DOI: 10.38027/ICCAUA2021212N3

The Study of the Use and Application of Design-Build Contracts and Build-Operate-Transfer Contracts in Construction Sector of Turkey

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Abstract
Design-Build (DB) and Build-Operate-Transfer (BOT) contracts are the two types of public-private-partnerships that are widely used in the region that are aimed in this study. The objectives of this study were to analyze and compare DB and BOT projects in terms of project costs and durations. In order to analyze and compare Design-Build (DB) and Build-Operate-Transfer (BOT) projects, this study collected data by means of convenient random sampling, from construction projects built by five ministries of Republic of Turkey. Statistical tests were conducted to determine if the metrics related to cost and schedule were significantly different from each other in these two types of projects. The findings of this study will help the public agencies decide what delivery method is best for their projects in terms of controlling costs and schedule. Results show that DB projects outperform BOT projects in terms of cost and schedule. The results of this research will enable governments to become more familiar with comparisons between DB and BOT distribution methods, and the findings will help the ministries to choose swhich delivery method is suitable for use on a project-based.
Keywords**:** Design-Build; Build-Operate-Transfer; Cost; Duration.

1. Introduction

The emergence of a public-private partnership gives governments the option to meet their infrastructure needs and demands in alternative ways. Acquisition of infrastructure projects using these methods requires both public and private sectors to adopt new skills, roles, responsibilities and risks, thus effectively managing all phases of a project's life cycle. Governments around the world are increasingly turning to public-private partnerships and public concession models to help create and finance infrastructure initiatives. However, infrastructure investors are concerned about the reliability of governmental partners, agreement structures and the long-term viability of some roads (Miller, 2013).
Design-Build (DB) is an old construction method. Former builders operated as an integrated service provider in design and construction. However, the use of other systems of the last century, for example, was dominated by the emphasis on competitive tendering. Recently, the situation has changed and the popularity of DB has increased dramatically. It is increasingly used in all types of construction and seems to be in greater demand in the future, (Kumar, Joshi 2016). Build-Operate-Transfer (BOT) delivery method can be defined as a start-up business initiative wherever personal organizations offer to create and operate a project that can normally be initiated by the government and can deliver ownership to the state. The BOT method is an alternative for the government to direct public projects to the private quarter. In addition to BOT, the private sector designs, finances, builds and manages the project, and ultimately the property is transferred to the government when a detailed concession amount is found, (Kumar, Joshi 2016).
BOT contracts prior to 1984, was applied by a limited number of western countries, the major reason of application of BOT model by Turkey and other countries in addition to the inadequacy of the public sector, the idea was to give some privileges to entrepreneurs wishing to invest in areas under state control.
This research is based on previous studies on building and highway construction projects. This study also collected data from projects completed by ministries within the scope of DB project delivery system and BOT project delivery system.
According to Bennett and Grice (1992), in terms of certainty over time, DB can provide complete contract certainty for customers from the earliest stages of their project, unless many changes have been made for the time of most customers. In general, DB encourages the design and construction phases to overlap. Bidding and redesign phases are eliminated the two events that may arise with a traditional approach. Procurement of materials, equipment and advanced construction works can precede at the same time before the construction certificate is completed.
Gransberg and Molenaar (2007), the DB project distribution system can reduce the overall project duration by approximately 14.5 percent. FHWA compared DB model estimates and found that on average DB projects saved 14 percent of the time. Florida DOT found a 37 percent time savings in the first 11 DB demonstration projects compared to the DB project distribution system.

Hale et al. (2009), used ANOVA analysis to compare the performance of DB projects, statistical analysis was used to determine which project distribution method was better than the other, ANOVA analysis was used to determine whether the differences were statistically significant. Hale et al. concluded that the cost growth for DB projects was significantly 4 percent lower than the cost growth for DBB projects. It was also concluded that the duration was significantly lower for DB projects. As a result of their study DB projects took less time, there was less cost growth, and projects are less expensive to build by DB project delivery method.

The standard structure for the risk of completion in a BOT project is a fixed-price, fixed-time construction contract with a reputable contractor with sufficient penalties for delays and cost overruns. This contractor's obligation is usually accompanied by a guarantee of completion by shareholders covering any excesses and delays that are not the responsibility of the contractor under the construction contract. By structuring the construction contract in this way, the risk of shareholders is minimized and the contractor takes most of the risk. The risk involved at this stage is high and potentially significant losses.

