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Public-Private Partnership Transportation Projects: An Exploratory Study

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***Abstract*—**When public transportation projects were delivered through design-bid-build and later design-build, governments found a serious issue: inadequate funding. With population growth, governments began to develop new arrangements in which the private sectors were involved to cut the financial burden. This arrangement, Public-Private Partnership (PPP), has its own risks; however, performance outputs can motivate or discourage its use. On top of such output are time and budget, which can be affected by the type of project delivery methods. Project completion within or ahead of schedule as well as within or under budget is among any owner's objectives. With a higher application of PPP in the highway industry in the US and insufficient research, the current study addresses the schedule and cost performance of PPP highway projects and determines which one outperforms the other. To meet this objective, after collecting performance data of all PPP projects, schedule growth and cost growth are calculated, and finally, statistical analysis is conducted to evaluate the PPP performance. The results show that PPP highway projects on average have saved time and cost; however, the main benefit is a faster delivery rather than an under-budget completion. This study can provide better insights to understand PPP highways' performance and assist practitioners in applying PPP for transportation projects with the opportunity to save time and cost.

***Keywords*—**Cost, delivery method, highway, public-private partnership, schedule, transportation.

I. Introduction

FOR years governments delivered infrastructure projects with considerable cost and schedule overruns through the traditional Design-Bid-Build (DBB) method, where a complete design phase is required to begin the construction phase [1]. Turning such linear order of phases into an overlap through one contract under Design-Build (DB) improved the project performance, mainly by time-saving. Despite the wide use of this method, governments faced serious challenges of financial shortage to address the outpacing population growth and demand and replacing old infrastructure. For instance, the Infrastructure Report Card by the American Society of Civil Engineers (ASCE) reveals a need for $2 trillion by 2027 to merely repair old US infrastructure [2], which highlights a staggering funding gap.

To ease the great financial burden on governments, PPP was developed as an arrangement in which private entities contribute to financing, services, risks, and rewards [3]. Like any evolving approach and developing market, PPP effectiveness needs to be investigated after a period of application, and performance analysis can provide a clear view in this regard, which is missed in research studies. Since when PPP has been introduced and adopted in the US in the 1990s, the application rate is not high; however, this study gathered all highway projects delivered through PPP, and analyzed their cost and schedule data statistically to find the performance status of the PPP market thus far.

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II. Literature Review

Studies on PPP project performance are limited despite other areas such as performance indicators, success factors, risk management, roles, finance, and legislation. Most studies focused on the assessment of PPP cost overruns, which indicate more cost savings in PPP over traditional delivery methods [4]. In 2007, [5] compared the performance of 21 PPPs, ranging from water projects to transportation, with 33 traditionally procured projects in Australia. The average cost and schedule overruns indicated PPPs' superior performance (11.6% averaged cost overruns vs. 35.3% for DBB projects and 13.2% averaged schedule overruns vs. 25.6% for DBB projects). Later, the same database was used for further statistical analysis, supporting the previous finding in terms of cost; however, schedule overruns showed no significant difference [6].

In another study, [7] summarized 14 prominent studies to assess the construction cost overruns of infrastructure projects around the world. Most of the studies were focused on European infrastructure projects, including the UK, Norway, Australia, and France. The author included the data from the literature and concluded that the average construction cost overrun of PPP projects was 13%, which is around half of that observed from conventionally procured projects. Reference [8] studied 12 PPP transportation projects, out of which two were in the US and the rest in Canada and compared cost and schedule changes with DB and DBB. Data from the first generation of large-scale PPP highways were collected through interviews with experts. Results showed that in 10 out of 12 projects, cost and schedule did not exceed their contract amounts, and PPP was advantageous to DB and DBB in controlling overruns. The research lacked a statistical comparison of PPP with DB and DBB performance, as Chasey et al. [8] did not collect hard cost and schedule data of DB and DBB projects. Furthermore, such a success ratio cannot be generalized to the US with only two projects.

The initial benchmark of PPP cost and schedule performance for the US transportation sector is a study by [9]. Different types of PPP transportation projects completed by 2013 were

examined. The collected data were verified by carrying out interviews with the parties involved in the projects. Making comparisons with published literature, including PPP projects in the international market and public-funded US projects [10], [11] emphasized the better performance of PPPs. Another study was conducted by [12] which addressed the influence of the contractual arrangement on the PPP performance by making a comparison between the government's goals and the actual outcomes.

