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FINAL REPORT ~ FHWA-OK-14-12

UNDERSTANDING A + B BIDDING PATTERNS AND POLICY IMPLICATIONS FOR ODOT PROJECT LETTINGS

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ODOT SP&R ITEM NUMBER 2257

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16 . ABSTRACT

A key challenge for Departments of Transportation around the country is to keep the cost of construction low while ensuring that projects will be completed in a timely manner. Those goals can often be conflicting. The purpose of this research project was to investigate the empirical relationship between project cost and project duration to offer recommendations to the Department of Transportation on the optimal use of time incentives in the procurement process.

We first surveyed all Transportation Agencies on their rules of implementation of A+B and incentive/disincentive designs. A complete survey of A+B and I/D letting practice is presented. Policy details such as application, scope and parameter choice are included in the report.

We utilized program evaluation techniques to assess the performance of A+B bidding in comparison to the standard contracting low bid practice. Using our statistical knowledge and information on alternative contracting methods adopted by ODOT and other state Departments of Transportation, we conducted economic evaluation of contracting practices. The end goal was to prepare guidelines for distinguishing between costly projects and those that are economically practical to speed up, and help ODOT to improve efficiency in highway construction.

We found evidence that item bids respond to the time incentive asymmetrically. As an example, items 202(C)0184 (Unclassified Borrow) and 619(B)2500 (Removal of Bridge Items) display especially favorable reactions to time incentives and hence projects that prescribe such items more heavily are desirable candidates for A+B letting consideration. There is evidence suggesting that bids (and the underlying cost) rise less steeply than for other items when time is a constraint. Naturally, acceleration on such items may be achieved at a relatively lower cost to the state department.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS				
SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY**	**TO FIND**	**SYMBOL**
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS				
SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY**	**TO FIND**	**SYMBOL**
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

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EXECUTIVE SUMMARY

The study aims to analyze data related to the performance of the A+B innovative contracting design that could help the Oklahoma Department of Transportation (ODOT) evaluate the costs and benefits of the design, leading to an assessment of current practices. A+B bidding is an innovative contracting design that allows contractors to propose an “A” bid for cost and a “B” bid for time. Since both cost and time matter in determining the winner, A+B bidding has the potential to reduce construction time while keeping the cost competitive. According to theory, as construction speeds up, cost goes up as well. So the net impact is unclear. In addition, the current practice of ODOT concerning the assignment of A+B bidding is primarily based on the size of projects and duration. Our goal is to identify any project related characteristics that could be added to the list to optimize the use of this innovative contract design as well as information on A+B practices across the states.

This study has three objectives. The first objective is to provide detailed statistics on how A+B bidding is being utilized in ODOT lettings. We provide a summary of the characteristics of A+B bidding projects, the competition in these projects, and how they compare to the rest of the projects offered regularly at lettings. The second objective is to quantity the effect of A+B bidding on the low bids ODOT received, which represents the direct cost to the State. This is achieved with advanced techniques from the literature of program evaluation. This enables us to separate the observed difference in low bid caused by differences between projects themselves rather than the difference in bidding method, and provides an accurate estimate on the impact due to the adaptation of the special provision of A+B bidding. The last objective of the study is to dig one step deeper from the project level, and to analyze how individual construction items within an A+B bidding project respond to the pressure of time in terms of changes in itemized bids. Then we focus on items that demonstrate favorable responses, in other words their itemized bids are increased the least in A+B bidding compared to standard bidding, to look for projects which use such items to a considerable extent as desirable candidates for ODOT’s expansion of implementation of the A+B design in the future.

1.0 INTRODUCTION

A key challenge for Departments of Transportation around the country is to keep the cost of construction low while ensuring that projects will be completed in a timely manner. Those goals can often be conflicting. The purpose of this research project is to investigate the empirical relationship between project cost and project duration to offer recommendations to the Department of Transportation on the optimal use of time incentives in the procurement process.

We utilize program evaluation techniques to assess the performance of “incentive/disincentive” (I/D) and A+B lettings in comparison to the standard contracting low bid practice. Using our statistical knowledge and information on alternative contracting methods adopted by ODOT and other state Departments of Transportation, we conduct economic evaluation of contracting practices.

The purpose of this research project is to identify and quantify the empirical relationship between procurement cost and project duration and to offer recommendations to the Department of Transportation on best practices relevant for time-related contracting provisions. Our economic analysis utilizes program evaluation techniques to thoroughly assess the performances of “incentive/disincentive” milestones (I/D) and “cost plus time bidding” (A+B) procurement mechanisms in relation to each other and the standard low bid format. We examine and compare bidding outcomes in terms of construction acceleration and final cost. With the research team’s statistical expertise and knowledge of alternative contracting methods, we first isolate projects that have been sped up under I/D and A+B incentive structures, and measure how much bidding levels and final procurement costs have been increased under these incentive structures, before comparing such increments to the welfare gains of the public. Next, we establish an algorithm to quantify the relationship between a project’s characteristics, such as location, task, size and item composition and its acceleration premium (price increase due to time constraints) by looking at how contractors revise bids of various construction materials within the project to expedite completion. The end goal was to prepare guidelines for distinguishing between costly projects and those that are economically practical to speed up, and help ODOT to improve efficiency in highway construction.

2.0 BACKGROUND

The Federal Acquisition Regulation guidelines, which dictate the available contracting options in any procurement activity using federal funds, demonstrate a clear preference for simple, price-based auction procedures-such as the lettings used by ODOT. However, theoretical analysis from a very influential research group (Bajari, McMillan and Tadelis (2009)) asserts that procurement officials should be allowed more flexibility in awarding contracts based on the characteristics of projects and bidders. Our work is related closely to the emerging interest in schedule-based contracting methods used in procurement auctions. It takes the literature a step further by proposing to engage in rigorous, data-driven quantitative investigation, by looking for the first time at itemized bids and using the wealth of information existing at this level to draw conclusions. At the end, we propose specific guidelines for State Transportation Agencies that could help improve efficiency in highway construction.

2.1 BACKGROUND OF TIME-RELATED CONTRACTING PROVISIONS

Construction of highway and bridge projects weighs in multiple considerations that relate to cost, schedule, quality and technology considerations. As a result of the increasing traffic volumes on the national highway systems, many transportation agencies are pressured to place a higher and higher premium (weight) on construction time, and begin to widely implement time-related construction provisions in procurement auctions. Time incentive structures can generally be divided into two categories:

Incentive/Disincentive Milestones (I/D) based on completion-date

This contracting method is probably the most established and widely used of all provisions. Under the I/D structure, the time frame for critical pieces of work (milestones) or full completion is determined by the DOTs and presented to contractors with the plan. Contractors are to be awarded bonuses for each day they fulfill the contract satisfactorily before the completion date stated in the plan, or to be charged a fee if completion is overdue.

Cost Plus Time Bidding (A+B)

This alternative has been steadily gaining popularity after it was recommended by the Federal Highway Administration. Here contractors propose their own construction times. Determination of the winner follows the low price rule, where each bid is the sum of the item cost (A component) and the (user-cost weighted) time cost (B component). The design is a variation of scoring auctions in the auction literature.

In practice, there is a multitude of alternatives for time-sensitive contracting mechanism. But many of them can be viewed as a slight variant of one of the above structures or a composite of both. Furthermore, since the two methods come with a considerable pool of observations from ODOT practices, we will draw on them for empirical analysis.

As part of our project analysis, we surveyed all Transportation Agencies on their rules of implementation of A+B and incentive/disincentive designs. A complete survey of A+B and I/D letting practice is presented in Table 1.

As Table 1 reveals, twenty three out of the forty four states responding to our request for information have A+B mechanism in places. The table also details a variety of incentive disincentive practices and penalty and reward caps that are implemented at the state level.

The Federal Highway Administration (FHWA) recommends a maximum amount of incentive payments as 5% of the total project cost. Many states employ the suggested cap in practice, but some states have set their own caps based on number of days, duration of project, type of work, or their budgets. It is also common for the incentive to be capped at either a maximum amount or a maximum number of days, or both, while disincentives are not normally capped. However, in Alabama, Nevada, New Jersey, Rhode Island, and Texas incentives are not capped at all.

The level of I/D rates are so varied that it is difficult to provide a general rule of setting I/D rates in each state. The factors affecting the adjustments are project conditions, market influences, and the level of acceleration. I/D rates vary by state and most states employ user cost as the basis. It is far less common to use liquidation damages as the basis (only in Mississippi and Nevada). The incentive provision is not always used. For example, the state of Nevada uses a disincentive provision only. Nearly one third of the states set I/D rates equal to the user cost. The table also shows that only eight states have a rate of disincentive strictly less than the user cost.

2.2 LITERATURE REVIEW

An important effort from the economics community to analyze time incentive designs was made by Lewis and Bajari (2011), who studied A+B contracts offered by the California Department of Transportation (Caltrans) between 2003 and 2008. A highly urbanized state with a large population, California is believed to bear significant welfare losses due to the disruption of regular traffic flow in work zones. Lewis and Bajari collected 79 A+B contracts alongside 603 projects that were auctioned off using the conventional low bid auction format. When comparing construction time, the researchers observed much quicker completion fromthe A+B type, taking on average 60% of the engineer's time estimate. Meanwhile, when the monetary outlay is considered, there is a 10% increment in bids submitted under the A+B design over the standard low bid procurement practice for similar work type and scope. Using statistics on California's daily traffic and construction-related traffic delays, the authors calculate that for an average construction job, the savings from road-user cost reductions ($6.4 million) substantially outweighed the increase in procurement costs (1.5 million). Based on the favorable results, they recommended that the usage of A+B bidding be expanded to all projects rather than the current practice of a selected few.

Another study is carried out by Gupta and Snir (2009), based on data collected from Minnesota Department of Transportation (MnDOT). Due to the limited number of projects under alternative auction designs, the authors concentrated on a relatively small sample of A+B projects to examine their cost realization at the completion of the projects rather than the expected payments from competitive bidding. In a game theoretic model, they derived an optimal bidding strategy to show that, contractors always have the incentive to propose an unrealistically low number in days, win the project, and then finish late with a penalty.

There is also a rich literature on time-related incentives in the field of engineering, most of which take a qualitative perspective. I/D milestones has been a contracting tool for DOT's for more than 20 years, but its usage is still quite limited, usually only selected when urgent completion in areas of high-traffic volume is needed. Through case studies, Gao (2010) provided an explanation for the small scope of incentive projects, placing emphasis on how critical it is to specify accurately the incentive and disincentive amounts for the contract. Failure to set incentives/disincentives correctly may result in amounts too low to provide contractors enough financial motivation to accelerate construction, or so high that they could exceed the public user cost and result in a waste of tax payers' money. He compared three common approaches from the literature to draw the policy recommendation that the rate of incentive should depend positively project duration.

Taking a descriptive approach, Arditi and Khisty (2005) studied the usage of I/D contracts in the Illinois Department of Transportation (IDOT) in the early 1990's, and concluded that acceleration of construction time is most likely accompanied by higher cost of procurement.

Herbsman and Chen (1995) conducted a survey of innovative time-reduction auction methods to summarize and contrast standard procedures, current applications, and pros and cons of each alternative. As an increasing emphasis is placed on construction time, more and more state transportation agencies begin to implement such designs alongside with the conventional method, although to limited scales. Most states have seen favorable results from such practices.

Zervos (2009) documented NASA's implementation of the Faster-Better-Cheaper (FBC) procurement philosophy in the early 1990s. The expectation was that FBC would lead to a more competitive award process. However, Zervos' empirical results indicate that NASA's choices of award mechanism and contract type were not in accordance with these expectations. This study indicates the importance of evaluating the effectiveness of both pricing mechanism and incentives in conducting procurement policy analysis.

