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AN EXAMINATION OF COMPETITION ON TRADITIONAL AND DESIGN-BUILD HIGHWAY CONSTRUCTION PROJECTS

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Abstract: With the rise of alternative delivery methods and best-value selection, agencies are no longer exclusively bound to choose the lowest bidder to execute a construction contract. Thus, previous assumptions about maximizing competition to achieve the lowest possible price need to be re-evaluated. Agencies must also consider the administrative burden of reviewing proposals for technical merit in addition to price and whether greater competition is always advantageous in these situations. Previous studies have used neoclassical economic theory to suggest the industry offers "perfect competition" and that more competition typically results in lower bid prices. These studies were conducted in a design-bid-build, low-bid scenario where maximizing the number of sealed bids was generally seen as advantageous for the agency. However, agencies are evolving from a neoclassical to a best-value procurement approach. This research fills a gap within existing literature by studying the relationship between number of proposers and price competitiveness for both low-bid and best-value projects. Examined are the relationship between delivery methods, number of proposers, and contract award values in the context of U.S. transportation projects. It includes an empirical analysis of 80 design-bid-build projects and 79 design-build projects from across the U.S. The results confirm that an increased number of proposers correlates with lower award growth (i.e., bid price vs. agency's estimate) for design-bid-build projects, as well as design-build projects procured by low bid. For design-build projects procured by best-value, award growth does not appear to correlate to number of bids. This finding suggests that design-build/best value projects do not experience a reduction in price competitiveness in performing a two-stage procurement process. Overall, this study contributes to the body of knowledge on delivery methods and on the role of competition in the construction industry. It also has implications for policy makers on how to balance the need for competition and fair price with flexibility required to achieve best value. Furthermore, the study will help inform practitioners on determining an optimum range of proposers under different delivery methods.

1 Introduction

Highway agency policies are evolving toward using alternative delivery methods and best-value selection to better spend public funding in a more efficient manner. With an ever-increasing demand on public funds, it is critical for agencies to understand how these alternative processes impact their ability to receive fair market value. One of the greatest impacts to receiving fair market value is competition. Previous studies suggest that the construction industry offers perfect competition (Runeson and Raftery 1998; Ngai et al. 2002; Skitmore et al. 2006). Many also tested this theory empirically, discovering that an increase in proposers equates to a more competitive price (e.g. Carr 1983; Wilson and Sharpe 1988; Flanagan and

Norman 1985; De Neufville and King 1991; Carr 2005; Shrestha et al. 2014). However, these studies were all conducted on design-bid-build (D-B-B), low-bid projects under traditional public sector procurement policies that were traditionally designed to maximize competition and ensure a fair price.

This paper fills a gap in the literature by comparing projects under alternative public procurement policies based on best value versus traditional policies based on lowest bid. The paper discusses both the quantity of proposers and their impact on receiving a competitive price for each policy methodology. Price competitiveness is measured by the award growth with the mindset that the lower the award growth the higher the competition, as seen in previous literature (Carr 2005; Shrestha et al. 2014). The traditional and alternative policies are studied through an analysis of the three commonly-used highway project delivery models: D-B-B, design-build/low bid (D-B/LB), and design-build/best value (D-B/BV).

This study's findings are based off a performance study of 159 U.S. transportation projects completed between 2005 and 2015. The paper first presents a brief review of delivery methods and procurement methods within highway construction followed by an economic background for examining construction procurement to frame the problem. Previous literature on competition is presented, showing discovered relationships between the number of proposers and their impact on the award growth/savings. The researchers then discuss the point of departure and methodology, finally discussing the results and their contributions to industry and literature.

2 Highway Project Delivery Methods in Construction

This paper presents a comparison of the traditional and alternative procurement policies within highway construction. The traditional procurement policies are represented by D-B-B whereas alternative policies are represented by D-B/LB and D-B/BV. Design-bid-build was formalized as a public delivery tool at the beginning of the Industrial Revolution with the Miller Act of 1935. Under D-B-B delivery, the agency procures engineering and construction services separately, with the agency retaining 100 percent of the drawing development and bearing the risk of design completion. Design-bid-build projects in the transportation sector use almost exclusively fixed-price, low-bid procurement with unit price contracts (Beard et al. 2001). Proposers prepare their bids using fully scoped documents, and the bid consists solely of construction cost development; consequently, D-B-B typically has low proposal preparation costs and is expected to have the highest average number of proposers. Agencies often chose D-B-B when competition is desired, with the assumption that D-B-B's lowest bidder award promotes a truly fair market price (Beard et al. 2001).