The amount offered by the Contractor is usually fixed. Therefore, DB cannot demand surplus from the customer if the contractor is subjected to extra costs due to errors in design or construction. Generally, DB projects are evaluated with a guaranteed maximum price. With a guaranteed maximum price, the designer must submit the project at or below the guaranteed price. This should encourage the design builder to use experience, imagination and creativity to benefit both parties. On the other hand, the tendency of flexibility in design changes in DB projects is much lower, so the degree of change is very low compared to BOT projects. Therefore, cost increase in DB projects is less, (Ratnasabapathy and Rameezdeen, no date).

In BOT projects, sponsors and contractors may fail to meet the quality requirements or may not be able to provide the final completed project according to the specification. Under these circumstances, such as the risk of time-out, it can cause project delays and thus increase costs. To overcome this risk, designers and supervisors must seek help from the insurance agent to insure their professional obligation. If necessary, it may seek support from the international insurance agency for insurance renewal through national insurance renewal procedures (Yang et al. no date).

Quality control should start at the early stage of design planning rather than construction. DB quality control is the most difficult to control because DB works immediately. Therefore, suitability to quality depends to a large extent on the original design and planning stage (Saaidin et al. 2016).

The motivation behind this research is the desire of the ministries to choose the most appropriate project distribution method according to their project needs and to obtain a more efficient method that meets their programs and makes their costs and time manageable.

2. Material and Methods

The steps in the research methodology are explained in this section. The study used statistical analysis to compare the cost and schedule performance measurement of BOT and DB operated by 5 ministries of Republic of Turkey.

The histogram in Figure 1 shows the number of DB projects for each Ministry.

This histogram shows that the maximum number of DB projects is associated with the Ministry of Energy and Natural Resources. The reason that the Ministry of Energy and Natural Resources and the Ministry of Transport and Infrastructure have more DB projects points to the fact that more projects are carried out per year for the two ministries. Ministries have started to use the DB distribution method in public projects long time ago and have determined that this method works well in the procurement system.

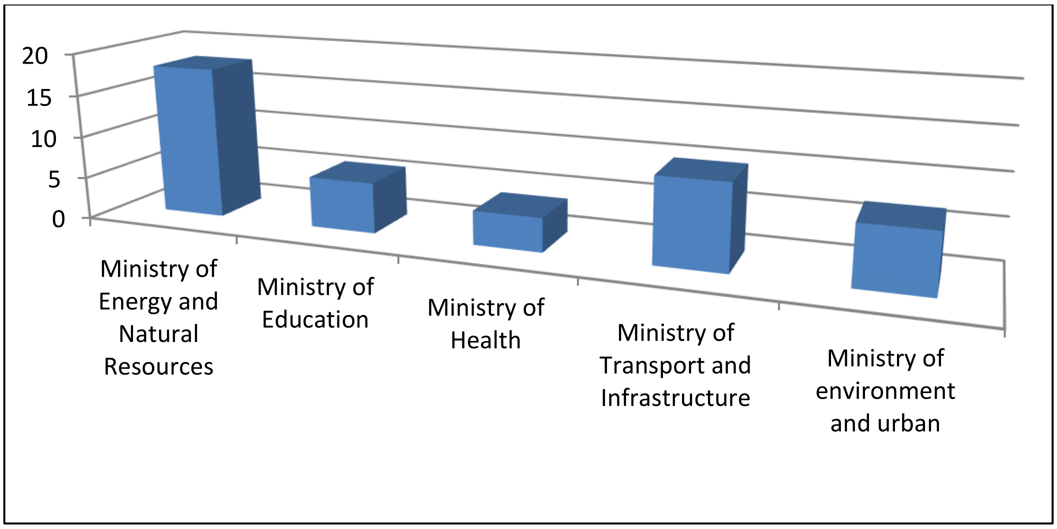

Figure 1. Number of DB projects in each ministry.

The histogram in Figure 2 shows the total cost range for the DB projects collected in this study.
Approximately 15 percent of DB projects collected in this study have a cost range less than $1 million. Approximately 36 percent of the DB projects collected is a combination of projects ranging from $1 million to $10 million. 22 percent of projects ranging from $10 million to $100 million. The remaining 27 percent of DB projects' costs are between $ 100,000 and $ 1billion. Finally 0 percent for the projects' costs which are over $1 billion.

