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# Temporal analysis of project completion-a comparative study between Public-Private Partnership (PPP) and private sector in the energy infrastructure

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## Abstract

The present study conducted to understand the timeline dynamics associated with project completion in the context of Public-Private Partnership (PPP) and the Private Sector. It is commonly recognized that PPP projects typically exhibit long durations compared to similar projects undertaken by the private sector. Semi structured questionnaire survey was conducted to collect data from the Industry experts on PPP and Private Sector projects. Subsequent to careful data cleansing, the structured dataset underwent for statistical analyses. Our findings indicate that building PPP projects takes significantly more time compared to private sector projects. The results suggest to identify ways to speed up project delivery. It is found that using Blockchain Technology, especially Corda, can help track project progress easily, closing gaps and making projects faster.

**Keywords:** Public Private Partnership (PPP); Energy Sector; Infrastructure projects; Block Chain

## 1. Introduction

The prevalence of public-private partnership (PPP) mechanisms as a strategic approach for implementing infrastructure projects is well-established internationally. Over the recent decades, there has been significant growth in the use of Public Private Partnership (PPPs) as a predominant methodology for the execution of infrastructure projects. This is evidenced by studies done by Al-Saadi and Abdou (2016), Alfen et al. (2009), and Li et al. (2005).

PPP is a strategy for the economic value of infrastructure outputs, and it covers a wide range of public-sector infrastructure (Cui et al., 2018). There has been a proliferation of schemes encouraging public-private sector collaboration to improve infrastructure through a broad variety of economic activities (Ullah et al., 2016). PPP agreements have been adopted by governments in many countries. Concerns over government spending is one explanation for this trend. These structures are viewed as a key component of modernizing public services, with the aim of improving their quality and performance (Carbonara et al., 2014). The paper highlights that successful implementation of PPP depends to a large extent, on the development of capacity, sound legal procedures, agreements, and contracts that clearly define the relationship between government agencies and private firm. (*Rachael Nsasira, Benon C. Basheka, Pross. N. Oluka, 2013).*

## 2. Material and methods

The current study incorporates both descriptive and exploratory elements. It relies predominantly on secondary data sourced from various government portals. The gathered information underwent analysis to address the research problem, and it is also found from diverse sources such as research papers, reports, and success stories accessible in the public domain.

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### 2.1. Data Collection Method

For better understanding the key issues discussions were undertaken with various department of the State Governments with high PPP projects turnover. Discussions were also held with various developer in infrastructure project domain and potential private player. Data on the website of various State Government and Government of India Department were analysed. Additionally, the date was collected from the web portal of PPP India.

### 2.2. Data Collection Tool

Data were collected from PPP project undertaken in the country and projects undertaken by private developers. There are two types of the collection of the secondary data (internal and external). The data of the PPP projects undertaken by various departments in the State of Madhya Pradesh were considered as internal source, whereas external sources included data from secondary sources like websites (government department and non-government organizations) and other published data which are available in the libraries and internet.

### 2.3. Sampling Methodology

The research is based on the comparative study of public private partnership (PPP) and private entity. So, the sampling framework was prepared in such a manner whereby all the information about PPP projects and private sector work in the energy infrastructure projects could be collected. The data available for government infrastructure projects and the private infrastructure project in different websites and the data for energy sector were imported in excel spreadsheets. All the collected spreadsheets were cleaned for missing and wrong information (including all possible outliers) and then the useful information was extracted for final data collection.

Statistical analysis was performed on the collected data to derive conclusions. To achieve this, a crucial element in the field of statistics, namely the sampling distribution, was utilized. The sampling distribution of the sample mean represents the distribution obtained by drawing an infinite number of samples from the population and calculating the mean of all the collected sample means

Hypothesis testing Technique (T -Test) was applied to test the significance of population parameters at 5% significance level.

### 2.4. Hypothesis Testing

Hypothesis testing was conducted to determine if there exists a significant difference between the mean completion time of energy sector PPP projects and energy sector private sector infrastructure projects.

#### *2.4.1. Scenario 1*

Null Hypothesis (H0): To study the significance relationship between Mean completion time of energy sector PPP projects is equal to mean completion time of energy sector private sector infrastructure projects.

Alternative Hypothesis (H1): To study there is no significant relationship between Mean completion time of energy sector PPP projects is not equal to than the mean completion time of energy sector private sector infrastructure projects. On the basis of above results. following study was also conducted.

#### *2.4.2. Scenario 2*

Null Hypothesis (H0): To study Mean completion time of energy sector PPP projects is equal to mean completion time (population mean) of all PPP projects undertaken in the Country.

