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Evaluation of Unbalanced Bidding on Highway Projects

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Unbalanced bidding is a persistent problem in highway project contracts, especially with asphalt overlay projects where pay quantities are subject to significant variation. Under unit-price contracts, contractors can strategically inflate or deflate specific bid items to maximize cash flow, making it difficult to manage project costs. This research examines the frequency and trends of unbalanced bidding in the Texas Department of Transportation (TxDOT) overlay contracts within the Fort Worth and Houston districts. Using bid and engineer's estimate records for 52 projects, the study quantifies item-level bid cost deviations and examines contractors' bidding patterns to determine whether unbalanced bidding occurs in those contracts. Initial review indicates measurable unbalanced bidding in early-stage items such as Traffic Control. However, the study also found that the contractors are bidding higher on later-phase items, e.g., Asphalt Overlay and Pavement Marking. There is insufficient evidence to prove that systematic unbalanced bidding occurs in highway contracts executed by the Texas DOT. Further study is required, using more bid data points, to validate whether unbalanced bidding patterns occur in highway construction contracts.

Keywords**:** Unbalanced bidding, Bid Items, Bid cost growth, Texas Department of Transportation (TxDOT), Overlay projects

Introduction

Highway overlay projects are a significant percentage of pavement maintenance programs in U.S. transportation agencies and rely heavily on unit-price contracts to accommodate unforeseeable field quantities. Unit-price contracts are used by almost all state and local transportation agencies, including the Texas Department of Transportation (TxDOT), as the dominant tradition in competitive bidding. In this approach, contractors bid on all pay items, and the total bid price is the sum of the products of each item's unit price and the quantities estimated by the engineer. The job is then usually awarded to the lowest responsive and responsible bidder. While this strategy promotes fairness and transparency, it also opens the door to strategic price manipulation across bid items—a practice known as unbalanced bidding. In this practice, contractors adjust unit rates, raising the prices of products expected to increase in quantity or occur early in the project schedule and lowering others to maintain competitive overall bidding while optimizing up-front cash flow. Although this method is not technically illegal, it is detrimental to the contracting process. It tends to generate distorted cost apportionment, cash-flow front-end loading, and likely cost growth as underestimated items grow in scope. An unbalanced bid in construction occurs when a contractor systematically overprices early work items and underprices later work items to gain a financial advantage.

Despite this definition, Shrestha et al. (2012) mention that unbalanced bidding remains common in U.S. public works. Their study of 70 Clark County Department of Public Works projects (1992–2008) documented statistically significant front-end loading behavior: contractors priced early activities, such as roadway excavation and aggregate placement, above later items, such as pavement marking, thereby capturing higher present-value revenue at the owner's cost. The authors concluded that these practices undermine economic sustainability, which they define as the efficient and responsible use of financial resources to generate long-term project value. As Cattell et al. (2007) and Green (1989) have noted, even when unbalanced bidding is economically sensible, it sacrifices transparency, offends the principles of fair competition, and shifts financial risk from the contractor to the owner.

The other well-known form of unbalanced bidding is rate loading by item, in which contractors tend to overprice selected pay items likely to see quantity increases during construction. According to Cattell (2007) and Green (1989), bidders expect the owner to refund them at the inflated unit price if the actual volumes of these commodities turn out to be higher, thereby allowing them to earn extra profit without violating the terms of the agreement. Shrestha et al. (2012) further observed that such a pricing practice indicates the contractor is attempting to exploit informational asymmetry in quantity estimation, especially for items related to excavation, embankment, or base course materials, where such field variation is normal. Though the contractor might find this game profitable in the short term, it distorts cost predictability and undermines the owner's budgetary control. It was also highlighted by Arditi and Chotibhongs (1983) that excessive reliance on individual rate loading can expose projects to controversy, cost overruns, and moral concerns with fairness in sharing financial risks. The identification of individual rate loading is therefore paramount to ensuring transparency and economic viability in public-sector contracting.