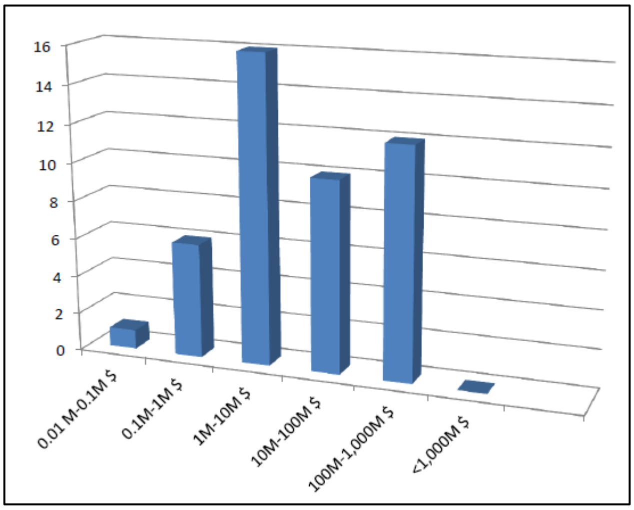

Figure 2. Total cost range for DB projects.

The histogram in Figure 3 shows the number of BOT projects by each Ministry. The study shows the highest rate for BOT projects refers to Ministry of Energy and Natural Resources and Ministry of Transport and Infrastructure. This rate also refers to the higher number of projects performed by these two ministries.

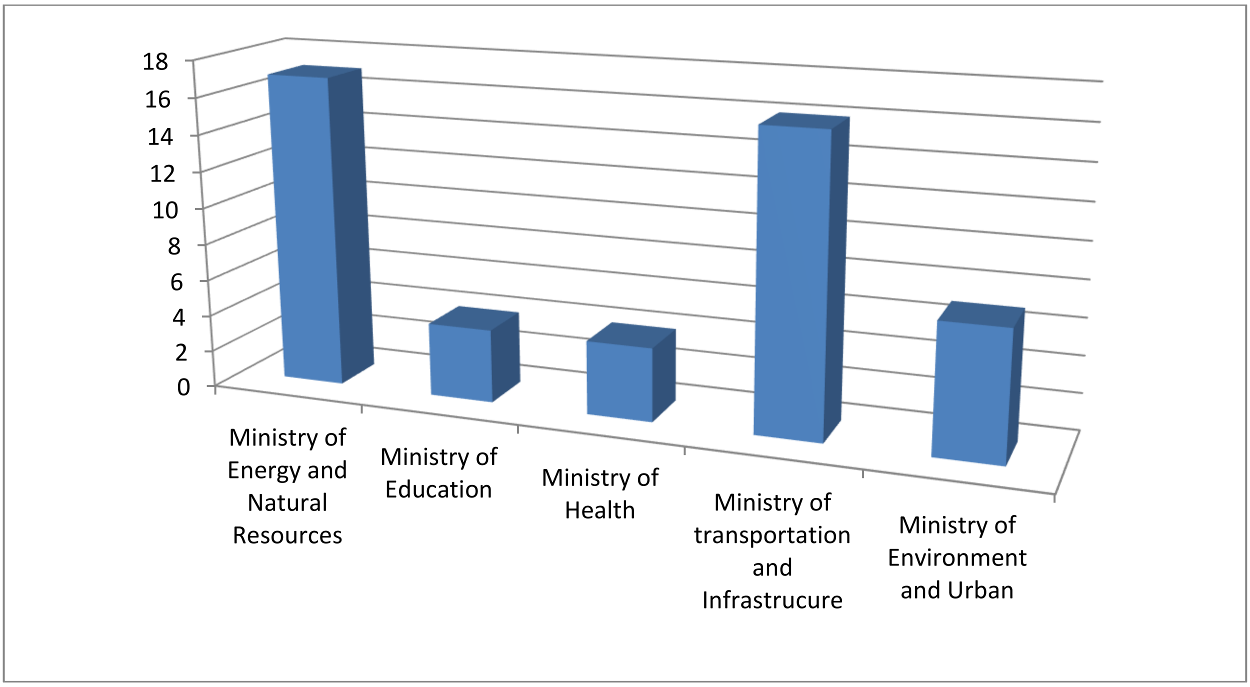

Figure 3. Number of BOT projects in each ministry.

