

IMPACT OF OWNERS' EARLY DECISIONS ON PROJECT PERFORMANCE AND DISPUTE OCCURRENCE IN PUBLIC HIGHWAY PROJECTS

Sogand Hasanzadeh,¹ Behzad Esmaeili,² Ghada M. Gad³, and Douglas D. Gransberg⁴

ABSTRACT

Disputes are common in the construction industry and lead to unnecessary cost and schedule overruns in projects. It is commonly believed that owners' early decisions regarding the selection of delivery methods, procurement methods, and contract types impact the frequency and severity of project disputes; however, no previous study has empirically tested this hypothesis, particularly in highway public projects. Therefore, this study empirically investigated the impact of owners' early decisions regarding project organization (i.e., delivery methods, procurement, and contract types) on performance measures (e.g., cost and schedule growth), specifically dispute performance metrics (e.g., frequency and severity of disputes), in public highway projects. A comprehensive literature review was conducted to identify factors that impact disputes in construction projects. This review was used to develop a survey instrument capturing both independent factors, including type of delivery methods (e.g., design-bid-build [DBB]), procurement methods (e.g., open bid), and contract types (e.g., lump sum), and dependent factors, including the frequency and severity of disputes as well as other project performance metrics (e.g., cost, time, and satisfaction measures). Then, the survey was distributed to procurement personnel in state departments of transportation (DOTs) across the United States. Data on 60 projects from 22 DOTs were received. The data obtained were analyzed to find any statistically significant differences between dispute frequency and severity; relevant performance metrics; and the various types of delivery methods, procurement methods, and contract types. The results of the analysis showed that in the case of project delivery methods, (1) construction management at-risk (CMR) outperformed DBB in terms of design satisfaction and construction satisfaction, (2) projects delivered using design-build (DB) had lower schedule growth compared to DBB projects, and (3) using alternative delivery methods can lead to lower cost and schedule growth. As far as the selection process was concerned, the results showed that (1) projects procured using qualifications-based selection had significantly less severe claims (i.e. lower cost and lower severity for the largest disputes) compared with projects procured using open bid and (2) procuring a project using best-value selection (i.e., through one-stage or two-stage requests for proposals) increases the chances of finishing a project with fewer claims, lower claim costs, and lower severity for the largest disputes. Appropriate team selection can ensure a smooth project delivery process, provide more a collaborative environment, and help achieve success. Finally, based on the study results, it can be inferred that contract types significantly impact schedule growth in highway projects. The impact of project organization decisions is presented to assist DOTs in selecting the appropriate project delivery methods, procurement methods, and contract type for their project goals and expected performance.

¹Graduate Research Assistant, Durham School of Architectural Engineering and Construction, University of Nebraska–Lincoln, 116 Nebraska Hall, Lincoln, NE 68588; Tel.: (402) 853-3267; E-mail: smohammadhasanzadeh@huskers.unl.edu

²Assistant Professor (corresponding author), Durham School of Architectural Engineering and Construction, University of Nebraska–Lincoln, 113 Nebraska Hall, Lincoln, NE 68588; Tel.: (402) 472-5504; E-mail: besmaeili2@unl.edu

³Assistant Professor, Department of Civil Engineering, California State Polytech University; Pomona, 3801 W. Temple Ave., Pomona, CA 91768; Tel.: (909) 869-2648; E-mail: gmgad@cpp.edu

⁴ Professor, Department of Civil, Construction, and Environmental Engineering; Iowa State University; 494 Town Engineering Building, Ames, IA 50010; Tel.: (515) 294-4148; E-mail: dgran@iastate.edu

INTRODUCTION

Conflicts on highway construction projects are essentially unavoidable due to the inherent complexity of constructing an infrastructure project, the diversity of organizations and individuals involved, and the significant financial requirements associated with such projects (FCC 2007). In fact, 10–30% of construction projects experience serious disputes, and in one in four disputes, claims are ultimately filed (Stipanowich 1998). The transactional costs associated with resolving disputes and claims are estimated to be between \$4 and \$12 billion per year (FFC 2007), ultimately consuming public funding. The cost of dispute resolution is not limited to lawyers' fees and employees' salaries and overhead; it also encompasses the cost of induced construction process inefficiencies as well as long-term hostile relationships that may prevent repeat business (FFC 2007). In fact, conflicts that result in claims can become very expensive and ultimately lead to poor project performance. Considering the significant impact of conflicts and disputes in this context, the absence of project disputes is often seen as an indicator of success alongside other metrics, such as absence of cost increases, schedule delays, and quality defects (Pocock et al. 1996).

A large number of studies have been conducted to identify innovative strategies for mitigating the negative impacts of disputes (Goodkind 1998; Thomas et al. 1990, 1992; Mitropoulos and Howell 2001; Harmon 2004; Cheung et al. 2004, 2006, 2008, 2010; Vallero and Vesilind 2006; El-Adaway and Kandil 2009; Gad et al. 2011; Chong et al. 2013; Song et al. 2014; Barry and Leite 2015). Since there is consensus in the literature that conflicts can be avoided by enhanced understanding and finding common ground between parties, owners can play a critical role in establishing a cooperative project environment (Mitkus and Mitkus 2013; Leicht et al. 2014, Gad et al. 2016; Zhang et al. 2016). More specifically, owners can take actions and make decisions in the planning and construction phases of a project timeline that can impact the frequency or severity of disputes (FCC 2007). During the planning phase, owners can determine project risk allocation based on the delivery method selected and establish a collaborative team approach by selecting the appropriate procurement method and contract type. During the construction phase, on the other hand, owners can minimize adversarial relationships by encouraging communication and open information sharing, paying invoices on time, empowering project personnel to solve unexpected issues at the lowest level before escalation, and using innovative dispute-resolution techniques. The focus of this study is on early decisions owners make in the planning phase.

Before the start of the project, some early decisions owners make that help prevent and resolve disputes relate to aspects of project organization, including decisions regarding delivery system, procurement method, and contract type. Using alternative delivery systems in combination with qualitative selection can lead to a collaborative project environment, improve communication, provide a higher level of trust, and improve risk allocation among project stakeholders (Cheung and Pang 2013; Leicht et al., 2014). Thus, there is a common perception in both academia and practice that alternative instead of traditional delivery methods, qualitative-based instead of low-bid selection, and cost-plus-fee with a guaranteed maximum price (GMP) instead of lump-sum price lead to better project performance in terms of dispute occurrence and management. While numerous studies have investigated the impact of delivery method, procurement method, and contract type on project performance metrics, such as cost and schedule (e.g., Konchar and Sanvido 1998; Shrestha et al. 2012; Minchin et al. 2013), no study has empirically investigated the dispute performance of projects based on early project organization decisions, such as delivery method, procurement method, and contract type.