This research involves analysing unbalanced bid patterns in TxDOT projects, including counties within the Fort Worth and Houston Districts. The historical bidding data used in the analysis includes the engineers' estimates and unit prices for each item, as submitted by the lowest-bid contractors, to determine whether bidding anomalies occur, either in the form of front-end loading or individual rate loading. The research identifies the critical bid items, determines their percentage cost variances, and tests the hypothesis regarding the relationship between item order and price differences. It is expected that, based on the identified trend, this research will determine whether the contractor strategically manipulates item prices to achieve early cash flow or maximize profit. In general, the study will investigate the economic equity and sustainability of the bidding process and provide information to help public agencies improve bid evaluation and detect unfair pricing in future highway contracts.

Scope of the Study

This study focuses on overlay roadway projects within the Fort Worth and Houston districts of TxDOT. The dataset comprises historical bid records containing engineers' estimates, contractor bid prices, and item-level information for recurring pay items such as traffic control, existing pavement repair, tack coat, asphalt overlay, and pavement markings. The research is limited to quantitative bid analysis and does not include stakeholder interviews or field surveys. Nevertheless, the findings are expected to provide valuable insights for improving transparency, fairness, and economic sustainability in public infrastructure procurement related to unbalanced bidding.

Research Objectives

The primary purpose of this study is to investigate and quantify unbalanced bidding behavior in TxDOT overlay construction projects. In this study, if the bid price deviation decreases as the work items are executed during construction, it is called unbalanced bidding. By examining bid data from the Fort Worth and Houston districts, the research aims to detect patterns of strategic pricing, specifically front-end loading that may influence project cost growth and economic sustainability. The objectives of this research are as follows:

1. To identify and measure the degree of unbalanced bidding across selected TxDOT overlay projects by comparing contractor unit prices with engineers' estimates.
2. To develop and apply the Bid Cost Growth metric to quantify item-level deviations and identify potential unbalancing behavior.
3. To analyze bid price deviation patterns with item order in the construction sequence to determine the presence of front-end loading.

Literature Review

Unbalanced bidding remains a persistent problem in construction procurement, given its implications for transparency, cost predictability, and economic sustainability. The concept predominantly arises under unit-price contracts, in which contractors provide rates for individual pay items and are reimbursed based on actual field quantities. Scholars like Arditi and Chotibhongs (2009) have linked it to a structural vulnerability in the traditional bidding process, which allows contractors to manipulate unit rates without sacrificing competitiveness in the overall bid. Although such a practice does not violate procurement legislation, it often raises ethical concerns and seriously impairs the fair distribution of financial risk between owners and contractors.

Among the various forms of unbalanced bidding, two predominate: front-end loading and individual rate loading. The prices of activities in the early stages would be inflated to maximize immediate cash flow through front-end loading. In contrast, rate loading would apply to items that may be affected by variations in quantity during construction. In support, Cattell, Bowen, and Kambugu (2007) offered that such pricing indicates strategic cash-flow management rather than overt malpractice, whereby the contractor can recover costs sooner rather than later, at some sacrifice to project-level fairness. Green (1989) further developed this ethical dimension by arguing that such strategies blur the distinction between competitive advantage and the procurement of an information asymmetry advantage in public bidding. Ethically, these price distortions call into question the concept of value for money, which is considered central to sustainable and transparent procurement.

Unbalanced bidding has also been discussed extensively in terms of economic consequences. According to Marion (2025), high front-end loading distorts the cash-flow balance and reduces a project's long-term efficiency, as funds are consumed prematurely. The practice, as emphasized by Green (1989) and Hyari (2017), especially when field quantities differ considerably from estimates, transfers a significant portion of financial risk from contractors to owners. Further, Shrestha et al. (2012) and Nyström (2019) have asserted that repeated incidents of unbalanced pricing of public infrastructure projects may lead to the loss of public confidence and systemic inefficiencies in project financing. In Texas, TxDOT has recognized the impact of unbalanced bidding and developed specific definitions and detection thresholds. The TxDOT Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges, 2024, distinguishes between two types of unbalanced bids: mathematically unbalanced bids, where there is disproportionate pricing of individual units, and materially unbalanced bids, which can affect contract award decisions.