Not all the US states have moved toward PPP contracts since 1991, when an act permitting each state to pass the unique enabling legislation on PPP transportation contracts was introduced [13]. Concerning research studies, despite Europe and the UK, a handful of studies focused on PPP project performance targeting the US market [14]. The most extensive research has been international, and there is a noticeable lack of studies in the US construction industry without combining different sectors and project types, focusing merely on PPP highway projects. Taking PPP highway projects including the recent ones into account, this study aims to address the effectiveness of PPP performance in the US highway industry.

III. Research Methodology

After defining the research need and objective and reviewing related literature the data on PPP highway projects were collected. The data were analyzed statistically, and PPP highway project performance was determined, with respect to cost, schedule, and construction intensity.

Data Collection

The existing PPP highway projects are available in Table I. More information on these projects, such as funding sources, can be found on the FHWA website [15]. The states of these 25 PPP highway projects include 15 states and Puerto Rico.

At first, a questionnaire was prepared and sent to all state Departments of Transportation (DOTs) who have completed PPP projects. Official emails were sent explaining the research goal (statistical tests on the whole sample, not individually). The respondents did not fill out the questionnaire, but they provided us with the documents and website links to determine the cost and schedule data of these projects. Thus, most data were collected through online research, along with review of the documents received. The source of the data collection is provided in the dissertation Appendix E [16].

Considering the available data, the main data were covered and/or calculated, including Estimated Completion Cost, Actual/Final Completion Cost, Cost Change, Estimated Duration, Actual/Final Duration, and Time Change. Therefore, the analysis of project performance was carried out using three performance metrics: Total Cost Growth; Total Schedule Growth; and Construction Intensity (design and construction).

Performance Metrics Development

It is necessary to identify cost and schedule performance metrics to compare the performance of PPP highway projects. This study applied widely used performance metrics by previous studies [10], including Total Cost Growth, Total Schedule Growth, and Construction Intensity.

TABLE I
PPP Highway Projects of This Study

Project Name	Location
PPP1. I-495 Express Lanes (Capital Beltway High Occupancy Toll)	Virginia
PPP2. Dulles Greenway	Virginia
PPP3. Elizabeth River Tunnels (Midtown Tunnel)	Virginia
PPP4. I-95 HOV/HOT Lanes	Virginia
PPP5. 91 Express Lanes	California
PPP6. South Bay Expressway (SBX, formerly SR 125 South Toll Road)	California
PPP7. Presidio Parkway (Phase II)	California
PPP8. SH 130 (Segments 5-6)	Texas
PPP9. North Tarrant Express (NTE Phase I) (I-820 and SH 121/183)	Texas
PPP10. LBJ Express (I-635 Managed Lanes Project)	Texas
PPP11. SH 288 Toll Lanes	Texas
PPP12. Port of Miami Tunnel	Florida
PPP13. I-595 Express	Florida
PPP14. US 36 Express Lanes – Phase II	Colorado
PPP15. I-77 Express Lanes	North Carolina
PPP16. Teodoro Moscoso Bridge	Puerto Rico
PPP17. Foley Beach Express	Alabama
PPP18. Penn Rapid Bridge Replacement Project	Pennsylvania
PPP19. Ohio River Bridges – East End Crossing	Indiana/Kentucky
PPP20. I-69 Section 5 (known as a failure)	Indiana
PPP21. State Street Redevelopment Project	Indiana
PPP22. Goethals Bridge Replacement	New York/Jersey
PPP23. Northwest Corridor	Georgia
PPP24. Greenville Southern Connector	South Carolina
PPP25. Southern Ohio Veterans Memorial Highway	Ohio

Based on the actual completion and estimated completion cost, *Total Cost Growth,* the amount of cost saving or overrun, was calculated as (1):

$$\text{Total Cost Growth}(\%) = \frac{\text{Total completion cost} - \text{Estimated cost}}{\text{Estimated cost}} \times 100 \quad (1)$$

Based on the actual completion and estimated completion duration, *Total Schedule Growth*, the amount of time saving or overrun, was measured as (2):

$$\text{Total Schedule Growt}(\%) = \frac{\text{Total completion duration} - \text{Estimated duration}}{\text{Estimated duration}} \times 100 \quad (2)$$

A further schedule-related metric is *Construction Intensity,* which can be calculated with the actual design and construction completion cost and duration as (3):

$$\text{Construction Intensity } \left(\frac{\$M}{day}\right) = \frac{\text{Total design and construction completion cost}}{\text{Total design and construction completion duration}} \quad (3)$$

Being defined as the daily total cost of work, *Construction Intensity* measures the speed with which the project is completed according to the amount of money spent and shows

how fast a project is completed [17], which in this study means how fast a project is designed and built.

