PPPs and Project Overruns: Evidence from Road Projects in India

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Abstract: Construction cost overrun and time overrun are significant problems in infrastructure projects. This study provides a comparative analysis of the incidence of project overruns in Public Private Partnership (PPP) and non-PPP road projects. Data from national road projects in India was used as the study sample. Means analysis, both using an unmatched sample and matched pair analysis indicated significant overruns between PPP and non-PPP projects. While cost overruns were higher in PPP projects, time overruns were higher in non-PPP projects. These trends persisted in OLS regression estimates. A three stage least squares regression estimated to address the simultaneity bias also showed that use of PPP increased cost overrun, though it did not affect time overrun. Results obtained in this study are contrary to the findings of the previous studies, which have been based on PPP projects in developed economies. The findings emphasize the need for developing countries like India to strengthen their capabilities in PPP models to take advantage of private sector efficiencies. **DOI: 10.1061/(ASCE)CO.1943-7862.0000797.** *© 2013 American Society of Civil Engineers.*

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Introduction

There has been a steady increase in the level of Public Private Partnership (PPP) in infrastructure projects over the years, particularly in the case of developing countries. Faced with the need to constrain deficit, governments have been liberalizing the infrastructure sector for PPP. For example in the 12th five year plan period (2012-17), the investment requirement in India was estimated at about $1 trillion, and more than 50% of the expected investment is expected to come from the private sector.

Infrastructure projects are more often than not, plagued by substantial cost and time overruns. Given the common occurrence of project overruns, there have been many research papers on this topic. What is different about this paper is to analyze, using empirical evidence, the impact of using PPP on project overruns. Previous studies that looked at the link between PPP and project overruns have been limited, and the analysis was based on a limited number of projects. An unique aspect of this study is a reasonably large sample set of projects, and the use of rigorous econometric techniques in the analysis. The sample for this study consisted of central sector road projects in India.

Given the perceived efficiency of the private sector, the hypothesis was that incidence of project overruns would be lesser in PPP projects as compared to non-PPP projects. Moreover, the overruns should show a decreasing trend over time with the advancements in engineering, construction technology, and project management. However, our results indicated that cost overruns were higher in PPP's as compared to that of non-PPP projects, whereas there was no impact on time overrun as a result of using PPP. In our dataset, we found that nearly 69 per cent and 89 per cent of the projects experienced cost overruns and time overruns respectively. It was seen that 88.1 per cent of PPPs had cost overruns as compared with 54.37 per cent in non-PPP projects. However, on an average, higher proportion of non-PPP projects had time overruns (92.23 per cent) as compared with PPPs (80.95 per cent). The average percentage cost overrun in a PPP was close to three times that of what was observed in a non-PPP project. These numbers achieve even more significance if we consider that the average project size of a PPP (Rs 382.46 crore, $76.49 million) is about 50 per cent more than that of a non-PPP project (Rs 253.89 crore, $50.78 million).

Literature Review

Time and cost form important parameters in construction and improvements in one may often result in trade-offs in the other. Given the common occurrence of cost and time overruns in construction and infrastructure projects (Flyvberg et al. 2003a, b), there have been several studies on this topic. Dey et al. (1994) indicated that changes in the construction environment are the primary barriers to project completion resulting in cost and time trade-offs. Arditi et al. (1985) showed a clear connection between delays and cost overrun. The results suggested that mistakes in the initial estimates of cost and time often manifest as overruns.

Several studies have sought to estimate the factors that lead to project overruns in construction projects. For instance, Hinze et al. (1992) analyzed cost overruns associated with Washington State highway projects and found that the cost overruns, expressed as a percentage of the contract amount, increased with project size. Flyvbjerg et al. (2004), in road infrastructure projects, found that cost escalation was strongly influenced by the implementation phase length and project type, and suggested that

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decision makers and planners should be duly concerned about long implementation phases. Sambasivan and Soon (2006) analyzed the causes and effects of delay in Malaysian construction projects, and identified 10 most important causes from a list of 28 different causes, using empirical techniques. Vijaymohanan and Kannan (2003) estimated the causes behind cost overruns in power projects in Kerala through a questionnaire approach. Using data from Norwegian projects, Odeck (2004) indicated that cost overruns were predominant in smaller projects as compared to larger ones.

Singh (2010) used empirical correlation models and mapped corresponding causes of overruns to their effects in infrastructure projects. The research involved data of over 800 projects, in various domains such as power, roads and water projects. However, the findings were very broad-based given the different sectors to which the projects belonged and thus reduced the specificity associated with the recommendations. Moreover, the study did not appropriately account for the endogeneity among the study variables. In terms of methodology, a variety of methods have been used to study the issue of project overruns. Singh (2010) used OLS estimates. Attalla and Hegazy (2003) used artificial neural networks and regression in predicting cost deviation in reconstruction projects. Shaheen et al. (2007) used neuro-fuzzy models in analyzing the causes of overruns.