Empirical research has shown that unbalanced bidding is a common phenomenon in both developed and developing economies. Shrestha et al. (2012) examined significant front-end loading in Clark County public works projects, where early items were consistently overpriced for activities such as roadway excavation and base placement. Nyström (2019), in his research on Swedish road projects, found systematic price distortions corresponding to the order of construction activities, confirming that even mature procurement systems are prone to this type of behavior. Cheng (1996) has also presented an economic explanation of front-end loading through the optimization of discounted cash flows, observing that contractors seek to improve their financial position by accelerating revenue collection in the early stages of a project. These findings indicate that unbalanced bidding reflects both financially rational and ethically ambiguous practices within infrastructure procurement. Despite these guidelines, unbalanced bidding persists as a subtle yet significant challenge due to regional variations in market competition and economic conditions. Previous studies, such as Nyström (2019) and Arditi and Chotibhongs (2009), indicate that the success of such controls would depend on data quality, transparency of cost estimates, and consistency in their enforcement.

Various researchers have attempted to develop analytical tools to identify and quantify unbalanced bidding. One of the first mathematical models to detect "materially" unbalanced bids was proposed by Arditi and Chotibhongs in 2009; it measures how item-level price deviations can lead to potential cost escalation. Later, Hyari (2017) and Polat, Bayrak, and Koseoglu (2018) proposed using statistical deviation techniques to compare contractors' bid unit prices with engineers' estimates and peer bids to identify anomalies. These various analytical frameworks indicate that unbalanced bidding can be empirically detected through abnormal deviations in price patterns. Recently, Thneibat (2024) suggested using advanced machine-learning-based anomaly detection algorithms to improve accuracy and automate identification.

Although there is a rich literature on unbalanced bidding from both international and national perspectives, the research gap persists at the district and even item levels within state transportation agencies. Most of the research conducted so far has approached the problem of unbalanced bidding in aggregate, without fully considering regional variations that may exhibit unique contractor bidding behaviors or strategies. For example, few direct empirical tests have been conducted to relate the magnitude of price deviations to their positions in construction sequences. Furthermore, few studies have examined the impact of project size on unbalancing intensities, and, as a result, it remains unclear whether smaller contracts experience greater price manipulation due to lower competition. This study will contribute to the current state of knowledge by examining unbalanced bidding behavior in the Fort Worth and Houston TxDOT districts, using item-level data and a normalized metric, Bid Unit Cost Growth, to assess the relationship among price deviations, project sequencing, and fiscal sustainability.

Research Methods

This study uses the methodology depicted in Figure 1. First, the authors identified problems associated with unbalanced bidding in highway projects. Given the limited number of studies on this topic, the authors seek to determine whether unbalanced bidding occurs in TxDOT highway projects. For this, the authors have identified the TxDOT website where the bid items and their estimated and bid costs were listed.

Before preparing the bid metric, the authors downloaded the bid cost data for highway projects in which asphalt overlay work was performed. The authors randomly downloaded 52 recent TxDOT highway projects in which asphalt overlay work was conducted. Once the data were downloaded, the authors identified the common bid items in most of these projects. There were five common bid items found in these bid data that were presented in most contracts, and they were:

1. Barricade, signs, and traffic control
2. Existing pavement repair
3. Tack coat
4. Asphalt overlay

5. Pavement marking

Bid items were standardized across projects using TxDOT bid item descriptions and specification numbers to ensure consistency. Only recurring items with comparable scopes and payment structures were retained for analysis. This approach minimized inconsistencies arising from project-specific bid item labeling. Traffic Control was treated as a lump-sum item and analyzed as a unit-equivalent cost relative to the engineer's estimate. This treatment is consistent with TxDOT payment practices and allows comparison of proportional bid deviations across all selected items. None of the contracts have missing items; however, in some contracts, certain items were not required, e.g., asphalt overlay or pavement repair activities.

