The Market Competitive Behavior in the Project-Based Industries

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Project-based industries are among the largest industries in the global economy and project-based organizations are also becoming prevalent in the emerging industries. In a project-based industry, a contract is usually awarded before the goods or services are completely provided by the contractors and contractors routinely compete for contracts under specific project awarding systems. The characteristic of the transactions and contractors' reactions to project awarding systems forms unique pattern of market competitive behavior of the project-based industries. This paper demonstrates the market competitive behavior and the problems of the ineffective competition under price-based and qualification-based project awarding systems. Several unanticipated adverse feedback behavioral loops generated from contractors' opportunistic bidding are discovered and analyzed. Managerial policy implications to project owners are also discussed and tested through a simulation model.

Keywords: bidding, pricing, competitive behavior, market competition, project awarding, system dynamics, project-based industry

1. Introduction

Project-based industries are among the largest industries in the global economy. They may include construction, aerospace, motion picture, pharmaceutical, healthcare, and defense industries (Taylor and Levitt 2004). In a project-based industry, businesses are usually transacted through a project by a project and most of contractors

or firms routinely compete for contracts under specific project awarding systems. Thus, a project awarding system would determine the market environment and certainly will affect the contractors' competitive behavior in the market. The phenomenon can be significantly observed from the government procurement projects.

In the public sector, government agencies regularly procure construction projects, service projects, or equipments through specific project awarding systems. The market structure of the public market is most likely corresponded to Monopsony (Carlton and Perloff, 2000), or buyer's monopoly, where government is the only buyer in the market and the government regulations have a direct impact on the market. Thus, the changes of project awarding system are naturally to be expected to induce specific market competition environments and contractors' competitive behaviors.

The market competitive behavior in a project-based industry can be defined as the degree to which individual firms compete against each other to gain higher market shares, earn higher profits, etc. It is the manner in which firms compete against each other, such as their pricing policies, bidding strategies, cost reduction strategies, etc. The market competitive behavior would determine the outcomes of contractors' performance and the development of the whole industry.

For decades, the price-based system has been extensively used for project awarding. In a price-based project awarding system, contractors are invited openly to submit sealed prices individually and the contractor who offers the lowest price for the project will be awarded. The price-based system is especially popular for the government procurement projects. Governments utilize this system for its simplicity and fairness and expect to obtain economical benefit through price competition. However, as many unreasonable price competitions and the consequently poor project performance have been frequently observed in the practices, many researchers have pointed out that the price competition itself is not sufficient to guarantee an economical and quality product. Accordingly, the qualification-based system, which considers more non-price criteria for project awarding, has been proposed as an alternative to find competent contractors. In recent years, although many research results have investigated the benefits and concerns of the conventional price-based system and the alternate qualification-based system, most of these studies have only concerned the project level viewpoint. Despite that the aforementioned two project awarding systems are getting prevalent around the world,

not a single research deals with the impacts of the project awarding systems on the contractors' competitive behavior as well as on the whole industry from a holistic perspective. This paper thus aims to fill the gap. A set of contractors' behavioral systems inherent in the project-based transaction process will be explored in this paper and a simulation model will be proposed as an explanatory model for the competitive behavior and managerial policies.

2. Review of the market competitive behavior under the price-based system

The basic principle behind the price-based system is that the price competition process encourages efficiency and innovation by contractors. For the public agencies, the price-based system will also protect the public from extravagance, corruption, and other improper practices by public officials. Yan and Hsueh (2008) have developed a holistic model to demonstrate the benefits and concerns of the price-based system in the construction industry. Since the construction industry is the most representative and the largest industry among project-based industries (Taylor and Levitt 2004), Yan and Hsueh' efforts are useful to be the basis of the development of the models in this paper.

The Bertrand competition model of Economics proposed that, in a price competition environment, companies will assess and predict prices that their competitors may offer before they determine their own price (Carlton and Perloff 2000). Accordingly, the bidding prices of previous tenders (hereafter termed market price) are important references for bidders of subsequent tenders and have feedback relationships with contractors' bidding prices as shown in Fig. 1. The previous bidding prices sequentially affect contractors' pricing in the subsequent tenders and form a reinforcing feedback loop, which allows project owners to obtain economical benefits.

On the other hand, previous studies have also suggested that an identical causal relationship between market price and number of competitors (Gruneberg and Ive 2000, Hillebrandt 2000, Runeson 2000). A higher market price will attract more competitors, but these competitors have to steeply cut prices to win contracts in the increasingly competitive market. Consequently, the market price might dramatically drop down and force some competitors to quit the market. This balancing feedback process depicts a company's behavior in response to the demand and supply relationship until

both the market price and the number of competitors are balanced.

