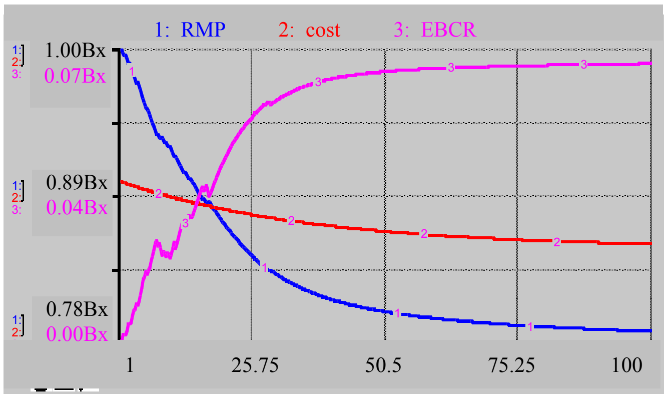

Figure 4. Market price trends after contractors account BCR

5. LEVERAGE ANALYSIS

In this section, the influence of market competition level and BCR factors on the equilibrium of market price is examined.

5.1 Analysis on Market Competition Level

As seem in the afore-mentioned case, the normal number of competitors assumed by most contractors is 7. Therefore, this research modifies the parameter of PNC as RANDOM (8-13) and RANDOM (3-7) to simulate the market price trends under two extremes of market competition level: very keen and very slack.

Results from the computer simulation reveal that, when contractors take BCR into account for pricing decision, even under different competition levels, the market prices tend to gather at same equilibrium price that is lower than contractors' cost. The only difference is seen in the speed of gathering (see Figure 5. where RMP curve stands for normal market circumstance, RMP2 curve stands for very keen competition level, and RMP3 curve stands for very slack competition level). It is found that competition level doesn't have determinative or significant influence on the equilibrium of market price.

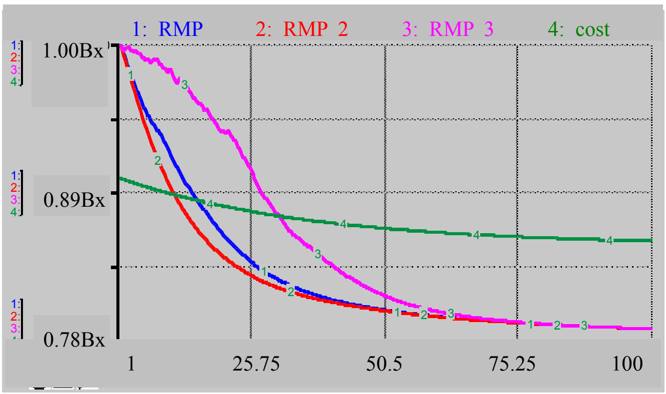

Figure 5. Market price trends under various competition levels

5.2 Analysis on BCR

Assume degree of strictness of owner's construction management on the project, including soundness of contract provisions and tightness of construction supervision, would directly affect the existence, and amount, of BCR. So EOAB can stand for an impact factor that represents the degree of strictness in different projects. The lower EOAB is, the less possible that contractors obtain BCR, and the lower expected BCR; and vice versa.

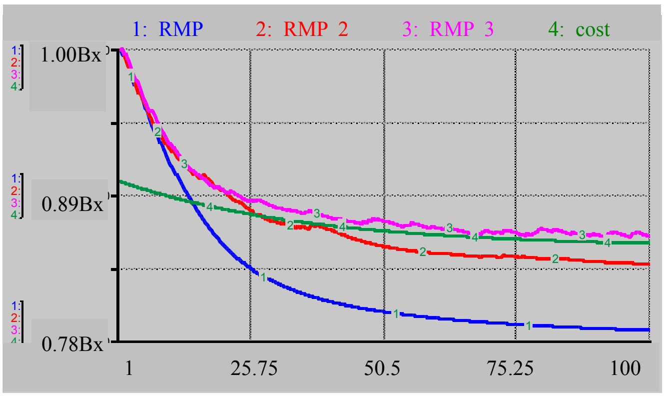

Figure 6. Market price trends under different BCR conditions

The EOAB is separately set as 0.7, 0.4, and 0.1 to simulate the market prices under different degrees of strictness in the owner's construction management on project. It is found in the result that, under same competition level, different BCR levels result in different equilibriums of market price. The smaller the EOAB is, the smaller the price gap between the market price and contractors' cost. Even, when EOAB is below a certain degree, hopefully the market price can be corrected to a level that matches contractors' cost (see Figure 6.). It is logic to infer from this result that, when contractors begin to take BCR into account for pricing decision, the key determinant of contractors' pricing and market price is BCR instead of market competition level.