Alternative Hypothesis (H1): Mean completion time of energy sector PPP projects is not equal to mean completion time (population mean) of all PPP projects undertaken in the Country.

#### *2.4.3. Scenario 3*

Null Hypothesis (H0): Mean completion time of energy sector private sector infrastructure projects is equal to mean completion time (population mean) of all private sector infrastructure projects undertaken in the Country.

Alternative Hypothesis (H1): Mean completion time of energy sector private sector infrastructure projects is not equal to mean completion time (population mean) of all private sector infrastructure projects undertaken in the Country.

### 2.5. Data Analysis

An analysis was undertaken to review the average construction period (in days) for PPP projects in Energy Sector. Summary of the Descriptive Statistics of the sample data of 77 such PPP project data acquired is presented below:

**Table 1** Descriptive Statistics of Completion Period for PPP projects in Energy Sector

| **Completion Period** | |
|---|---|
| Mean | 2183.87 |
| Standard Error | 175.86 |
| Median | 1715 |
| Standard Deviation | 1543.19 |
| Sample Variance | 2381440.88 |
| Kurtosis | 1.42 |
| Skewness | 1.28 |
| Range | 7044 |
| Minimum | 147 |
| Maximum | 7191 |
| Sum | 168158 |
| Count | 77 |
| Confidence Level (95.0%) | 350.26 |

It was observed that the mean Completion Period (Gestation Period) is around 2183.87 days but the maximum number of days comes to around 7191 days. The data was examined for the possibilities of probable outlier to reduce noise in the data statistics. The box pot was plotted to find out the possible outliers.

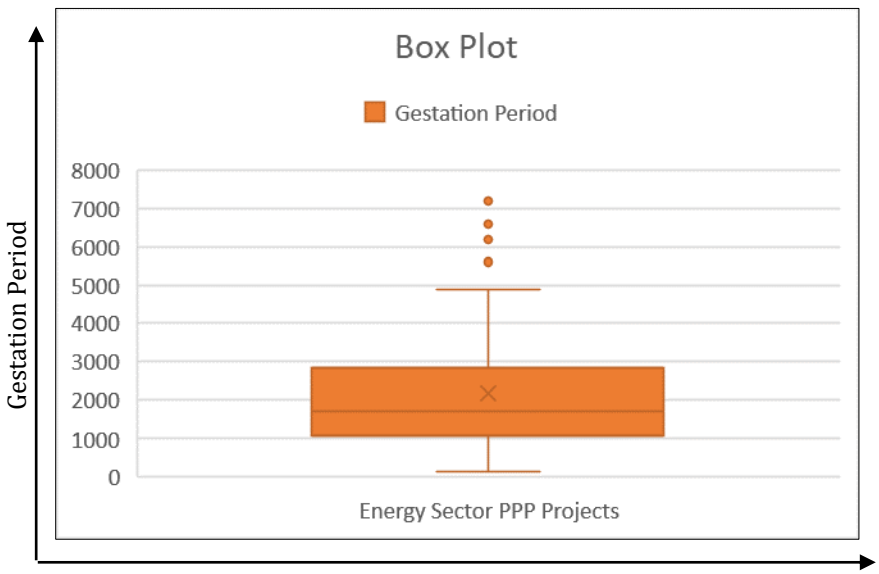


**Figure 1** Box Plot Showing possible outliers

It was observed that a there were few values above the higher whisker of the box plot the same were removed as a part of data cleaning exercise. The various statistics for computation of outliers for first quartile an amount was 1070, for third quartile amount 2337, Inter Quartile Range (IQR) 1767 and 1.5. IQR 2650.5 with upper limit 4365.5 Based on this,

all project completion period figures greater than 4366 were removed and the revised descriptive Statistics of the sample Energy Sector PPP projects is presented below.

**Table 2** Descriptive Statistics of Completion Period without Outlier

| **Completion Period** | |
|---|---|
| **Mean** | 1859.94 |
| Standard Error | 128.49 |
| Median | 1596.00 |
| Mode | #N/A |
| Standard Deviation | 1082.67 |
| Sample Variance | 1172180.63 |
| Kurtosis | -0.50 |
| Skewness | 0.63 |
| Range | 4106.00 |
| Minimum | 147.00 |
| Sum | 132056.00 |
| Count | 71.00 |
| Confidence Level (95.0%) | 256.26 |

From the table above, it is evident that the mean completion period for Public-Private Partnership Projects in the Energy Sector still exceeds 1850 days. Upon analyzing the frequency distribution of the completion period on the histogram with a bin distribution of 500 days, it was observed that a Pareto frequency delay corresponds to the completion bin of 2500 days.

