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Impact of considering need for work and risk on performance of construction contractors: An agent-based approach

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ABSTRACT

Competitive bidding is the main mechanism of allocating projects in the construction market. In the traditional single criterion bidding method, the markup decision has a significant impact on a contractor's business success. Contractors usually take into consideration several factors in the process of determining their markup. This study has reviewed the literature and identified a range of contractors' behaviors when making their markup decision within a competitive bidding environment. An additive markup function consisting of three components, namely competition, risk, and need for work, was developed in order to replicate markup behaviors of contractors. Then, agent-based modeling has been employed for simulating the bidding process within a market formed of a set of heterogeneous contractors with different risk attitudes and defined markup behaviors. This model was used to study the impact of considering need for work and risk allowance in markup determination on financial performance of contractors in various market scenarios. Results suggest that the optimal policy is moderation in both dimensions of risk attitude and need for work.

1. Introduction

Once a contracting firm has made the decision to bid on a project, it is then faced with a more challenging decision which is to select a bid price that is low enough to win the project and at the same time high enough to make a good profit. A reasonable objective for each construction company is maximizing its profit in order to ensure survival in the market. However, while profit maximization is usually the most frequently used bidding objective [7], many researchers argue that it should not be the sole criterion upon which the markup is based. A contractor's need for work might sometimes play a conflicting role with short-term profit maximization and thus is identified as a major factor when determining the optimum markup for a project [1,12,39]. For instance, if a contractor is in a bad financial situation and is in urgent need of cash flow to cover its overhead and its general and administrative expenses, winning the project becomes a priority even if it comes at the expense of a much lower profit. Thus, the need to continuously cover some fixed costs such as offices' rentals, utilities, personnel salaries, insurance payments on property and equipment, and others might sometimes drive the contractor to submit a very low bid in order to at least breakeven and stay in the business. Moreover, the attitude of a contractor towards risk is another primary factor in determining the optimum markup for a project. Contractors have varying perceptions about market conditions and projects' uncertainties according to their inner state, bidding preferences and risk tolerance [33]. In fact, a construction project can be considered as a lottery with different profit outcomes and with a level of uncertainty resulting from the expected variance in the final cost of the project. The value of this lottery and its desirability differs from one contractor to another depending on their risk attitudes. Thus, it is important to consider the behavior of a contractor towards risk when making decisions under uncertainty such as the optimum markup decision, and in complex and risky environments such as the construction field. A third major component that defines the markup choice by contractors and that is outside their control is the intensity of competition in the market determined by the number of potential opponents bidding on the same project and their observed competitiveness degree. Contractors need to adjust their profit margins from one project to the other depending on the change in the number or identity of competitors [9]. Some other less important factors affecting the optimal markup decision were also identified in the literature such as type of project and inherent complexity, client character and record of payment, reliability of subcontractors, and the degree of uncertainty in cost estimates.

Several researchers listed and ranked the different factors a contractor takes into consideration when deciding whether to bid on a certain project or not and determining which markup to use. Moreover, many analytical and simulation models were presented in the literature that provided insight into the complexities and dynamics of the bidding

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process in the construction industry. These models reflected the multi-attribute nature of the bid/markup decision and devised approaches to help contractors in making bidding decisions carefully. However, findings from such models remain mere theoretical recommendations since top management in contracting firms keep relying on their subjective assessment, their experience and their intuition in determining their optimum markup [1,11,16].

The main contribution of multi-attribute bidding models is that they reflected the invalidity of the homogeneous bidding behavior assumption adopted in previously developed bidding models and paved the way for a new set of studies emphasizing heterogeneity in bidding preferences among contractors operating in the same environment and between groups of bidders operating in different markets. For instance, Oo et al. [32,33] designed bidding experiments to imitate the decision to bid and optimal markup selection in two construction markets, Hong Kong and Singapore, and showed that the two nations exhibited different behaviors in response to four bidding factors, namely number of bidders, market conditions, project type and size. Kim and Reinschmidt [25,26] addressed the heterogeneity in the risk behavior of contractors and used an evolutionary simulation approach to investigate its effect on the markup decision, the contractor's success, and the market structure within a competitive environment. Ho and Hsu [23] also considered heterogeneity among contractors in their competitive advantage over each other and followed a game theoretic approach to explore the effect of several bid compensation strategies on encouraging bidders to put more effort into project planning and tender preparation.