In this section, this paper would highlight an inherent problem of the price-based system called contractors' opportunistic bidding behavior. Lo et al. (2007) proposed that contractors will opportunistically cut the bidding price to take more market share when they have an expectation of obtaining beyond-contractual rewards. The beyond-contractual reward (BCR) is defined as the cost reductions through cutting corners and the compensations gained from claims.

Based on the aforementioned evidences, six adverse feedback loops hidden within the price-based system are explored as follows:

Opportunism is one of the most important behavioral assumptions in economic theories. It says that companies always want more of what they like, and this may imply that interests are pursued in an opportunistic fashion (Williamson 1985). Accordingly, it is inferred that, when contractors have experienced obtaining BCR in the past, they tend to repeatedly cut corners and raise abnormal claims[1] to maximize profit, regardless the reasonableness of the award price. The behavioral tendency would induce two adverse loops (R1 and R2 in Fig. 1)

There are two other reinforcing loops with adverse effects shown in Fig. 4 as R3 and R4. When a contractor deliberately cuts a price, the cost recovery rate[2] will decrease, making the contractor needs to cut corners and abnormally raise claims in the project execution phase for survival. After a period of time and experience accumulated, the contractor may have confident expectations of BCR and offer lower prices for future projects. This reinforcing feedback process will constantly intensify contractors' opportunism and the adverse effects.

Rooke et al. (2004) proposed that opportunistic contractors tend to expend more effort on generating profit from claims than from improved construction methods. Accordingly, if there is potential BCR which is readily attainable, the opportunism will discourage contractors' willingness to improve their capabilities, especially when the award price is quite low and most contractors survive upon BCR. This forms another two loops as R5 and R6 in Fig. 1.

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[1] An abnormal claim refers to the claim which is deliberately issued by a contractor for increasing profit. This is different from the necessary claim which is issued by a contractor for work award.

[2] Cost recovery rate = bidding price / cost. A contractor will face loss if the cost recovery rate of a project falls below 1.