The histogram in Figure 4 shows the total cost range for the BOT projects collected in this study. About 6 percent of the BOT projects collected in this study had a cost range between 1 million and 10 million dollars. And nearly 31 percent of the cost of projects ranged from $ 10 million to $ 100 million, and the highest value in the cost range ranged from $ 100 to $ 1 billion, which was 44 percent and the remaining 19 percent of BOT projects were above $ 1 billion.

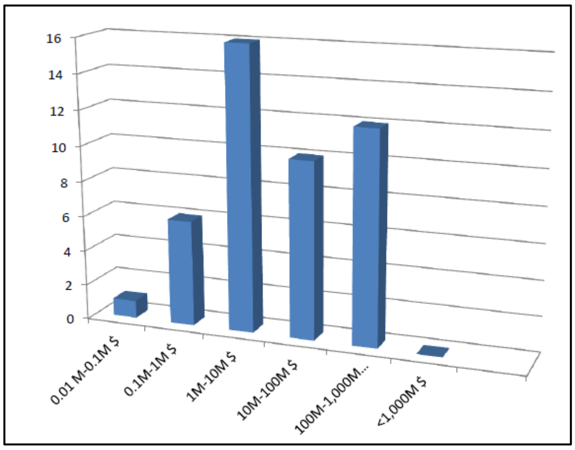

Figure 4. Total cost range for BOT projects.

2.1. Data Analysis

2.1.1. Statistical Tests

The data were analyzed using two-way Analysis of Variance (two-way ANOVA) test, Levene's test, Shapiro Wilk test and a t-test for unequal variances.

To use the two-way ANOVA test, the following four assumptions were assumed;

- The sample is randomly selected or through a suitable random sampling,
- Dependent variable must be on the range scale or rate scale,
- Depending on the dependent variable normally distributed, and
- The variances of the two groups should be equal.

Levene's test is used to evaluate the homogeneity of variances, which is a prerequisite for parametric tests. The significance of the Levene's test is below 0.05, if the variances are significantly different and parametric tests cannot be used. Levene's test assumed that the variances of the two groups were the same.

The Shapiro Wilk test is used to test normality. This test rejects the null hypothesis when the P value is less than or equal to 0.05. Rejecting the normality test ensures that the data has a 95 percent confidence that the data does not conform to the normal distribution. Not refusing the normality test only allows the researcher to indicate that the data was normally distributed.

The t-test with unequal variances is used to check whether the data of the two sets of samples are significantly different when their variances are not equal. The typical way to do this is to state that in the null hypothesis, the tools of the two sets of samples are equal. The t-test used in this study to assume normal distribution of unequal variances.

2.1.2 Study Hypothesis

To perform the statistical test, test hypotheses are determined as follows;

The null hypothesis Ho: $\mu 1$ (DB) = $\mu 2$ (BOT);

Alternative hypothesis H1: $\mu 1$ (DB) $\leq$ $\mu 2$ (BOT)

μ 1 indicates the Design-Build mean and $\mu 2$ indicates the Build-Operate-Transfer mean.

Ho's acceptance means that the type of data has no significant impact on project performance. Acceptance of H1 means that there is a significant difference between the performance of DB and BOT projects for a given performance indicator.

3. Findings

3.1 Normality Assumption Test

Figure 5 shows the costs of DB and BOT projects for all ministries. The histograms do not follow a normal distribution because both of the graphics are shifted to the left. A Shapiro test was also performed to analyze normality numerically.