This paper focuses on three of the most influential bidding factors identified in the literature namely, the market competition, the contractor's risk behavior and his need for work. None of the prior studies discussed the interaction among the aforementioned markup defining components and the relative dominance of one on the other within a market of heterogeneous contractors exhibiting different bidding behavior and strategies. How does considering a contractor's need for work in his markup decision affect his longterm performance in the market? To what extent should a markup be adjusted to account for need for work without compromising profitability? How is this process affected by the risk behavior of a contractor and how do these two components interact? To answer the latter questions, this study presents an agent-based simulation model of the construction bidding process where contractors are modeled as autonomous agents competing on projects over time which allows observing the long-term effect of a contractor's risk attitude, his need for work and the market competition intensity on his optimal markup, his financial growth and survival, and his bid success rate. Hence, the three main objectives of this paper can be summarized as follows: (1) observing the impact of a contractor's risk attitude on his markup decision taking into account his need for work and the market competition, (2) assessing if and to which extent considering need for work in the markup decision affects the financial growth of a contractor and his market share, and (3) identifying emergent market patterns in a diverse competitive environment exhibiting different degrees of risk tolerance and different levels of need for work considerations.

2. Previous works

Following the very first statistical construction bidding models that focused on the sole criterion of profit maximization [8,19,21] in determining the optimal markup for a contractor, several multi-attribute models were presented in the literature that emphasized the importance of considering multiple factors when making bidding decisions. Indeed, the first addition to the aforementioned profit maximization models was the introduction of the risk notion based on utility theory and concepts. A group of studies emerged in this regard and focused on the impact of the risk behavior of a contractor on his bidding decisions [13,24,43]. Then, the literature on this topic went in two directions: a set of empirical studies that focused on defining the most influential factors in a contractor's optimal markup decision, and another set of articles that attempted at modeling the multi-attribute nature of the optimal markup decision using different approaches.

2.1. Multi-attribute nature of markup decision

Ahmad and Minkarah [1] presented the results of a survey administered to US contractors to determine the main factors considered in their bid/no bid and markup decisions. This study identified the contractor's need for work, type of job, degree of hazard, economic conditions, competition, degree of uncertainty in cost estimate, and reliability of subcontractors among others as important factors in determining the project markup value. Also, Shash [39] presented the findings of a questionnaire that collected feedback from 85 top UK contracting firms about the most prominent factors that affect their bidding decisions and their weights. Degree of difficulty, risk involved, current workload and need for work were identified as the most influential ones among several other listed factors. Chua and Li [12] conducted interviews with competitive bidding experts and top contractors in the Singapore construction industry through which they identified the potential level of competition, the inherent project risk, the contract type, the company's bidding position and its need for the job as essential considerations in bidding decisions. In turn, Dulaimi and Shan [16] identified forty factors that medium and large size contractors in Singapore perceive to be important when considering their bid markup decision. These factors were classified into project characteristics, company's attributes, bidding situation, economic environment, and project documentation. Furthermore, Ye et al. [45] presented a study that defined key factors contractors in China consider when preparing tender prices for public projects. These factors were ranked and classified under different categories including construction cost, contractor heterogeneity, payment terms, potential competitors, client requirements, market conditions, and third-party stakeholders.

All of the aforementioned empirical studies identifying factors that contractors take into consideration when faced with bidding decisions highlighted that the firm's internal conditions (including need for work, risk behavior, current workload, financial capacity, firm size and others) are equally and sometimes more important than project attributes and market characteristics. In a study conducted by Ahmad and Minkarah [1], need for work was identified as the most influential factor in making a contractor “desperate to get the work”. Also, in his survey about UK contractors, Shash [39] reiterated the observation that 90% of the respondents identified need for work as the main incentive that would make them take any measures to win the job. In fact, more than 70% of contractors pass through situations where they are in urgent need for the job and have to bid accordingly [12]. Hence, the focus of this paper will be on studying to which extent the need for work component affects the bid markup decision and the survival of a contractor in a risky and competitive market.

2.2. Multi-attribute bidding models

Inspired by the former studies which highlighted key attributes that form the basis of the bid markup decision, some researchers went further to develop multi-attribute bidding models that can assist contractors in determining their optimal markup. For example, Seydel and Olson [38] presented a quantitative method based on the analytical hierarchy process that can be used by contractors to determine their optimal markup for a particular project given their bidding preferences at that time. This model took into consideration three factors in the markup decision which are profit maximization, risk exposure minimization and workforce continuity. On the other hand, DeNeufville and King [14] focused on two influential factors in a contractor's bidding behavior which are risk and need for work, and developed profit markup utility functions for different possible combinations of these two factors based on an empirical investigation of the bidding decisions of 30