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Modeling bidding competitiveness and position performance in multi-attribute construction auctions

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ABSTRACT

Currently, multi-attribute auctions are becoming widespread awarding mechanisms for contracts in construction, and in these auctions, criteria other than price are taken into account for ranking bidder proposals. Therefore, being the lowest-price bidder is no longer a guarantee of being awarded, thus increasing the importance of measuring any bidder's performance when not only the first position (lowest price) matters.

Modeling position performance allows a tender manager to calculate the probability curves related to the more likely positions to be occupied by any bidder who enters a competitive auction irrespective of the actual number of future participating bidders.

This paper details a practical methodology based on simple statistical calculations for modeling the performance of a single bidder or a group of bidders, constituting a useful resource for analyzing one's own success while benchmarking potential bidding competitors.

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1. Introduction

The procurement process in the construction context is characterized by contractors that usually bid short-term project contracts rather than longer-term supply chain contracts [1]. In addition, the unique project delivery system constitutes another founding stone of this industry [2]; therefore, the supply chain in construction is disaggregated and distinguished by a collection of large and small firms, related bulk material suppliers, and many other support professionals [3]. In this context, the supply chain for a construction project generally encompasses architects and engineers, prime and specialty subcontractors, and material suppliers characterized by adversarial short-term relationships and driven by the competitive bidding process in which the "low bid wins" has been the dominant pricing model for many years [3].

In this sense, in 1974, Pim implied that any bidder who faces an auction against other $N-1$ competitors should expect a $1/N$ probability value of being the lowest bidder [4]. For obvious reasons, Pim's model was named the "equal probability model" [5]; however, this model did not take into consideration two major issues. First, there are usually bidders who outperform others, i.e., not all bidders can be equally successful when competing simultaneously under the same tender; otherwise, there would not be a winner (Pim's model therefore produces results that are only valid on average). Second, the number of bidders N is not generally known before the tender reaches its deadline, so the probability value $1/N$, despite being extremely simple, cannot be calculated either.

Of course, other bid tender forecasting models appeared (e.g., Carr (1982); Friedman (1956); Gates (1967); Skitmore (1991); and Wade and Harris (1976) [6–10] to cite some of the most representative) that solved, at least partially, these two major disadvantages of Pim's model at the expense of adding additional hypotheses and requiring more elaborated calculations. In fact, since then, Pim's model has always been used as a mere "control model".

Nevertheless, it remains unclear how well any company or bidder performs concerning its economic bids [11] and, in particular, how effective it is when compared to its competitors, especially in multi-attribute auctions in which other awarding criteria apart from the price are considered [12,13]. Hence, economic positions

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other than the first (lowest bid) can eventually win when taking into account the technical score. In this connection, multi-attribute auctions, due to their non-price criteria, have been proven to increase project success considering the whole project cycle [14,15], a fact that will undoubtedly encourage their use.

Initially, an alert reader might think that trying to model any bidder's performance would be as simple as calculating a relative frequency curve that would describe how often this bidder ends up being the first (lowest), second (second lowest), third… and so on, but in real-life situations, there are usually an insufficient number of previous encounters among bidders for these probability values to be calculated with any representativeness and/or accuracy [16]. Therefore, this straightforward approach is not generally feasible, and an alternative is required.

Concerning the importance of describing a bidder's position performance, it is worth highlighting that the term "performance" is far more complex than a Win/No Win ratio [17]. Instead, the concept of performance is directly related to how often any bidder reaches high positions. For example, a bidder that was repeatedly second when competing against 30 bidders would most likely have higher chances of being first in future tenders if it competes against only five bidders. However, assuming similarity between tenders, would it be able to beat another bidder that repeatedly occupied the first position competing against five bidders? These and other insights can be discovered by using a position performance approach without the need of complicated statistical procedures.

The importance of using the method suggested above lies in the fact that any bidder who needs to know how effective he or she is when competing against others will always need a framework with which to compare performances with those of rivals [18], and this can only be effectively achieved by using a quantitative and objective approach that, to the best of our knowledge, has not been proposed within the bidding literature to date.