Alternative to D-B-B, D-B is a newer delivery method, and has been experiencing recent growth in highway construction. Design-build's nationwide use originated from the enactment of Federal Highway Administration (FHWA) Special Experimental Project Number 14 (SEP-14) – Innovative Contracting in 1990 (FHWA 2002). Further federal support for the method included the D-B Contracting Final Rule and section 1503 of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). Design-build has experienced sustained growth through providing faster project completion and a better handling of complex projects, infusing more contractor knowledge and ingenuity.

Design-build was first documented as a highway construction delivery model in 1987, under the Florida Department of Transportation (Ellis et al. 1991). In a D-B delivery, the agency contracts with a single entity to perform both design and construction services. Through this model, the agency transfers control risk of design completion to the contractor, with typical requests for proposals (RFP) containing 15 to 50% completed drawings (Molenaar and Gransberg 2001). Design-build projects tend to be more complex than D-B-B, are typically executed with lump sum contracts, and can be procured through either low bid or best value. Recent FHWA research on alternative contracting methods has found significant differences between D-B/LB and D-B/BV characteristics, stating D-B/LB and D-B/BV should be separated when analyzing and comparing performance metrics (FHWA 2016).

Design-build/low bid projects tend to be low in complexity, and are typically solicited with a 50% or higher level of design development. Due to the inclusion of design development, it is expected that proposal development will require more resources, specifically greater cost to prepare proposals, and it is expected that D-B/LB will have a lower quantity of proposers than D-B-B. Alternatively, D-B/BV is characterized by a lower level of design completion than D-B/LB at time of procurement, approximately 15% to 30% (Molenaar and Gransberg 2001). Due to a higher complexity, lower level of design, and resource-intensive proposal preparation, it is expected D-B/BV will have the lowest quantity of proposers. Design-build transfers a higher level of risk to the contractor, compared to D-B-B, and promotes multi-firm partnering. Both of these characteristics will also cause a lower number of proposers. Beyond the delivery method, the way in which a project is procured has significant impacts on proposers and performance, which is discussed below.

3 Highway Construction Procurement Models

The selected procurement process will significantly impact the number of contractors presenting price proposals for highway construction projects. As noted above, D-B-B projects are typically associated with a single phase, low-bid procurement. The two most commonly used D-B procurement processes defined by the code of federal regulations are single phase (one-step) and two phase (two-step) (USCFR 2013).

In a one-step D-B procurement, agencies evaluate contractor's response to their advertised RFP. The contractor proposals include both technical qualifications and project price. In contrast to the one-step process, the two-step procurement process includes both an advertised request for qualifications (RFQ) and a RFP. Contractors respond to the RFQ with their qualifications and preliminary designs, and the agency evaluates and creates a short-listing of qualified proposers, inviting these select firms to respond to the RFP. These invited contractors then respond to the RFP with both their design development package and cost proposal (Ramsey et al. 2016). The number of invited proposers is typically three to five (USCFR 2013), but determined by agency regulations. The number of proposers invited to respond to the RFP could also be limited by the number of proposers who respond to the RFQ. Federal regulations allow the use of one-step procurement on D-B if, among other things, the scope is well defined and/or low in complexity (USCFR 2013).

Although agencies may use one-step D-B, most favor a two-step process. A 2002 FHWA survey concerning D-B procurement practices found that most of the 14 agencies surveyed use a two-step procurement process for D-B projects (FHWA 2015). The code of federal regulations also supports this, stating that an agency "should consider using two-phase selection procedures for all design-build projects" (USCFR 2013). Based on these findings, it is expected that D-B-B will be exclusively one-step, with D-B using a combination of both. The researchers expect that nearly all D-B/BV will be procured using a two-step process. Alternatively, due to D-B/LB's lower complexity projects, it is expected that D-B/LB will be procured with both one and two-step procurement processes. Previous research concerning the role of competition in the construction industry is numerous, but only on D-B-B projects; D-B/LB and D-B/BV's specific relationship between competition and number of proposers is absent and has yet to be studied.