This research aims to fill this knowledge gap and empirically compare the performance of public highway projects (i.e., cost, time, satisfaction, and dispute performance) with different delivery systems, procurement methods, and payment methods. To achieve this objective, an in-depth literature review was conducted to develop a data-collection instrument, the resulting questionnaire was distributed among state departments of transportation (DOTs) to create a project performance database, and the database was then

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statistically analyzed to determine the impact of project organization on project performance. It is expected that this study's results will empower highway department agencies to make informed decisions by clarifying the potential impact of their early decisions in terms of the effects project organization has on project performance and dispute occurrence in highway projects.

BACKGROUND

A comprehensive literature review was conducted to clarify the relationship between owners' early project decisions and project performance in terms of the time, cost, satisfaction, and incidence of disputes. This review helped us develop a comprehensive data-collection instrument. The salient results of previous studies that guided us for this study are summarized here.

Project Dispute Performance

Quantifying project success is challenging because the definition of success often varies by stakeholder. For example, a contractor may consider construction speed and profitability to be the most important measures of success, whereas an owner may emphasize within-budget completion or construction quality. These conflicting views of success can result in poor overall project performance if expectations are not communicated. In the literature and in practice, the outcomes most frequently used to define project success are cost, time, and quality—also known as the iron triangle (Atkinson 1999). Other researchers have suggested more subjective outcomes, such as functionality and participant satisfaction (e.g., Ashley et al. 1987), aesthetics (e.g., Sanvido 1992), safety records and flexibility for users (e.g., Kometa et al. 1995), friendliness of the environment (e.g., Kumaraswamy and Thorpe 1996), specification fulfillment (Songer and Molenaar 1997), and absence of legal claims (e.g., Pocock et al. 1996), as additional indicators of project success.

To study dispute in this context, one needs specific metrics to assess and compare the performance of different construction projects. In one of the seminal studies, Diekmann and Girard (1995) defined two key components of dispute assessment: dispute frequency and dispute severity. Dispute frequency was defined as number of disputes that occur in a construction project. Dispute severity was considered in terms of the time and cost associated with solving a dispute. By analyzing a large database of construction projects, Diekmann and Girard (1995) used a logistic regression model to predict the likelihood of dispute occurrence based on several variables, such as people criteria (e.g., experience and competency of owner and contractor, team building, etc.), project criteria (e.g., size and complexity of the project, site limitations, etc.), and process criteria (e.g., scope definition, adequacy of technical plans and specifications). In conclusion, they stated that while people, project, and process factors all play a role in determining the likelihood of disputes, the impact of people factors are most significant. Since Diekmann and Girard's approach for measuring project dispute performance has been frequently adopted by other researchers (Molenaar et al. 2000), we decided to use similar metrics to assess dispute performance in the current study.

Project Delivery Methods

Project delivery methods determine the contractual responsibility of project stakeholders (i.e., owner, contractor, and architect) and the sequence of activities needed to complete a project. The most common project delivery methods in highway construction are design-bid-build (DBB), construction-management-at-risk (CMR), and design-build (DB). DBB is usually considered a traditional delivery method, and the other two are considered alternative delivery methods. DBB involves three sequential phases: design, bid, and construction. The owner hires an engineer to design the project and develop the plans and specifications. The project is then put up for a competitive bid and a contractor is procured to build the project. The project award is usually based on the lowest responsive bid in the form of a fixed price contract. As far as disputes are concerned, DBB is known to lead to adversarial relationships among project participants due to

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sequential processing, fragmented relationships, and separate goals and interests among project stakeholders. Sequential processing prevents contractors from providing input during the design phase, which leads to potential change orders later on. In addition, since the designer and contractor contract with the owner as separate entities, they have different and sometimes contradictory goals and interests, which may lead to disputes.

To address these challenges, alternative delivery methods have been developed. In the CMR model, the contractor becomes involved early in the project and can provide input during the design phase. However, the contractor and designer are still two separate entities with different interests and objectives, creating the potential for disputes. To avoid this problem, in the DB model, the owner hires one entity to serve as both the engineer and the contractor. This setup allows the contractor to provide input during the design phase, creates a single point of responsibility for construction and design, and facilitates fast-track delivery. In addition, because construction can start before the design is completed, the DB model saves time. The owner can also capitalize on the contractor's expertise during the design phase of the project and the architect/engineer's expertise during the construction phase. In theory, alternative delivery methods like the CMR and DB should outperform traditional delivery methods (i.e., DBB) in dispute management. However, as explained in following paragraphs, there is limited empirical evidence to support this claim.

Comparing various project delivery methods in terms project performance is a prolific area of study, and numerous studies have been conducted to determine the impact of delivery method on project performance metrics, such as cost, schedule, quality, sustainability, and safety (Konchar and Sanvido 1998; Molenaar et al. 1999; Ibbs et al. 2003; Hale et al. 2009; Korkmaz et al. 2011; Molenaar et al., 2014; Esmaeili et al. 2015). The majority of these studies have focused on building projects (i.e., vertical construction) or industrial projects, and a limited number of studies have compared the performance of these project delivery methods for highway projects (i.e., horizontal construction). Nonetheless, limited studies have compared various project delivery methods in terms of dispute performance. It should be noted that projects facing cost increases, schedule delays, and a large number of work defects are prone to litigations and disputes. The salient results of major studies that have investigated the impact of project delivery methods on project performance are summarized here.

Impact of project delivery methods on project performance

In January 2006, the Federal Highway Administration (FHWA) published the results of a comprehensive national study conducted to evaluate the effectiveness of DB contracting (FHWA 2006). The results revealed that in terms of project duration, the procurement time for DB projects is longer, but once a contract is awarded, there are significant time savings. In terms of impact on project costs, there was no significant difference between DB and DBB models. In addition, DB projects had fewer change orders than DBB projects; however, the cost per change order was greater for DB projects. Since the ratio of change orders to total project cost for both DB and DBB delivery methods was almost the same, the authors concluded that the higher cost of change orders can be attributed to the larger size of DB projects. The report also found that the dollar value of claims per project was significantly lower for DB projects than for DBB projects.