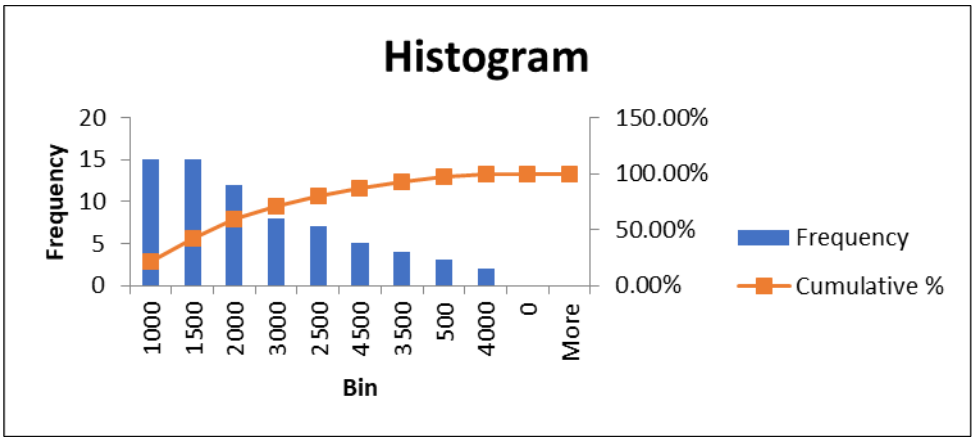


**Figure 2** Frequency Distribution of the Completion Period for PPP Project in Energy Sector

### 2.6. Private Sector Energy Projects

A similar analysis was conducted for the Private Sector Energy Projects. The data for this analysis were taken from the infrastructure project data base available on the various government department portal.

The data obtained was cleaned and analysed in a similar manner. Summary of the Descriptive Statistics of the sample data of 443 such Private Energy Sector project data acquired is presented below:

**Table 3** Descriptive Statistics of Completion Period for projects undertaken by Private Sector

| **Completion Period** | |
|---|---|
| Particulars | Value |
| Mean | 688.07 |
| Standard Error | 29.98 |
| Median | 459.00 |
| Mode | 881.00 |
| Standard Deviation | 631.02 |
| Sample Variance | 398188.17 |
| Kurtosis | 8.05 |
| Skewness | 2.39 |
| Range | 4962.00 |
| Minimum | 90.00 |
| Maximum | 5052.00 |
| Sum | 304816.00 |
| Count | 443.00 |
| Confidence Level (95.0%) | 58.92 |

It was observed that the mean Completion Period is around 688 days but the maximum number of days comes to around 5052 days. The data was examined for the possibilities of probable outlier to reduce noise in the data statistics. The various statistics for computation of outliers given as first quartile value was 268, for third quartile, 910, Inter Quartile Range (IQR) value was 642 and 1.5 IQR it was 963 and upper limit found as 1422. Based on the above all project completion period figures greater than 1422 were removed and the revised descriptive statistics of the sample Private Sector Energy Projects is given below

**Tabel 4** Private Sector Energy Projects is presented below

| **Completion Period** | |
|---|---|
| **Particulars** | **Value** |
| Mean | 534.37 |
| Standard Error | 16.81 |
| Median | 426.00 |
| Mode | 881.00 |
| Standard Deviation | 338.20 |
| Sample Variance | 114382.22 |
| Kurtosis | -0.60 |
| Skewness | 0.71 |
| Range | 1327.00 |
| Minimum | 90.00 |
| Maximum | 1417.00 |
| Sum | 216421.00 |

| | |
|---|---|
| Count | 405.00 |
| Confidence Level (95.0%) | 33.04 |

From the table above, it is observed that the completion period for private sector government projects in the energy sector is approximately 543.37 days (1.48 years)

### 2.7. Hypothesis Testing: Significance Study

A 95% confidence interval to estimate a population mean tells us that we have 95% confidence that this interval contains the actual population mean. Significance study for 5 % significance level has been undertaken to insure whether the delay (if any) in case of PPP project is significant or not when compared to the average completion period for project executed by private sector.

**t- Test:** When dealing with samples without knowledge of the population standard deviation, the t distribution is utilized to estimate it from the sample standard deviation. To compute a confidence interval for a population mean, it is crucial that the data is obtained through randomization, and the population is approximately normally distributed; however, the use of the t distribution for constructing a confidence interval remains robust even if the normal distribution assumption is violated.

*2.7.1. Scenario 1*

- Null Hypothesis (H0): Mean completion time of energy sector PPP projects is equal to mean completion time of energy sector private sector infrastructure projects.
- Alternative Hypothesis (H1): Mean completion time of energy sector PPP projects is not equal to than the mean completion time of energy sector private sector infrastructure projects.