4 Role of Competition and Price in the Construction Industry

4.1. Neoclassical Economics and the Construction Industry

The study of competition within the construction industry deals with the expected price of construction. Two fundamentally different approaches exist to estimate the expected construction price within construction economics literature. The first is the probabilistic approach that originated from Friedman in 1956, which has gained acceptance and wide publicity. This approach has led to construction price determination, known as tendering theory, and has appeared in a substantial amount of literature (e.g. Gates 1967, Rosenshine 1972, Carr 1987).

The second, and competing, approach was first presented in literature by Hillebrandt (1974). It follows the neoclassical microeconomic theory of price determination in construction. Runeson and Raftery (1998) concluded that the neoclassical microeconomic theory is a more suitable analytical framework than the tendering theory, both in terms of its predictions and in the conformity with empirical studies of the construction industry (Ngai et al, 2002). As such, several researchers have employed neoclassical microeconomic theory as a useful lens for analyzing the construction industry (Runeson and Raftery 1998; Ngai et al. 2002; Skitmore et al. 2006).

A full, in-depth review of this theory is well beyond the scope of this paper, but a succinct discussion on neoclassical economics provides a helpful framework for understanding how competition impacts construction. In summary, neoclassical economic theory provides a basis for the concepts of supply and demand, and compares most economic markets to the model of perfect competition. Under the condition of perfect competition, buyers purchase goods or services with the goal of maximizing utility, producers sell goods to maximize profits, and the market determines the price at which the good or service can be offered. This theory proposes that each buyer and each seller is too small a portion of the process to have their actions impact market price. However, in limiting the buyers and/or sellers (i.e. limiting competition) a single entity's actions can impact markets, increasing/decreasing the expected price. The opposite of perfect competition is monopoly, in which only one supplier is available and prices will increase substantially (Ngai et al 2002). Most markets fall in between perfect competition and monopoly, but the neoclassical economic theory provides the rationale for why most agencies prefer higher levels of competition.

4.2. Existing Literature: Competition's Impact on Construction Pricing

In the construction industry, most public sector and many private sector agencies view competition as one of the best ways to ensure a fair and reasonable price. Public procurement regulations emphasize the importance of competition for that reason, to most efficiently spend public funds (American Barr Association 2007; US GSA 2015). This is also cited as one reason that the federal government and most states, including regulations for departments of transportation, have historically required the use of D-B-B delivery with award of construction contracts to the lowest bidder. The assumption is that greater competition would ensure the lowest prices and burden to the tax payer (Beard et al. 2001). Several studies in the construction industry have examined the validity of that assumption, researching the relationship between competition and price.

Among the first to examine the relationship between competition and price in the construction sector were Flanagan and Norman (1985). They presented both a theoretical analysis and performed a statistical analysis of 1500 building projects' relationship between the number of proposers and construction pricing. They found that increasing the size of tender lists (those invited to bid) will help ensure competitive prices, but there is little value beyond adding four to five proposers in their model. Carr (2005) analyzed over 400 bids from school building projects in New York, and concluded that up to eight proposers is advantageous for reducing bid prices, with four proposers on average yielding a bid cost equal to the agency's pre-bid estimate. Carr (2005) also found a contract award price drop of four to six percent per added proposer, but only up to six proposers. After six proposers, the savings per additional proposer dropped below 2%, and after eight there was no discernable savings in adding more proposers. Shrestha et al. (2014) similarly showed a statistically significant, negative relationship between the number of proposers and the bid prices of city street projects in Nevada. Carr (1983) demonstrated how competitors tend to lower their markups, and thus overall price, as they become aware of more firms competing for the same requirement.

In summary, both public policy and previous literature have advocated for a healthy level of competition to ensure low prices. Some studies have advocated for no restrictions, while others have placed a targeted number of proposers, ranging from four to eight (de Neufville et al. 1977; Flanagan and Norman 1985; Carr 2005). These studies were conducted on bid prices using a D-B-B, sealed bid approach. Less research has been conducted on the relationship between price and competition in the context of alternative delivery methods or best-value selection methods. This study intends to address that gap.

4.3. Evolution of Competition in Highway Construction Procurement Policies: Best Value

Highway contracting policies are evolving away from pure cost, low bid evaluations and toward a more flexible and holistic evaluation, best value (El Wardani et al 2006). This evolution does not present a divergence from the theory of neoclassical economics, rather it is an evolution of the object of contractor competition. Competition is defined as the act of striving to surpass another to receive acknowledgement, prize, supremacy, etc. For low bid projects, competition is contractors attempting to win the job by presenting a bid lower in cost than their competitors. Therefore, the means of which to measure competition are cost-based, (i.e. the level of savings, or lack thereof, received when selecting the lowest bidder).