In another study, Shrestha et al. (2012) investigated the relationship between project performance metrics (i.e., cost, schedule, and change orders) and project characteristics of 130 large highway projects (>\$50 million) mostly constructed in Texas. This study departed from previous studies by comparing large highway projects and considering absolute performance metrics, such as cost per lane distance, delivery duration per lane distance, construction duration per lane distance, and cost per change order. The study concluded that construction speed and project delivery speed per lane mile were significantly faster in DB projects than in DBB projects. While there was no significant difference between the mean cost-related

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metrics of DB and DBB projects, the metric for cost per change order had a significant positive correlation with the nature of construction (i.e., reconstruction versus new construction), design work days per week, and working days lost. This research represents one of the most significant studies on performance comparisons of highway projects delivered using traditional and alternative methods; however, the study offered no comparison related to frequency and severity of disputes.

Furthermore, Minchin et al. (2013) compared the cost and time performance of 60 bridge and asphalt highway paving projects delivered using DB and DBB systems. All projects were constructed in Florida between 2007 and 2012 with project costs of more than \$7 million. After analyzing data with multiple statistical techniques, they found that cost performance in DBB projects was significantly better than in DB projects both in preliminary estimates versus award price and award price versus final price. Regarding time performance, DB slightly outperformed DBB projects, but the difference was not statistically significant.

As mentioned before, limited number of studies have examined the impact of various project delivery methods on dispute performance of projects. The summary of the results of these studies are presented here. One of the earliest studies attempting to determine the impact of the DB system on dispute performance was conducted by Ndekugri and Turner (1994) in the United Kingdom. They distributed a postal survey among contractors, designers, and building clients to determine professions' attitudes toward DB, the advantages and disadvantages of DB, and the impact of DB on performance metrics (e.g., time, cost, quality, and legal disputes). From the 200 organizations that were contacted, 74 responses from 11 organizations were collected. There was consensus among respondents (79% of contractors, 86% of architects, and 89% of clients) that the single point of responsibility provided in the DB model reduces the risk of litigation and arbitration; however, respondents mentioned that to reduce the number of disputes in the DB model, there should be a clear client brief and contractor proposal, use of un-amended standard forms, cost-plus-fee with a GMP as the pricing method, and minimal variation after contract award. It is notable that Ndekugri and Turner (1994) called the DB model a procurement method instead of a delivery method that is not consistence with other studies (Konchar and Sanvido 1998; Molenaar et al. 1999; Ibbs et al. 2003; Hale et al. 2009; Korkmaz et al. 2011; Shrestha et al. 2012). Overall, Ndekugri and Turner's (1994) study took a novel approach; however, its major limitation is related to use of a survey to collect experts' perceptions about the influence of delivery methods on the frequency of disputes. To avoid potential bias created due to relying on experts' perceptions, the present study measured dispute performance based on actual frequency and severity of disputes for each project.

In one of the few studies published about project performance in terms of dispute occurrence, the Federal Facilities Council (2007) compiled a report of presentations given by speakers who are experts in resolving construction disputes. A key finding of this study was that, contrary to the perception that fewer claims are anticipated in shared-risk contracts, no difference was seen in claim frequency between shared-risk versus contractor-allocated-risk contracts. The study also looked at choice of dispute resolution method, showing that arbitration encouraged inflated claim values whereas other methods, such as dispute resolution boards and mediation, did not affect claim frequency (FCC 2007).

Further, Pishdad-Bozorgi and de la Garza (2012) conducted a literature search and interviews with experts to identify key categories of claims and underlying influential factors leading to those claims. They argued that the DB model, compared to the DBB model, has a lower frequency of claims related to errors and omissions, misrepresentation, differing site conditions, cost overrun, and schedule delay because 1) risk for erroneous design and different site conditions is transferred to the design-builder, 2) communication is enhanced between the designer and builder, 3) it uses a cost-plus-fee with a GMP, and 4) design and construction overlap. On the other hand, Pishdad-Bozorgi and de la Garza (2012) did not reach any

conclusion regarding change orders and non-conforming or defective work claims. As far as change orders are concerned, they mentioned that the DB model might lead to fewer change orders because 1) the procurement process in the DB model is more inclined to qualifications-based selection that reduces adversarial project relationships and 2) the designer and builder are on the same team and will communicate more efficiently to prepare design documents. However, if the owner is not sophisticated enough to develop a request for proposal (RFP) or the project scope is not fully developed, the DB model may lead to more frequent claims. A similar argument was made for non-conforming or defective work claims. While the delivery of higher-quality products can be facilitated by having the design-builder serve as the single point of responsibility, hiring the most reputable and qualified design-builder team, and maintaining close collaboration between the designer and contractor teams, fixed-price contracts can lead to a higher number of owner claims against the contractor due to immature scope, the absence of rigorous performance requirements, and a lower level of owner involvement and control. One of the main limitations of Pishdad-Bozorgi and de la Garza's study is the lack of statistical data to support claims. To address this limitation, the current study created a project delivery database of completed projects by documenting both the frequency and severity of claims.

Project Procurement Methods

Procurement method refers to the process by which owners select (or purchase the services) of design and construction members, which can significantly affect the type of relationships created later in a project as well as the ultimate project outcome (Beard et al. 2001; AGC 2004). There are three common types of procurement methods: (1) open bid (the sole selection criteria is the lowest bid), (2) qualifications-based selection (only qualifications, such as technical capability and experience with similar projects are used to determine the final selection of members and cost of construction), and (3) best value (both total cost of construction and qualifications are factors in final selection of members and the process typically involves reviewing request for qualifications (RFQ) and/or request for proposals (RFPs) in one or two stages).

Few studies have evaluated the impact of procurement methods on various project performance metrics. Molenaar et al. (1999) compared the performance of public DB projects with three different procurement methods used by public owners: one-step, two-step, and qualifications- methods. They found that the two-step method had the least cost increase (3% over budget) and schedule delay (2% behind schedule). The one-step projects delivered, on average, 4% over budget and 3.5% behind schedule. The qualifications-based procurement method had the highest cost overrun (5.6% over budget) and schedule delay (3.5% behind schedule). In a similar study, El Wardani et al. (2006) investigated the relationship between the DB procurement method and project performance by collecting data from 76 DB projects in the United States. The performance metrics were time, cost, and quality, and the procurement methods were sole-source, qualifications-based, best-value, and low-bid selection. The study aimed to develop a series of guidelines to help owners select the procurement method that best served their DB project goals. While the findings of the study showed that no specific procurement method outperforms the other methods in all performance metrics (i.e., cost, schedule, and quality), the qualifications-based selection method had the lowest cost increase. Thus, previous studies examining the impact of procurement methods on project performance have reported inconsistent findings, and no study has specifically investigated the impact of procurement methods on project disputes, all demonstrating the gap in knowledge that must be studied.

