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Highway Project Cost and Schedule-Related Performance Comparison Based on Locations

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Design-Bid-Build (DBB) remains the most common approach for building highways used by the State Department of Transportation (DOT). About 80% of highway projects are still built using this method. This study collected data on 140 DBB highway projects with total costs exceeding $10 million from five Texas DOTs: Austin, Dallas, Fort Worth, Houston, and San Antonio. The study analyzes cost- and schedule-related data from these projects and compares their performance across these five districts. Statistical test results show that projects completed under the Houston district had higher cost growth than those in Austin, Dallas, and San Antonio. However, the projects completed under the Houston district had significantly lower schedule growth than those completed under the Austin, Dallas, and Fort Worth districts. This study shows that the project owner also plays a key role in highway project performance and that the district management style is key to reducing cost and schedule growth. The study's main contribution is that DOTs should identify effective working practices used across district offices to control highway project costs and schedules, so these practices can be applied in future projects to improve performance.

Keywords: design-bid-build, total cost growth, total schedule growth, construction intensity, Texas DOT

Introduction

Highway infrastructure projects are very important for economic growth, public safety, and getting around. Design-Bid-Build (DBB) has long been the most common and traditional way to deliver projects in the United States. This is especially true for public-sector projects, such as those run by state departments of transportation (DOTs). In DBB, the design is completed before bidding begins, and the contract is awarded to the lowest bidder, emphasizing cost competitiveness. However, this method has been criticized for its inefficiencies, including cost overruns, schedule delays, and change orders. These problems can occur when engineers and contractors do not work together well, when risks are not communicated effectively, and when planning phases do not allow sufficient collaboration.

The Texas Department of Transportation (TxDOT) uses the DBB method to deliver most highway projects. It operates a vast network that supports one of the state's largest economies. TxDOT has completed thousands of projects over the years, so it has accumulated a wealth of data for research. Previous studies have predominantly focused on national or statewide patterns; however, district-level variations, shaped by factors such as geography, contractor availability, and local administrative

practices, have been insufficiently examined. For example, districts in cities may face different problems than those in the country, such as higher material costs, a shortage of workers, or rules that are harder to follow in certain locations.

This exploratory study examines the performance of DBB highway projects throughout five TxDOT districts: Austin, Dallas, Fort Worth, Houston, and San Antonio, utilizing the data of 140 projects. This study seeks to identify localized patterns and inefficiencies by analyzing key performance indicators, including cost growth (the percentage increase in final costs relative to the original contract award), schedule growth (the percentage increase in project duration), and construction intensity (cost per day, adjusted for efficiency).

The impetus for this district-level emphasis stems from the recognition that statewide averages can obscure substantial variation. For instance, previous research has shown that smaller projects (those costing less than $10 million) are more likely to go over budget because they receive less scrutiny or because of economies of scale. This study aims to confirm this trend in Texas circumstances. In the end, the findings help us understand better how contextual factors affect DBB outcomes. They also give TxDOT ideas on improving project delivery, procurement techniques, and resource allocation to complete projects more efficiently and deliver greater value for taxpayers' money. This research builds on existing literature by filling gaps in localized analysis, paving the way for more targeted interventions in highway project management.

Research Objectives

The goals of this study are as follows:

1. To analyze cost growth and schedule growth metrics for DBB projects across five TxDOT districts (Austin, Dallas, Fort Worth, Houston, and San Antonio) based on a dataset of 140 projects.
2. To examine district-specific differences in project outcomes, accounting for variables such as geography, administrative oversight, and contractor pools.
3. To identify gaps in existing practices and provide recommendations for improving DBB project management within TxDOT with a focus on reducing inefficiencies in highway projects.

Literature Review

Konchar and Sanvido (1998) conducted one of the earliest comprehensive empirical studies on project delivery, analyzing over 350 projects and demonstrating that Design-Build (DB) techniques regularly surpassed DBB in both time and cost compliance. Their research set a standard by showing that DB delivery was slower but better at maintaining schedules, whereas DBB projects often incurred higher final costs and took longer to complete. Sullivan et al. (2017) conducted a meta-analysis of 4,600 projects, confirming that DB projects exhibited lower cost increase (2.8%) compared to DBB projects (5.1%), as well as reduced average schedule delays (10.7% versus 18.4%). These recurring themes of DBB's heightened risk of inefficiency have compelled public agencies to examine the potential for process improvement meticulously.