Piacenza (2006) modeled inefficiency for public transportation firms in Italy as a function of regulatory scheme for subsidization and environmental factors (aggregating to the delivery speed). Using this approach, Piacenza found that the incentive-maximizing regulatory structure provided by the fixed-price regime indeed results in inefficiency reduction for the firms that use low price contracts.

In the next section, we will describe the data and research methodology related to this work.

3.0 DATA COLLECTION

Data collection and consolidation in the project was done in three parts: first, we collected information directly from letting documents available on the ODOT website; second, we requested and acquired information, which was not available online directly through ODOT staff; and third, we had a couple of meetings with ODOT engineers to extract quantifiable information from text or graphical documents.

(i) Collecting Online Letting Data

We included all projects between 2004 and 2011 from regular monthly lettings administered by ODOT. Information can be distinguished by the level of aggregation of information, namely, we collected project award level data and item level data. Project award level data encompass all observed characteristics from the letting report, including letting date, project id, location, description of work type, urban/rural type, road type, plan holders, bidders, all bids submitted, and the letting outcome.

A unique feature of our data collection is that we took a step further from project award level information to dip into the rich reservoir of information at the itemized level. For a project of average size, there are usually scores of item lines listed in the plan. Each item line includes the name of the construction item, the quantity used, and the price estimate by engineers. Therefore, the sample size at item level is easily 100 times greater than that at the project level. With the help of pdf conversion technique, we were able to obtain the entirety of records at the item level, particularly the itemized bid on every item prescribed in the plan, identity of the contractors submitting the bid, item number, item description, specified quantity, unit bid price and total bid price (which is the product of quantity and unit bid price).

(ii) Collecting Additional Information from ODOT

By necessary, information that is not released on the website was requested. Specifically, we asked ODOT engineers for information on the actual construction of projects after they were successfully procured in monthly lettings and the special provisions of incentive/disincentive and lane rental that are used in contracting in addition to the special provision on A+B bidding. Construction information was based on finalized projects, which provides information on the net difference between low bid and the actual paid amount.

(III) Meetings with ODOT Engineers

Besides requesting additional information, we also solicited the help of ODOT engineers to understand their rule of thumb in choosing A+B bidding or A-only bidder in practice. How the decision is made in practice regarding whether to use A+B bidding is important for our analysis because we are able to look for the difference in the performance of projects with A+B bidding after accounting for selection patterns.

Another clarification we requested from ODOT concerned the details of how traffic/road closures were selected from different projects. This information is also critical to our comparison of A+B bidding versus A-only bidding, because the way traffic is regulated in the work zone can have an impact on the cost of the contractor and therefore the procurement cost incurred to the State. However, we learn from ODOT that such information is usually specified in the detailed construction plan, which is not only difficult to look for but also require engineering expertise to understand. Since traffic regulation is related to the traffic volume on the road, for instance, full closure is less likely to be allowed on busy highways than on remote county roads. We used the type of road where the construction took place as a proxy for the effect of traffic closure on cost.

4.0 DATA DESCRIPTION

Next, we present summary statistics for the data. Overall, the use of A+B bidding is at a relatively small scale. Of all 2438 projects successfully contracted between 2004 and 2011, 127 have special provision SPN102-4, where contractors are expected to submit an A bid for cost and a B bid for time, compared to the great majority of 2311 projects that are procured via the standard low bid auction format, in which the contractor with the lowest bid is awarded the project.

In Table 2, we contrast the characteristics of projects procured through standard A lettings and A+B lettings along different dimensions. Judging by the engineer’s cost estimate, A+B projects are much larger, on average estimated to cost about $10 million. On the other hand, a typical project using the A-only bidding format is expected to cost $1.5 million. If we move on to the bids received, it is not surprising that the difference in size is also reflected in the bids submitted by all bidders and in the low bids, since the engineer's estimate is a good indicator on the construction cost. To facilitate the comparison between these two groups, we constructed a measure of relative bid, as the ratio of dollar bid divided by the engineer's estimate. In standard A-only projects, bids are on average 5% higher than the engineer's estimate, while the premium is slightly lower for the A+B bidding group, where bids are 2% over the estimate. For low bids, however, the pattern is reverse, as the low bid from A-only projects is 6.8% below the estimate, but only 4.6% under the engineer's benchmark for A+B bidding. In agreement with the bigger size of A+B bids, we also observe A+B projects to be longer in duration, lasting 268 days in term of calendar days. The number of item lines in the plan of an A+B work is also noticeably higher, nearly four times as many as in an A-only project. This suggest that an A+B bidding project tend to be both larger and more complicated in tasks as there are many more construction materials involved in the job.

Now we turn to the characteristics of procurement competition rather than the project itself. Generally speaking, the larger the number of bidders, the greater the competition intensity, and the lower the procurement cost will be for the buyer, in this case, ODOT. Meanwhile, competition intensity may not be directly dependent on project size or duration, but rather the state of the market, e.g. how many contractors are eligible and willing to compete for the project. We measure competition in two ways: through the number of plan holders and the number of bids, where both variables are positively related to healthy competition in a letting. While the A+B mechanism seems to attract more plan holders, the number of bids actually submitted is smaller in A+B than in A-only lettings. Nevertheless, these numbers are much more comparable than the characteristics of the projects themselves. To examine more carefully which firm participated in A+B bidding, we present contractors' plan holding and bidding frequencies between 2004 and 2011 in Table 3, where the division into different groups is based on their participation, i.e. whether they purchased a plan and whether they submitted a bid, in A+B lettings. As expected, we see that firms that chose to participate in A+B projects constitute a subset of all contractors in ODOT monthly lettings. In particular, there are 73 contractors who have submitted a bid in A+B lettings, relative to 134 contractors who have purchased at least a plan, and 242 contractors that did not once purchase a plan or submit a bid for an A+B project. Regarding the frequency of participation in ODOT letting, A+B letting participants are much more active than A+B non-participants, as indicated by the greater number of plans purchased, bids submitted, and projects awarded. This suggests that participants in A+B lettings tend to be frequent bidders and winners.

For the subset of finalized projects, A-only projects eventually cost to the State an amount close enough to the lowest bid at the letting. The actual payment and low bid are almost identical for A-only bidding with a mere 0.1% differential. Contracts procured via the A+B format on average cost 6.2% more to the State than the low bid from the letting. On the contrary, the number of days a project takes until completion is considerably higher than the number of days specified in the plan across groups, although the performance of A+B contracts on “punctuality” is relatively better. Since the construction data are based on the net difference of the entire project, we don’t observe what might be responsible for the number of charged days to exceed the calendar day duration in the plan.

In sum, a stark difference is present between A-only and A+B contracts. This is understandable when we take into account ODOT’s consideration in choosing between letting methods. From discussion with ODOT staff we learned that assignment of A+B bidding, as expected, is not a random process. Instead, the primary criteria of whether a project is selected to be procured via the A+B bidding process include its size, the type of road it is on, and the area where the construction site is located. A+B bidding is adopted with a higher probability when a project is in populous metropolitan areas or close to busy interstate freeways. This means that, in order to correctly evaluate the effect of A+B bidding on procurement cost, we should focus on A-only projects that are similar in characteristics to A+B projects. Due to this reason, we defer the analysis of itemized data until a more appropriate comparison group is selected.

Next we summarized lane rental provision usage in A+B bidding. 39 out of 127 A+B projects are supplemented with a lane rental clause. The minimum fee is $1,000 per lane per hour, and the max is $65,000, averaging out to be $17,115 across. The specific distribution among divisions is presented in Table 4a.

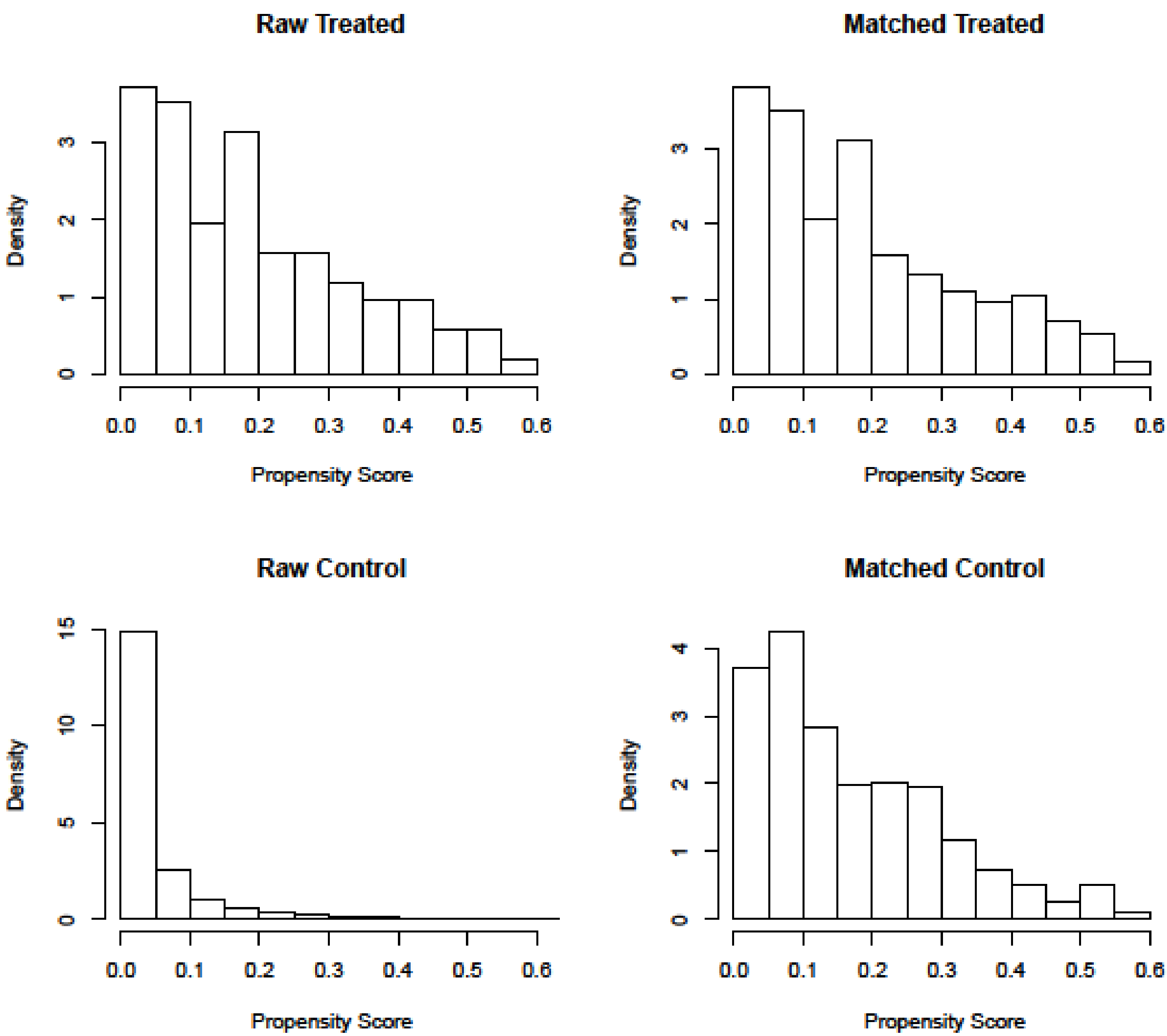
In Table 4b, we examined how the final payment and number of days charged are affected by the usage of lane rental provisions in A+B projects. With information on whether lane rental penalties are present, we examine the actual payment and construction time charged separating projects with and without lane rental provisions. We observed a difference in percentage, but only significant at 15% confidence level.