Project Contract Types

In project organization, contract type refers to the method the owner uses to pay the contractor for services. There are four common contract types (AGC 2004): fixed price or lump sum, unit price, cost plus a fee, and cost-plus-fee with a GMP. Under a lump-sum contract, the contractor will deliver a specific amount of work (known as the scope of work) for a fixed amount of payment. For unit price, the contractor will be paid according to a predetermined price per unit for the major elements of the project. For cost plus a fee,

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the contractor will be paid based on the actual costs expended on the project plus an agreed-upon fee to cover overhead and profit. In cost-plus-fee with a GMP, the owner and contractor agree that the total project cost should not exceed a specific ceiling (or maximum price). Since the contractor guarantees that the price will not surpass a cost-plus-fee with a GMP amount, if the accumulation of actual costs goes over the ceiling, the contractor should pay, and if the cost falls under the ceiling, depending on the terms of the contract, the contractor may share in savings.

In one of the few studies that have compared the performance of various contracting methods, Bogus et al. (2010) compared the performance of public water and waste water projects procured under a cost-plus-a-fee contract with a cost-plus-fee with a GMP with those secured with a traditional lump-sum contract. The data were limited to nine projects, and the results showed that the mean cost growth of projects procured under a cost-plus-a-fee contract with a cost-plus-fee with a GMP was significantly less than that of projects procured under a lump-sum contract.

RESEARCH HYPOTHESES

The main objective of this study is to measure the impact of owners' early project decisions (i.e., project delivery method, procurement method, and contract type) on project performance, specifically dispute occurrence in public highway projects (Figure 1). To achieve this objective, different hypotheses were defined and grouped based on independent variables. The null hypotheses are presented below:

A: Project delivery methods and project performance

The first hypothesis examines differences among project delivery methods in terms of their impacts on project performance. This hypothesis will be followed up with post hoc analysis to see whether there are statistical differences between each delivery methods (e.g., DBB versus DB). In addition, since CMR and DB are considered alternatives to traditional DBB project delivery methods (Rojas and Kell 2008), the second hypothesis seeks to determine whether there are differences between traditional and alternative project delivery methods in terms of performance measures:

- $H_{A.1}$: *There is no significant difference between the project performance metrics of projects delivered using different delivery methods (i.e., DBB, DB, and CMR).*
- $H_{A.2}$: *There is no significant difference between the project performance metrics of projects delivered using traditional delivery methods (i.e., DBB) and projects delivered using alternative delivery methods (i.e., DB and CMR).*

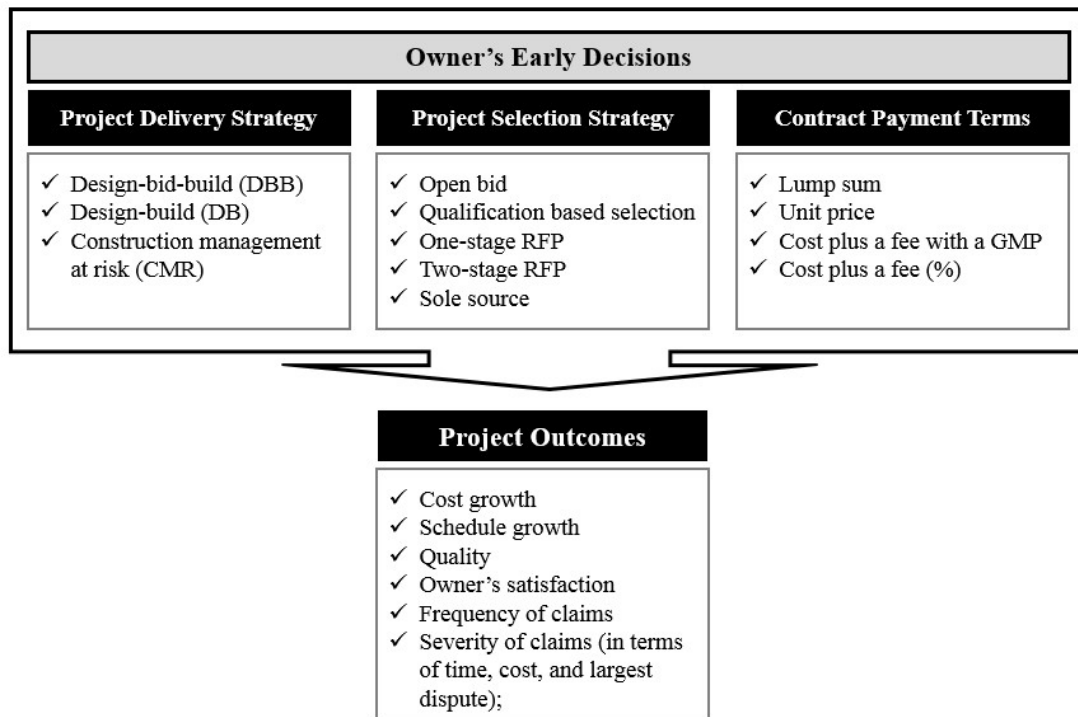


Figure 1. Research Framework

B: Project procurement and project performance

Similar to the previous hypotheses, the first hypothesis examines differences among project procurement methods in terms of their impacts on project performance. Furthermore, since previous studies have demonstrated that there is a significant difference between the performance of building projects procured solely based on price, the second hypothesis was developed to study differences between the performance measures of projects for which price was the only criteria versus projects that include both price and non-price criteria. Hypotheses related to project procurement are provided here:

- H_{B,1}: *There is no significant difference between projects procured using different procurement methods (i.e., open bid, qualifications-based selection, one-stage RFP, and two-stage RFP) in terms of project performance metrics.*
- H_{B,2}: *There is no significant difference between the project performance metrics of projects procured using open bid and other procurement methods (i.e., qualifications-based selection, one-stage RFP, and two-stage RFP).*

C: Contract types and project performance

Since the allocation of financial risk and level of accounting transparency are different in various compensation methods, which can impact team behavior and project performance (Franz 2014), the last hypothesis was developed to examine differences in project performance in various contract types:

- H_{C,1}: *There is no significant difference between projects that use different contract types (i.e., lump sum, unit price, cost-plus-fee with a GMP, and cost plus a fee) on project performance metrics.*

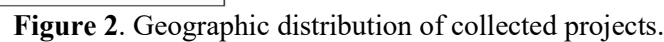
METHODOLOGY

The objective of this study was to empirically investigate the impact of different delivery methods, procurement methods, and contract types on dispute occurrence in and the ultimate success of public highway projects. To achieve this objective, a web-based questionnaire was developed that had several distinct sections. In addition to asking about respondents' background and project characteristics, questions asked about delivery type, procurement type, contract type, and team behavior as the independent variables and dispute performance and project performance metrics as the dependent variables.