Other studies, on the other hand, complicate the story by showing how construction project management varies across different contexts. For instance, Minchin et al. (2013) assessed Florida Department of Transportation (FDOT) projects over multiple years. They found that, in that context, DBB projects exhibited better cost management than DB projects, despite being less timely in

delivery. Their research underscores that state-level institutions, management methods, and regulatory frameworks significantly influence project outcomes. Although DBB is commonly linked to cost overruns and delays, these risks are not always present or inherent; instead, they depend on the specific administrative, economic, and managerial contexts in which projects are carried out.

The way that procurement works in the DBB model is also quite important. Nguyen et al. (2018) showed that using best-value procurement tactics in DBB, rather than selecting only the lowest bid, led to greater stability and less growth in both cost and schedule. Their examination of 162 public construction projects revealed that best-value methodologies incentivized qualifications and historical performance, alleviating concerns that lowest-bid procedures may intensify in intricate or very uncertain undertakings. This shows that DBB's main weaknesses, partly due to its delivery methods, are exacerbated or mitigated by the way contractors are selected.

The scope and complexity of a project significantly affect how well it is delivered. Shrestha et al. (2012), in their assessment of U.S. highway enhancement initiatives, determined that. In contrast, DB methodologies typically facilitate expedited delivery; however, the relative benefits of DB over DBB diminish as project scale escalates. More specifically, the scope and size of a project can be more important than the delivery system itself. For example, highly complex or large-scale DBB projects can sometimes perform as well as or better than DB-structured projects, especially when agencies have established advanced oversight protocols.

In the Texas context, Shrestha et al. (2021) conducted one of the most extensive and comprehensive studies of DBB highway project outcomes in the state. Their research examined more than 4,000 projects completed between 1987 and 2015 and found that cost management has improved significantly since 2001, especially for larger projects. Even with this progress, small projects (under $10 million) continued to experience high-cost growth, unlike larger projects. The investigation also indicated that the frequency and types of change orders differed, especially in smaller contracts. This split shows that, in Texas's world of DBB project delivery, project size and complexity are among the most prominent factors affecting risk exposure.

Recent developments utilize predictive analytics to tackle these performance issues. Shrestha et al. (2025) employed Natural Language Processing (NLP) to analyze prior bid documents and change orders, developing models that predict cost overruns and schedule delays with high precision. These methodologies show promise, but they rely heavily on the quality and granularity of the available data. The authors expressly warn that differences in policies, contractor pools, and geography at the district level can create data trends that statewide averages might obscure.

The literature reveals three prevailing trends: (1) DBB highway projects generally exhibit more significant cost and schedule escalation compared to DB or Construction Management at-Risk (CMAR) projects, although regional studies may identify exceptions; (2) best-value procurement within DBB can enhance outcomes, particularly for intricate projects; and (3) project size consistently serves as a predictor of risk, with smaller projects being the most susceptible to cost and time overruns.

Even with these insights, there are still holes in the research. National benchmarks are beneficial; however, most research is multi-state, national, or single-state, lacking comprehensive sub-state (district) disaggregation. The Texas studies mentioned earlier are a great source of data. Still, none of them have systematically evaluated how well different districts do or investigated what makes a project succeed or fail at the district level. Districts, as administrative entities with distinct geographies, climates, labor markets, and management cultures, may encounter varied outcomes even

under a consistent statewide policy framework. This is especially true for Texas, which is large and diverse; thus, local project contexts are likely to differ widely.

The insufficient focus on district-level analysis represents a significant research deficiency. By not accounting for spatial variation, earlier research may miss practices or conditions that either worsen or mitigate risk at the local level. These kinds of mistakes make it harder for managers and policymakers to focus on the areas that require the most development. Consequently, there is an immediate need for research that goes beyond statewide averages, using district-level data to elucidate the regional distribution of cost and schedule risks and the causes of these disparities.

The Texas Department of Transportation and other large public agencies might use district-level information to make significant changes to how they execute projects. These practices can reveal inefficiencies or strengths that are not obvious, help ensure that oversight and resources are distributed more fairly, and encourage districts with different performance records to share what they know. This study seeks to bridge the literature gap by specifically addressing these topics and providing actionable recommendations for DBB project delivery in Texas and comparable environments.