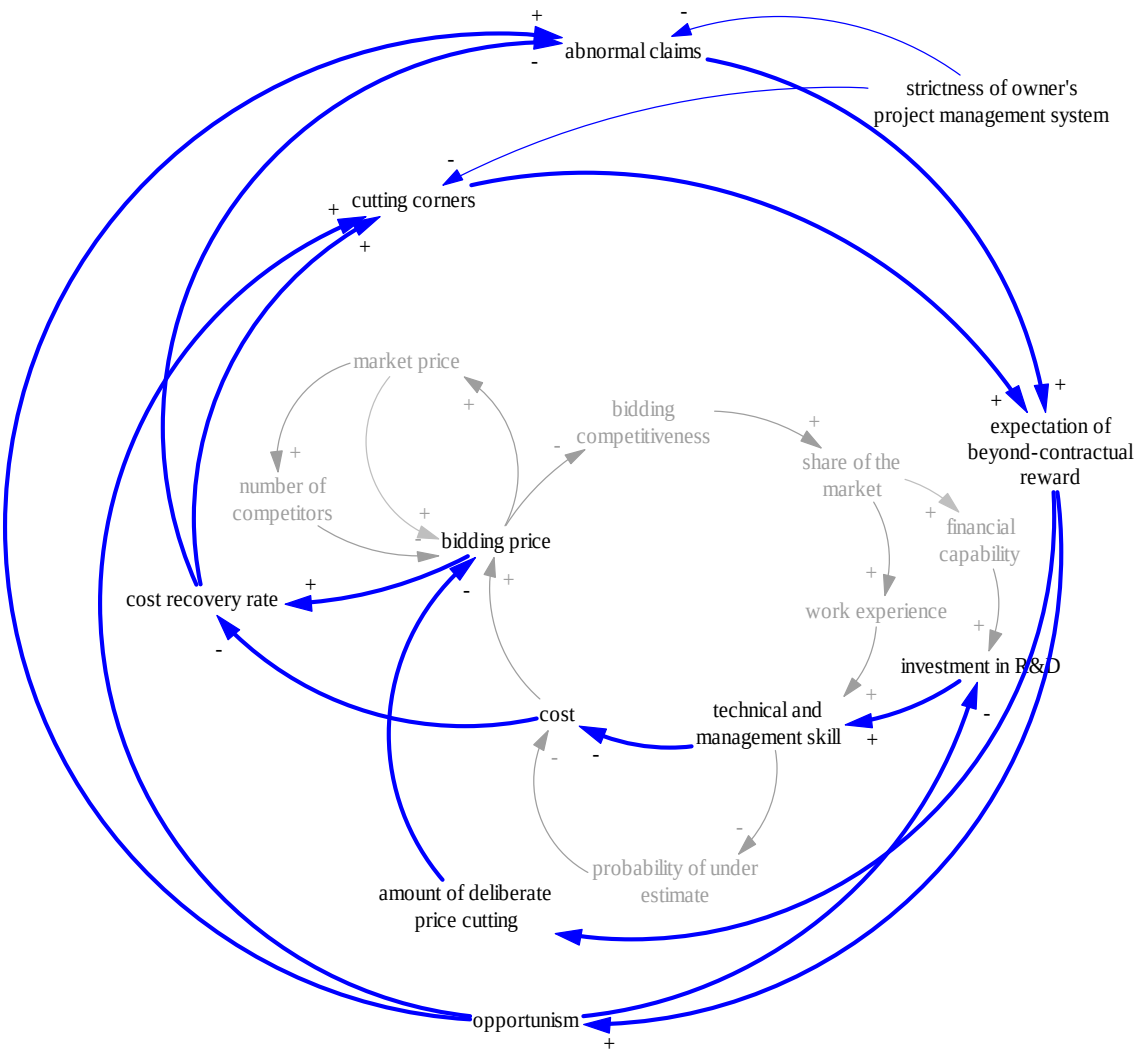


Fig. 1 The contractors' behavioral feedback loops under the price-based system

Table 1 The adverse feedback loops generated from opportunistic bidding

Code	Loop contents
R1	Opportunism—cutting corners—expectation of BCR—opportunism
R2	Opportunism—abnormal claims—expectation of BCR—opportunism
R3	Expectation of BCR—amount of deliberate price cutting—bidding price—cost recovery rate—cutting corners—expectation of BCR
R4	Expectation of BCR—amount of deliberate price cutting—bidding price—cost recovery rate—abnormal claims—expectation of BCR
R5	Opportunism—investment in R&D—technical and management skill—cost—cost recovery rate—cutting corners—expectation of BCR—opportunism
R6	Opportunism—investment in R&D—technical and management skill—cost—cost recovery rate—abnormal claims—expectation of BCR—opportunism

As contractors' opportunistic bidding behavior forms these six adverse feedback loops which will continuously intensify over time, it can seriously damage the ideal functions of the price-based system.

3. Review of the market competitive behavior under the qualification-based System

Compared with the price-based system, the qualification-based system is designed to find qualified and competent contractors instead of lowest bidders. Besides price, non-price criteria, such as contractors' past performance, work experience, technical and management skills, financial capability, etc., are adopted in the system. The qualification-based system can also be recognized as the "best value" selection system, while some studies distinguish best value selection and the qualification-based system on whether the price is included or not in the project awarding criteria (Beard et al. 2001, Wardani et al. 2006). The use of the qualification-based system will lead contractors to form additional reinforcing feedback loops.

The inclusion of non-price criteria generates reinforcing loops which lead contractors to increase competitiveness and expand their businesses in a positive way. An experienced contractor can gain more competitiveness in the selection phase and consequently obtain more share of the market and more work experience. In addition, qualification-based system usually requires contractors to submit a technical proposal and brief on how projects are planned and what construction methods and materials are chosen. Contractors can create their competitiveness through innovative designs, materials, and construction methods, so as to raise the project quality and better satisfy owners' need (Yan et al. 2005b). Accordingly, reputable contractors with better technical and management skills will be able to prepare quality proposals and win contracts. Consequently, they have more chances to further improve technical and management skills through execution of works and R&D. These positive reinforcing feedback loops can be recognized in Fig. 2. For another benefit, when contractors' financial capability is considered in a qualification-based system, a contractor having good financial capability will have more bidding competitiveness and market share, then the contractor can further enhance his financial capability.

In addition to the aforementioned effects of the use of the qualification-based system on contractors' competition, this paper would highlight an exceptional advantage of qualification-based system in which the capability to deal with contractors' opportunistic bidding behavior. Lo and Yan (2008) have suggested that the success of the qualification-based system is highly dependent on the linkage between contractors' past performance and the evaluation of contractors' qualifications. Once a contractor's past performance becomes an important criterion to evaluate a contractor's qualification, contractors are forced to minimize corner cutting behavior and abnormal claims, so as to improve their performance record and competitiveness. This behavioral tendency forms four reinforcing feedback loops, which provide contractors an incentive to respect their performance in the construction phase (Fig. 2). With the functions of the feedback loops, an opportunistic contractor who tends to obtain BCR will face the loss of competitiveness due to unfavorable performance record. Thus, once the project owner puts more efforts on evaluating a contractor's past performance, contractors will be directed to respect their performance in the project execution phase and their opportunism can be significantly reduced.