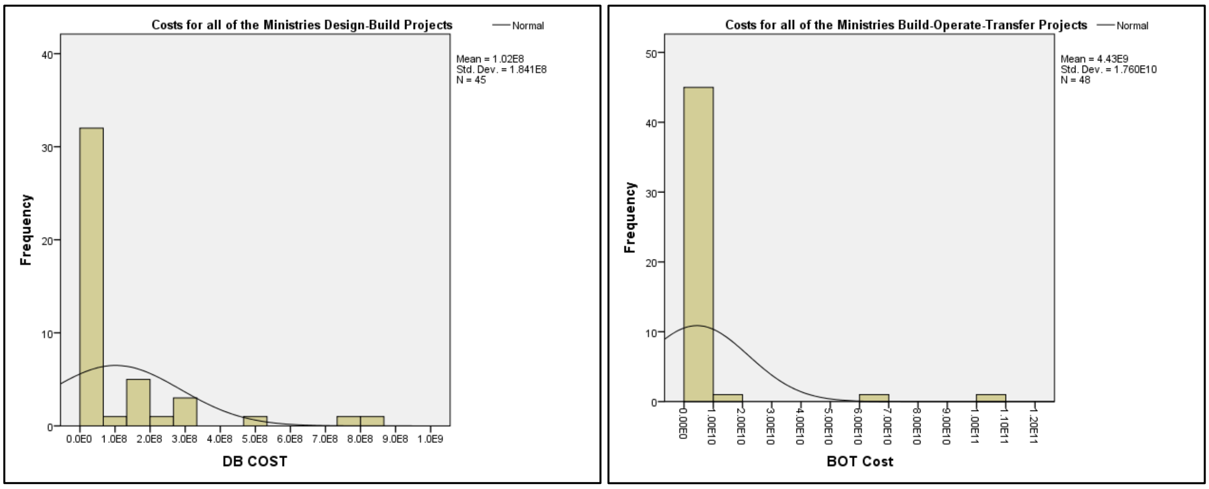

Figure 5. Cost histograms of projects for all of the ministries.

Table 1 shows the results of the Shapiro test for the costs of the projects of all ministries. It indicates that the p value is less than 0.05 for both types of projects, so the null hypothesis is rejected for normality since the data is not normally distributed.

Table 1. Shapiro Wilk test for the cost of all of the ministries' projects

Performance metrics	Statistics	P Value
DB Projects' Costs	0.612	P < 0.01
BOT Projects' Costs	0.267	P < 0.01

Note: P value is significant at 0.05 alpha level

Figure 6 shows the durations of DB and BOT projects for all ministries. The graphics do not follow a normal distribution because both graphics are shifted to the left. A Shapiro test was performed to determine if the data follows the normal distribution.

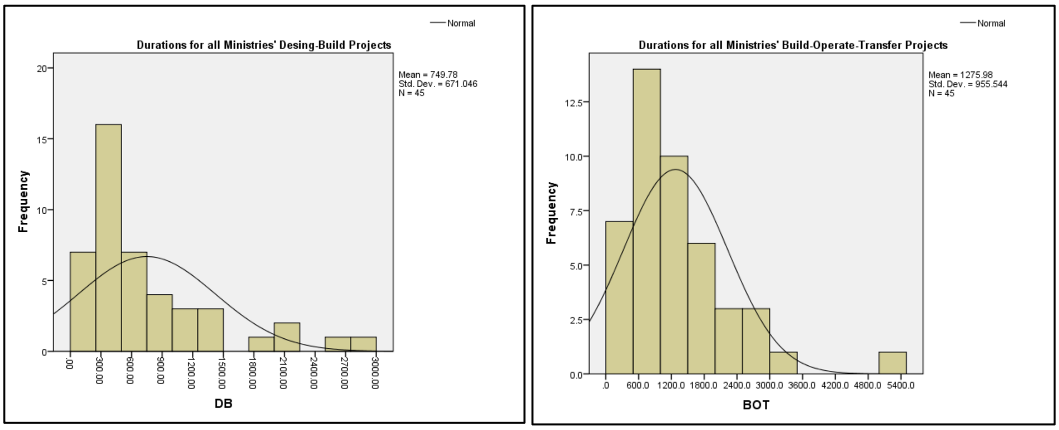

Figure 6. Duration histograms of projects of all of the ministries' projects.

Table 2 shows the results of the Shapiro Wilk test, which shows that the time data in the DB and BOT of projects are not normally distributed as the p value is less than 0.05. The results of this test reject the null hypothesis where the data is normally distributed.

Table 2. Shapiro Wilk test for the durations of all of the ministries' projects.

Performance metrics	Statistics	P Value
DB Projects' Durations	0.809	P<0.01
BOT Projects' Durations	0.818	P<0.01

Note: P value is significant at 0.05 alpha level

However, the ANOVA test is a robust test and since the data is larger than 30 samples, a violation of normality does not affect the test results.