Among a list of three project delivery systems—DBB, DB, and CMR— respondents selected the option best matching their project delivery method. To determine procurement type, respondents were asked how they solicited project proposals (i.e., open bid, qualifications-based selection, one-stage RFP, two-stage RFP, and sole source) from each project participant (i.e., contractor, design-builder, architect, and subcontractors), and they were also asked to determine the importance of selection criteria (i.e., price, quality of technical proposal, design concept, etc.) for each project participant. A question was included to collect the contract payment types used for each project participant, including lump sum, unit price, cost-plus-fee with a GMP, cost plus a fixed fee, and cost plus a percent fee. Questions were also included to determine the nature of owner relationship (repeat versus first time) with project stakeholders for different project delivery methods, team experience with each delivery system (six-point Likert scale), and communication patterns for each delivery system (six-point Likert scale). Respondents were also asked to evaluate the different categories of trust between their organization and the contractor using a six-point Likert scale. The three categories of trust (i.e., competence trust, organizational trust, and relational trust) identified from the literature were incorporated into the questionnaire along with their definitions.

To measure dispute performance in a project, we included questions about the frequency of, the financial severity of claims, the time-loss severity of claims, and the severity of the largest dispute (1 = low, 6 = high). These questions were successfully used in previous studies (Diekmann and Girard 1995). For the project performance metrics, we included questions about cost growth, schedule growth, construction satisfaction, design satisfaction, and the project's overall success. All questions related to performance were based on a six-point Likert scale. Participants were asked to complete the questionnaire for three recently completed highway projects preferably with different delivery methods.

The target population was state DOT employees involved in the procurement and project delivery process. To develop the sampling frame, we browsed the DOT websites to identify individuals who might be potential study respondents and created a database of 112 potential respondents from 44 state DOTs and their contact information. These potential respondents were then contacted by phone to request participation in the survey. Of these 112 potential respondents, 77 were willing and had the required expertise to respond to the survey. Before being sent to all respondents, the survey was pilot tested on 10 respondents familiar with this topic who were asked to provide comments and feedback on the survey questions and report any issues that needed to be revised in the survey. The survey was distributed via email with an explanatory cover letter and a link to a web –survey, and a follow-up reminder email was sent after two weeks. Responses were received for 60 projects from 22 states. The project geographic distribution is shown in the Figure 2. Four projects were removed from analysis due to a large number of unanswered questions. Out of the 56 remaining projects, 27 were DBB, 23 were DB, and six were CMR. Of the 56 respondents, 82% worked in construction and alternative project delivery sections, with the remaining in the design and contracts/procurement sections. The respondents' experience ranged from five to 33 years with an average of around 21 years of experience.



RESULTS AND ANALYSIS

Project Delivery Methods

Table 1. Statistical summary of project performance metrics for different project delivery methods

Project performance metrics	DBB			DB			CMR		
	M	MR	N	M	MR	N	M	MR	N

Frequency of claims	2	31.06	27	2	26.52	23	1.5	24.58	6
Severity of claims (cost)	3	28.94	27	2	28.54	23	2.5	26.33	6
Severity of claims (time)	2	27.89	27	2	30.28	23	1.5	24.42	6
Severity of largest dispute	2.5	28.13	27	2	29.48	23	2.5	26.42	6
Design satisfaction ^{a†}	4.5	24.46	24	4	25.75	24	5	37.42	6
Construction satisfaction ^{a†}	5	26.52	26	5	26.85	23	5	38.83	6
Cost growth ^{a*, b†}	2	28.78	23	1	21.27	22	2	32.67	6
Schedule growth ^{a† b*}	3	30.46	23	1	22.23	22	1	22.75	6
Overall success	5	28.37	27	5	27.78	23	5.5	31.83	6

DBB = design-bid-build, DB = design-build, CMR= construction management at-risk

M = median, MR = mean rank, N = number of data points

Likert scale for performance measures: frequency of claims (1 = low, 6 = high), financial severity of claims (1 = low, 6 = high), time-loss severity of claims (1 = low, 6 = high), severity of the largest dispute (1 = low, 6 = high), cost growth (1 = -10-0%; 2 = 0-10%; 3 = 10-20%; 4 = 20-30%; 5 = 30-40%; 6 = higher than 40%), schedule growth (1 = -10-0%; 2 = 0-10%; 3 = 10-20%; 4 = 20-30%; 5 = 30-40%; 6 = higher than 40%), construction satisfaction (1 = extremely unsatisfied, 6 = exceed expectations), design satisfaction (1 = extremely unsatisfied, 6 = exceed expectations), and the project's overall success (1 = low, 6 = high).

$H_{A.1}$ significant results: ^{a*} $p < 0.1$, ^{a†} $p < 0.2$

$H_{A.2}$ significant results: ^{b*} $p < 0.1$, ^{b†} $p < 0.2$

While descriptive statistics provide interesting information about the pattern in which disputes occur for different project delivery methods, statistical tests should be conducted to objectively measure the significance of the observed differences. As mentioned earlier in the research methods section, the Kruskal-Wallis and Mann-Whitney U test were used to test the research hypotheses. The test results for the hypotheses related to the impact of project delivery method on project performance metrics are explained here.

Null Hypothesis $H_{A.1}$: *There is no significant difference between the project performance metrics of projects delivered using different delivery methods (i.e., DBB, DB, and CMR).*

Explanation: Considering a confidence level of 90% and an asymptotic significance level less than 0.1, project delivery method had a significant impact on cost growth (chi square = 4.888; p -value = 0.087). However, post hoc analysis showed no significant difference in pairwise comparison of cost growth for different delivery methods. Considering a confidence level of 80% and an asymptotic significance level less than 0.2, project delivery method had a significant impact on design satisfaction (chi square = 4.057, p -value = 0.132), construction satisfaction (chi square = 3.648, p -value=0.161), and schedule growth (chi square = 4.079, p -value=0.130). Post hoc analysis revealed that CMR outperformed DBB in terms of design satisfaction (Z-score = -12.958; adjusted p -value=0.140) and construction satisfaction (Z-score = -12.314; adjusted p -value = 0.195) and that projects delivered using DB had lower schedule growth compared to DBB projects (Z-score = 8.229; p -value = 0.161). It is important to note that since the number of CMR projects in the database is small compared to DBB and DB projects, the inferences made about CMR projects are indicative rather than conclusive.