Alternatively, best value evaluations are based on assessments of a holistic scoring system which can include, but is not limited to, qualifications, previous experience, technical scoring, innovation in design, etc. (USCFR 2013). This equates to proposers competing against one another not for the lowest cost, but for the optimal holistic score. If we are to assume the neoclassical theory of competition holds true, a correlation of number of proposers and award growth would not exist for D-B/BV which provides the motivation and importance of the findings held within this paper.

5 Point of Departure

This study askes the question, *how do the number of proposers impact the price competitiveness of the winning proposers' proposal under different delivery methods?* The researchers are specifically interested in studying how the number of proposers impact D-B/LB and D-B/BV as this represents a current gap within literature. To answer this question, an analysis on the delta between the engineering estimate and the executed contract values (award growth) was performed.

6 Data Collection and Method of Analysis

The database used for this paper is part of a national study on the risks and benefits of alternative contracting methods for highway construction (FHWA 2016). This study collected performance data from 159 projects that were completed between 2005 and 2015. These projects were collected from 26 state DOTs and the FHWA Office of Federal Lands Highway. The D-B projects were drawn from DOTs which actively engaged in those delivery methods. The D-B-B projects were sampled to be similar in location, size, and time of award to the D-B projects. The data from each project was obtained through a questionnaire that was administered to the agency's project representative by email with phone correspondences as required. The data used from the questionnaire for this research paper includes: project delivery method, number of proposers, engineering estimate, and contract award.

The researchers selected award growth as the dependent variable of interest. Existing literature has established several performance metrics which have been accepted by the research community. Award growth is one of these metrics often discussed in highway construction literature (e.g. Ellis et al. 1991; FHWA 2006; Shrestha et al. 2011). Award growth is a measure of the agency's over or under estimation of project value via comparing the engineering estimate to the actual contract award amount. As seen in equation one for award growth, shown below, a lower award growth value is desirable, with a negative growth indicating agency savings.

[1] Award Growth = (Award Amount – Engineering Estimate) / Engineering Estimate

The independent variable of interest is the number of proposers. Previous studies have used both award growth (or very similar measures) and the number of proposers when examining the relationship between competition and price (Carr 2005; Shrestha et al. 2014). The researchers analyzed the correlations between these two metrics for the delivery methods of D-B-B, D-B/LB, and D-B/BV. The primary statistic used is the Spearman correlation coefficient, which is most appropriate when one variable is continuous (award growth) and one is ordinal in nature (number of proposers) (Sheskin 2011).

7 Findings

Figure 1 shows the percentage of projects of each delivery method that experienced different numbers of proposers. As can be seen, there are many projects with three (specifically D-B/BV) and four (specifically D-B/LB) proposers. D-B-B projects experience five proposers most frequently, but has a wide array of number of proposers. Of note, 12% of D-B-B projects have at nine or more proposers.