Finally, we summarized information on the use of incentive/disincentive rates in A+B bidding. We were provided with SPN102, the official provision of A+B bidding, for 110 out of 127 A+B projects. Based on the incentive/disincentive rate and maximum number of days incentives can be paid, the average of early maximum completion bonus is $425,088, or 6.7% of the contract value, quite close to the 5% target of ODOT.

5.0 EMPIRICAL ANALYSIS

As the assignment of A+B bidding is non-random, the difference in the procurement cost shown in Table 2 is at least to some extent caused by dissimilarity between projects. If projects of the standard design are unlikely to be procured via an A+B mechanisms, bidding differences across A+B and standard A-only projects can be attributed to the intrinsic dissimilarity in project themselves as much as to the difference in the letting mechanisms. To put it in numbers, the fact that on average the low bid for A-only projects is $1.39 million, while the low bid for A+B projects is $8.99 million, should be viewed as the result of size differentials across projects as much as, if not more than, the use of the A+B mechanism. The identification of potential outcomes hinges on a control group which approximates the randomization in assignment so as to produce meaningful estimators of the treatment effect. In other words, **to be able to compare the success of one mechanism over the other we need a comparable set of projects whose main difference is the contracting mechanism employed.** Therefore, we employ the statistical method of matching to select a subsample of all 2311 A-only projects which are eligible candidates for A+B bidding to form a comparison group that could resemble projects procured via the A+B mechanism more closely.

Discussion with ODOT reveals several factors under consideration in determining when a project is preocured though A+B bidding. Among them are project size, duration, and proximity to populous metropolitan areas or busy interstate freeways. For example, for the number of days to completion, the rule-of-thumb cutoff value is 150 for A+B bidding to be eligible. The results in Table 2 confirm that rules are followed fairly well in practice. On the other hand, we were informed that the type of work, which is of importance in driving a contractor's bid, is not a priority factor in ODOT selection of A+B bidding projects. The numbers presented in Table 5, suggest that the proportion of bridge and grade, drain, surface (resurface) projects tend to be considerably higher in A+B than A-only projects. This observation motivates our adoption of the set of criteria that includes size, duration, location, highway type, and work type to conduct matching without replacement



Using the 2311 A-only bidding projects that are available throughout the eight-year window, we arrive at the subgroup of 252 projects offered via standard low price letting process out of the full sample. Judging from the histograms of propensity scores presented in Figure 1, the preliminary matching has improved considerably the overlap of characteristics between A+B and A-only projects. Descriptive statistics in tables 6, 7, and 8 also confirm reinforce this belief. First we compare projects across characteristics used for matching; notice that a better balance is achieved in almost all matched characteristics. Next, we provide a comparison of projects across characteristics that were NOT used for matching. Although some variables are not considered when selecting A only projects to match with A+B ones, it is informative to see how the unmatched characteristics compare across groups. Notice that, relevant information that was not used to match these contracts e.g., bids received, low bid, number of bids and the number of plan holders, is also more comparable between the selected group of A and A+B projects. We believe that this indicates that our "matching" (selection) method was successful.

With the selective group of standard lettings, we proceed to estimate the effect of A+B design on bidding using the method of nearest neighbor matching. We are able to achieve an exact match for district of location, work nature and type of road 96% of the time. We also incorporate regression techniques with the matching method to allow adjustment to any remaining differences in contract value or duration between matched A+B and A-only projects. Estimated coefficients are shown in Table 9 as follows. In the first specification, exactly one match is used to achieve the highest precision, while the two closest neighbors are employed in the alternative setting as a robustness check. With the logarithmic bids as the variable of interest, the estimated effect of speed incentive provisions on winning bids is 0.013 and 0.019, respectively. **To put the numbers in context, for a project worth $10 million, application of A+B bidding causes the winning bid to increase by 1.34% to 1.90%, or between $134,000 ($10million*1.34%) and $190,000 ($10million*1.90%). Nevertheless, the estimate is not statistically different from zero in either case, implying that we do not have statistically significant evidence that the A+B design raises the contracting cost to the State. Combined with the “time bid" received as part B of the mechanism, where winning contractors bid to use 81.5% of time specified in the plan of the project, the innovative A+B design amounts to**

speeding projects by 49.5 days without raising the procurement cost to the State significantly. The favorable evidence is different from the findings in Lewis and Bajari (2011). They find that A+B bidding reduces construction duration by 40% in California, where the value set by Caltrans is considerably larger than ODOT's parameter choice that leads to a more moderate acceleration of 18.5% in our data. Under the assumption of a convex cost function, it is not surprising to experience a spike in the effort required, and thus cost incurred, to cut down construction time by 20% from 80% than from unity. Followings that logic, ODOT's practice should be more applicable to mid-sized cities with average population density.

5.1 Reduced form estimation

Now that we have evaluated the general performance of A+B bidding, in terms of its impact on the low bids received by ODOT and its effect on the construction time. In order to take a deeper look and give recommendations on how the current practice can provide useful information on more informed assignment of A+B bidding in the future, we turn to data at the itemized level. Due to the great sample size of itemized data, we focus on the item composition of A+B bidding projects and the selected subgroup of A-only projects as explained in the previous section.

Let us first review the basic statistics on construction items used in these projects. Based on itemized observations from A+B projects, 127 projects were procured using the A+B method between 2004 and 2011. On average, a project is worth $9.91 million in engineer's estimated values, $9.64 million in winning bids received, and prescribes 129 items. 1886 unique items are used. Each item is used an average of 8.65 times with the most frequently used item, 509(A) 1326 "CLASS AA CONCRETE", appearing 164 times (used more than once by a project on average.) Of itemized observations from the subgroup of A only projects that were matched to A+B characteristics 202 standard A only projects are selected. On average, a project is worth $4.25 million in engineer's estimated values, $4.29 million in winning bids received, and prescribes 86 items. 1634 unique items are used. Each item is used an average of 10.86 times with the most frequently used item, 509(A) 1326 "CLASS AA CONCRETE", appearing 198 times. We provide the list of 30 most frequently used items and their frequencies in Table 10, where items are rank in descending order of frequency.

However, besides frequency, the quantity and unit price of an item helps to convey a more complete picture of how much an item is actually involved in the construction project.

Therefore, we also look at the “intensity” of the item’s use by evaluating the value of the item in proportion to the total value of the project. On average, each item makes up 0.72% of the total project value for A+B, and 1.15% for selective A only. But there is much variation in the weight of items used in a project. We provide the list of 30 most heavily used items as well as the percentages of their usage in a project in Table 11.

If we compare Tables 10 and 11, it is revealed that there is limited overlap between items that are used frequently and items that are involved at a considerable weight. To explore items that are important in terms of both usage and intensity in ODOT lettings, we present the summary of items that are used by at least 20 observations within A+B bidding and the refined subgroup of A-only bidding, and comprise at least 3% of the total project value for these projects. First, we present the summary statistics on item usage measured by frequency and percentage of total contract value for A+B projects, placed in a descending order in terms of percentage of total contract value. Right below Table 12 on A+B bidding, we report in Table 13 the items selected using the same criteria based on the subgroup of A-only bidding project.

As our objective is to look for different patterns in itemized bids between A+B bidding and A-only bidding, we examine itemized bids from the same construction material that is used regularly in both A+B bidding and the subgroup of A-only bidding that are similar to A+B in project size, duration, type and location, aiming to quantify the effect on bidding which has resulted from different letting mechanisms used.

As a result, we are able to identify thirteen construction items that are used by at least 25% of A+B and 25% of A-only projects, where the proportions of usage should take up 3% or more of total contract value so that these items are not negligible. We categorized the items into 4 groups to facilitate the presentation of density curves based on the proximity of their item number classifications. When producing the overall distribution of itemized bids, cut-off values around 99% are selected to remove outliers in relative bids which are more than 300% the engineer’s estimate. We examined the omitted extreme values carefully before determining whether to include them in subsequent analysis.

The summary statistics of the first group is presented in Table 14, and the density curves of the distributions are presented in Figure 2, where the relative bids on excavation, borrow and base are presented. These are bids divided by engineer's estimates. Our analysis of itemized bids is based on a measure we call relative bid, percentage bid, or simply rbid. It is constructed as the bid divided by engineer's estimate, to facilitate comparison of items what are used in small quantities by a project versus items that are used in large quantities by a project.

Figure 2: Density plots of relative bids for excavation, borrow and base

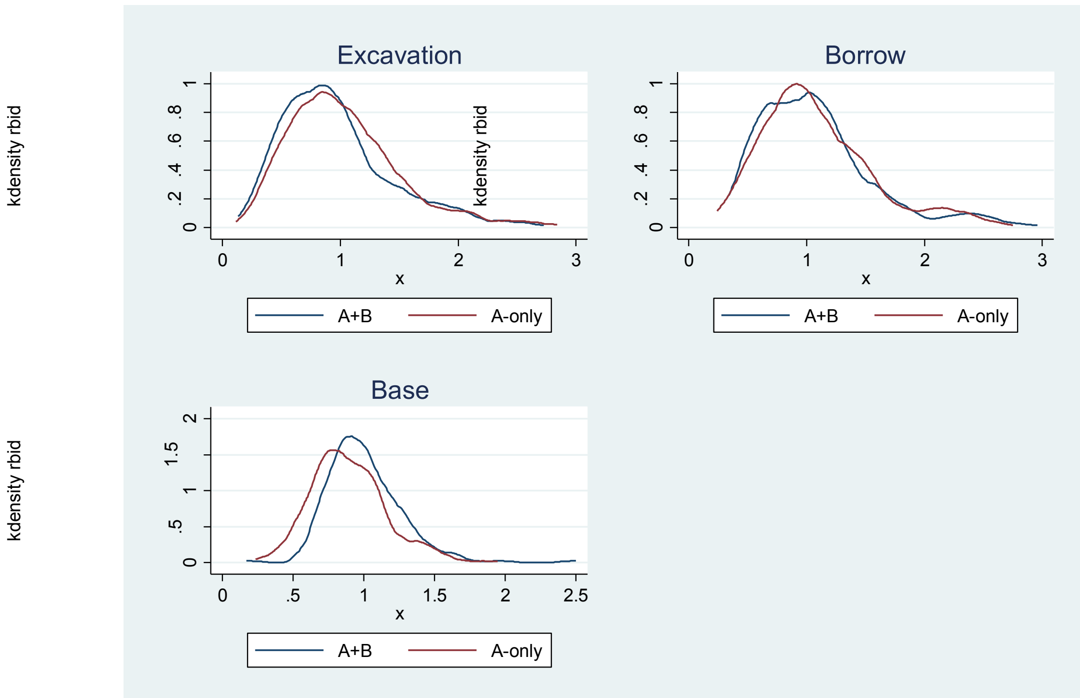


Table 15 and Figure 3 present statistics and distributions of relative bids on asphalt concrete S3, asphalt concrete S4 (PG 76-28 OK) and asphalt concrete S4 (PG 64-22 OK). These are bids/engineer's estimates. Similarly, for the remaining two groups, we present the basic statistics of itemized bids and their probability distributions.