In recent years, infrastructure projects in developing countries are increasingly being developed as PPP model as compared to the traditional public procurement. In the PPP format, the private sector assumes a significant share of the project risks as compared that of the traditional public sector procurement. Apart from accessing private capital for project development, it is felt that private sector involvement can reduce the inefficiencies seen in the traditional procurement, such as project overruns. While there have been many studies that have compared traditional procurement and PPP on project costs and time (for example, Blanc-Brude et al. 2009), on the whole, there have been very few studies on the impact of PPP on project overruns. This study is an attempt to address that gap. Summary of the studies that addressed this topic is given below.

In a perception based study of different project stakeholders, Hampton et al (2012) made a comparison between the traditional public sector procurement and PPP models on time overruns. It was perceived that there was greater "delay potential" under traditional vis-à-vis PPP procured projects. The respondents preferred PPP for achieving best "time performance". Based on a study of 12 large PPP highway projects in North America and benchmarking with the findings of previous studies, Chasey et al. (2012) found that PPP projects had significantly lower cost and time overruns. A study by Iacobacci (2010) based on 19 PPP projects that were completed substantially indicated that these projects had a high degree of cost and time certainty (i.e., lower overruns) as compared to traditional procurement. Grimsey and Lewis (2007) in their article cite several studies done on UK projects, which showed that PPP projects had significantly lower cost and time overruns as compared to public projects. Evidence of superior performance of PPP projects in terms of overruns was also found by Bain (2007) and Infrastructure Partnerships Australia (2007).

Methodology

The main variables of interest for this study are the cost and time overrun. The cost overrun was defined as the difference between the actual costs incurred for completing the project and the initial project cost estimate. It was calculated as follows:

$$\text{Cost overrun} = \text{Actual expenditure incurred} - \text{Initial project cost estimate} \quad (1)$$

The time overrun variable was defined as the difference between the estimated project duration and the actual time taken to complete the project. It was calculated as follows:

$$\text{Net duration} = \text{Date of project commencement} - \text{Date of project approval} \quad (2)$$

$$\text{Time overrun} = \text{Net duration} - \text{Project duration} \quad (3)$$

Depending the actual cost and time taken vis a vis the estimates, the overrun can be positive, negative, or nil. The overruns have been analyzed using comparison of means, OLS regression and 3SLS regression.

Comparison of Means

The first level of analysis involved a means comparison of cost and time overruns between the PPP and non-PPP projects. Since the data did not exhibit any particular form of distribution, the non parametric Wilcoxon rank-sum technique was used for comparing the means. It was seen that the dataset was highly imbalanced because of difference in terms of sample size and variable values of other project characteristics. Therefore, to increase the accuracy of the means comparison we used a matching technique. We matched the PPP and Non-PPP projects data based on parameters like road length, number of lanes and project duration. The method of Coarsened Exact Matching (CEM) using stata software, as suggested by Blackwell et al. (2009) was used for matching PPP and Non-PPP projects. CEM was used to match both exact values and values that were closely related. After the matching, the means were compared for PPP and Non-PPP projects using Wilcoxon rank-sum (Mann-Whitney) mean comparison test.

OLS Regression

An OLS regression model was estimated to see the impact of explanatory variables, on the dependent variables, viz., cost overrun and time overrun. Equation (4) and (5) gives the estimation used for calculating cost overrun and time overrun.

$$\begin{aligned}\text{Costoverrun} = {} & \alpha_{c0} + \alpha_{c1}\text{timeoverrun} + \alpha_{c2}\text{RoadLength} \\ & + \alpha_{c3}D\_\text{Lanes} + \alpha_{c4}\text{ProjectDuration} \\ & + \alpha_{c5}D\_\text{Terrain} + \alpha_{c6}D\_\text{Consultant} \\ & + \alpha_{c7}\text{CostKmLane} + \alpha_{c8}\text{Contractor} \\ & + \alpha_{c9}\text{Estimate} + \alpha_{c10}D\_\text{Multilateral\_Banks} \\ & + \alpha_{c11}D\_PPP + \alpha_{c12}D\_\text{Land\_Use} \\ & + \alpha_{c13}D\_\text{Category} + \alpha_{c14}D\_\text{Multi\_State} \\ & + \alpha_{c15}\text{TimeLapse} + \alpha_{c16}\text{PerCapitaStateGDP} \\ & + \alpha_{c17}\text{PropertyRightsIndex} + \varepsilon_i \end{aligned} \quad (4)$$