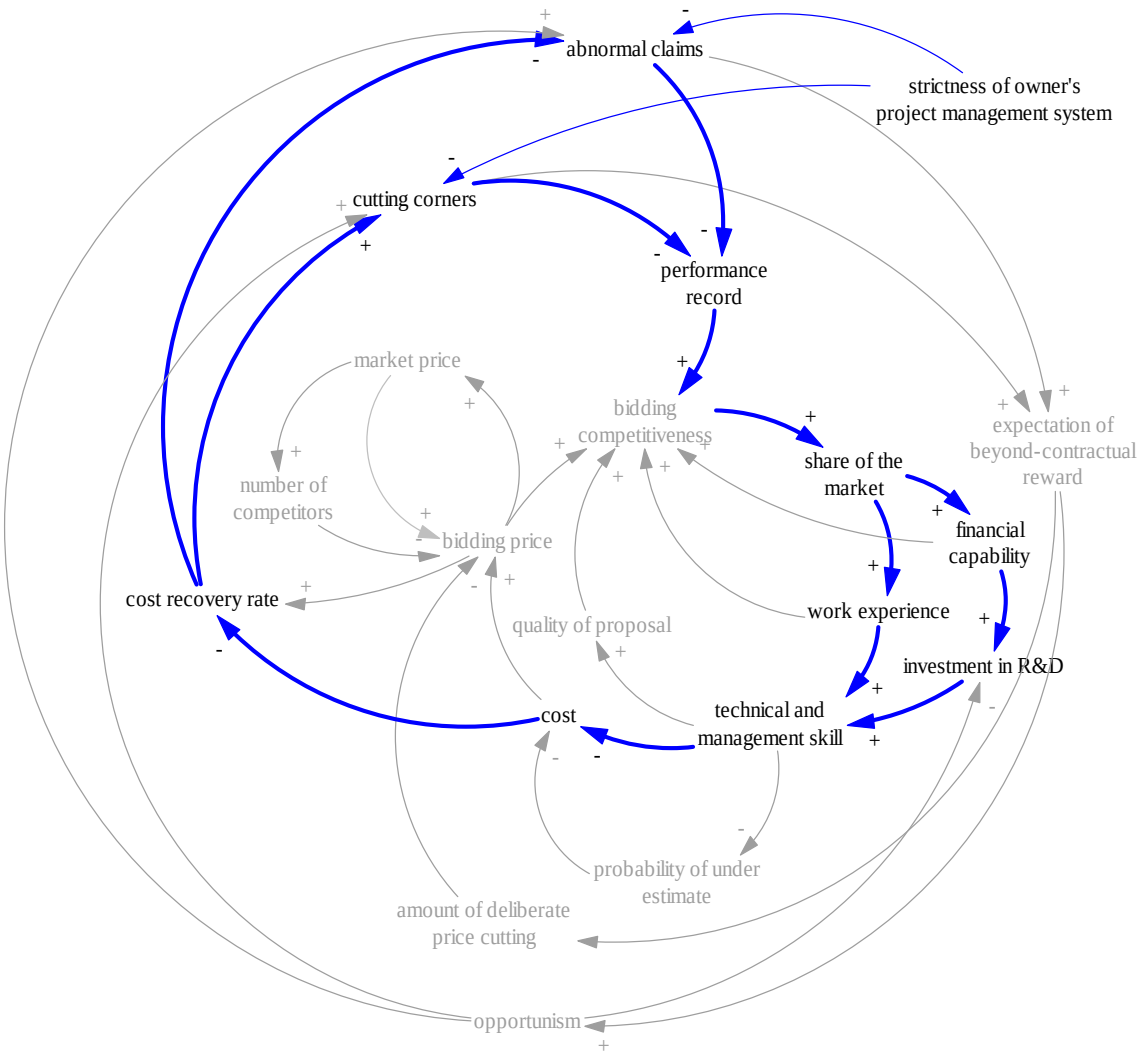


Fig. 2 The contractors' behavioral feedback loops under the qualification-based system

Table 2 The additional feedback loops when a qualification-based system is implemented

Code	Loop contents
R7	Performance record—bidding competitiveness—share of the market—work experience—technical and management skill—cost—cost recovery rate—cutting corners—performance record
R8	Performance record—bidding competitiveness—share of the market—work experience—technical and management skill—cost—cost recovery rate—abnormal claims—performance record
R9	Performance record—bidding competitiveness—share of the market—financial capability—investment on R&D—technical and management skill—cost—cost recovery rate—cutting corners—performance record
R10	Performance record—bidding competitiveness—share of the market—financial capability—investment on R&D—technical and management skill—cost—cost recovery rate—abnormal claims—performance record

4. Policy implications to the project owners

According to the systematic reviews of contractors' competitive behaviors, two implications are highlighted as follows:

1. The importance to improve owner's project management system.

   The feedback loops analysis indicated that contractors' expectation of BCR can intensify their opportunism and the opportunistic bidding behavior. Therefore, the key motivation in contractors' opportunistic bidding is the potential BCR in a project management system. For this reason, reducing the possibility and amount of BCR should always be the most important task for project owners. The owners must put more efforts into improving their project management system, including the soundness of contracts and strictness of monitoring system. A sound contract should include comprehensive documentation, specifications, and drawings. Once the strictness of owner's project management system is improved, the adverse loops may go obsolete. This policy is specifically important for the implementation of a sole price-based system.