Hypothesis H_{A2}: *There is no significant difference between the project performance metrics of projects delivered using traditional delivery methods (i.e., DBB) and projects delivered using alternative delivery methods (i.e., DB and CMR).*

Explanation: The second hypothesis related to the impact of traditional and alternative delivery methods on project performance metrics was rejected for schedule growth (Z-score = 4.073; p -value = 0.044) and cost growth (Z-score = 1.693; p -value = 0.193). Thus, it can be concluded that using alternative delivery methods can lead to lower cost and schedule growth.

We also collected and analyzed other information about influential variables that can help provide more insight into the results (as detailed in the methodology section), including partnering, nature of owner relationships with project stakeholders (i.e., first time versus repeat), level of project stakeholders' team experience, communication patterns, and trust. According to the responses, 51.7% of DBB projects, 43.5% of DB projects, and 66.7% of CMR projects had a formal partnering agreement. Since there were few differences in formal partnering agreements from one project delivery method to another, its effect cannot be used as a differentiator. Regarding the nature of relationships, in all DBB projects, owners had worked previously with all architect/engineers (A/E) and general contractors (GCs) (Table 2). This finding is interesting because contractors are typically selected based on the least expensive responsive competitive bid, and there is typically no guarantee that the owner will select the same contractor again. On the other hand, in DB and CMR projects, owners had a first-time relationship with 26% of design-builders and 33% of construction manager agencies. It should be noted that the probability of claims and disputes is larger in projects in which the owner and contractor are working together for the first time.

Table 2. Nature of owner relationship with project stakeholders in different project delivery methods

	DBB		DB	CMR	
Nature of relationship	A/E	GC	DB	A/E	CM agency
First time	0%	0%	26%	0%	33.3%
Repeat	75.9%	82.7%	65.2%	83.4%	66.7%
No response	24.1%	17.3%	8.8%	16.6%	0.0%

A/E = architect/engineers, GC = general contractor, DB = design-builder, CM agency = construction management agency

The level of project stakeholders' team experience was almost the same for all project delivery methods except DB, for which experience was slightly lower in most categories (Table 2). The median was used to measure the central tendency of the data rather than the mean since median is less affected by outliers, particularly for smaller sample sizes (Gibbons 1985).

Table 3. Team experience (median) with each delivery system (1 = low; 6 = high)

Team experience variables	DBB	DB	CMR
Contractor's upper managerial support and responses	5	4.5	5.5
Contractor's organization experience with this type of project	5	4	5.5
Experience and competence level of the contractor's project individuals	5	5	5.5
Level of experience and effort of financial planners and adequacy of financial plan	4	4.5	4
Team's prior experience as a unit	4	4	5

Because communication impacts disputes and claims, as discussed in the literature review, questions were included in the survey regarding the formality and timeliness of communication, electronic file and information sharing, the quality of the input shared during the pre-construction phase of the project, and the adequacy of technical plans and specifications. The results showed that, on average, communication patterns in projects delivered using CMR were better than in projects delivered using DB and DBB (Table

4). Notably, projects delivered using DBB had the poorest performance in terms of the quality of the input shared during the pre-construction phase, electronic file and information sharing within the project team, and the adequacy of technical plans/specifications.

Table 4. Communication patterns (median) for each delivery system (1 = low; 6 = high)

Communication patterns	DBB	DB	CMR
Formality of communication among team members	4	4	4
Timeliness of communication	4	4	5
Electronic file and information sharing used by project team	3	4	5
Quality of the input shared during the pre-construction phase of the project	2	4	5
Adequacy of technical plans/specifications	4	5	6

In terms of trust, the median of responses revealed that project principals in projects delivered using CMR had a slightly higher level of competence trust, organizational trust, and relational trust compared to the other project delivery methods (Table 5). Competence trust is based on the confidence gained from an individual's knowledge or an organization's cognitive abilities. Organizational trust is developed through organizational policies and addresses formal and procedural arrangements. Relational trust is based on emotions that bond people together, thereby improving their performance and morale in working relationships. A more detailed discussion of the impact of trust levels on dispute occurrences can be found in Hasanzadeh et al. (2016).

Table 5. Trust type score (median) for each delivery system (1 = poor; 6 = excellent)

Trust type	DBB	DB	CMR
Competence trust	4	5	5
Organizational trust	4	4	5
Relational trust	4	4	5

Risk identification and allocation practices in each type of project resulted in median responses of 3, 4, and 5 for DBB, DB, and CMR projects, respectively, indicating that in projects delivered using CMR and DB, team members were in a better situation to identify and manage events that might lead to claims.

Procurement Methods

The descriptive statistics for the project performance metrics for different procurement methods are summarized in Table 6. The majority of projects were procured using open bid or two-stage RFPs. In terms of frequency and severity of claims, the common trend was improved dispute performance (in terms of claim frequency and severity) in moving from open-bid selection to two-stage RFP, one-stage RFP, and finally qualifications-based selection. A similar trend can be seen for overall project success, with qualifications-based selection leading to the highest probability of success and open-bid leading to the lowest probability of success. One interesting observation is that although projects procured using qualifications-based selection led to the highest degree of construction satisfaction, they led the lowest degree of design satisfaction. The only project performance metric for which open bid outperformed other procurement methods was cost growth. As far as time performance is concerned, low-bid had the highest schedule growth and one-stage RFPs had the lowest schedule growth.