A first impression after contrasting the statistics of the thirteen items is that, for the same item used in A+B bidding and A-only bidding, their itemized bids are not similar between the two groups, and sometimes, can be fairly different. Such differences, although nuanced in magnitude, are important because the projects under comparison are already quite similar given that they are selected via the matching method performed in the last section. A first

Figure 3: Density plots of relative bids for for asphalt concrete S3, asphalt concrete S4 (PG 76-28 OK) and asphalt concrete S4 (PG 64-22 OK)

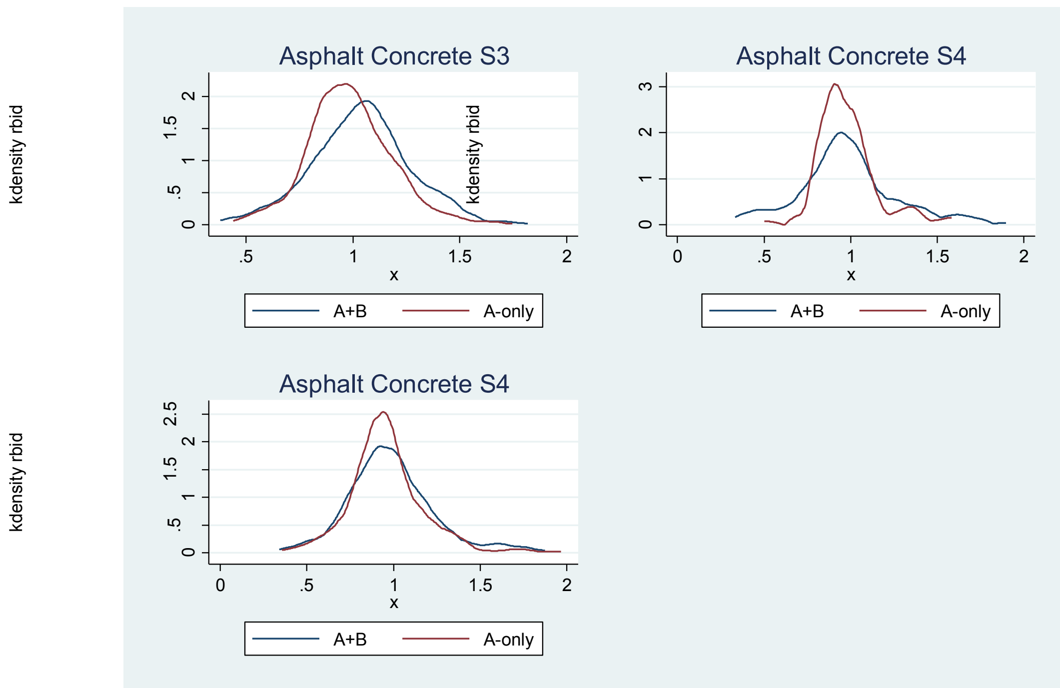


Figure 4: Density plots of relative bids for structural steel, class AA concrete, reinforcing steel

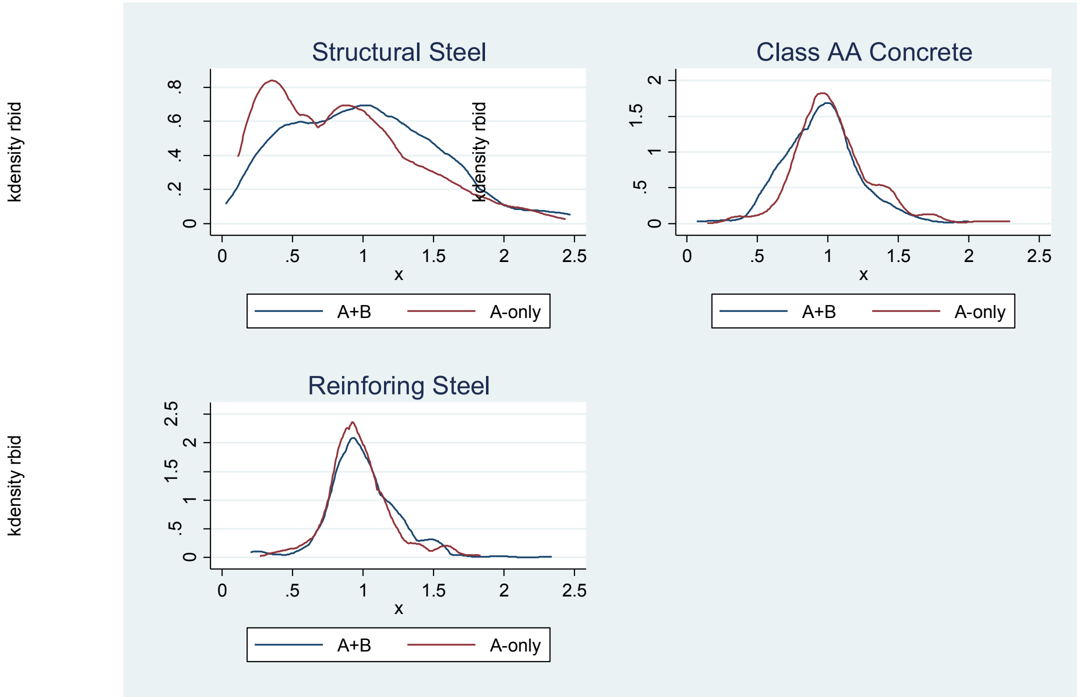
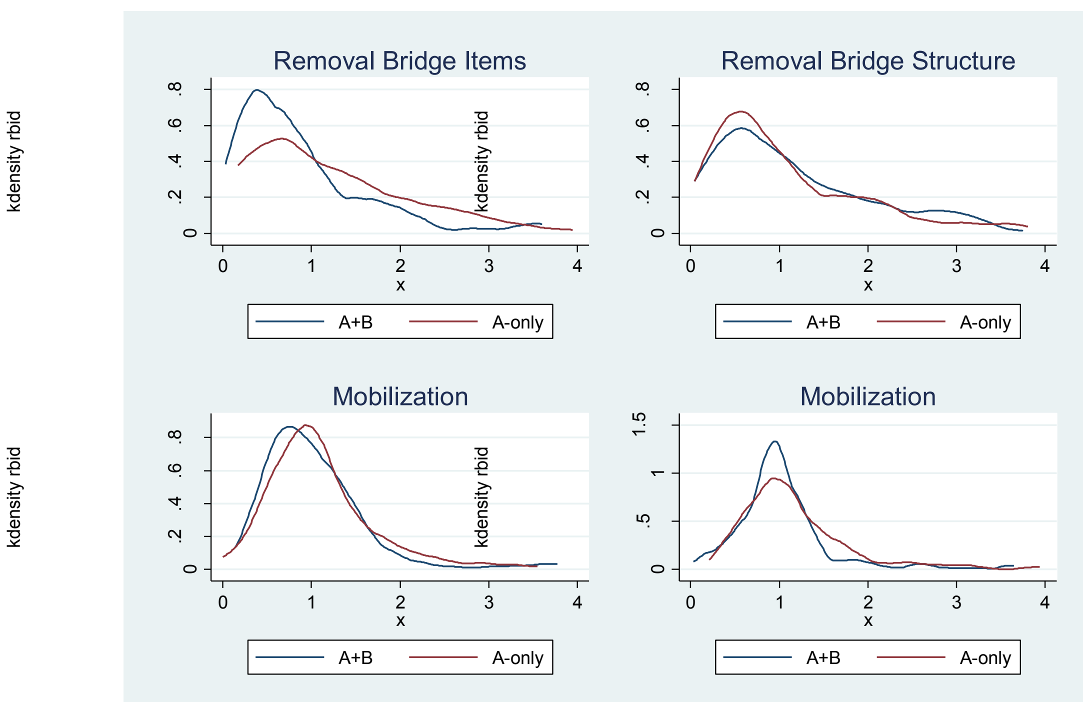


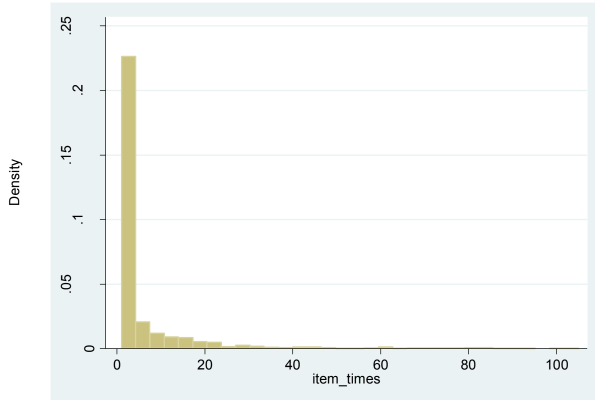
Figure 5: Density plots of relative bids for removal of bridge items, removal of bridge structure, and mobilization

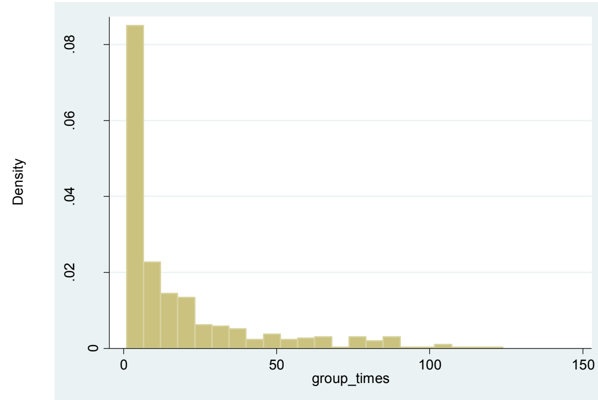


impression after contrasting the statistics of the thirteen items is that, for the same item used in A+B bidding and A-only bidding, their itemized bids are not similar between the two groups, and sometimes, can be fairly different. Such differences, although nuanced in magnitude, are important because the projects under comparison are already quite similar given that they are selected via the matching method performed in the last section. For example, with SPN102 incorporated, bids tend to be higher for Unclassified Borrow, Aggregate Base and several types of Superpave, but this relation is sometimes reversed for Removal of Bridge Items and Removal of Bridge Structure. The graphs are not providing a complete picture though. They don't control for other factors that may contribute to differences in relative bids such as the estimated duration of a project, the number of items that can be used as a proxy for complexity or the number of bidders that can indicate the level of competitiveness at the project level. To account for the factors that may contribute to the differences in bids, we carry out a simple linear regression of the relative bid of a project as a function of project level characteristics and the results are reported in Table 18.

Even with the rich information obtained at itemized level, the number of observations for individual items can still be limited. From discussions with ODOT, we learned that, while it is possible to group similar items in order to increase the number of observations, this must be done on a case-by-case basis. So in order to achieve the balance between increasing the number of observations and retaining the idiosyncratic nature of different items, we proceed to analyze first without grouping items together, and then carry out a parallel analysis with items grouped based on the first digits in the item number. To give some idea of how the consolidation of similar items may increase the number of observations, we present in Figure 6 the histograms of item frequencies with and without consolidation. The one on the left is based on individual items, while the one to the right is constructed after items are grouped as suggested above. There is an evident improvement in terms of the increased item appearance after grouping.

Figure 6: Item and group level frequencies





As explained above, to avoid combining items that are not homogenous in nature, we concentrate on the group of frequently used items, which arrives at a sample of around 10,000 in itemized observations. Our objective is to investigate and identify how bids on the same items but from A+B bidding and A-only bidding can be related to the trade-off between time and money, and then take the identified patterns to a broader scale. In the regression analysis, our primary interest is in bidding differentials, across A-only and A+B bidding projects, the general trade-off as well as the intensified trade-off as the project duration becomes longer. Therefore, in additional to the introduction of dummy variables (binary variables of 0 and 1) identifying items and an indicator for items when they are from A+B projects, we also include several measures of project durations, and the cross products between item dummies and durations. This is the term that can capture how bids are adjusted as time is a factor in A+B bidding because faster completion increases a contractor's probability of being awarded the contract.