2. The importance to use contractors' past performance as main criteria in the qualification-based awarding system.

   Different from the situation in the price-based system, the use of non-price criteria has been demonstrated to increase the competitiveness of the non-opportunistic and competent contractors. Some useful criteria should include contractors' past performance, financial capability, work experience, quality of key personnel, and technical proposals. It should be noted here that the inclusion of contractor's past performance has exceptional usefulness in reducing a contractor's willingness to sacrifice project quality and raise claims. Since contractors' BCR seeking behavior (including cutting corners and raising claims) will negatively affect their performance records, contractors are forced to trade off the benefit from BCR and its damages on their bidding competitiveness. To make these loops more effective, the owners need an objective and sensitive performance rating system. Several researchers are working on this line of research such as contractor's

performance prediction (Alarcon and Mourgues 2002), contractor's quality performance assessing model (Yasamis et al. 2002), and quality-based contractor rating model (Minchin and Smith 2005).

5.Virtual experiments

The simulation model for analyzing the market competitive behavior

In this section, a contractor's pricing model, which can be used to simulate the market competitive behavior in the project-based industries, has been developed to conduct virtual experiments on the managerial policies of the price-based and qualification-based systems.

Previous studies have developed many models to explain contractors' pricing behavior under the price-based system. Most of these models regarded contractors' pricing as an optimum decision with the consideration of "cost" and "market competition" factors (Yan et al. 2005a). In addition to these two factors, Lo et al. (2007) proposed that beyond-contractual reward (BCR) as an important factor which has to be considered for analyzing contractors' pricing behavior and developed a contractor's pricing model for the price-based system to depict the interaction relationships between contractors' pricing decisions and various factors. As the price is not the only selection criterion in the qualification-based system, the model in this paper was developed accordingly, with considerations of "cost", "market competition", "BCR", and "contractor's qualification".

The conceptual feedback structure of the proposed model is shown as Fig. 3. Lo et al. (2007) has depicted the effects of factors related to "market competition", "cost", and "BCR" on a contractor's bidding price. Firstly, from market competition perspective, as the level of market competition increases, contractors will be forced to lower their bidding prices. Then, from cost perspective, the contractor's cost condition will determine the bottom line of his pricing behavior. Finally, from BCR perspective, it is assumed that contractors may accidentally submit an unreasonable low price and then adopt some actions to make up their sacrifices through obtaining BCR. Once contractors have experienced obtaining BCR in the past, they tend to repeatedly cut corners and raise abnormal claims to maximize profit, regardless the reasonableness of the award price. Contractors' expectation of BCR will evolve from contractors'

previous experiences and will affect contractors' decisions in determining their bidding prices.