Gaps in the Literature

Various studies have identified cost and schedule growth in DBB highway projects and compared them with DB and CMAR projects to determine which project delivery method is more cost- and schedule-efficient. However, cost growth, schedule growth, and construction intensity by project location have not been compared. This study has collected cost and schedule data for five Texas DOT district highway projects with costs exceeding $10 million. The study's results show whether a project's location or management style affects project cost and schedule performance. During the literature review, the authors did not find studies focusing on the effects of various management styles on the cost and schedule performance of DBB highway projects. This study fills this gap, and its findings provide a clear picture of whether projects under different districts' project management styles affected their performance.

Research Methods

The authors used a generalized research method to conduct this study. The following tasks were conducted to complete the research. They are:

1. Identification of the problems
2. Literature review
3. Determining the research gaps
4. Collecting project performance data of highway projects
5. Developing performance metrics
6. Creating a research hypothesis
7. Developing null hypotheses
8. Conducting statistical tests
9. Concluding and
10. Providing the recommendations to the practitioners

The first three sections of the research method have already been described. The following sections describe the remaining tasks.

Data Collection

The authors searched the Texas DOT database to download cost, schedule, and change order data for DBB highway projects. The data were downloaded by visiting the TxDOT website. The authors did not use randomly selected samples because all recent TxDOT projects in these five districts were available on the website. The authors downloaded all the recent project data with costs exceeding $10 million. The downloaded data consists of project ID, location, district name, county, CCSJ number, contract award amount, change orders, final amount paid, contract days, days used, etc. The data were collected from projects completed from 2017 to 2025. To determine the project size based on the final amount paid, all costs were normalized to the first quarter of 2025 using the National Highway Construction Cost Index (NHCCI, 2025). Equation 1 was used to convert the final amount paid into equivalent first-quarter 2025 costs.

$$Adjusted\ Final\ Amount\ Paid = \frac{NHC\ Cost\ Index\ of\ 1st\ Quarter\ 2025}{NHC\ Cost\ Index\ at\ Time\ Project\ Completion}\ x\ Final\ Amount\ Paid \ldots\ldots (1)$$

Performance Metrics Development

One cost-related and two schedule-related performance metrics were developed to determine whether the project performance of DBB highway projects was effective. Total Cost Growth was used to measure whether the projects were completed within budget. Equation 2 shows how the Total Cost Growth is calculated for each highway project.

$$Total\ Cost\ Growth = \frac{(Final\ Amount\ Paid - Contract\ Amount)}{Contract\ Amount}\ x\ 100 \ldots\ldots\ldots\ldots (2)$$

One of the schedule-related metrics was Total Schedule Growth. These metrics measure whether the projects were completed within the allotted time durations. Equation 3 shows how this metric is calculated for these highway projects.

$$Total\ Schedule\ Growth = \frac{(Final\ Completion\ Duation - Contract\ Duration)}{Contract\ Duration}\ x\ 100 \ldots (3)$$

The final metric related to schedule is Construction Intensity. This metric measures how quickly the project is built and how much money is spent each day to assess the highway project's construction speed. Equation 4 provides the formula for calculating this metric.

$$Construction\ Intensity = \frac{Adjusted\ Final\ Amount\ Paid}{Final\ Completion\ Duration}\ x\ 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Research Hypotheses

The authors have developed three research hypotheses to determine whether the cost- and schedule-related performance metrics of DBB highway projects completed by various district offices from the Texas DOT are significantly different from one another. Equations 5-7 present the research hypotheses for this study.

$$Total\ Cost\ Growth_i \geq Total\ Cost\ Growth_j \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

$$Total\ Schedule\ Growth_i \geq Total\ Schedule\ Growth_j \ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

$$Construction\ Intensity_i \geq Construction\ Intensity_j \ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Statistical Tests

To conduct a statistical test, the data distribution should be verified. If the data are not normally distributed, a nonparametric statistical test should be conducted to determine whether the medians of these performance metrics differ significantly across the DBB projects completed by the five districts under the Texas DOT. Therefore, the Shapiro-Wilk normal distribution test is conducted. If the p-value of the test is greater than 0.05, then the data are not normally distributed. Then, the Kruskal-Wallis nonparametric test is conducted to assess whether the median values of these performance metrics differ significantly across Texas DOT districts. This test is used instead of the Mann-Whitney test because the independent variable has more than two groups. The null hypothesis of the Mann-Whitney test is that the medians of Total Cost Growth, Total Schedule Growth, and Construction Intensity are not significantly different from those of the DBB highway projects completed by these five districts. If the p-value is less than 0.05, the null hypothesis will be rejected, confirming the research hypothesis that there is a significant difference in the median values of these performance metrics for the highway projects completed by these five districts. To determine which district's highway project performance differs significantly from the others, a post hoc test must be conducted. The post hoc test will confirm which district's highway project performance differs from the others.