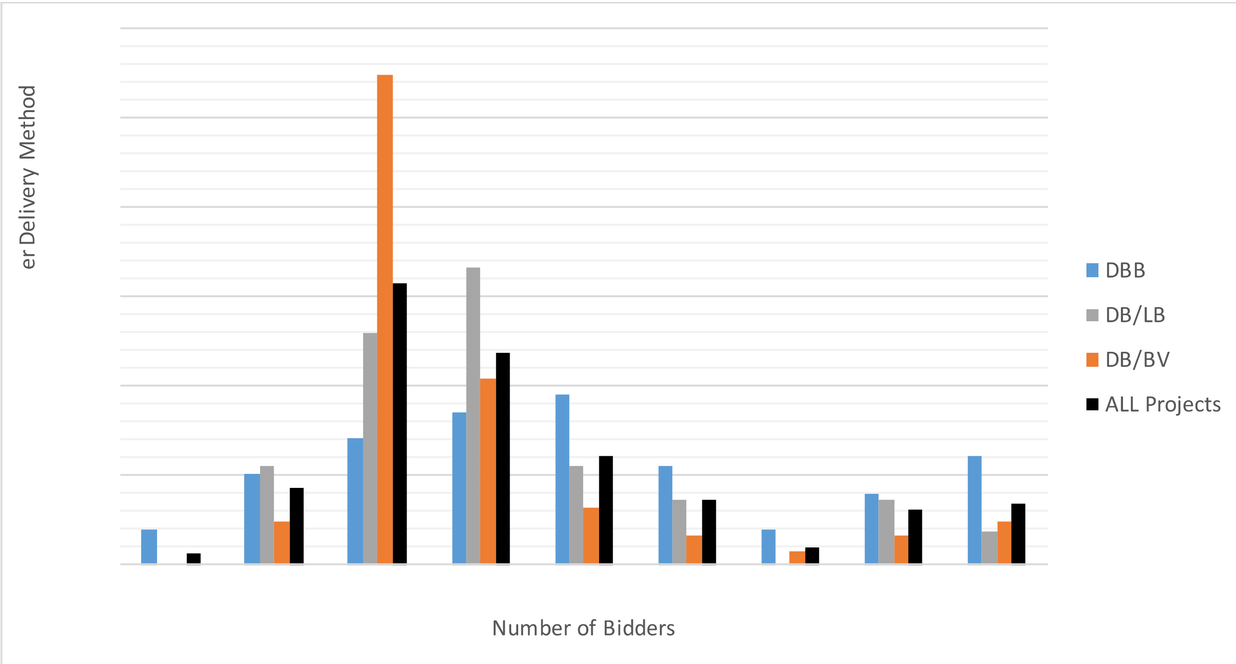

Figure 1: Percentage of Projects with Number of Proposers Per Delivery method

Prior to assessing the relationship between number of proposers and award growth, the researchers removed any projects that were less than $2M and projects that were higher than $100M in contract award value. These extremes were removed as an attempt to compare like-projects as well as to remove projects where any engineering errors would be magnified (i.e. small project equates to mistakes being a large percentage of the estimate) or where any engineering errors would be muted (i.e. large project equates to mistakes being a very small percentage of the estimate).

Table 1 shows the project award values, durations, complexities, and completion dates of the projects in the dataset by each delivery method. This is presented to provide the reader a better understanding of the data characteristics. Table 1 shows uniformity of project characteristics across delivery methods. This uniformity strengthens any findings when comparing across delivery methods.

Table 1: Dataset Descriptive Statistics

	Project Award		Project Duration		Complexity			Completion	
	Min ($M)	Max ($M)	Min (Days)	Max (Days)	Non (%)	Mid (%)	High (%)	Min (Year)	Max (Year)
D-B-B (N=80)	2.1	91.0	89	1,826	5	41	54	2006	2015
D-B/LB (N=23)	2.2	80.8	69	1,380	17	52	31	2007	2014
D-B/BV (N=56)	2.6	99.5	189	2,007	5	42	53	2005	2015

Table 2 depicts award growth experienced on D-B-B, D-B/LB, and D-B/BV projects per number of proposers (positive percentage equates to award growth, contract value greater than engineering estimate, whereas a negative percentage equates to award savings, contract value less than engineer estimate). As can be seen, only the award growth experienced on projects with two to five proposers are shown to enable a fair comparison between the three delivery methods. The researchers chose to not show any data over five proposers, as one focus of this study is D-B and federal regulations suggest agencies invite no more than five firms to submit price proposals on D-B projects (USCFR 2013).

Table 2: Number of Proposers versus Average Award Growth

	D-B-B Award Growth		D-B/LB Award Growth		D-B/BV Award Growth	
Projects with:	n	Mean	n	Mean	n	Mean
2 Proposers	6	9.9%	3	-2.7%	2	11.1%
3 Proposers	9	6.5%	5	5.9%	31	-7.8%
4 Proposers	15	-7.8%	7	-13.1%	11	-4.7%
5 Proposers	19	-12.9%	3	-13.1%	4	-13.5%

Table 3 shows the Spearman Correlation coefficients for D-B-B, D-B/LB, and D-B/BV projects with two to five proposers. As can be seen, D-B-B is the only delivery method with a statistically significant relationship in this range, with a modest correlation of -0.436 (*p=0.002*). The correlation is negative indicating that when number of proposers increases, award growth decreases. Table 3 also shows the Spearman Correlation coefficients for all D-B-B and D-B/LB projects within the database. Figure 1 shows that over 20% of all projects had more than 5 proposers. The researchers felt this warranted an inspection as to the correlation of number of proposers and award growth for the full dataset of D-B-B, D-B/LB, and D-B/BV projects. As shown, both D-B-B and D-B/LB have a statistically significant correlation when all projects are taken into consideration. Both correlations are negative indicating that when number of proposers increase, award growth decreases. The correlations are relatively modest between 0.40 and 0.50 (*p=.00 –.02*).