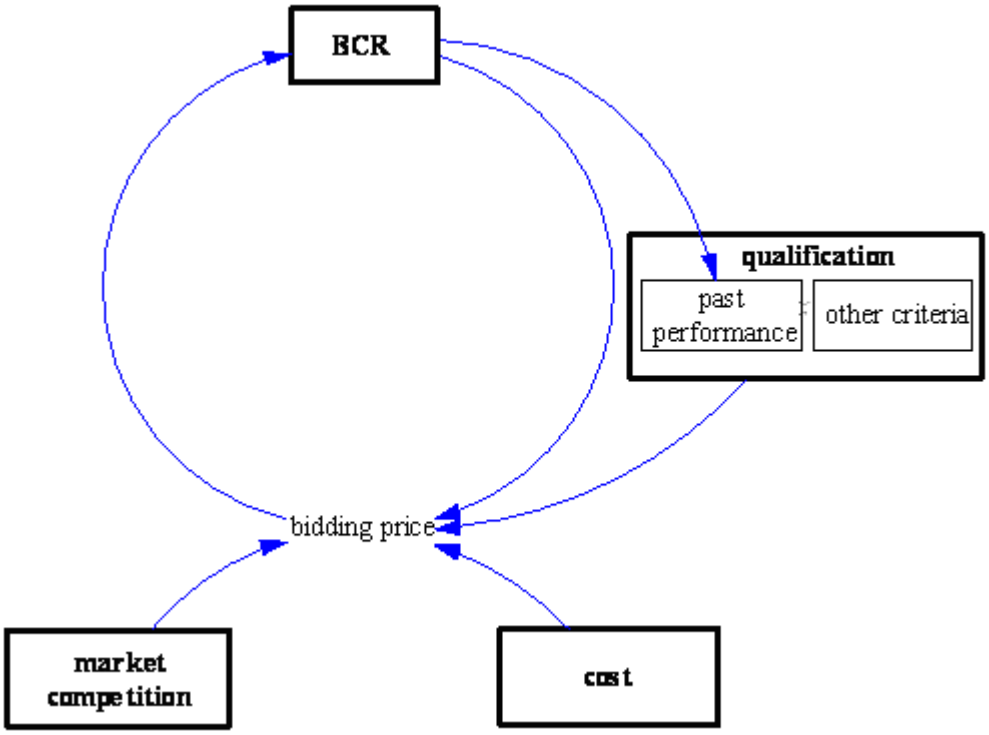


Fig. 3 The conceptual framework of the simulation model

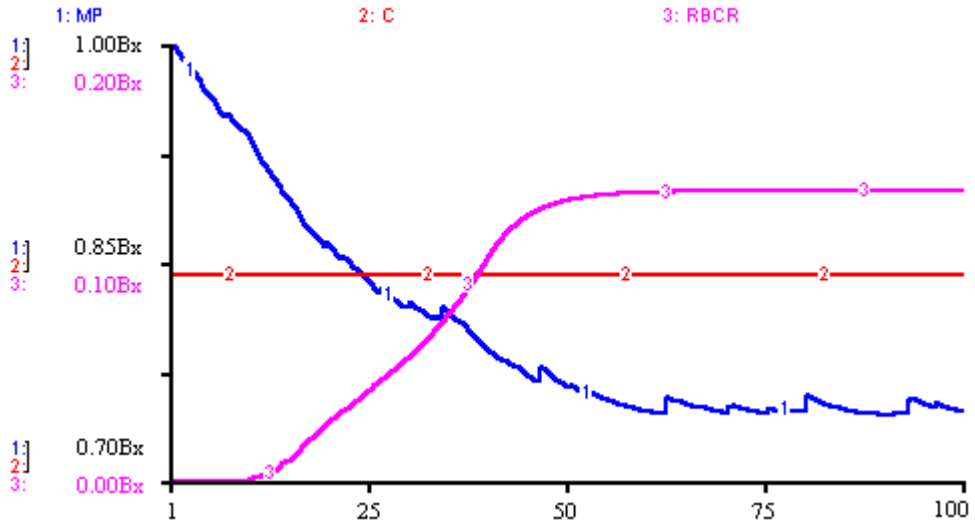
Since the qualification-based system considers not only price but also the level of contractor's qualification, contractors with better qualifications could take the competitive advantage to elevate their bidding price. Although many criteria will be used to evaluate a contractor's qualification, the adoption of contractors' past performance specifically generates a feedback relationship between qualification and BCR. Once owners adopt contractor's past performance to evaluate a contractor's qualification, contractors' BCR seeking behavior will deliver a negative effects on the qualification and let the contractor face the competitive disadvantage in the tender stage.

Policies test 1: the importance of the owner's project management system

This section simulates the market price trend under the price-based system. The simulation result shows that, 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 (Fig. 4). Contractors' expectation of BCR is a

feedback process in which the *RBCR* is evolved from contractors' previous experiences. After a period of time and experience accumulated, the *RBCR* in the projects supervised by specific project owners will become more assessable and converge toward the limit. The level of *RBCR* reflects the gaps between market price level and contractor's cost in Fig. 4.

In cases without regard for BCR, the price-based system assumes that the bidding prices of all contractors reflect their cost, and they abide by the contract and requirements for quality. However, results of the simulations reveal that, when excessive room for BCR exists in the market, contractors who apply opportunistic bidding behavior enjoy a higher possibility to take extra market share. Moreover, after contractors obtain BCRs, consequently their expectation for BCR in future construction projects rises. This will induce them to tender even lower prices, and then pursue compensation from BCR. Hence, even when the market price is moving toward a certain equilibrium level with time, the market price turns out to be lower than contractors' cost, forcing other contractors in the market to survive upon BCR.