To measure whether the lowest bidders in these projects were using unbalanced bidding processes to win the contract, the bid growth metric, Bid Cost Growth, is developed and shown in Equation 1.

$$Bid\ Cost\ Growth = \frac{(Bid\ Cost\ of\ the\ Lowest\ Bid\ Contractor - Estimated\ Bid\ Cost)}{Estimated\ Bid\ Cost}\ x\ 100 \ldots\ldots\ldots\ldots\ldots (1)$$

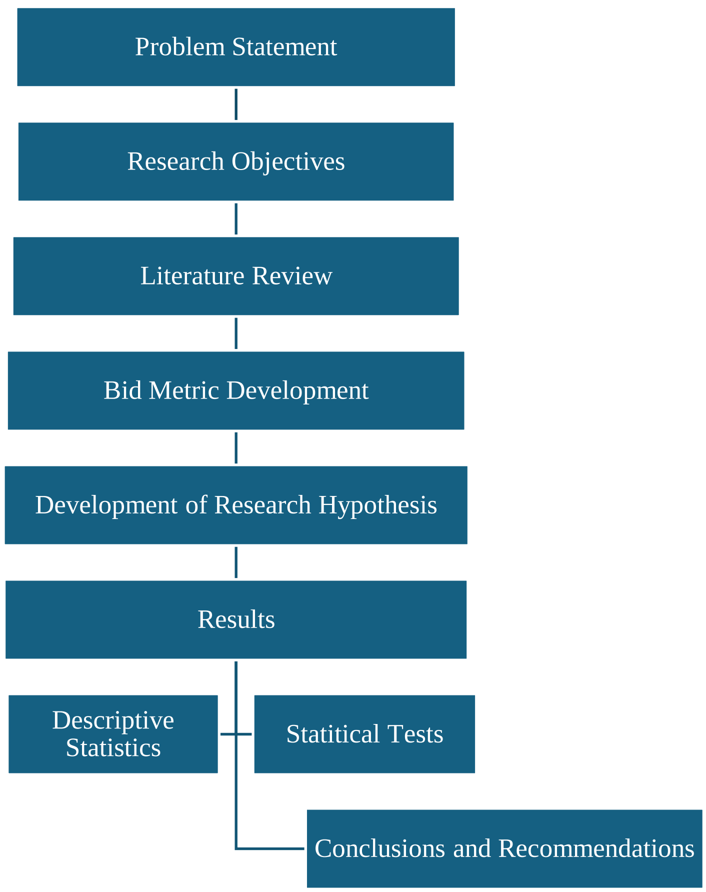

Figure 1. Research methodology

Bid Cost Growth Metric Development

Bid cost growth measures the deviation of the lowest-bid contractor's bid from the engineer's estimate of the bid items. This shows how much above or below the contractor's bid for the work items is compared to TxDOT's estimated cost. The Bid Cost Growth is measured as a percentage and is calculated for all five bid items stated above across all 52 highway overlay projects.

Development of Research Hypothesis

The main research hypothesis of the study is that the contractor will bid higher on bid items completed earlier than on those completed in the later phases of project construction. This hypothesis is based on Cheng (1996), who found that contractors are improving their cash flows by collecting revenue at the early stage of projects. One way to do this is to bid the first item, in this case, Traffic Control, higher than the estimated cost. In terms of Bid Cost Growth, the research hypothesis can be stated as:

"The Bid Cost Growth of the Barricade, signs, and traffic handling items is significantly higher than the Bid Cost Growth of the remaining four bid items."