Conclusions and Recommendations

The statistical test results, conclusions, and recommendations are presented. The authors review findings from past studies, compare them, and determine the reasons for differences in project performance. The study's primary contribution is highlighted, and the findings' implications for practitioners are summarized.

Results

This section will cover the descriptive statistics of the performance metrics for the highway projects completed by the five districts. Then, the results of statistical tests, e.g., Shapiro-Wilk and Kruskal-Wallis tests, will be presented. The first section will describe the descriptive statistics of the Total Project Cost, Total Cost Growth, Total Schedule Growth, and Construction Intensity.

Descriptive Statistics

The data were collected from five Texas DOT districts. The data were collected only for projects with costs greater than $10 million to control for variability in project cost. Some small projects performed differently compared to large projects in terms of cost growth, schedule growth, and construction intensity. First, project sizes, measured by total amount paid, were calculated to determine whether the projects considered in this analysis across these five districts are similar. Table 1 shows the descriptive statistics of the total amount paid for these projects. The number of highway projects considered in this analysis for Austin, Dallas, Fort Worth, Houston, and San Antonio was 28, 27, 31, 28, and 26, respectively. The average values for all these projects indicate that the project size considered in this analysis across all five districts is similar, at $31.89 million.

Table 1. Descriptive statistics of Total Amount Paid

Metrics	**Austin**	**Dallas**	**Fort Worth**	**Houston**	**San Antonio**	**Total**
Sample Size	28	27	31	28	26	140
Mean ($M)	32.34	36.46	30.23	32.25	28.26	31.89
SD ($M)	16.36	17.57	17.43	17.45	19.20	17.55

Before conducting the statistical tests, the data from each district were examined to identify outliers in cost growth, schedule growth, and construction intensity. Figure 1 shows the box plots of the Total Cost Growth of the projects in these five districts. The data show that there are no extreme outliers in these samples.

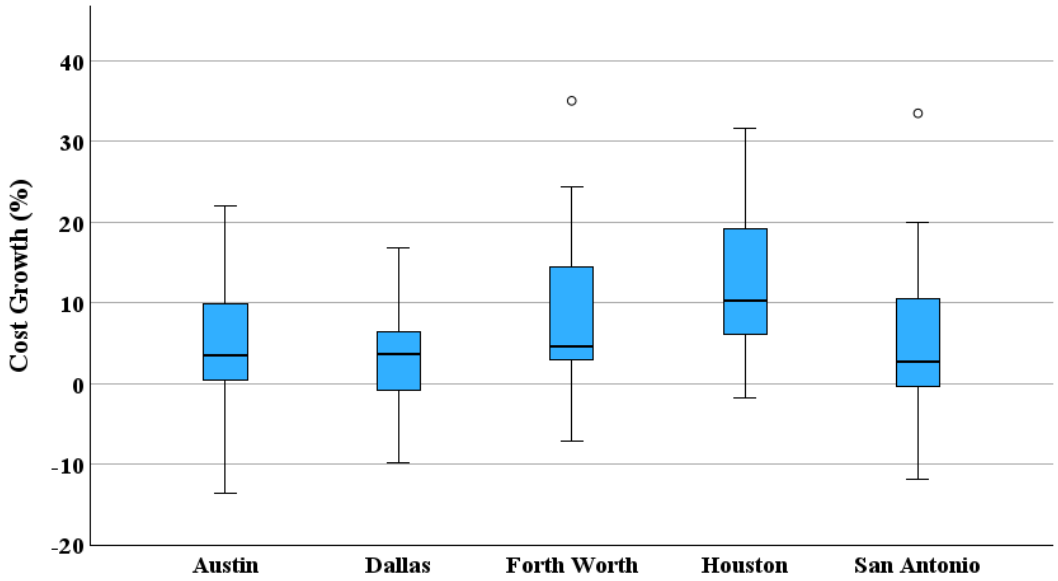

Figure 1. Box plots for Total Cost Growth

Figure 2 shows the box plots of Total Schedule Growth for all five district highway projects. Very few data points are outliers, and only one qualifies.