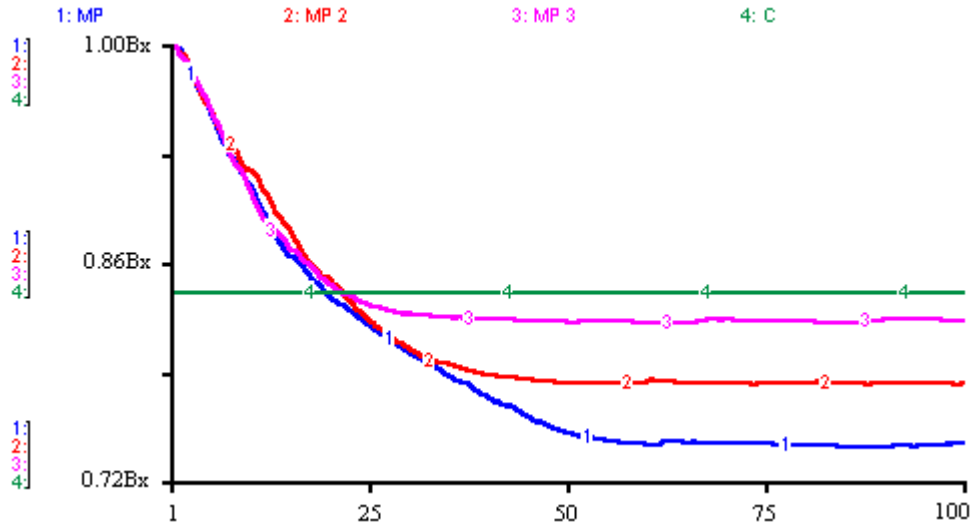
Note: X-axis represents times of bid opening. Y-axis represents market price level.

Fig. 4 Simulated market price trends after the contractors consider BCR in pricing

The paper further examines the importance of the owner's project management system. Since the degree of strictness of the owner's management system on the project is assumed to affect the maximum amount of BCR, *MBCR* can be used to

represent different strictnesses of management systems in different projects. The lower *MBCR* is, the stricter the project management; and vice versa.

The *MBCR* is separately set to simulate the market prices under three different degrees of strictness of owner's management systems on projects. The simulation result shows that, at the same competition level, different BCR levels result in different equilibriums of market price (see Fig. 5). It is logical to infer from this result that, when contractors begin to take BCR into account for pricing decisions, BCR would be the key determinant of contractors' pricing and market price. Therefore, the simulation results demonstrate that reducing the possibility and amount of BCR should always be the most important task for project owners.



Note: X-axis represents times of bid opening. Y-axis represents market price level.

Fig. 5 Simulated market price trends under different project management systems

Policies test 2: the importance of using the contractor's past performance as the main criteria in the qualification-based system

This section tests the market competitive behavior under the qualification-based system. A scenario is designed to simulate a contractor's dynamic pricing behavior when his qualification is worse than the general level of competitors' qualification. As a contractor's competitors might improve their qualification over time, this paper assumes that the general level of competitor's qualification score (RQS) will gradually increase as time proceeds and simulate its effects on the contractor's pricing behavior.

As shown in Fig. 6, to win the bid, the contractor is forced to cut price for his relative disadvantage in qualification. After a period of time, the contractor can perform quality projects and establish quite performance record to elevate qualification. However, as the price competition pressure forces the competitive price level continuously declines, the price level may be lower than the contractor's cost and the contractor will be forced to obtain BCR to make up the sacrifices. In this situation, the contractor's performance will gradually decrease if the contractor's BCR seeking behavior succeeds. Consequently, contractor's qualification will converge to a stable level around the general level of competitors' qualification (see curve *CQS* and *RQS* in Fig. 6) and the competitive price will fall below contractor's cost to the bottom line price, *C-RBCR*.