To maintain the robustness of our findings, we concentrate on the thirteen individual items identified earlier as both frequent and heavily involved. Selective coefficients on variables of interest from regression analysis are presented in Table 18. As a demonstration, we focus on two particular items, 619(B) 2500 REMOVAL OF BRIDGE ITEMS and 619(D)1397 REMOVAL OF EXISTING BRIDGE STRUCTURE. Both items exhibit interesting patterns in the bids received between A+B bidding and A-only bidding. Regression coefficients are provided in the first line of table 17, while standard errors of the estimates are in parentheses. Asterisks indicate statistical significance at 1% (***), 5% (**) and 10% (*) confidence levels. In all specifications, we control for characteristics on project and vendor, e.g. project size, duration, vendor's distance, backlog, and the level of competition.

The highlighted coefficients before the A+B letting indicator indicate that, relative to bids from A-only projects, bids on these two items are much higher compared to their engineering estimates. This can be viewed as speed premiums when contractors are under pressure to achieve faster completion in A+B bidding. At the same time, we observation an interesting pattern in the next two rows. **The product of A+B indicator with duration picks up the negative sign. This means that, the longer the duration, as measured by engineer's estimate, the B days bid, and the total days taken, the lower the bid, when all other factors are constant. Such effects are statistically significant in all cases except for one. To put it in a different way, longer duration (thus less pressure in time) seems to reduce bids on the two items from A+B lettings, which is consistent with the trade-off between time and money**. Again to ensure robustness, we excluded outliers which could significantly affect the findings upon consulting with ODOT engineers. **Out of the 13 frequently used items we analyzed, five namely "202(C) 0184 UNCLASSIFIED BORROW", "411(S4) 5950 SUPERPAVE, TYPE S4(PG 76-28 OK)", "506(A) 1322 STRUCTURAL STEEL", "509(A) 1326 CLASS AA CONCRETE", "511(B) 6010 EPOXY COATED REINFORCING STEEL", displayed similar patterns of bidding differences between A+B bidding and A-only bidding, albeit less significantly or less consistently than the two primary cased discussed above.**

After we discussed our preliminary findings with ODOT engineers, we learned that such impressions are not considered to be well-known based on their experience of working with contractors on the field. This lead us to believe that, through the micro level analysis on detailed item level records that are often passed by other studies, we may have identified patterns of individual items in the trade-off between time and cost that can be used to allocate A+B bidding in future practice.

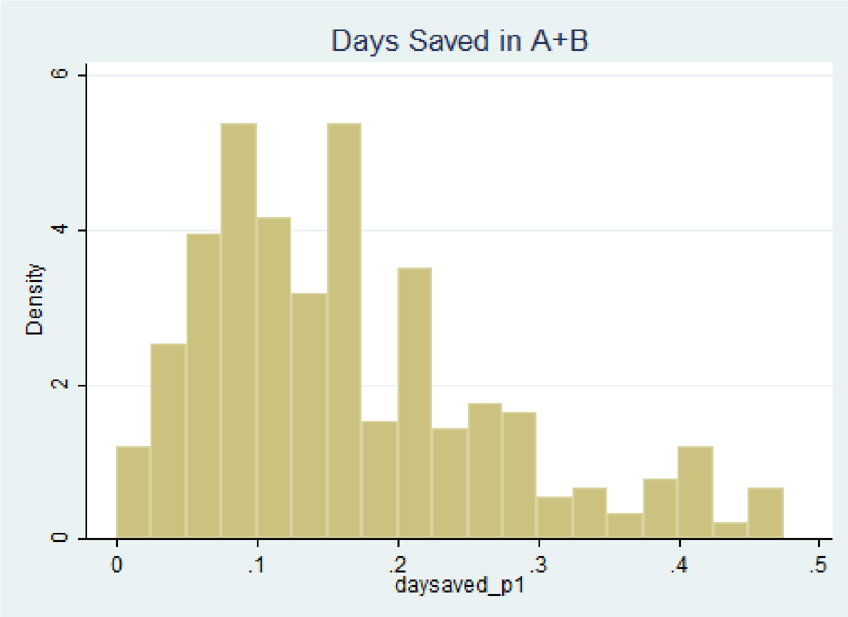
5.2 Structural estimation

Next, we move on to utilize more advanced econometric techniques to quantify how the "time premium" escalates with time, quantity, and various other factors in the plan of a project and provide predications as to when it is most economical to use time incentives. This is to carefully measure the bidding differentials due to time pressure in A+B lettings.

To this end, we propose two structural methods from the literature. In the first approach, we set up an explicit model of the acceleration cost for individual items as a function of project characteristics and the time bidders offer to save relative to the engineer's estimate. Then we compare the acceleration cost across all items to distinguish between "costly" items and "economical" items. The second approach studies vendors' bidding behaviors in a more flexible setup, where profit margins on various items are calculated to explore the differentials associated with the time incentive in A+B lettings.

Our discussion so far mainly concerns the cost side of A+B bidding: we looked at how bids on a collection of frequent items which make up the project cost are adjusted when faster construction is awarded. To evaluate the A+B letting in achieving efficient trade-offs between cost and time, it is important to examine both cost and time. Now we turn to the other front, namely time, to see how much time vendors propose to save in the A+B lettings. We measure the savings as the difference between engineer's estimated duration and the "B days" proposed by bidders. The number of days saved by vendors on average under A+B bidding is 49 days, approximately 18% of the engineer's estimate. The majority of vendors propose to save between 10%-20% of the estimated duration. This moderate number suggests that construction firms respond to incentives/disincentives actively but reasonably and we don't see a lot dramatically reduced B bid submitted in biddings. We present the entire distribution of time saved in the Figure 7. Nevertheless, such savings are letting outcomes and may be realized to different extent in the actual contract. To evaluate whether the lettings savings translated into real savings for ODOT, a detailed breakdown of total number of days charged in construction into specific categories of working days, weather days, etc, is required. But given the burden it entails on ODOT staff to provide such information, it is beyond the scope of the current study.

Figure 7: Time savings distribution



Moving forward, we quantify the different responses in itemized bids more systematically using structural estimation methods. The first step of our structural analysis is to estimate how a firm's cost changes as a function of time, in other words, the cost of acceleration. The idea is as follows: Traditionally, since only proposed bids are observed in A-only lettings, we can infer a firm's cost from its bid, but are unable to trace out the change in cost when construction duration is subject to change. However, under the A+B letting design, firms choose "A" the bid dollar cost and "B" the time at once, with the cost critically dependent on the time selected. On the one hand, faced with various incentive/disincentive rates set by ODOT in different projects, firms should be more motivated to speed up when the rate is large. This is because a smaller duration, weighed by the large incentive rate, benefits firms more by increasing their chances of winning the contract. From the sample of all A+B lettings, we are provided with a group of rate/time combinations to map out how contractors choose different schedules in B, in response to the different incentive/disincentive rates. On the other hand, in a given A+B letting, if there is more than one participating firm, they may propose different numbers in B bid, again generating multiple observations to recover the relationship between changes in cost and construction time after you control for idiosyncratic firm characteristics. Thanks to a special feature of our data, a third source for the identification of cost as a function of time is available. In 20 out of 127 A+B lettings, a C bid is recorded in addition to the B bid, for which a separate incentive/disincentive rate is set by ODOT and firms may select their own duration. This has made available additional variations regarding how different contractors react to incentive/disincentives and help us in the identification of cost change as a function of the construction time proposed.

First we carry out our estimation with project rather than itemized bids because the B part of A+B bidding is observed at the project level. Estimation results from the model are reported in Table 19. The dependent variable is the logarithm of the number of days a project is accelerated, measured by the difference between engineer's time estimate and the B bid proposed by firms. Of the independent variables, we include a binary indicator of lane closure penalty, which is equal to 1 if a special provision on lane rental is found for the project and equal to 0 otherwise.

Intuitively, the sign of the coefficient in front of the rate of incentives/disincentives should be negative as now dollar cost and time are both used in the calculation of low bid to determine the winner. The magnitude, however, of the coefficient (0.227<1) shows that firms' acceleration is inelastic in the incentive/disincentive rate, i.e. **the number of days accelerated is relatively irresponsive to change in time incentives, because the cost of acceleration is fast increasing (convex) in time.** To put it in numbers, consider the following example: Suppose the incentive/disincentive rate for a project is set at $10,000/day, and a firm proposes in B bid to finish 25 days ahead of the engineer's time. If the rate is increased by $1,000 to $11,000/day, firms should be willing to put more efforts into acceleration. Based on a coefficient of 0.227, the firm will adjust B bid by reducing construction time by an extra 6 days (about 2.3%). If the incentive rate is increased by another $1,000 to $12,000/day, following the same logic, the firm should try even harder to accelerate. However, due to the convex cost function, it can only reduce construction time by an additional 5 days (or about 2.1%). This agrees with the general impression **that it may only take firms some smart planning or logistics to achieve a small reduction in time, but much more serious efforts are required when larger reductions are the target.** Admittedly, the coefficient is only statistically significant with a confidence level of 80% (p value = 0.162). This could be attributed to the fact that in more than 60% of observations, firms propose exactly the same time in B as the engineer's time, making the number of days accelerated to zero and reducing the level of variance in the observations that could help identify significant coefficients. These observations are used in the analysis. However, many zeros at the one end of the saving days distribution adversely affects the significance of the relationship between days accelerated and time incentives. Most other coefficients are consistent with findings from previous research. Longer projects, projects that have an explicit lane rental provision and contractors with establishments of $50 million or above are all positively affecting acceleration rate. A notable exception is the instate contractor dummy, since the negative sign in front of it suggests fewer days will be accelerated when the firm is based in Oklahoma. It is counterintuitive as normally local firms enjoy the advantage of familiarity with the terrain, existing networks and short traveling distances over national firms. This effect is not statistically significant.

Our structural analysis confirms that construction cost is not only increasing but also convex in time (i.e., increasing at an increasing rate). Based on economic theory, the coefficient before the incentive/disincentive rate directly corresponds to the parameter which governs the concavity of firms' acceleration cost. Therefore, we are able to predict the shape of construction cost (convex) based on the estimate of 0.227. Next, we apply a semi-parametric model using project bids to examine how the higher cost of construction due to acceleration are passed onto the monetary bid in "A" received by the government. It differs from usual parametric models in the sense that all variables are normalized by taking division over the engineer's estimate. According to theory, the bid of an A+B letting consists of three parts: a base cost for completing the work, an acceleration cost due to faster completion proposed in B relative to the engineer's time, and a profit margin for operating business. Following such considerations, a flexible reduced form function is set up to quantify how much the preference given to faster firms causes the bids submitted, and in turn procurement cost, to go up.

For project level estimations, we employ the relative project bid, in A normalized by engineer's estimate as our main dependent variable. For factors that are used to explain observed variations, we include characteristics on projects (e.g. size, duration, etc) and characteristics on contractors (e.g. instate firm or out-of-state firm, distance to work site). In addition, we use the product of days accelerated, constructed the same as before, and the weight of incentives/disincentives, since both are closely correlated with the amount of efforts necessary to achieve faster completion. The innovative feature is the use of a specific term that accounts for unobserved heterogeneity in the cost of a firm trying to accelerate a project. We report the regression coefficients in table 20.

The negative coefficient of the establishment dummy means that large firms increase bids to a smaller extent in order to achieve acceleration. In contrast, in-state firms inflate bids to a bigger extent. The sign is a little counterintuitive, but it agrees with the finding earlier that in-state firms are relatively less inclined to accelerate. Nevertheless, we don't have characteristics of these firms, e.g. employment size, financial conditions, length of experience, to explain exactly why firms based in Oklahoma behave this way. The positive sign in front of the product of days accelerated and incentive/disincentive rate over engineer's estimate – the potential percentage of direct social benefit/cost of acceleration/delay agrees with expectations. When this percentage is higher, bids will be increased more, either due to greater efforts needed or higher leverage/profit enjoyed. Specifically, if it goes up by 10%, we expect the dollar bid as a proportion of the engineer's estimate to rise by 4.5%. This estimate provides a feel of how preferences given to faster rather than cheaper contractors may inflate the procurement cost. This coefficient is not statistically significant with 90% confidence, also due to the multiple zeros observed for the number of days saved when different incentives/disincentives rates are set in different A+B bidding.