6. CASE VERIFICATION

In this section, 44 sample projects from two major traffic construction project supervising agencies in Taiwan, NEEB and DGH, are analyzed to verify if construction project market segments with varies strictness of construction management would vary in equilibrium of market price. The bid-opening date of sample projects spans from 1995-2003, and the award price amounts vary from 1.5 to 35 billions TWD.

6.1 Strictness of construction management

This research takes the viewpoint of contractors to analyze the strictness of construction management on project by NEEB and DGH. Among nineteen contractors who have participated in projects of both NEEB and DGH, four contractors have closed down and only twelve of the rest fifteen contractors agreed to be interviewed. Every contractor interviewed graded on NEEB and DGH based on previous experience from two aspects: soundness of contract provisions (for materials and construction) and tightness of construction supervision (for materials and construction). The scores ranged from 1 to 7; 1 means very loose and 7 means very strict.

Results from the questionnaire survey reveal that NEEB scores higher than DGH in each item. Beside, results obtained from t-test indicate significant difference in the soundness of contract provisions and tightness of construction supervision (see Table 1.). It can be inferred that, contractors have lower expected BCR for NEEB project where the construction management is more strict; on the contrary, contractors have higher expected BCR for DGH projects where the construction management is less strict.

Table 1. Analysis on strictness of construction management

Evaluation aspects		Average		t-test
		NEEB	DGH	(p value)
Soundness of contract provisions	for material	6.50	5.42	0.001
	for const.	6.42	5.08	0.001
Tightness of construction supervision	for material	6.67	5.25	0.000
	for const.	6.58	5.08	0.000

5.2 Award price level

This section is dedicated to analyze whether award price level in projects of NEEB and DGH vary with strictness of construction management, and the index for award price level is bid/budget ratio.

It was found the data of sample projects have a tendency that the later the bid is opened, the higher the bid/budget ratio; and the higher the number of bidders, the lower the bid/budget ratio. This suggests that sample projects in this research are under the influence of background conditions in the market. Therefore, to exclude the influences of date of bid-opening and number of bidders on the bid/budget ratio and precisely compare the award price level of two agencies, this research applies multi-variate linear regression to figure out each variable's relative degree of impact on bid/budget ratio, as shown in Equation (5):

$$PL = \beta 1T + \beta 2 N + \beta 3Ga + \beta 4Gb \quad \text{...(5)}$$

where PL represents bid/budget ratio, T is date of bid-opening, N is number of bidders, Ga is NEEB, and Gb is DGH. Since NEEB and DGH represent two categories, they are expressed with two dummy variables. Each dummy variable is marked as 0 or 1 only [17]; 0 stands for "inexistence" and 1 stands for "existence".

Results of the analysis reveal that (see Table 2.), excluding the effects of bid-opening date and number of bidders on bid/budget ratio, the parameter estimation obtained in variables of NEEB and DGH are 0.624 and 0.585 respectively, meaning that under similar market background condition, bid/budget ratio for project operated by NEEB will be higher than that operated by DGH.

Reliability of regression analysis is supported with the fact that each variable has significant influence on the bid/budget ratio of the sample projects (t-value of each variable is less than 0.05). Meanwhile, all the variables are independent to each other, so there is no concern of multi-collinearity (CI value of each variable is less than 30). Therefore, this analysis result can substantially account for the assumption that when contractors participate in projects of DGH, they would expect for higher BCR and tender with lower price; so the award price level is significantly lower than that in the case of NEEB. In other words, the simulation of this research is supported in that different BCR conditions result in different market prices.

Table 2. Results of multi-variate linear regression

Variables evaluated	β	t-test (p value)	CI	R^2
Date of bid-opening	0.034	0.000	4.097	0.989
Number of bidders	-0.014	0.007	8.163	
NEEB	0.624	0.000	1.000	
DGH	0.585	0.000	1.659	

7. CONCLUSIONS

The competition market in construction industry is typically divided into several segments by factors of location, technology, scale, and other production conditions. However, it's found in this research that construction projects feature in time lag and room for manipulation between the signing and performing of contract. This makes BCR another crucial factor in the segmentation of the competition market by contractors. Results from both computer simulation and case study reveal a significant relation between equilibrium of market price and BCR. Different equilibrium price would be obtained under different BCR condition. It is inferred that, in the construction project market with less mature construction management system, opportunistic bidding behavior can very possibly be regarded as an alternative equilibrium pattern of market.

Contractors' opportunistic bidding behavior has long negatively affected quality of public project and free market competition mechanism. In the past, authorities concerned have invested immense efforts to improve the bidding system in an attempt to solve this problem. Results of this research, however, have disclosed another perspective; the key motivation in contractors' opportunistic bidding behavior is their excessive expectation in BCR under current construction management system. Within the price competition mechanism, if the problem of BCR exists, even if the bidding system is further improved, in order to survive, contractors would still prefer opportunistic bidding behavior. Therefore, to improve the construction management system so as to lower the possibility for contractors to gain BCR is crucial to ensure project quality.

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