Table 3: Number of Proposers Correlation to Average Award Growth

	D-B-B Award Growth		D-B/LB Award Growth		D-B/BV Award Growth	
Projects with:	Spearman's Correlation	p-value	Spearman's Correlation	p-value	Spearman's Correlation	p-value
2-5 Proposers	-0.436	*p = .002*	-0.288	*p = .246*	-0.054	*p = .716*
2-15 Proposers (Full dataset)	-0.403	*p = .000*	-0.474	*p = .022*	-0.141	*p = .300*

8 Discussion

The following discussion considers the owner/agency perspective, being that lower award growth equates to lower prices and is advantageous to the taxpayer. The discussion does not consider the potential negative impacts (i.e. cost of industry to prepare and cost of agency to review, previously found to be up to 20% of the contract price (Ramsey et al. 2016)). The three main findings of this analysis are: 1) a correlation is found between number of proposers and price competitiveness in D-B-B and D-B/LB; 2) no correlation is found between number of proposers and price competitiveness in D-B/BV; and 3) over half of all projects have three to four proposers.

The correlation between the number of proposers and award growth within D-B-B and D-B/LB agrees with existing literature: increased number of proposers correlates with lower award growth (e.g. Carr 1983; Flanagan and Norman 1985; De Neufville and King 1991; Carr 2005; Shrestha et al. 2014). For D-B-B, the dataset findings are that agencies receive substantial price competition through fifteen proposers; agencies experienced 38% in award savings at nine proposers. This is supported by a moderate correlation between number of proposers and award growth (Spearmen's Correlation Coefficient = -0.436). This disagrees with Carr's (2005) findings of minimal award savings experienced after eight proposers. However, no statistically significant difference of the award growth means exist, and this paper does not disprove Carr's (2005) findings. Alternatively, Table 2's findings show agencies begin to receive award savings for projects once there are four proposers agreeing with previous literature (Flanagan and Norman 1985; Carr 2005).

On small and non-complex projects, agencies can choose to use a D-B/LB procurement by providing a high level of design in the solicitation documents. Federal guidance suggests three to five proposers for D-B projects (USCFR 2013). However, our data suggests agencies still can receive award savings for D-B/LB through nine proposers; agencies experienced 32% in award savings at nine proposers. This is supported by a moderate correlation between number of proposers and award growth (Spearmen's Correlation Coefficient = -0.474). This represents the first finding of correlation between number of proposers' and competitive price for D-B/LB in literature. It appears that D-B/LB and D-B-B have similar proposers-award growth trends. However, the cost of the agency to review and cost of industry to prepare proposals is much greater on D-B/LB projects if the proposals require industry to develop a design during solicitation. These costs must be taken into consideration before making any statements as to the optimal number of proposers on a D-B/LB project.

The final delivery method, D-B/BV, has no correlation found between number of proposers and price competition. Table 2 shows an increase in award savings as the number of proposers increase, though not statistically significant. This finding suggests that D-B/BV projects do not experience a reduction in price competitiveness in performing a two-stage procurement process. This may be because contractors are competing on their technical proposals versus price, and/or may be due to 75% of D-B/BV projects having three to four proposers. Along with D-B/BV, over 50% of D-B/LB projects have three to four proposers. This likely depicts that either agencies agree with the federal guidelines mentality and/or natural market conditions limit the number of contractors willing to bid on D-B projects. These federal regulations are in existence as D-B, specifically D-B/BV, proposals include substantial scope development and are resource-intensive to develop and review. Having a large quantity of proposers on a D-B project place considerable strain on the industry. Ramsey et al. (2016) found the cost to industry can be up to 20% when there are 11 to 15 proposers. Design-build proposals also require substantial resources by the agencies to review, especially D-B/BV since their reviews require resource-intensive technical scoring. Ramsey et al. (2016) also found the owner takes approximately three times longer for projects with an unrestricted number of proposers in comparison to limiting proposers through the two-step process to three to five.

Alternatively, D-B-B projects are found to have a wide range of number of proposers. Although five proposers are the most common, it only occurred on less than 20% of projects. This finding, specifically that over 10% of D-B-B projects with over nine proposers, is likely an indicator of the agency's choosing D-B-B when competition is desired, with the assumption that D-B-B's lowest bidder award promotes a truly fair market price (Beard et al. 2001). This could also be an indicator of low proposal preparation costs as many contractors would be more willing to bid if proposal costs were low.