IV. Data Analysis

Before analyzing the cost data of PPP projects, the estimated completion cost of projects was adjusted to the base cost of 2021 using Engineering News-Record (ENR) [18]. It was appropriate to use National Highway Construction Cost Index (NHCCI) provided by Federal Highway Administration (FHWA), however, NHCCI has only a cost index starting from 2004 [19]. Some projects included in this dataset were completed before 2004. Therefore, ENR cost indices were used to convert the cost data of these projects based on the cost of 2021 [18].

Descriptive Statistics

Cost and Schedule Data

The collected data were analyzed for descriptive statistics and revealed the average and median adjusted final completion cost of PPP as $1.018 billion, and $747.16 million, respectively. Also, the average final completion duration was found to be 831 days, while the estimated completion duration was 856 days.

Cost and Schedule Performance Metrics

Table II shows the mean and median of PPP highway projects. The total cost growth was negative, which indicates that the PPP projects had cost savings. The analysis of total schedule growth data showed that PPP projects on average were completed ahead of estimated durations with a negative mean value. In terms of working days PPP projects saved 6 days on average. The median total schedule growth was 0, indicating that half of the PPP projects were completed on time. The minimum value of total schedule growth was -20.05%, and the maximum was 40.00%. The analysis of construction intensity data showed that the mean for PPP was 0. It is evident from the results that, on average, PPP projects result in higher time saving than cost savings.

TABLE II
Descriptive Statistics of PPP Performance Metrics

PPP Highway Projects	Mean	Median
Total Cost Growth	-0.44%	0%
Total Schedule Growth	-0.67%	0%
Construction Intensity	1.3 M$/day	1.2 M$/day

The construction intensity was found to be high in PPP projects ($1,300,000/day). One possible reason is the private sector's willingness to complete projects faster due to the value for money. This involves private agencies' motives for and expectations from such partnerships as a return on their investment after a project's completion, which facilitates increased project intensity and faster project delivery.

In PPP projects, the private sectors fund a major part of the projects while some sources of funding come from the owner. Therefore, the private sectors have a vested interest to complete the project faster for value for money. Another reason might be due to engaging a greater number of various specialized advisors, experts, and third parties, which results in higher contract costs and money spent per day during project delivery. This finding shows that the PPP delivery method can be beneficial to owners if private financing/or operations/or maintenance are needed in a project. Also, results show a negative mean value for the cost growth (-0.44%), which indicates completion under budget. About half of the PPP projects had negative total cost growth. This lower cost growth may lie in the fact that the private sector's involvement reduces the challenging pressure of lack of public funds and helps better meet cost-saving goals. Regarding the negative mean of total schedule growth and completions ahead of schedule (-0.67%), one possible reason could be the higher involvement of various parties and external experts in PPP and subsequently the challenges of managing coordination, communication, and speed up work, while maintaining quality. In PPP projects, the schedule is important but not as important as the cost, as the private parties always look for a higher return on investment. However, it was found that under PPP delivery, greater benefits, in terms of schedule, have been achieved compared to cost benefits.

V. Conclusions

Project completion within or ahead of schedule as well as within or under budget is among any project's objectives. With a higher application of PPP in the highway industry in the US and insufficient research, PPP's effectiveness needs to be examined. The current study filled this research gap in infrastructure project delivery methods and contracts by addressing a quantitative assessment of the project performance of all PPP highway projects in the US, including the most recently completed ones. This study found that on average, the PPP projects had completions ahead of schedule as well as cost underruns. Also, it was revealed that PPP projects can result in schedule benefits to a greater extent compared to cost benefits. The primary contribution of the present study to the body of knowledge is to address the project performance of PPP highway projects in the US from the outset until the present. This study's findings can encourage entities in the US highway industry to consider PPP among their top choices and employ it more confidently.

Nonetheless this study had some limitations. Data accessibility was the major challenge preventing a more in-depth analysis of some elements in the performance data. By accessing all PPP contracts, more performance metrics could be studied, such as change orders, safety, and quality. Future research should include other variables, such as project procurement process and management style to determine whether these variables might have a more significant impact than project delivery methods on project performance.

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