Table 6. Statistical summary of project performance metrics for different procurement methods

Project performance metrics	Open bid			Qualifications-based selection			One-stage RFP			Two-stage RFP		
	M	MR	N	M	MR	N	M	MR	N	M	MR	N
Frequency of claims ^{a†; b†}	2	31.35	23	1	16.10	5	2	23.30	5	2	27.00	21

Severity of claims (cost) ^{a†; b*}	3	31.15	23	1	14.00	5	2	25.20	5	2	27.26	21
Severity of claims (time)	2	28.98	23	1	15.40	5	2	24.80	5	2	29.40	21
Severity of largest dispute ^{a†; b†}	3	30.74	23	1	13.70	5	2	24.90	5	2	27.86	21
Design satisfaction	4	24.57	21	4	20.20	5	5	27.60	5	5	28.55	20
Construction satisfaction	5	25.20	22	5	35.50	5	5	29.80	5	4	26.19	21
Cost growth	1	24.50	20	2	27.20	5	1	29.10	5	1.5	25.18	20
Schedule growth ^{b**}	3	28.85	20	2	27.80	5	1	17.20	5	2	23.65	20
Overall success ^{b**}	5	24.13	23	5	36.00	5	5	29.20	5	5	28.76	21

M = Median, MR = Mean rank, N = Number of data points

$H_{B.1}$ significant results: ^{a*} $p < 0.1$, ^{a†} $p < 0.2$

$H_{B.2}$ significant results: ^{b*} $p < 0.1$, ^{b†} $p < 0.2$

To test hypotheses related to procurement methods, the Kruskal-Wallis and Mann-Whitney U tests were used. The implications of these results are explained here.

Hypothesis $H_{B.1}$: *There is no significant difference between projects procured using different procurement methods (i.e., open bid, qualifications-based selection, one-stage RFP, and two-stage RFP) in terms of project performance metrics.*

Explanation: This hypothesis was rejected for three dispute-related performance metrics: frequency of claims (chi square = 4.759; p -value = 0.190), severity of claims (cost) (chi square = 5.321; p -value = 0.150), and severity of the largest dispute (chi square = 5.237; p -value = 0.155). The post hoc analysis did not reveal any significant differences between procurement methods and frequency of claims; however, the results for severity of claims (cost) and severity of the largest dispute were significant. Projects procured using qualifications-based selection had significantly less severe claims in terms of cost (test statistic = 17.172; adjusted p -value = 0.139) and less severe claims in terms of the largest dispute (test statistic = 17.039; adjusted p -value = 0.146) compared with projects procured using open bid.

Hypothesis $H_{B.2}$: *There is no significant difference between project performance metrics of projects procured using open bid and other procurement methods (i.e., qualifications-based selection, one-stage RFP, and two-stage RFP).*

Explanation: Grouping projects based on the importance of price criteria when selecting stakeholders proved to be helpful in magnifying the differences between performance metrics. As far as dispute performance is concerned, this hypothesis was rejected for frequency of claims (Z-score = 2.617; p -value = 0.106), severity of claims (cost) (Z-score = 3.069; p -value = 0.080), and severity of the largest dispute (Z-score = 2.476; p -value = 0.116). This means that procuring a project using qualifications-based selection and best-value selection (one-stage RFP, and two-stage RFP), which use non-price criteria, will increase the chances of finishing a project with less frequent claims, lower cost of claims, and lower severity of the largest dispute. In addition, Hypothesis $H_{B.2}$ also was rejected for schedule growth (Z-score = 2.022; p -value = 0.155) and overall success (Z-score = 1.611; p -value = 0.204). This shows that projects procured using best-value selection resulted in lower schedule growth and higher overall success.

Per received responses, 88% of owners used open-bid procurement (only price criteria) to select their general contractor in DBB project. Further, 81% of owners used both price and non-price criteria (best-value procurement) to select their design-builder in DB projects, and all owners (100%) selected their construction manager in CMR projects by considering both price and non-price criteria. In addition to information about procurement type, we also collected data about the importance of selection criteria for each project participant (i.e., architect, general contractor, design-builder, and construction manager

agency) across different project delivery methods. The responses to this question are summarized in Table 7. As expected, the most important selection criterion for general contractor in DBB projects was cost, and technical proposal, design concept, and interview performance were of least importance in the selection process. The surprising finding is that even for selection of the design-builder in DB projects, although quality of the technical proposal, experience conducting similar projects, and overall experience were very important criteria, cost was still the most important selection factor. For CMR projects, design concept was the most important selection criterion followed by technical proposal and price.

Table 7. Importance of selection criteria for each project participant in different project delivery methods (medians); (1 = most important; 6 = least important)

	DBB		DB	CMR	
Selection criteria	A/E	GC	DB	A/E	CM agency
Price	6	1	1	5	3
Technical proposal	4	6	2.5	2.5	2.5
Design concept	4	6	2	3.5	1
Similar project	3.5	5.5	3	3.5	4.5
Experience	3	3	3	3	4
Interview performance	4	6	3.5	4.5	5
A/E = architect/engineers, GC = general contractor, DB = design-builder, CM agency = construction management agency					

Contract Types

The statistical summary of the project performance metrics for different payment methods is presented in Table 8. The majority of projects were reimbursed using unit-price (51%) or lump-sum (44%) payment methods. While projects using unit-price reimbursement had slightly higher frequency and severity of claims and moderately larger cost and schedule growth, they had higher mean ranks of construction satisfaction and overall success than lump-sum payments.

Table 8. Statistical summary of project performance metrics for different payment methods

Project performance metrics	Lump sum			Unit price			Cost-plus-fee with a GMP			Cost plus a fee		
	M	MR	N	M	MR	N	M	MR	N	M	MR	N
Frequency of claims	2	25.38	24	2	29.14	28	3.5	43.75	2	2	27.50	1
Severity of claims (cost)	2	26.88	24	3	28.36	28	3.5	38.50	2	2	24.00	1
Severity of claims (time)	2	28.25	24	2	26.73	28	3.5	43.25	2	2	27.00	1
Severity of largest dispute	2	27.75	24	3	27.57	28	3.5	39.50	2	2	23.00	1
Design satisfaction	5	26.87	23	5	25.52	26	4.5	29.00	2	5	38.50	1
Construction satisfaction	5	26.33	24	5	29.23	28	4.5	26.00	2	5	37.50	1
Cost growth	1	22.61	22	2	27.44	25	2.5	39.25	2	1	13.00	1
Schedule growth ^{a†}	1	21.77	22	3	29.20	25	3	28.50	2	1	9.00	1
Overall success	5	21.77	24	5	29.57	28	4	16.25	2	4	11.50	1

M=Median; MR= Mean rank; N=Number of data points

H_{C.1} significant results: ^{a*} $p < 0.1$, ^{a†} $p < 0.2$

The results of the Kruskal-Wallis analysis for

Two hypotheses related to the impact of project payment method on performance metrics were tested using the Kruskal-Wallis analysis. The implication of statistical analysis for each hypothesis is explained here.