$$\begin{aligned}\text{Timeoverrun} = {} & \alpha_{t0} + \alpha_{t1}\text{costoverrun} + \alpha_{t2}\text{RoadLength} \\ & + \alpha_{t3}D\_\text{Lanes} + \alpha_{t4}\text{ProjectDuration} \\ & + \alpha_{t5}D\_\text{Terrain} + \alpha_{t6}D\_\text{Consultant} \\ & + \alpha_{t7}\text{Contractor} + \alpha_{t8}\text{Estimate} \\ & + \alpha_{t9}D\_\text{Multilateral\_Banks} + \alpha_{t10}D\_PPP \\ & + \alpha_{t11}D\_\text{Land\_Use} + \alpha_{t12}D\_\text{Category} \\ & + \alpha_{t13}D\_\text{Multi\_State} + \alpha_{t14}\text{TimeLapse} \\ & + \alpha_{t15}\text{PerCapitaStateGDP} \\ & + \alpha_{t16}\text{PropertyRightsIndex} \\ & + \alpha_{t17}\text{InfraIndex} + \upsilon_i \end{aligned} \tag{5}$$

where α_{c0} and α_{t0} are constant terms; α's are vectors of estimable parameters; ε_i's and υ_i's are disturbance or error terms that capture unobserved effects

The model comprised variables that were commonly used in literature (see for example Singh 2010). Conceptually, the variables were divided into three categories—project technical variables, economic variables, and state specific context variables. A total of 17 independent variables were used in the estimation models. Description of these variables is given below. Data sources for the different variables are given in Table 1.

Project Technical Variables

These variables pertain to the technical and engineering features of the project. The variables were classified under this category are as follows:

1. Road Length, *RoadLength*: The length of road is an indicator of the size of the project. Greater the road length, greater is the requirement for resources and pre-construction planning. Increased road length increases the requirement for more land and heightens the land acquisition process. The natural expectation in this case, is increased overrun with increased length.
2. Number of Lanes, *D_Lanes (dummy)*: The projects in the dataset are either 4 or 6 laning projects, i.e., it is either a 2-lane to 4-lane project or a 4-lane to 6-lane project. A 6-lane project will involve lateral land acquisition on the 4-lane road, which is better developed than a 2-lane road, thereby hiking land prices and at the same time facilitating a time-consuming litigation process. So, greater the number of lanes, greater overrun is expected. There were a total of 135 4-laning projects and 10 6-laning projects.
3. Terrain, *D_Terrain (dummy)*: This variable is an indicator of project complexity where the presence of difficult terrain is taken into account. For example, a rocky terrain would force the requirement for additional resources, for drilling in the rock and providing suitable support systems before laying the road. Since most of these requirements were based on in-situ measurements, the resources to address a difficult terrain were generally unaccounted for during pre-construction planning (Swaminathan 1999). Hence, overruns were expected to increase with difficult terrain.
4. Foreign Consultant, *D_Consultant (dummy)*: Consultants were primarily involved in the design stage, for the technical design and traffic forecasts for the tolling process. Ineffective design often leads to excessive resource utilization and delay apart from causing accidents, resulting in overrun. Foreign consultants were routinely engaged with the expectation that they would be able to produce a more effective design. Therefore, the presence of foreign consultants is expected to lead to a reduction in overruns.
5. Contractor, *Contractor*: This variable is an indicator of the construction effectiveness of the contractor. The contractor is the sole entity involved during the construction phase and is entirely responsible for any delays and excess costs that are incurred. More effective the contractor, the lesser would be the project overrun.

Economic Variables

These variables captured the financial and commercial features of the project.

1. Time taken, *ProjectDuration*: This indicated the initial estimated time for completing the project and is another indicator of project size. Greater project duration generally increased the resource requirement, which should increase the overrun. Longer projects were also susceptible to changes in the construction environment, such as changes in weather, commodity prices, etc. which could heighten the overrun. However, an alternate possibility is the increased duration results in better pre-construction planning that shortens the delay.
2. Estimated Cost, *Estimate*: This is the estimated initial cost of the project and is an indicator of project size. A greater estimated cost was expected to result in overrun, but a greater estimate also forced the need for better pre-construction planning which should reduce overrun. In other words, a trend similar to that seen for *ProjectDuration* was expected.
3. Cost/km/lane, *CostKmLane*: This is another indicator of complexity in the project. Increased cost/km/lane was an indication of greater number of bridges and culverts in the construction and the presence of difficult terrain. A higher degree of project complexity was expected to result in increased overrun.
4. Multilateral Banks, *D_Multilateral_Banks (dummy)*: The variable is used to indicate the presence of multilateral or bilateral funding for the project. Projects that receive assistance from such institutions are expected to follow more stringent processes in all aspects of project development. This detailed compliance can potentially result in an increase in project overruns.
5. PPP, *D_PPP (dummy)*: This variable captured the type of project, PPP or non-PPP. Because of the involvement of private sector, PPP projects were expected to have lower delays and overruns.
6. Land Use, *D_Land_Use (dummy)*: This variable indicated the presence of forest land along the path of the road under construction. Obtaining government clearance when a road was passing through or adjacent to forest land was a cumbersome and time consuming process. Therefore, the presence of forest land was expected to result in project overruns.
7. Category, *D_Category (dummy)*: This variable was used to capture the political will that was seen in the case of fast-track projects. Government is expected to process land acquisition and other clearances faster for those projects that have been identified for fast track development as compared to standard projects. Therefore, overruns were expected to be lower for such fast track projects.
8. Multi-State, *D_Multi_State (dummy)*: Highways account for significant traffic flow across state borders, providing avenues for the governments to collect taxes on both sides. A better road is expected to increase the traffic and hence, the tax collected. The quicker these roads are established, the sooner the traffic will increase. In other words, overruns are expected to be lesser in inter-state projects.