Since we are not confirmed whether the data derived comes from the same population rather based on the research work undertaken it is likely that the two data comes from a different population (hence unequal variance) the following test was undertaken for analysis: t-Test: Two-Sample Assuming Unequal Variances.

**Table 5** Findings T-Test: Two-Sample Assuming Unequal Variances

| **Particulars** | **Mean Completion Time-Private** | **Mean Completion Time-PPP** |
|---|---|---|
| Mean | 688.0722348 | 1859.943662 |
| Variance | 398188.1667 | 1172180.625 |
| Observations | 443 | 71 |
| Hypothesized Mean Difference | 0 | |
| Df | 78 | |
| t Stat | -8.88178286 | |
| P(T<=t) one-tail | 9.15053E-14 | |
| t Critical one-tail | 1.664624645 | |
| P(T<=t) two-tail | 1.83011E-13 | |
| t Critical two-tail | 1.990847069 | |

Findings from the above analysis favours the Alternative Hypothesis and hence it can be concluded that there is a significant difference between the mean completion time of energy sector PPP projects form the mean completion time of energy sector private sector infrastructure projects.

*2.7.2. Scenario 2*

Null Hypothesis (H0): Mean completion time of energy sector PPP projects is equal to mean completion time (population mean) of all PPP projects undertaken in the Country.

Alternative Hypothesis (H1): Mean completion time of energy sector PPP projects is not equal to mean completion time (population mean) of all PPP projects undertaken in the Country. From secondary data with sample count 71, population mean 1132.52, sample deviation 1082.67 and sample mean 1859.94 were calculated and t value for this was 0.07973734 while P value was 0.936673682.

The p-value, close to one at 0.93, indicates a lack of significant difference between the population mean and sample mean. Consequently, it can be inferred that the delay in energy in PPP is roughly equivalent to the overall delay in the population mean. This suggests that the project for the energy sector originates from a population with a mean matching the value stated in the null hypothesis.

*2.7.3. Scenario 3*

Null Hypothesis (H0): Mean completion time of energy sector private sector infrastructure projects is equal to mean completion time (population mean) of all private sector infrastructure projects undertaken in the Country.

Alternative Hypothesis (H1): Mean completion time of energy sector private sector infrastructure projects is not equal to mean completion time (population mean) of all private sector infrastructure projects undertaken in the Country.

In the analysis of the secondary data, the population mean was found to be 747.3784. The sample data revealed a sample deviation of 631.0215, a sample mean of 688.0722, and a sample count of 443. Additionally, the t-statistics value was calculated, resulting in a t-statistics of 0.004465 and a corresponding p-value of 0.996439.

With a P-value very close to one (0.99), it indicates that there is no significant difference between the population mean and the sample mean. Consequently, it can be inferred that the delay in energy in the private sector is approximately the same as the overall delay in the population mean. This suggests that the project for the energy sector actually originates from a population with a mean equal to the value stated in the null hypothesis.

## 3. Results and Discussion

The survey, based on 50 people approached, yielded 37 responses, with 4 being multiple responses and 33 being unique. The response rate exceeded 70%, and around 66% of the received responses were unique.

The occupation distribution among survey participants in the infrastructure sector showed that 70% were in the service sector, 12% in business, and 18% in other occupations. The majority of respondents, totalling 33, indicated a notable presence from the service sector. The survey participants in the infrastructure sector were well-educated, with 3% having undergraduate qualifications, 36% holding graduate degrees, and the majority, comprising 61%, possessing postgraduate degrees or higher.

The survey on PPP project execution revealed that 42% of participants observed faster execution, while 58% reported slower execution. Further analysis of slower execution considered the average time delay in implementing PPP infrastructure projects. Results indicated that none of the respondents reported delays of less than one year, 74% experienced delays of one to three years, 11% faced delays of 3 to 5 years, and 16% encountered delays exceeding 5 years.

In terms of key reasons for slow execution, participants cited poor administration, slow responses from the private sector, and other unspecified factors. Overall, the majority of participants believed in an average delay of more than one year but less than five years in PPP project execution.

## 4. Conclusion

From the result of the hypothesis and the survey a significant difference is clearly observed between the time taken in completion of the it is observed that there exists a significant difference between the mean completion time of energy sector PPP projects and energy sector private sector infrastructure projects.

## Compliance with ethical standards

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*Disclosure of conflict of interest*

The opinion and observations presented in the paper are professional and impartial and is not perceived to in conflict with any other work done in this field.

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