Hypothesis H_{C.1}: *There is no significant difference between projects that use different contract types (i.e., lump sum, unit price, cost-plus-fee with a GMP, and cost plus a fee) on project performance metrics.*

DISCUSSION

One of the early decisions owners make for a new project entails selecting a delivery method to complete the project. Based on the analysis performed, it can be concluded that alternative project delivery methods outperform traditional methods in terms of schedule growth, cost growth, design satisfaction, and construction satisfaction, which is consistent with previous studies (FHWA 2006; Shrestha et al. 2012). These findings can be explained by that fact that early involvement of design-builders or construction managers can reduce the number and magnitude of change orders, increase constructability, and reduce schedule growth and unnecessary costs (Konchar et al. 1998, Warne 2005). On the other hand, as far as dispute performance is concerned, the results of this study did not show any significant difference between projects delivered using alternative versus traditional methods, which corroborates findings from the Federal Facilities Council (FCC 2007). These results are interesting because the common perception among contractors and owners is that a single point of responsibility in DB projects should reduce the risk of litigation or arbitration (Ndekugri and Turner 1994). To explain these findings, one can turn to the arguments provided in a qualitative study conducted by Pishdad-Bozorgi and de la Garza (2012). According to Pishdad-Bozorgi and de la Garza (2012), while the risk for erroneous design and different site conditions is transferred to the design-builder and enhanced communication between the designer and builder may result in a lower frequency of claims, if the owner is not sophisticated enough to develop an RFP or the project scope is not fully developed, the DB model may lead to more frequent claims. Therefore, to reduce the number and severity of potential disputes in alternative delivery methods, owners need to provide a mature scope and rigorous performance requirements (Ibbs et al. 2003; Pishdad-Bozorgi and de la Garza 2012).

Another major decision that an owner should make in the process of acquiring a new project is choosing an appropriate procurement method to select the team that will deliver the project (El Wardani et al. 2006). Examining the performance of 60 public highway projects, this study indicates that projects procured using qualifications-based selection have significantly less severe claims in terms of cost and their largest disputes are also less severe compared to projects procured using open bid. Moreover, procuring a project using best-value selection (one-stage or two-stage RFP) will increase the chance of finishing a project with fewer claims, lower claim costs, less severe large disputes, lower schedule growth, and higher overall success. These results indicate that considering non-price criteria can increase the probability of project success and leads to a higher likelihood of project goals being met, which is consistent with the current body of knowledge suggesting that traditional price-based procurement limits opportunities for collaboration (Franz 2014; Hasanzadeh et al. 2015).

The findings of the current study align well with previous literature arguing that the initial savings from price-based competition in open-bid procurement are erased over the long term due to poor contractor performance, ultimately leading to lower project success. For example, Abdelrahman and his colleagues (2008) showed that best-value selection can lead to reduced cost growth from 5.7% to 2.5% and a reduction in claims and litigation by 86% in construction projects. Further investigation revealed that in projects using alternative project delivery methods relying on a single entity to deliver the project, such as DB and CMR, a multi-criteria procurement approach is more effective at increasing the likelihood of overall project success, and more than 80% of owners preferred to choose their design-builder or construction manager based on qualifications-based or best-value selection methods. The nature of the open-bid procurement method could be the reason for the numerous change orders in many construction projects (Beard et al. 2001). Fragmentation, poor communication, and the inevitability of excessive variations in project scope are well-known causes of schedule overruns and disputes in projects procured using the open-bid method

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(Latham 1994; Morledge et al. 2006). In addition, the qualifications-based and best-value procurement methods are more flexible approaches since they allow the owner to evaluate the potential contractors, design-builders, and construction managers based on factors that are specific to each project. Therefore, adopting an appropriate procurement method can lessen the potential risks of selecting an unsuited contractor or design-builder, avoid poor project performance, increase constructability, shorten project duration, reduce claims, and increase the likelihood that the owner's expectations will be met.

Regarding contract types, the results did not show any significant difference between the performance metrics of projects with various payment terms. This finding can be explained by the fact that in addition to payment terms, there are other factors that shape the nature of a contract, such as level of owner intervention, owner's flexibilities, administrative burden for accounting transparency, and working relationships that influence the environment in which the team interacts and project performance (Franz 2014, Suprpto et al. 2016). Measuring the impact of these variables on project performance in future studies will be promising.

In sum, successful acquisition of a highway project requires initial decisions about project delivery method, procurement method, and contract type. However, the results of this study demonstrated that the role of project delivery methods and contract types in determining dispute occurrences is not significant. The only decision that significantly impacts the dispute performance of highway projects is the selection of a procurement method. The findings suggested that evaluating the qualifications of potential stakeholders can help build more collaborative teams, which may reduce the frequency and severity of disputes in highway projects.

CONCLUSIONS

While previous studies have investigated the role of early decisions on project performance, such as cost and schedule growth, there was lack of knowledge regarding the impact of those early decisions on highway projects' dispute performance. To address this knowledge gap, the current study aimed to investigate the effect of project organization characteristics (i.e., delivery, procurement, and contract types) on performance measures, specifically dispute frequency and severity in public transportation projects. Therefore, a database of 60 completed public transportation projects was created by distributing an online questionnaire to state DOTs. By analyzing the data using inferential statistics, it was found that using alternative delivery methods (i.e., DB and CMR) will result in lower cost and schedule growth and including selection criteria other than price in the selection process can reduce the frequency and severity of disputes in public highway projects. This study strengthens the theoretical foundation for understanding the impact of owners' early decisions, such as their choice of delivery method, procurement method, and contract type, on project performance metrics, specifically the frequency and severity of disputes. The results also provide empirical evidence for decision makers at state agencies to define project organization by understanding the potential impact of their decisions on successful project completion in dispute-free environments.

This study has some limitations that also present worthwhile avenues for future research. First, in this study, the impact of the three most important early decisions on project performance were studied separately. Further investigation is recommended to examine how different combinations of these decisions can impact project performance, specifically dispute performance. Second, the contribution of this study's quantitative findings can be expanded by conducting semi-structured interviews with key stakeholders of projects that experienced disputes to find out what happened in these projects, search for different causes of the disputes, and examine contracts and the influence of contract clauses on the frequency and severity of disputes. Third, in the database created for this study, the number of CMR projects compared to DBB and DB projects was small. It is suggested to expand the database by including more CMR projects; however, it seems CMR is still not a very popular delivery method in highway projects.

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