The research hypothesis must be converted to a null hypothesis to conduct a statistical test. The non-parametric statistical test verified whether the Bid Cost Growth of the first item in the bid document is equal to that of the remaining four bid items stated above. The null hypothesis is stated below.

$$Bid\ Cost\ Growth_{Traffic\ handling} = Bid\ Cost\ Growth_{Pavement\ repair} = Bid\ Cost\ Growth_{Tack\ coat} = Bid\ Cost\ Growth_{Asphalt\ overlay} = Bid\ Cost\ Growth_{Pavement\ marking} \cdots\cdots (2)$$

Results

The Bid Cost Growth was calculated for each bid item across all 52 highway overlay projects. First, the Bid Cost Growth data were used in the box plots to assess for outliers. Figure 2 shows the box plot of Bid Cost Growth for these five bid items. The box plots show some outliers in the data, but the authors have decided not to remove them. The more data is removed, the more outliers will occur, and the sample size will decrease.

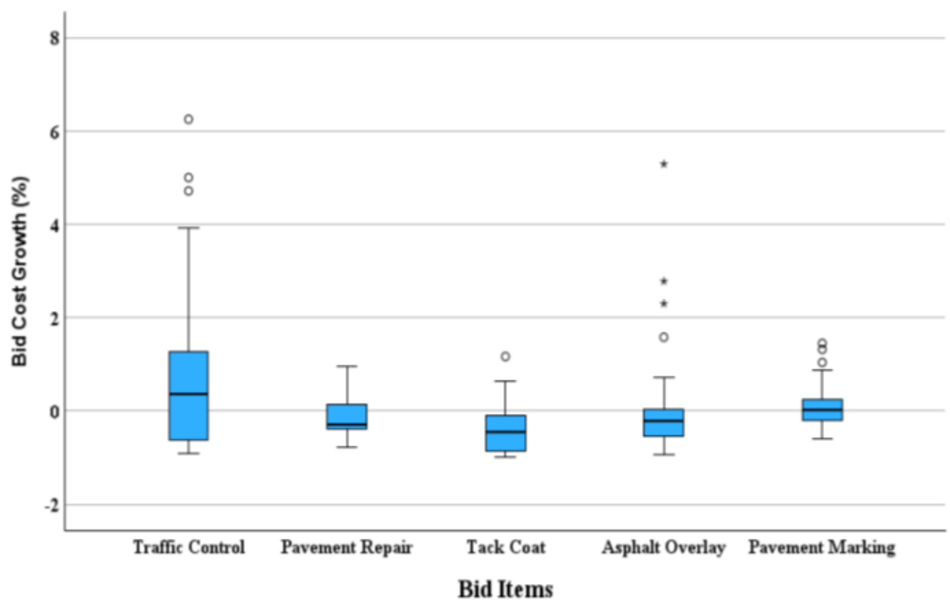

Figure 2. Bid Cost Growth box plots

Descriptive Statistics

Then, the Bid Cost Growth data were analyzed using descriptive statistics to calculate the mean, median, and measures of variation. Table 1 shows the sample size, mean, and median of Bid Cost Growth for all five bid items. The results show that the traffic control bid items have a positive mean bid cost growth, indicating that, on average, the contractor is bidding these items at a higher rate than the estimated cost. However, for the next two bid items, the average bid cost growth is lower than the estimated cost.

Table 1. Descriptive statistics of Bid Cost Growth

Metrics	Traffic Control	Pavement Repair	Tack Coat	Asphalt Overlay	Pavement Marking
Sample Size	51	29	27	48	51
Mean (%)	67.7	-15.6	-39.7	2.31	8.3
Median (%)	35.7	-28.0	-46.1	-22.5	1.0

Statistical Tests

The data showed that not all bid items are present in all 51 contracts, because some items, e.g., tack coat and asphalt overlay, are not required if a concrete overlay is done. In some overlay contracts, pavement repairs are also not required. Therefore, not all the contracts included all these items. Due to the reduced sample size, the authors conducted a power analysis for the Tack Coat item, which has the fewest samples. The SPSS power analysis results showed that, with an effect size of 0.25 and a sample size of 27, the power is 0.60 at an alpha level of 0.05. This shows that there is 60% chance of finding a significant finding in this data set