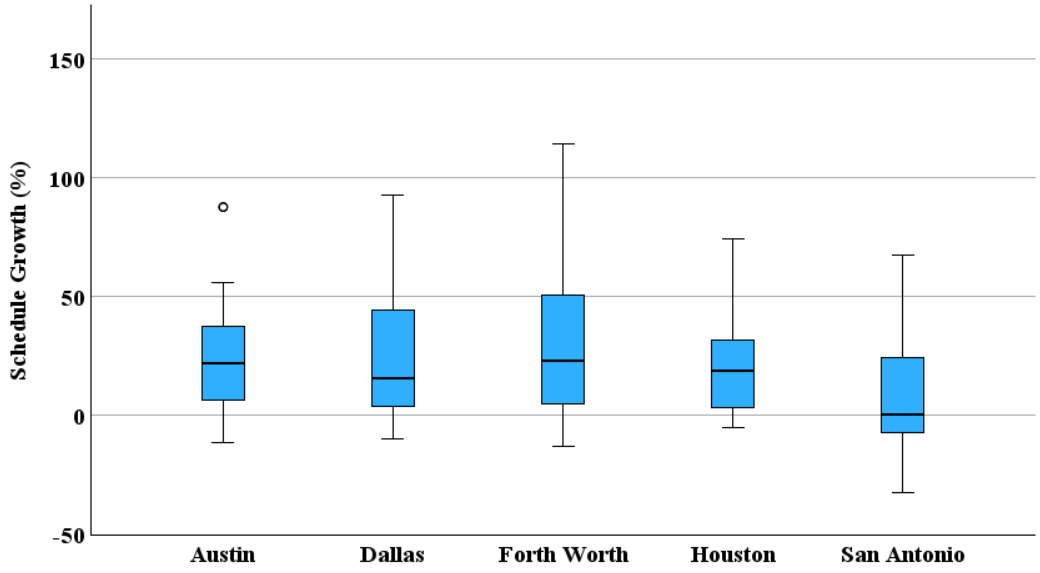

Figure 2. Box plots for Total Schedule Growth

Figure 3 depicts the box plots for the Construction Intensity of highway projects built under five Texas DOT districts. In these box plots, some project data are outliers. However, the authors did not remove these outliers because doing so would create more outliers.

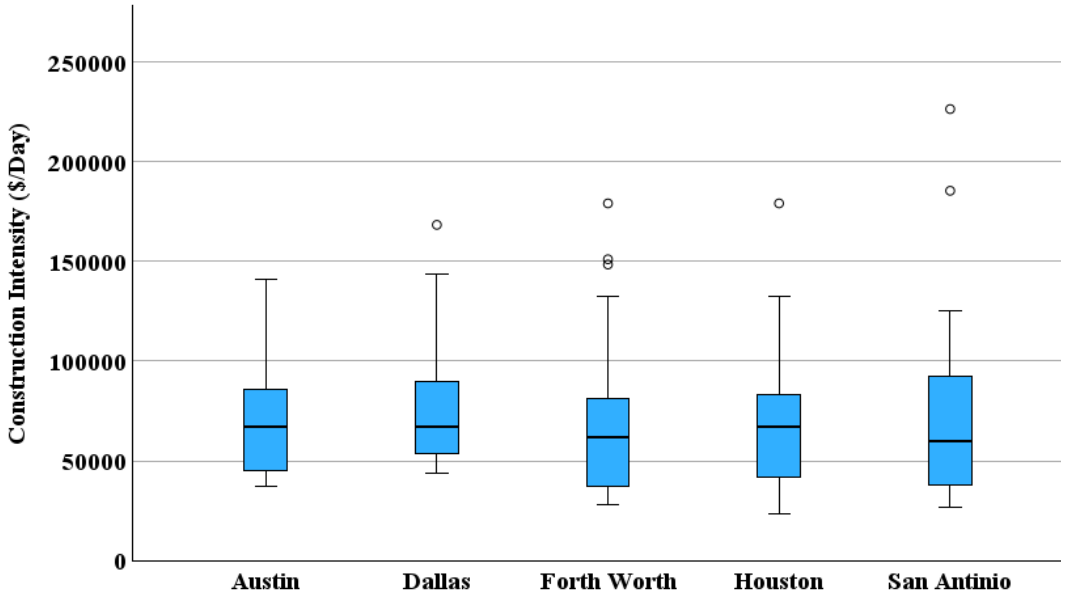

Figure 3. Box plots for Construction Intensity

Statistical Tests Results

Before conducting hypothesis testing, it should be verified that the data for all three metrics are normally distributed. To confirm this, the Shapiro-Wilk test was conducted with Total Cost Growth, Total Schedule Growth, and Construction Intensity data. Table 2 shows the results of this test. The results showed that none of the three data sets were normally distributed, as the p-values were all less than 0.05.