Next we explore the unique advantage offered by the rich information available in itemized data to examine the change of bids from A+B bidding at a more micro level. So we apply our structural methods to itemized data. In transitioning from project level to item level analysis, two challenges are presented. First, project level variables that transfer to item level analysis will be the same for all items from the same project, resulting in the same number appearing in many different entries and thus causing potential difficulties in identification due to lack of variations. Second, as the specific effect of a firm in a letting is produced from project level observations, by definition it should be the same for all items in a project. Nevertheless, to capture unobserved heterogeneity, the effect should be specific to the item, therefore creating an inconsistency. Both challenges have to be resolved before proceeding with itemized level analysis. In last month's report, we introduced more advanced statistical methods including structural estimation to project level data, and provided quantitative analysis on how faster construction by contractors may pass higher procurement cost onto the government agency.

While the view of whether it is worth the additional cost to accelerate construction may differ among people and could well vary from case to case, our policy recommendation concentrates on the question of whether the trade-offs are more affordable for some projects than for the others, and to identify the common feature shared by projects that are more economical to accelerate, providing guidance for future assignment of A+B letting.

Therefore, in order to borrow the technique from project level to item level implementation, we conduct an adapted version of the project level model. First, we use the relative item bid as the response variable of interest, the bid price of the item divided by the estimated price by engineers. Independent variables include firm characteristics (operating capacity, in or out-of-state status, and distance to work site), and the value of saved days in a project as a percentage of the total project cost, i.e. days accelerated in B bids multiplied by the incentive/disincentive rate then divided by project's engineer's estimate. For simplicity, we ignored the term of firms' unobserved heterogeneity at this moment. We implemented the regression model to eleven selected construction items, which have been identified previously as "frequently used and important items" based on their wide usage and non-marginal weight in use. Three items from the group of eleven demonstrate the most prominent patterns in terms of their response to time incentives. Their regression coefficients are presented in Table 21.

We are mostly interested in the coefficient of the variable value of saved days as a percentage of total project cost. This term should pick up whatever effect faster construction has on the cost of procurement. A positive sign suggests that the item is costly to accelerate and a negative sign suggest otherwise. We present the three items which demonstrate the most notable response in bids to time incentives. The coefficients from the eight remaining items are much smaller in size and statistically insignificant, therefore omitted. Out of the three items presented above, for items 202(C)0184 (Unclassified Borrow) and 619(B)2500 (Removal of Bridge Items) the coefficient is negative in the fourth row, while for 619(D)1397 (Removal of Existing Bridge Structure) it has a positive value. The unexpected negative sign could be the result of multiple factors, such as imperfect adaptation of project level regression to the item level. But the observation has practical policy implications: when some construction items witness considerably higher bids submitted due to accelerated schedules, other items tend to experience such bid increases to a lesser extent, if at all. If we can identify projects that use the latter group of items in considerable proportion, and the features they have in common, it is possible to achieve faster completion in these project without paying a high cost in the future.

Following such rationale, we proceed to look for patterns in projects that use these selective items with non-negligible percentages. Firstly, we study the group of A+B projects to locate those that utilize the individual items identified above, i.e. 202(C)0184, 619(B)2500, and 619(D)1397, with the percentage of at least 1.5% of the engineer's project estimate. We focus on patterns in the description of work types. For items 202(C)0184 and 619(D)1397, around 30 A+B projects are found to prescribe the items with non-negligible proportions. Nevertheless, those projects cover a broad variety of types, ranging from Bridge & Approaches, Grade & Drain & Surface, to Joint Seal and Resurface. On the other hand, projects that use item 619(B)2500 non-negligibly are much more homogenous in nature, where thirteen out of sixteen are bridge rehabilitation or repair work. Taking into account the negative coefficient in front of the variable of interest, **we may infer that projects primarily of bridge repair are suitable for A+B letting method.**

Next, we take the above analysis to the large pool of standard A-only projects, and evaluate the number of potential projects which may be subjects of A+B letting. Here we focus on item 619(B)2500. From over 2300 standard A-only projects, we find 102 of them use 619(B)2500 with a weight of 1.5% or higher. Again, the projects are highly homogenous in the types of work involved. Specifically, 83%, or 85 out of 102, are bridge repair/rehabilitation. This suggests that **bridge repair work in general constitute good candidates when it comes to the assignment of A+B letting method.**

The policy recommendations given above can be carried out in practice conveniently since project types are referenced directly. But they should also be taken with caution. The current step for selecting suitable items for A+B consideration is fairly straightforward, with some important strategic considerations left out. Therefore, we might revise the procedure in the future to account for these factors. For example, when lower bids are observed in some items, we need to make sure that their costs are not transferred to other items from the same project, resulting in no project level difference of procurement cost. However, the rationale for making policy suggestions follows through. That is, we take item-wise patterns identified from A+B projects to standard A-only projects, look for projects that use those items in considerable proportion, and offer recommendations regarding when A+B letting should be adopted to realize gains in financially sensible ways.

In continuation to the structural estimation we refined the model to allow the trade-off between time and cost (bids) to depend on not only the nature of items, but also the weight of these items in the entire project. Such flexibility is achieved by adding to the regression the additional term of an item's percent out of the total engineer's estimate, and its cross-product with the number of saved days from the B-part bid from an A+B letting.

First, we implement the analysis to selective items individually. A group of eleven "frequently used and important items" are selected, based on both broad usage and non-marginal weight in use. With the more flexible setting, we are pleased to see that findings are largely consistent with previous results, underlying the robustness of the revealed pattern. To facilitate comparison with results from last time, we present in Table 22 the regression coefficients from both specifications of the selected three from the group of eleven items which are observed to demonstrate noteworthy patterns in their response to time incentives.

From the consistent findings similar conclusions emerge: **items 202(C)0184 (Unclassified Borrow) and 619(B)2500 (Removal of Bridge Items) display especially favorable reactions to time incentives is present, and hence projects that prescribe such items heavily are desirable candidates for A+B letting consideration.**

To cement the evidence that item bids respond to the time incentive asymmetrically, we carry out a model where all itemized observations from A+B lettings are pooled together. We employ cross products of item indicator and "saved days" to allow flexibility at the item level. Results are presented in the Table 23.

Again, **item 619(B)2500 (Removal of Bridge Items) exhibits the most favorable bidding pattern when the pressure of acceleration is higher.** The rest of the items (omitted here) all have coefficients less than 1 in size and highly statistically insignificantly. The negative sign of the cross product between saved days with item indicators can be interpreted as the following:

as the number of proposed saving days in “B” goes up, bids submitted for these items are expected to decrease relative to engineer’s estimate. This is not to say that bids actually are lower when more saved days are proposed. Instead, **this is evidence suggesting that their bids (and the underlying cost) rise less steeply than other items when time is a constraint. Naturally, acceleration on such items may be achieved at a relatively lower cost to the state department.**

Bidding patterns detected for individual items are helpful. But as individual items at best constitute a small proportion of the engineer’s estimate for the entire project, the favorable effect of the time/cost trade-off is limited. So next, we perform the above analysis to item groups, where the grouping is based on items that are similar in nature. We followed guidelines learned from discussion with ODOT, and constructed ten groups of items. The groups envelop all individual items that we focused on before, but also cover similar yet less frequently used items from the same general type, e.g. “Common Excavation” and “Unclassified Excavation” are both included in item group “202(A)”. We also followed ODOT suggestion and combined “411(B)” and “411(C)” to form the general group of “Asphalt Concrete/Super Pave” items. Estimation results are fairly consistent with regressions based on individual items. Coefficients of groups with the most prominent patterns are presented in Table 24.

The two groups, 202(C) “Borrow Related Tasks” and 619(B) “Removal of Various Items”, continue to display favorable bidding behaviors under time incentive. The negative coefficient suggests that, compared to other groups, acceleration in these items can be achieved with smaller increments in bid. We do observe that the magnitude for 619(B) is considerably reduced from the individual item specification, which can be explained by the variety of items in the group, such as “Removal of Pavement”, “Removal of Bridge Items”, and “Removal of Guardrail”. Both groups take up non-negligible weight of the engineer’s estimate of the entire project, 2.9% and 3.3% respectively. So for an average-sized project with engineer’s estimate, assignment of A+B letting based on composition of these items can lead to beneficial savings for the state department.

6.0 RECOMMENDATIONS

Based on the analysis performed, we provide the following recommendations that could help optimize ODOT's practice of A+B bidding:

1. The current assignment that takes into account project size, duration, and location has led to satisfactory performance of A+B bidding projects. In particular, we have found that the construction time is moderately reduced while the low bid received by ODOT is not significantly increased. This means less construction related delay which is directly beneficial to the public but no more pressure on budgets.
2. We have found evidence that the construction cost increases at an increasing rate through time, and this provides favorable evaluation to the incentives/disincentives rates set currently by ODOT in A+B bidding. The rate is large enough to motivate contractors, but not too large to lead to costly decisions. We are able to observe reasonably faster completion without too much hike on low bids.
3. Our analysis at the itemized bid level reveals that quite a bit of variation exists within a project among different construction items. Some demonstrate more favorable patterns than others regarding the trade-off between time and money. This means that, the examination of item composition of projects assigned to A+B bidding could lead to savings when projects involving items with favorable patterns are given priority consideration.
4. But we also realize studying the detailed composition of items in the project can be time-consuming. Therefore, we have identified the types of projects that are more likely to heavily involve favorable items and therefore generate favorable outcomes under A+B. Of those, repair work and rehabilitation of bridge is the most responsive category, where faster completion can be achieved most economically for the state.

7.0 CONCLUSIONS

The following conclusions can be drawn from the preceding analyses:

1. ODOT has been fairly successful in its application of the relatively new contracting method of A+B bidding.

2. The incentives/disincentives rates set by ODOT engineers, although based on experience and not on statistical analysis of prior data have performed well to stimulate faster completion without driving the cost up significantly.
3. The decision making to assign projects under the A+B bidding rule could be supplemented by some factors that are not currently under consideration. One is the nature of work, and the other is item composition.
4. There are potential benefits for ODOT to expand the application of A+B bidding given its favorable performance so far. The current practice is rather limited at a rate of 127 out of 2488 total projects in our observation window from 2004 to 2011. An expansion of the use of this design to a larger number of projects can significantly raise the benefits to the public without increasing the direct cost of procurement.