Before conducting hypothesis testing, it is necessary to determine whether the Bid Cost Growth data are normally distributed for these five bid items. To verify the normal distribution of the data for these five bid items, the Shapiro-Wilk test is also conducted. This test's null hypothesis is that the Bid Cost Growth across all five bid items is normally distributed. If the p-value of this test is less than 0.05, the null hypothesis will be rejected, indicating that the data are not normally distributed. Table 2 shows the Shapiro-Wilk test results. The test results show that the p-values for all five bid items are less than 0.05, indicating that the data are not normally distributed.

Table 2. Shapiro-Wilk test results for Bid Cost Growth

Bid Items	No. of Sample	Statistics	p-value
Traffic Control	51	0.83	<0.01*
Pavement Repair	29	0.92	0.03*
Tack Coat	27	0.89	0.01*
Asphalt Overlay	48	0.64	<0.01*
Pavement Marking	51	0.91	<0.01*

* Significant at alpha level 0.05

Another assumption for conducting the parametric test is that the variances of Bid Cost Growth across these five bid items are equal. To verify this assumption, the homogeneity-of-variances test should be conducted. Levene's test is conducted to see whether the variances of Bid Cost Growth among these five bid items are not significantly different. Table 3 shows the results; the variances among these bid items are not equal because the p-value was less than 0.05, so the null hypothesis of equal variances was rejected.

Table 3. Levene's test results for Bid Cost Growth

Metrics	**Degree of Freedom**	**Levene Statistics**	**p-value**
Bid Cost Growth	201	15.42	<0.01*

* Significant at alpha level 0.05

As the normality and homogeneity of variances tests rejected the assumptions that the data are normally distributed and that the variances across these five bid items are equal, the parametric test of ANOVA cannot be conducted. Therefore, the non-parametric Kruskal-Wallis test will be conducted to verify whether the mean Bid Cost Growth among these five bid items is significantly different from each other. The Kruskal-Wallis test results, shown in Table 4, indicate a significant difference in Bid Cost Growth among these five bid items. As the p-value was less than 0.05, the null hypothesis of no mean difference was rejected, and the research hypothesis was supported.

Table 4. Kruskal-Wallis test results for Bid Cost Growth

Metrics	**Number of Samples**	**Statistics**	**p-value**
Bid Cost Growth	206	19.25	<0.001*

* Significant at alpha level 0.05

The Kruskal-Wallis test indicates a significant difference in the mean Bid Cost Growth among these five items. However, the above test cannot find which bid item's Bid Cost Growth is significantly higher compared to the other bid items. Therefore, post-hoc pairwise comparison was conducted to determine which bid item's cost growth is significantly different. The post-hoc pairwise comparison test results are shown in Table 5. The results showed that the Bid Cost Growth for the first bid item, "Traffic Control," is significantly higher than that of the other four bid items, as indicated by p-values < 0.05. However, the Bid Cost Growth of the remaining four bid items is not significantly different from one another because the p-values were greater than 0.05, so we retain the null hypothesis that the mean Bid Cost Growth of these four items is equal.