Table 2. Shapiro-Wilk test results

Metrics	No. of Samples	Statistics	P-values
Total Cost Growth	140	0.97	0.01*
Total Schedule Growth	140	0.94	<0.01*
Construction Intensity	140	0.88	<0.01*

** Significant at 0.05 level (reject the null hypothesis)*

As the data were not normally distributed, a non-parametric Kruskal-Wallis test was conducted to determine whether the median values of Total Cost Growth, Total Schedule Growth, and Construction Intensity were significantly different for the highway projects completed by these five districts. Table 3 shows the results of this test. The results showed that the Total Cost Growth and Total Schedule Growth differed significantly across the projects completed in these five districts, as indicated by p-values < 0.05. However, Construction Intensity did not differ significantly across the highway projects completed by these five districts, as the p-value was 0.76 (greater than 0.05), and the null hypothesis was not rejected. This confirms that the median Construction Intensity across all five highway projects is the same.

Table 3. Kruskal-Wallis test results

Metrics	No. of Samples	Statistics	P-values
Total Cost Growth	140	17.90	<0.01*
Total Schedule Growth	140	9.34	0.05*
Construction Intensity	140	1.85	0.76

** Significant at 0.05 level (reject the null hypothesis)*

The post hoc test for the Kruskal-Wallis test was conducted to determine significant differences in Total Cost Growth and Total Schedule Growth among the highway projects completed by these five districts. The post hoc test results are presented in Table 4. This table shows only the projects from locations where significant differences were detected at the 0.05 alpha level. The results show that the Total Cost Growth for highway projects completed by the Houston district (12.16%) is significantly higher than those of Austin (5.37%), Dallas (2.48%), and San Antonio (5.10%). Regarding Total Schedule Growth, the projects completed by the San Antonio district (8.44%) had significantly less schedule growth than those in Austin (26.60%), Dallas (23.20%), and Fort Worth (33.00%). The difference in schedule growth is also significant at the 0.05 alpha level.

Table 4. Kruskal-Wallis post hoc test results

Metrics	Districts - Pairwise Comparison		Test Statistics	P-values
Total Cost Growth	Houston (12.16%)	Austin (5.37%)	30.37	<0.01*
		Dallas (2.48%)	41.32	<0.01*
		San Antonio (5.10%)	5.08	<0.01*
Total Schedule Growth	San Antonio (8.44%)	Austin (26.60%)	27.28	0.01*
		Dallas (23.20%)	22.21	0.04*
		Fort Worth (33.0%)	30.45	<0.01*

** Significant at 0.05 level (reject the null hypothesis)*

Discussions and Conclusions

This study collected the Texas DOT's highway project cost and schedule data, which were completed by various district offices. Management styles and the process of overseeing projects from design to construction vary across offices, so it is hypothesized that cost- and schedule-related project performance will vary depending on who oversees the project. To test this hypothesis, about 140 highway projects with total costs over $10 million were collected. Three performance metrics, e.g., Total Cost Growth, Total Schedule Growth, and Construction Intensity, were used to test this hypothesis. The data were collected from five district offices: Austin, Dallas, Fort Worth, Houston, and San Antonio.

The results show that the average size of the projects considered in this study was about $32 million across all five districts. The statistical tests showed that the Total Cost Growth and Total Schedule Growth vary significantly across districts. It was found that the Houston district has significantly higher cost growth compared to Austin, Dallas, and San Antonio. In contrast, the highway projects completed under the Houston district had significantly lower schedule growth than those completed under the Austin, Dallas, and Fort Worth districts. This study did not focus on identifying the primary reasons for higher cost growth in the Houston district compared to the other three districts. However, some of the possible reasons for cost growth in the Houston district can be the types of projects constructed, rural vs. urban projects, workforce and materials availability, change order management issues, contracting capacity of the district, owner's staffing availability, local permitting regulations, or the relationship between the Houston district and the contractors. As this study concluded that location is correlated with the project performance of highway projects, the State DOT should ensure

that all their district offices are working together in terms of estimating the cost of the projects, change management, partnering, and sharing the best practices that can reduce the cost and schedule growth of their projects.

No such study has been conducted previously to determine whether the locations of district offices affect the cost- and schedule-related performance of highway projects. Even though this study did not correlate project performance with any specific factors, the findings indicate that some factors do affect highway project performance. Therefore, the authors recommend conducting future studies to examine district offices' project management styles and their correlation with highway project performance.

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