9 Conclusions

This is the first study to examine the role of competition in highway construction using alternative project delivery methods. This paper contributes to the bodies of knowledge on both construction economics and alternative project delivery methods. Agencies can use these findings when developing their procurement strategies for highway construction. The paper's findings regarding D-B-B and D-B/LB agree with existing literature: increased number of proposers correlates with lower award growth. Design-bid-build's correlation between number of proposers and competitive price (award growth) has been well documented in previous literature (Carr 1983; Wilson and Sharpe 1988; Flanagan and Norman 1985; De Neufville and King 1991; Carr 2005; Shrestha et al. 2014). Although unsurprising, this paper's finding of number of bidders and competitive price (award growth) correlation means that agencies choosing D-B-B procurement will often see benefits in price of promoting greater levels of competition.

The D-B/LB and D-B/BV's findings are of greater interest to industry and academia. The D-B/LB finding suggests that the focus of the procurement process (low-bid versus best-value) may have more of an impact on bidder-competition relationships than the delivery type. The D-B/BV projects were found to have no correlation between award growth and number of bidders. This finding suggests that D-B/BV projects do not experience a reduction in price competitiveness in performing a two-stage procurement process. This finding may also represent contractors competing on their technical proposals versus price, but more research is need to validate this conclusion.

The US government is moving away from low-bid, pure cost evaluations towards a more flexible and less prescriptive, best-value regulation (El Wardani et al 2006). This does not present an evolution from neoclassical economics, but rather an evolution of the object of contractor competition. For low-bid projects, competition is contractors attempting to win the job by presenting a bid with a lower cost than the competition. A best-value evaluation allows for the inclusion of qualifications, previous experience, technical scoring, etc. (USCFR 2013). Therefore, for best-value projects, competition is contractors attempting to win the job by presenting a bid with a holistically better solution to the problem, as defined by the agency provided RFQ/RFP. The lack of correlation between number of bidders and award growth within D-B/BV may not negate neoclassical theory. Rather, the neoclassical "perfect competition" concept may exist amongst D-B/BV bidder's technical scores versus their price.

10 Limitations

A few limitations must be considered when interpreting or implementing these findings. First is the criteria measure for the level of competition, the number of proposers. Competitiveness can also be impacted by changes in the market conditions (Ngai et al. 2002). When there the market is "flooded" with work, contractors have a lower need for work and may add significant premiums to their bids (De Neufville R. and King D. 1991). Another limitation includes a lack of visibility on the number of steps used to procure D-B projects. As noted previously, the researchers were forced to rely on previous literature to assume that best-value projects mainly used a two-step selection procedure while most low-bid projects used a one-step procedure. Previous literature shows that this can have significant impacts on the cost to industry, contractor's willingness to bid, and number of proposers expected (Ramsey et al. 2016). Concerning the cost to industry and agencies, this research was unable to compare the costs of reviewing a bid versus the savings due to competition of having another proposer. The non-price benefits, such as potential benefits of competing designs were also not studied. Finally, there are significant challenges for the agency to develop an engineering estimate for D-B/BV as the scope is only ~30% complete and still conceptual (Molenaar and Gransberg 2001). The lack of correlation between bidders and award savings in D-B/BV could potentially be significant "noise" caused by a potentially large variance in engineering estimate accuracy.

11 Future Research

Many of the limitations provide opportunities for future research improving the results of this study including: 1) accounting for market conditions and where possible explore other metrics of cost and competition; 2) discussing procurement procedures used for each of the projects within the dataset to allow for more diverse and stronger conclusions; and 3) compare savings gained through increased number of proposers against the cost of reviewing them. Future research could also include extending this work to other sectors, such as buildings or water/wastewater to see if the findings are consistent with this study. Finally, future research may include a comparison on D-B/BV technical scoring and number of proposers to discover if there is any correlation.

References

American Bar Association. (2007). *Model Code for Public Infrastructure Procurement*.

Beard, J., Loukakis, M. C., and Wundram, E. C. (2001). Design-build: Planning through Development. McGraw-Hill, New York.

Carr, Paul G. (2005). "Investigation of Bid Price Competition Measured through Prebid Project Estimates, Actual Bid Prices, and Number of Proposers." *Journal of Construction Engineering and Management*

Carr, R. I. (1983). “Impact of Number of Proposers on Competition.” *Journal of Construction Engineering and Management,* 109(1), 61–73.