Table 5. Pairwise comparison test results for Bid Cost Growth

Pairwise Comparison	**Difference (%)**	**Standard Error**	**p-value**
Traffic Control vs. Pavement Repair	83.3	24.4	<0.01*
Traffic Control vs. Tack Coat	107.4	25.0	<0.001*
Traffic Control vs. Asphalt Overlay	65.4	21.1	0.02*
Traffic Control vs. Pavement Markings	59.4	20.8	0.04*
Pavement Repair vs. Tack Coat	24.0	28.1	0.91
Pavement Repair vs. Asphalt Overlay	-17.9	24.7	0.95
Pavement Repair vs. Pavement Markings	-23.9	24.4	0.86
Tack Coat vs. Asphalt Overlay	-42.0	25.2	0.46
Tack Coat vs. Pavement Markings	-48.0	25.0	0.31
Asphalt Overlay vs. Pavement Markings	6.0	21.09	0.99

* Significant at alpha level 0.05

Conclusions and Recommendations

The State DOTs are evaluating whether contractors are using unbalanced bidding, in which they tend to bid higher on items scheduled for early completion to improve their cash inflows during construction. To determine contractors' bidding trends, the authors collected data on 52 recently completed asphalt overlay projects from the TxDOT bid data. The bid items were sorted by the order in which they are completed during construction. Five bid items, e.g., traffic control, pavement repair, tack coat, asphalt overlay, and pavement markings, were selected for the analysis. The bid cost growth for all these items was calculated to identify unbalanced bidding in these construction contracts.

The research hypothesis of this study was that contractors bid higher on items completed early in the project to increase cash flow. The bid cost growth data were first tested for normality and the assumption of homogeneity of equal variances. The statistical test results showed that the bid cost growth data across all five bid items were not normally distributed, and the variances were also unequal among these items. Therefore, the parametric test ANOVA could not be conducted. The authors selected the Kruskal-Wallis nonparametric test to determine whether the bid cost growth of these items differed significantly from one another.

The statistical test results showed that the contractor was bidding the “Traffic Control” bid item significantly higher than the other bid items. However, in subsequent items, e.g., “Pavement Repair” and “Tack Coat,” the contractors were bidding below the estimated cost. During the construction phase, the contractor will receive payment for the “Traffic Control” items first, and then for the remaining bid items after completing the work. When the Bid Cost Growth for the last work items, “Asphalt Overlay” and “Pavement Markings,” was analyzed, it showed that the contractors are bidding above the estimated cost. Looking at the pattern of contractors' bids, most contractors are bidding significantly higher on the first bid item, “Traffic Control.” Still, a decreasing bid-cost growth pattern is not evident in these contracts. The findings of this study do not align with previous studies, in which researchers found that contractors were bidding strategically (unbalanced bid) to achieve high cash flow on their projects.

The major practical implication of these study findings is that the state DOT must have a policy to detect the unbalanced bidding in their construction contracts, even though this study did not find any systematic unbalanced bidding. However, the bid cost growth for the first item was higher in this study, and it is required that the state DOT improve the estimation accuracy for Traffic Control items, as the estimate is prepared using a lump-sum amount. Also, the state DOT must conduct a pre-bid meeting with potential bidders to ensure that no unbalanced bids are submitted for the contracts.

Although this study shows that contractors are bidding higher on the first item, it has not proven that the bidding pattern is unbalanced. It should be noted that the first bid item, “Traffic Control,” is difficult to estimate because there is no systematic process for estimating it; generally, State DOTs include a lump-sum amount in this item during the estimating process. In addition, the contractors bid on this item without following any estimating process, which may result in higher bids. As a result, this study could not determine whether there is a pattern of unbalanced bidding in the TxDOT, which contrasts with Shrestha et al.’s (2012) findings. Some of the limitations of this study are a low sample size, inconsistencies in bid items across samples and project locations, and the effect of district-level management on contract management. The power analysis shows that there is little power to detect a statistical difference in the samples. If similar overlay contracts conducted by multiple contractors under the same district's jurisdiction at comparable locations (urban or rural) with similar project costs can be collected and analyzed, the findings will have greater validity, as more confounding variables can be controlled for. The authors recommend conducting further research to determine whether unbalanced bidding occurs in highway projects, using additional State DOT data. In addition, the authors recommend using other cost metrics, e.g., the total cost growth of items whose quantities increased during construction relative to bid quantities. This will show whether contractors are strategically bidding items higher to maintain high cash flow during construction.

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