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APPENDIX

TABLES

TABLE 1: A+B Letting Mechanism and I/D for Various State Highway Agencies

State	A+B	I/D rates	Cap[1]
Alabama	No	I/D = user cost	No cap
Alaska	No	I/D = user cost	5% of the total project cost
Arizona	Yes	I ≤ D = user cost	$\frac{\text{state estimate}}{\text{state estimated duration}} * 20\%$
Arkansas	Yes	I/D = user cost	Number of days (variable based on user cost, duration of project, type of work)
California	Yes	I ≥ D > user cost	5% of the total project cost
Colorado	Yes	I/D = user cost	30 days, 150,000-200,000
Connecticut	No	I ≤ D or I ≥ D but D ≤ user cost	No cap
Delaware	Yes	I/D < user cost (sometimes I and D not equal)	Varies (set dollar amount)
Florida	No	I/D = user cost	3-5% of the total project cost
Georgia	Yes		
Hawaii	No	I ≤ D = user cost	Varies
Idaho	Yes	I/D = user cost	Varies
Illinois	No		
Indiana	Yes	I ≤ D < user cost	Varies (based on budget and the total project costs)
Iowa	Yes	I/D = user cost adjusted down to avoid heavy penalization	Varies (usually not capped)
Kansas	No	I ≤ D = user cost, Incentive is very rare	5-10% of the total project cost
Kentucky	Yes	I/D = user cost	Varies
Louisiana	Yes	I ≤ D = user cost, Incentive is very rare	min {5% engineer's estimate, amount it takes to reduce estimated contract time by 10%}
Maine	No	I/D = user cost	10% of the total project cost or 250,000-300,000
Maryland	Yes		
Massachusetts	No	I/D = user cost	Varies (based on user cost)
Michigan	Yes	I ≤ D = user cost	5% of the total project cost, Disincentive is not capped.
Minnesota	Yes		

[1] As there are no caps for the disincentive, all caps mentioned apply only to incentives.

Mississippi	Yes	I > D = liquidated damages	5-10% of the total project cost, Number of days (varies)
Missouri	Yes	I/D = user cost and/or contract administration costs	Number of days (varies)
Montana	No	I ≤ D < user cost	varies (based on experience/goal)
Nebraska	Yes	I/D ≤ user cost (infrequent)	5-10% of the total project cost
Nevada	No	No incentive, D = liquidated damages	No cap
New Hampshire	No	I/D < user cost (infrequent)	Varies
New Jersey	No	I/D = user cost + engineers' cost estimates (I/D very infrequent)	No cap
New Mexico	No	I/D ≤ user cost or I/D > user cost (infrequent)	3-10% of the total project cost
New York	Yes		
North Carolina	Yes	I/D < user cost (usually 1/7 or lower)	Varies (based on contract time/confidence in contractor/judgment/experience)
North Dakota	Yes	I/D ≥ user cost + engineers' cost estimates (infrequent)	30 days
Ohio	No	I ≤ D ≤ user cost	5% of the total project cost, Disincentive is not capped.
Oklahoma	Yes	I/D = user cost	Number of days (varies)
Oregon	No	I/D < user cost	Varies
Pennsylvania	Yes	I/D ≤ user cost	5% of the total project cost
Rhode Island	No	I/D ≤ user cost	No cap
South Carolina	Yes	I/D < user cost	Number of days (usually 20-45)
South Dakota	No	I/D ≤ user cost (only sometimes less)	5% of the total project cost (usually 2%) Number of days (usually 30)
Tennessee	No	I ≤ D = user cost (I paid monthly, D per day)	5% of the total project cost
Texas	Yes	I/D = user cost	No cap
Utah	Yes	I/D = 10% of user cost	Varies (based on judgment/experience)
Vermont	No	I/D = user cost	5% of the total project cost
Virginia	Yes	I/D ≤ user cost or I/D > user cost	Number of days (varies)
Washington	No	I/D ≤ user cost or I/D > user cost	Number of days (varies)
West Virginia	No	I/D < user cost	5% of the total project cost
Wisconsin	Yes	I/D ≤ user cost	5% of the total project cost
Wyoming	No	I/D = user cost	Number of days (varies), Disincentive is not capped.

TABLE 2: **Descriptive statistics (full sample)**

Project Characteristics	Standard		A+B	
	Mean	Std. Dev.	Mean	Std. Dev.
Engineer's Cost Estimate in Million	1.504	2.889	9.914	13.607
Bids Received in Million	1.495	2.600	10.307	12.907
Relative Bid (Bid/Estimate)	1.053	0.309	1.021	0.205
Winning Bid in Million	1.395	2.660	8.994	11.707
Relative Winning Bid in Million	0.932	0.191	0.954	0.155
Winning Bid from Finalized Projects in Million	1.156	1.973	5.971	8.728
Actual Amount Paid from Finalized Projects in Million	1.167	2.015	6.239	9.186
Payment Amount Differential in percentage	0.1%	11.6%	6.2%	12.3%
Calendar Day Duration	119.5	89.8	268.2	169.5
Calendar Day Duration of Finalized Projects	112.7	83.6	277.9	145.8
Actual Days Charged of Finalized Projects	259.4	244.7	378.9	256.3
Duration Differential in percentage	147.2%	197.3%	80.2%	108.8%
Number of Plan Holders per project	6.704	3.106	8.283	3.083
Number of Bidders per project	3.869	1.903	3.133	1.427
Project Complexity (number of pay items)	38.4	39.3	129.3	88.9
8941 bids received from 2311 standard projects, 2161 of which are finalized.				
398 bids received from 127 A+ B projects, 92 of which are finalized.				

TABLE 3: Comparison of plan holding and bidding frequencies of firms based on their participation in A+B bidding

	Number of contractors in this group	Average number of plans bought by contractors in this group	Average number of bids submitted by contractors in this group	Average number of projects won by contractors in this group
Contractors that never purchased plans for A+B projects	242	24.4	6.97	2.05
Contractors that have purchased plans for A+B projects	134	119.8	61.4	11.9
Contractors that have bid on A+B projects	73	165.7	88.2	22.4

TABLE 4a: Lane rental provision usage in A+B bidding

Division	Frequency	Percentage
3	7	17.95
4	9	23.08
8	23	58.97
Total	39	100

TABLE 4b: Final payment and number of days differentials due to the usage of lane rental provisions in A+B projects

	Number of projects	Final payment differential (%)		Days charged differential (%)	
		Mean	Std. Dev.	Mean	Std. Dev.
With lane rental	28	7.6	14.7	61.2	91.9
Without lane rental	64	5.5	11.1	88.9	115.2

Table 5: Work type and location of A+B bidding and A-only projects

		A+B	A-only
Work type	Bridge	73.2% (44.4%)	53.3% (49.9%)
	Grade	48.1% (50.1%)	14.5% (35.2%)
	Drain	48.1% (50.1%)	14.3% (35.0%)
	Resurface	12.6% (33.3%)	22.4% (41.7%)
	Surface	49.6% (50.2%)	14.7% (35.4%)
	Traffic	11.8%	15.0%

		(32.4%)	(35.7%)
Location	Div 3	28.4%	15.5%
	Div 4	23.6%	17.3%
	Div 8	33.1%	16.0%
Highway type	Interstate	33.9%	14.8%
	US highway	22.8%	29.8%
	SH highway	37.8%	31.5%
	City street	5.5%	8.7%

Table 6: Comparison of characteristics used for matching between A+B bidding and matched A-only

		A+B	Subgroup of matched A- only
# observations		127	202
Engineer's estimate		$9.91M (13.6M)	$4.25M (3.83M)
Calendar days		268 (169)	230 (108)
Work type	Bridge	73.2% (44.4%)	70.1% (45.9%)
	Grade	48.1% (50.1%)	47.1% (50.3%)
	Drain	48.1% (50.1%)	46.6% (50.0%)
	Resurface	12.6% (33.3%)	8.8% (28.4%)
	Surface	49.6% (50.2%)	46.6% (50.0%)
	Traffic	11.8% (32.4%)	9.3% (29.1%)
Location	Div 3	28.4%	33.3%
	Div 4	23.6%	20.6%
	Div 8	33.1%	33.3%
Highway type	Interstate	33.9%	8.3%
	US highway	22.8%	27.5%
	SH highway	37.8%	35.8%
	City street	5.5%	17.2%

Table 7: Comparison of characteristics not explicitly used for matching between A+B bidding and matched A-only

	A+B	Subgroup of matched A- only
# observations	127	202
Bids received	$10.31M (12.09M)	$4.24M (3.67M)
Relative bid received	1.02 (0.20)	1.02 (0.18)
Winning bids received	$8.99M (11.70M)	$3.98M (3.52M)
Relative winning bids	0.95 (0.16)	0.95 (0.14)
Number of plan holders	8.28 (3.08)	8.61 (3.54)
Number of bidders	3.14 (1.41)	4.05 (1.96)

Table 8: Comparison of characteristics of finalized projects between A+B bidding and matched A-only

	A+B	Subgroup of matched A- only
# observations	92	152
Winning bids from finalized projects	$5.96M (8.73M)	$3.41M (3.41M)
Actual amount paid From finalized projects	$6.24M (9.19M)	$3.48M (3.53M)
Payment amount differential in percentage	6.17 (12.31)	1.59 (11.21)
Calendar day duration of Finalized Projects	227 (145)	220 (112)
Actual days charged of finalized Projects	419 (267)	508 (290)
Duration differential in percentage	80.25 (109.83)	148.31 (172.72)

Table 9: Estimation of the effect of A+B bidding on low bids received

	Average rreatment effect for A+B bidding on low bid
Exactly One Match	0.013
	(0.025)
Two Nearest Matches	0.019
	(0.023)

TABLE 10: 30 most frequently used items and their frequencies

	A+B		Selective A only	
Rank	Item Code	Frequency	Item Code	Frequency
1	509(A) 1326	164	509(A) 1326	198
2	515(A) 6013	154	230(A) 2806	194
3	504(A) 1304	147	506(A) 1322	190
4	511(B) 6010	145	202(A) 0183	172
5	230(A) 2806	138	509(B) 1328	165
6	202(A) 0183	132	509(D) 0325	158
7	855(A) 8812	130	233(A) 2817	157
8	619(B) 4728	117	642 0098	152
9	506(A) 1322	116	223 2801	152
10	233(A) 2817	109	511(A) 1332	150
11	241 2832	109	501(B) 1307	146
12	619(A) 0920	106	855(A) 8812	145
13	509(D) 0325	106	619(A) 0920	145
14	880(C) 8842	106	201 0102	144
15	880(B) 8824	105	880(J) 8905	141
16	880(E) 8860	104	619(B) 4728	141
17	223 2801	104	408 5774	135
18	501(B) 1307	103	205 4229	134
19	408 5774	103	511(B) 6010	131
20	880(B) 8818	102	504(A) 1304	130
21	509(B) 1328	102	227 0100	129
22	880(B) 8821	102	515(A) 6013	128
23	523(B) 6560	99	619(C) 0924	126
24	523(A) 6550	99	850(A) 8110	125
25	205 4229	94	619(D) 1397	125
26	642 0098	94	411(S4) 5960	120
27	804(B) 2916	94	220 2800	120
28	619(D) 1397	94	514(A) 6010	118
29	880(F) 8878	94	514(B) 6292	118
30	411(S3) 5945	93	601(A-1)1353	118

TABLE 11: 30 most heavily used items and their percentage in a project and their percentages