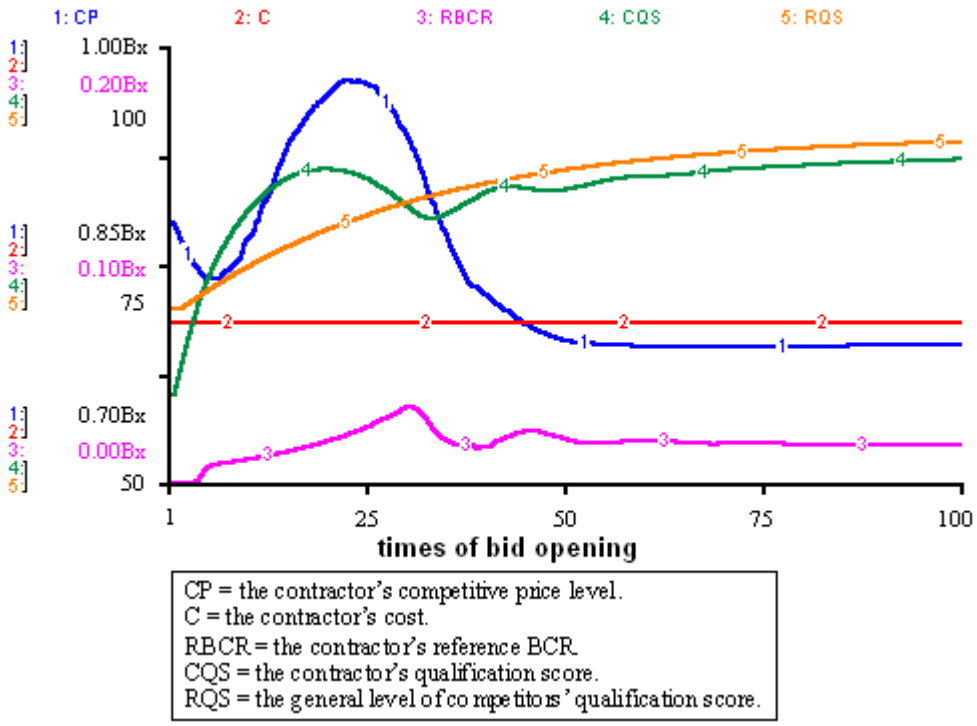


Fig. 6 Simulated market price trends under qualification-based system

In this section, the effects of the owner's quality consciousness on contractors' pricing behavior are evaluated. This paper uses different settings of owner's tolerance of defects (*OT*) to represent different levels of owner's quality consciousness. As the owner's quality consciousness is higher, the owner's tolerance of defects is lower and

contractor's work performance will be more strictly rated into qualification score.

Comparing with the case shown in Fig. 6, Fig. 7 shows the impacts of low tolerance of defects on contractors' pricing. As the owner's tolerance of defects is lower, the *RBCR* decreases and the competitive price would be closer to contractor's cost. The simulation results suggest that, once owners keep high quality consciousness with low tolerance of defects and always rate contractors' performances strictly, contractors' BCR seeking behavior can be effectively controlled and contractors' bidding price can be directed to a reasonable level. The results indicate the importance of the weight of past performance in the qualification evaluation process to enlarge the competitive advantage of contractors who provide higher quality products and reduce the effects of contractors' opportunistic price cutting.

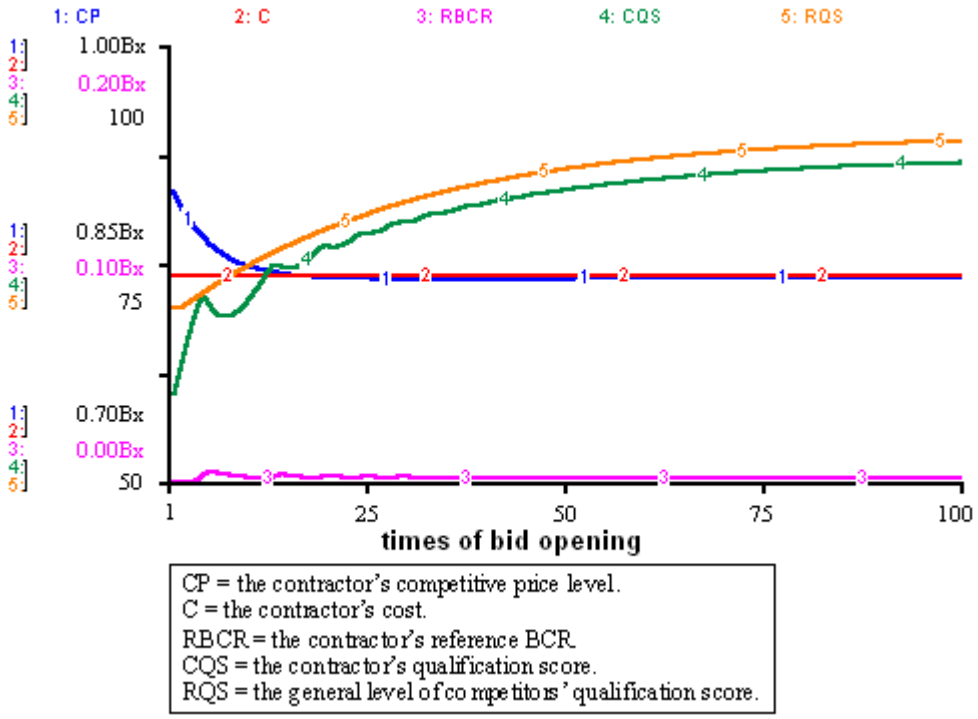


Fig. 7 Simulated market price trends when contractor's past performance is included as the main project awarding criterion

6. Conclusions

In a project-based industry, a contract is usually awarded before the goods or services are completely provided by the contractors. The characteristic of the

transactions in the project-based industries would induce a unique market competitive behavior and the pattern of the industrial development. It is thus worthwhile to have a comprehensive understanding of this new market competitive behavior. With the Systems Dynamics approach, this paper takes an across-projects viewpoint to analyze the persistent relationships between the project awarding system and market competitive behavior. Instead of showing how a project awarding system induces a project outcome, this paper focuses on discovering contractors' competitive behavioral loops under specific market environments. Several unanticipated adverse feedback loops generated from contractors' opportunistic bidding are discovered and analyzed. Through the understanding of the whole system of contractors' behavior, project owners' managerial policies can thus be evaluated and improved.

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