3.2. Equal Varıance Test

Table 3 shows the Levene statistics of cost metrics. The cost metrics of M2, M3 and M5 have p values of more than 0.05. However, the p values for M1 and M4 are below 0.05. Therefore, the variance of the cost metrics in DB and BOT are not equal for projects M1 and M4. In addition, the variances of the costs of all ministries' projects are not equal, since the p value is below 0.05. To overcome the violation of this assumption, the costs of these two groups should be compared statistically using the t-test, assuming unequal variances.

Table 3. Variance test homogeneity results for cost metrics for all ministries' projects.

Ministries	Statistics	P Value
M1 Projects' Costs	5.793	0.022
M2 Projects' Costs	4.703	0.062
M3 Projects' Costs	5.087	0.065
M4 Projects' Costs	6.215	0.020
M5 Projects' Costs	2.493	0.140
Costs for all of the Ministries Projects' Costs	8.821	0.004

Note: P value is significant at 0.05 alpha level

Table 4 of these groups are equal. If the p value is less than 0.05, the null hypothesis of equal variances is rejected. All timing metrics have a p value greater than 0.05, except for the duration of M5 projects. Therefore, the duraion metrics of M5 projects' variances are not equal. Also, the differences of the duration of all ministries of projects are not equal, since p value is more than 0.05. To overcome the violation of this assumption, the tools of these three metrics should be compared statistically using the t-test, assuming unequal variance.

Table 4. Variance test homogeneity results for duration metrics for all ministries' projects.

Ministries	Statistics	P Value
M1 Projects' Durations	0.002	0.967
M2 Projects' Durations	1.340	0.280
M3 Projects' Durations	1.212	0.313
M4 Projects' Durations	4.085	0.055
M5 Projects' Durations	10.452	0.007
Costs for all of the Ministries Projects' Durations	2.179	0.143

Note: P value is significant at 0.05 alpha level.

The results of ANOVA and t-tests for the costs of the projects of the five ministries are shown in Table 5, the results show that the cost averages of only M2 projects differ significantly between DB and BOT projects, but statistical analysis is significant. There is also a big difference between the averages of DB and BOT projects for all ministries. However, the results are statistically significant. ANOVA test was performed for M2, M3 and M5 ministries to determine whether their averages differ significantly. However, for the data of M1, M4 and all ministries together, since the variances of these groups are not equal, t-test was performed for unequal variances. The findings show that they were not statistically significant for the t-test and ANOVA tests, except for M5 ANOVA results.

Table 5. ANOVA and t-test for Unequal Variance Results of Cost Metrics.

Ministries	DB Projects' Means	BOT Projects' Means	T Statistics	P Value
M1	122767736.7	278943558.2	-1.733	0.092
M2	19468590.8	129621212.1	9.790	0.014
M3	201089595.5	129621212.1	0.150	0.712
M4	95317829.8	12917209494.0	-1.376	0.182
M5	69890199.1	44435901.5	0.137	0.718
All Ministries	101631086.2	4432617883.0	-1.650	0.102

Note: P value is significant at 0.05 alpha level.

4. Conclusion

The projects include highways, schools, hospitals, dams, airport terminals, offices and residential projects. The examples are large enough with 93 projects in total, 45 DB projects and 48 BOT projects.

4.1. Cost

The results of the average costs of the ministries show that the costs for DB projects for M3 and M5 ministries are higher than the mean costs of BOT projects. For M1, M2 and M3, there is a significant difference between the average costs of project types, where the costs of BOT projects are higher than DB projects.

The results of ANOVA and t-test analysis also show that the results are statistically significant for ministries M1, M3, M4 and M5, except M2, where the P value is less than 0.05. In addition, to the ANOVA analysis for each ministry, the cost analysis of all ministries was done together and consequently the p value was found to be statistically significant.

4.2. Duration

Besides median values, results for average project times showed that the duration of BOT projects for all ministries except M3 was significantly higher than DB projects.

ANOVA analysis results for project times show that they are statistically significant for M1, M2, M3 and M5 with P values greater than 0.05. However, M4 results were found to be statistically insignificant.

In addition to the ANOVA analysis conducted separately for each ministry, the duration analyzes for all ministries were done together and the result was found to be statistically insignificant.

The results of this research will enable governments to become more familiar with comparisons between DB and BOT distribution methods, and the findings will help the ministries to choose swhich delivery method is suitable for use on a project-based.

Acknowledgement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interests

The Authors declare no conflict of interest.

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