	A+B		Selective A only	
Rank	Item Code	Weight	Item Code	Weight
1	414(B1) 5800	0.59	505(E) 6250	0.51
2	414(A1) 6855	0.44	411 4280	0.44
3	414(A1) 6853	0.44	414(A1) 6853	0.32
4	411 4280	0.43	436 0100	0.28
5	414(A1)M5755	0.33	648(B) 0200	0.26
6	411(S5)M5970	0.30	414(I) M5270	0.26
7	436 0100	0.28	508 6359	0.26
8	414(A1) 5755	0.21	411(D) 5970	0.26
9	414(B1) 5760	0.16	414(A1) 5756	0.23
10	615(H) 0110	0.16	414(A1)M5754	0.23
11	508 6359	0.15	414(A1) 6854	0.22
12	414(I) 5270	0.14	411(S6) 5980	0.20
13	414(D) 4368	0.12	414(P) 6000	0.17
14	505(C) 6075	0.11	414(A) M0261	0.16
15	505(D) 6065	0.11	411(C) 5950	0.16
16	414(P) 6000	0.11	414(I) 5270	0.16
17	414(A1) 6858	0.10	411(C) 5955	0.15
18	414(A1)M5757	0.10	414(A1) 5754	0.14
19	411(S4)M5955	0.08	419 4152	0.14
20	414(A1)M5754	0.08	411(S2)M5930	0.14
21	414(B) 0302	0.08	545 4815	0.14
22	411(S3)M5945	0.08	414(B1) 5758	0.13
23	510(A) 6341	0.08	411(S3)M5945	0.13
24	510(B) 6333	0.08	202(E) 0110	0.13
25	510(A) 6350	0.08	202(E) 0132	0.13
26	411(C) 5955	0.08	414(A) 0261	0.13
27	411 4285	0.08	510(A) M6333	0.13
28	202(C) 0182	0.08	411(B) 5945	0.12
29	411(S3) 5945	0.07	643 5100	0.12
30	505(G) 1000	0.07	317(F) M4270	0.12

Table 12: Important items from A+B projects: items used often and with non-negligible percentage

A+B				
Rank	Item Code	Item Description	Frequency	Percentage
1	414(P) 6000	(SP)P.C. CONCRETE FOR PAVEMENT	28	11.0%
2	411(S3) 5945	(SP)ASPHALT CONCRETE TYPE S3(PG 64-22 OK)	93	7.3%
3	414(G) 5275	P.C. CONCRETE FOR PAVEMENT	21	6.5%
4	411(B) 5945	SUPERPAVE, TYPE S3(PG 64-22 OK)	21	6.3%
5	509(A) 1326	CLASS AA CONCRETE	164	5.0%
6	414(A1) 5725	(SP)DOWEL JOINTED PCCONCRET PAVEMENT (PLT.)	28	4.8%
7	503(A) 1313	PRESTRESSED CONCRETE BEAMS (TYPE IV)	27	4.7%
8	411(S4) 5950	(SP)ASPHALT CONCRETE TYPE S4(PG 76-28 OK)	47	4.5%
9	303 0192	AGGREGATE BASE	57	4.1%
10	641 1399	MOBILIZATION LSUM B	37	4.1%
11	411(S3) 5935	(SP)ASPHALT CONCRETE TYPE S3(PG 76-28 OK)	27	3.9%
12	411(S3) 5940	(SP)ASPHALT CONCRETE TYPE S3(PG 70-28 OK)	22	3.9%
13	641 1552	MOBILIZATION LSUM RDY	86	3.5%
14	619(B) 2500	REMOVAL OF BRIDGE ITEMS	64	3.3%

Table 13: Important items from subgroup A-only projects: items used often and with non-negligible percentage

Subgroup A-only				
Rank	Item Code	Item Description	Frequency	Percentage
1	411(B) 5945	SUPERPAVE, TYPE S3(PG 64-22 OK)	27	12.2%
2	411(S3) 5945	(SP)ASPHALT CONCRETE TYPE S3(PG 64-22 OK)	115	9.0%
3	411(S2) 5930	(SP)ASPHALT CONCRETE TYPE S2(PG 64-22 OK)	41	7.3%
4	411(S4) 5950	(SP)ASPHALT CONCRETE TYPE S4(PG 76-28 OK)	26	6.7%
5	503(A) 1313	PRESTRESSED CONCRETE BEAMS (TYPE IV)	71	6.4%
6	411(S4) 5955	(SP)ASPHALT CONCRETE TYPE S4(PG 70-28 OK)	62	5.9%
7	503(A) 1312	PRESTRESSED CONCRETE BEAMS (TYPE III)	29	5.5%
8	411(S3) 5940	(SP)ASPHALT CONCRETE TYPE S3(PG 70-28 OK)	52	5.3%
9	509(A) 1326	CLASS AA CONCRETE	198	5.2%
10	411(C) 5960	SUPERPAVE, TYPE S4(PG 64-22 OK)	29	5.0%
11	303 0192	AGGREGATE BASE	70	4.7%
12	516(A) 6094	DRILLED SHAFTS 48$ DIAMETER	22	4.6%
13	202(A) 0183	UNCLASSIFIED EXCAVATION	172	4.4%
14	503(A) 1311	PRESTRESSED CONCRETE BEAMS (TYPE II)	26	4.4%
15	202(C) 0184	UNCLASSIFIED BORROW	114	4.2%
16	411(S4) 5960	(SP)ASPHALT CONCRETE TYPE S4(PG 64-22 OK)	120	3.8%
17	641 1399	MOBILIZATION LSUM B	97	3.8%
18	516(A) 6096	DRILLED SHAFTS 60$ DIAMETER	46	3.8%
19	641 1552	MOBILIZATION LSUM RDY	96	3.3%
20	202(D) 0184	UNCLASSIFIED BORROW	28	3.0%
21	505(B) 6019	CLASS B BRIDGE DECK REPAIR	33	3.0%

Table 14: **Descriptive statistics on relative bids for excavation, borrow and base**

Item Code	Item Description		Mean Relative Bid	# of obs.
202(A) 0183	UNCLASSIFIED EXCAVATION	A+B	0.990 (0.527)	415
		A-only	1.136 (0.845)	684
202(C) 0184	UNCLASSIFIED BORROW	A+B	1.437 (1.484)	270
		A-only	1.196 (0.835)	419
303 0192	AGGREGATE BASE	A+B	1.015 (0.306)	199
		A-only	1.136 (1.116)	268

Table 15: **Descriptive statistics on relative bids for asphalt concrete S3, asphalt concrete S4 (PG 76-28 OK) and asphalt concrete S4 (PG 64-22 OK)**

Item Code	Item Description		Mean Relative Bid	# of obs.
411(S3) 5945	SUPERPAVE, TYPE S3(PG 64-22 OK)	A+B	1.047 (0.256)	297
		A-only	0.991 (0.219)	434
411(S4) 5950	SUPERPAVE, TYPE S4(PG 76-28 OK)	A+B	0.981 (0.285)	143
		A-only	0.981 (0.173)	90
411(S4) 5960	SUPERPAVE, TYPE S4(PG 64-22 OK)	A+B	1.027 (0.352)	278
		A-only	0.981 (0.287)	450

Table 16: **Descriptive statistics on relative bids for structural steel, class AA concrete and epoxy coated reinforcing steel**

Item Code	Item Description		Mean Relative Bid	# of obs.
506(A) 1322	STRUCTURAL STEEL	A+B	1.124 (0.705)	378
		A-only	1.003 (0.765)	800
509(A) 1326	CLASS AA CONCRETE	A+B	0.981 (0.285)	533
		A-only	0.981 (0.332)	801
511(B) 6010	EPOXY COATED REINFORCING STEEL	A+B	1.027 (0.265)	469
		A-only	0.981 (0.230)	495

Table 17: Descriptive statistics on relative bids for removal of bridge items, removal of existing bridge structure, mobilization

Item Code	Item Description		Mean Relative Bid	# of obs.
619(B) 2500	REMOVAL OF BRIDGE ITEMS	A+B	1.036 (1.231)	213
		A-only	1.568 (1.487)	130
619(D) 1397	REMOVAL OF EXISTING BRIDGE STRUCTURE	A+B	1.276 (1.094)	302
		A-only	1.360 (1.388)	482
641 1399	MOBILIZATION	A+B	1.119 (0.908)	113
		A-only	1.134 (0.719)	400
641 1552	MOBILIZATION	A+B	1.072 (0.701)	273
		A-only	1.247 (0.858)	368

Table 18: Regression analysis at the item level

Variables	Spec1: Engineer's estimate used as measure of Duration	Spec 2: "B" bid used as measure of Duration	Spec 3:Total days charged used as measure of Duration
619(B) 2500 from A+B letting	13.260***	6.429*	10.852**
	(3.277)	(3.045)	-3.485
619(D) 1397 from A+B letting	6.644**	3.776*	4.498*
	(2.162)	(1.813)	(1.866)
619(B) 2500 from A+B letting*Duration	-2.264***	-1.002	-1.440*
	(0.625)	(0.602)	-0.618
619(D) 1397 from A+B letting*Duration	-1.232**	-0.737*	-0.728*
	(0.393)	(0.342)	(0.311)

Table 19: Project level bid estimation (Dependent variable: Logarithm of the number of days a project is accelerated)

	Log Days Accelerated
Log Incentive/Disincentive Rate	0.227
	(0.162)
Log Engineer's Time	1.001***
	(0.307)
Log Engineer's Estimate	-0.280
	(0.174)
Lane Closure Penalty (Dummy)	0.090
	(0.254)
Firms' Capacity over $50M (Dummy)	0.549***
	(0.202)
Instate Contractor (Dummy)	-0.124
	(0.211)
R^2	0.1018
Number of projects	459

Table 20: Relative bid regression (Dependent variable: relative project bid)

	Bid/Engineer's Estimate
Firms' Capacity over $50M (Dummy)	-0.032* (0.018)
Instate Contractor (Dummy)	-0.108*** (0.022)
(Days Accelerated*Incentive/Disincentive Rate) /Engineer's Estimate	0.449 (0.360)
Specific Term/Effect of a Firm in a Project	-0.034*** (0.006)
#observations	459

Table 21: Itemized regression results on frequently and intensely used items

	202(C) 0184 UNCLASSIFIED BORROW	619(B) 2500 REMOVAL OF BRIDGE ITEMS	619(D)1397 REMOVAL OF EXISTING BRIDGE STRUCTURE
Firms' Capacity over $50M (Dummy)	-0.243* (0.075)	-0.252 (0.451)	-0.474* (0.274)
Instate Contractor (Dummy)	-0.042 (0.090)	1.472*** (0.558)	0.288 (0.311)
Distance to Work Site	-556.9 (1108.67)	2442.65* (1406.92)	-1850.78 (4449.90)
(Days Accelerated*Incentive/Disincentive Rate) /Engineer's Estimate	-5.875*** (1.427)	-5.123* (3.176)	4.377 (5.402)
#observations	279	213	302

Table 22: Itemized regression results on frequently and intensely used items

	202(C) 0184 UNCLASSIFIED BORROW	619(B) 2500 REMOVAL OF BRIDGE ITEMS	619(D)1397 REMOVAL OF EXISTING BRIDGE STRUCTURE
	Specification 1 (from last month's report)		
(Days Accelerated*Incentive/Disincentive Rate) /Engineer's Estimate	-5.875*** (1.427)	-5.123* (3.176)	4.377 (5.402)
	Specification 2 (with additional terms added for more flexibility)		
(Days Accelerated*Incentive/Disincentive Rate) /Engineer's Estimate	-6.551*** (1.601)	-6.650* (3.701)	0.920 (8.918)
#observations	279	213	302

Table 23: Regression results on pooled A+B itemized observations

Variable	Coefficient
(Days Accelerated*Incentive/Disincentive Rate) /Engineer's Estimate	1.294 (1.474)
(Days Accelerated*Incentive/Disincentive Rate) /Engineer's Estimate * item 202(C) 0184	-2.580 (5.292)
(Days Accelerated*Incentive/Disincentive Rate) /Engineer's Estimate * item 619(B) 2500	-4.847* (2.650)
(Days Accelerated*Incentive/Disincentive Rate) /Engineer's Estimate * item 619(D)1397	-0.950 (5.382)
#observations	53534

Table 24: Itemized regression results on frequently and intensely used items

	202(C) BORROW RELATED	619(B) REMOVAL OF VARIOUS ITEMS
(Days Accelerated*Incentive/Disincentive Rate) /Engineer's Estimate	-5.052*** (1.631)	-1.392*** (0.620)
#observations	230	372