Carr, R.I. (1987) Optimum markup by direct solution, *ASCE Journal of the Construction Engineering and Management*, 113(1), 138-139.

de Neufville R. and King D. (1991) Risk and need-for-work premiums in construction bidding, *ASCE Journal of Construction Engineering and Management,* 117, No.4, 1991, 659-673.

de Neufville, R., Hani, E. H., and Lesage, Y. (1977). Bidding models: effect of proposers' risk aversion. *J. Constr. Div.*, ASCE, 103(1), 57-70.

El Wardani, M. A., Messner, J. I., & Horman, M. J. (2006). Comparing procurement methods for design-build projects. Journal of construction engineering and management, 132(3), 230-238.

Ellis, R. D., Herbsman, Z. J., and Kumar, A. (1991). "Evaluation of the FDOT Design/Build program." *Florida Department of Transportation*.

Federal Highway Administration. (2002) Special Experimental Projects No. 14 - Alternative Contracting (formerly Innovative Contracting) https://www.fhwa.dot.gov/programadmin/contracts/sep_a.cfm. [Accessed February 7, 2017].

Federal Highway Administration. (2015) Current Design-Build Practices for Transportation Projects (Cancelled). https://www.fhwa.dot.gov/construction/contracts/pubs/dbpractice/index.cfm. [Accessed February 9, 2017].

Federal Highway Administration. (2016) Quantification of Cost, Benefits and Risk Associated with Alternative Contracting Methods and Accelerated Performance Specifications. *Federal Highway Administration Project, Contract No. DTFH61-11-D-00009, 2013-2016.*

Flanagan, R. and Norman, G. (1985) Sealed Bid Auctions: An Application to the Building Industry, Construction Management and Economics, 3(2), 145 – 161.

Gates, M (1967) Bidding strategies and probabilities, *ASCE Journal of the Construction Division*, 93(CO1), 75 – 107.

Hillebrandt, P.M. (1974) Economic Theory and the Construction Industry, London: Macmillan.

Lam, T., and Gale, K. (2014). “Highway maintenance: impact of framework agreements upon project financial performance.” *Construction Management and Economics*, 32(5), 460–472.

Molenaar, K. R., and Gransberg, D. D. □2001□. “Design-builder selection for small highway projects.” *J. Manage. Eng*., 17□4□, 214–223.

Ngai, S.C. and Drew, D.S. and Lo, H.P. and Skitmore, R.M. (2002) A theoretical framework for determining the minimum number of proposers in construction bidding competitions. *Construction Management and Economics* 20(6):pp. 473-482.

Ramsey, D., El Asmar, M., & Gibson Jr, G. E. (2016). “Quantitative performance assessment of single-step versus two-step design-build procurement.” *JCEM, 142(9), 04016033.*

Rosenshine, M. (1972) Bidding models: resolution of a controversy, *ASCE Journal of the Construction Division*, 98(CO1), 143-148.

Runeson, G. and Raftery (1998) Neo-Classical Micro-Economics as an Analytical Tool for Construction Price Determination, *Journal of Construction Procurement*, Vol.4, No.2, 116 – 131.

Skitmore, M., Runeson, G., and Chang, X. (2006). “Construction price formation: full-cost pricing or neoclassical microeconomic theory?” *Construction Management and Economics*, 24(7), 773–783.

Sheskin, D. J. (2011). Handbook of parametric and nonparametric statistical procedures. crc Press.

Shrestha, P. P., Pradhananga, N., & Mani, N. (2014). Correlating the quantity and bid cost of unit price items for public road projects. *KSCE Journal of Civil Engineering*, 18(6), 1590-1598.

Tennant, S., and Fernie, S. (2014). “Theory to practice: A typology of supply chain management in construction.” *International Journal of Construction Management*, 14(1), 56–66.

United States Code of Federal Regulations, (2013). Title 23—Highways, Chapter 1—Federal Highway Administration Department of Transportation, Part 636—Design-Build Contracting, Subpart B – Selection Procedures, Award Criteria.

United States General Services Administration. (2015). “Federal Acquisition Regulation.” Washington, D.C.

Wilson, O.D. and Sharpe, K. (1988) Tenders and estimates: a probabilistic model, *Construction Management and Economics,* Vol. 6, 225 – 245.