This paper is organized as follows: Section 2 reviews the short literature on bidding performance, and then it presents the actual construction tender dataset that will be used as an example. Finally, it devotes the third subsection to outlining the methodology proposed for calculating a bidder's position performance. Section 3 develops calculations by means of a real case study, taking advantage of the tender dataset introduced in Section 2.2. Section 4 presents the major results including a validation subsection, and Sections 5 and 6 present the discussion addressing the mathematical limitations of the methodology and the conclusions, respectively.

2. Materials and methods

2.1. Literature review

Bidding performance concerns the relationship between bids submitted by different bidders in a competition [19]. Currently, as a likely consequence of the near global economic slowdown and construction demand shrinkage, the internationalization of construction companies has become of significant interest [20], and this jump into the international market forces firms to take part in foreign countries' bidding processes, multilateral funds and overseas tenders [21]. As a consequence, to beat other local and foreign competitors, a culture that enhances a company's competitiveness and performance becomes vital for success [22].

Similarly, predictive information concerning the competitiveness of contractors is a potentially valuable asset for many decision makers involved in the construction procurement process [23]. For instance, it is frequently stated that "the resulting fierce competition for jobs forces construction companies to look for more sophisticated analytical tools to analyze and improve their bidding strategies" [17]; this leads to the conclusion that "[construction] managers need statistical estimation techniques for effectively mining data generated by auctions to predict future behavior and to dynamically improve operational decisions" [24].

One approach to acquiring competitiveness information is by monitoring past bidding behavior [23], but this seems to be done rather subjectively in the construction setting [25], in contrast to other industries in which there seems to be a more structured monitoring [26], in particular in terms of innovative approaches to procurement (e.g., online auctions, dynamic bidding models, combinatorial auctions, sequential markets, e-marketplaces).

In a more general construction context, scattered efforts have been made to develop conceptual frameworks for assessing and comparing construction company's performance [27].

Obviously, this research gap also encompasses the lack of frameworks for bidding performance [28–30], for which only sporadic studies have appeared, most of them related to bidding accuracy, namely, cost estimating accuracy [31,32]. The scarce number of measurements for bidding competitiveness in the literature proposes indices that describe how close each bidder i's bid (b_i) was to the lowest bidder's bid ($b_{\min}$) in a particular auction, for instance [19]:

$$C = \frac{b_i - b_{\min}}{b_{\min}} \tag{1}$$

where C is the measure of competitiveness and ranges from 0 (maximum competitiveness, when $b_i = b_{\min}$) to $+\infty$ (ideally, when $b_i = \infty$ or is infinitely expensive).

However, concerning competitiveness in bidding, paradoxically, a significant amount of research has been published linking the size of the bidder and the size of the contracts, i.e., proving that there are usually some affinities between them [19,33].

On the other hand, Data Envelopment Analysis (DEA), a non-parametric method for the estimation of production frontiers, has begun to be used to gain insight into bidders' comparative performances. This approach was first used in 2005 to develop a contractor prequalification system aiming to assist auctioneers in tenders to select the best contractors, as well as to inform contractors concerning their performance providing guidance for future improvement [34]. Five years later, another study stated that the best bids/candidates in the selection process are usually located on the DEA frontier, an outcome that has immediate applications regarding bid/no-bid decisions [35].

Particularly, the present work differs from these two studies on DEA in terms of how the concept "performance" is applied and to what end within a construction contract. Namely, "performance" in these works is conceived as how effectively the bidders carry out a contract when awarded, a measurement that can be used later by the auctioneer to rate future bidding proposals and to compare them, which definitively has nothing to do with analyzing how likely it is that each potential bidder will occupy a given position when competing against others, the main goal of the present study.

On the other hand, quite recently, Wang et al. [36] developed a Revenue/Cost Analysis Model for competitive bidding strategy planning. This approach used Price/Performance analysis models (P/PAM), marginal utility functions, and profit function to form a new method for planning the bidding strategy of maximum expected profit while trying to take into account that the auctioned item generally varies with the price.

Our study can be considered complementary to the one developed by Wang et al. [36], as the latter developed a tool for obtaining the maximum profit when bidding mid-term, but the method itself requires highly processed information that cannot always be derived solely from the application of marginal utility and profit functions, unlike the tool proposed here that can be

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