Table 1. Data Sources for Variables

Variable Name	Data source	Description
Technical variables		
Road length	Program implementation status reports (quarterly), Ministry of Statistics and Programme Implementation (MOSPI) (2012)	Project size indicator, represented in km
Number of lanes	Program implementation status reports (quarterly)—MOSPI (2012)	Project size indicator, either 4 or 6, indicating 4-laning and 6-laning process
Time undertaken	Program implementation status reports (quarterly)—MOSPI (2012)	Project size indicator, difference between the time of project approval and project commencement, represented in months
Terrain *(dummy)*	Authors' analysis based on topographical maps from Survey of India	Construction complexity indicator, 1 for any sloping terrain along the route, 0 otherwise
Foreign consultant *(dummy)*	Program implementation status reports (quarterly)—MOSPI (2012)	Design effectiveness indicator, 1 for a foreign consultant, 0 otherwise
Cost/km/lane	Our calculations	Construction complexity indicator, total estimated cost/road length/number of lanes, represented in crore/km/lane
Economic variables		
Contractor	Program implementation status reports (quarterly)—MOSPI (2012), CPWD (2012) contractor grades, construction week online (2012)	Execution effectiveness indicator, contractor grades used as follows, Grade I – 1 Grade II – 2 Grade III – 3 others – 4
Estimated cost	Program implementation status reports (quarterly)—MOSPI (2012)	Project size indicator, represented in crore
Multilateral banks *(dummy)*	Program implementation status reports (quarterly)—MOSPI (2012)	Financing effectiveness indicator, 1 for a foreign / multilateral bank funded project, 0 otherwise
PPP *(dummy)*	Program implementation status reports (quarterly)—MOSPI (2012), PPP project database (2011 a, b)	PPP indicator, 1 for PPP, 0 otherwise
Land Use *(dummy)*	Authors' analysis based on maps of national parks & sanctuaries in India from survey of India	Land acquisition effectiveness indicator, 1 if any forest /sanctuary land falls within the pathway of the road, 0 otherwise
Category (GQ/NS/EW) *(dummy)*	Program implementation status reports (quarterly)—MOSPI (2012)	Political will indicator, 1 for GQ/NS/EW, 0 otherwise
Multi-state *(dummy)*	Program implementation status reports (quarterly)—MOSPI (2012)	Tax sensitiveness indicator, 1 for roads that cross state borders, 0 otherwise
Time lapse	Our calculations	Built capacity indicator, represented as number of months since Jan. 2000 to the date of project approval
State-specific variables		
Per-capita state GDP	Central Statistical Office (2012)	State economic effectiveness indicator, represented in dollars/person
Property rights index	Debroy et al. (2011)	Land acquisition effectiveness indicator, state-specific, ranging from 0 to 1, averaged for multi-state projects
Infrastructure index of district	Centre for Monitoring Indian Economy (CMIE) (2012)	District infrastructure effectiveness indicator, district-specific, averaged for multi-district projects

9. Time Lapse, *TimeLapse*: This variable has been used to capture the effect of technology development and expertise acquired in construction project management. More recent projects were expected to have lower overruns as a result of better planning and management.

District and State Specific Indicators

These location specific variables have been used to capture the features of the operating environment of the project

1. Per-capita State GDP, *PerCapitaStateGDP*: This variable is an indicator of the income and the level of demand for transport services in the state. States with a higher per-capita State GDP have a higher level of economic activity and hence, have a stronger demand for road transport infrastructure. It was expected that higher income states would have a more robust environment for development of infrastructure projects, which would result in lower project overruns.
2. Property Rights Index, *PropertyRightsIndex*: This variable is an indication of the legal framework available in the state to safeguard the private property of the individuals. Road development projects invariably involve acquisition of land. Acquisition of private land can become difficult in those states where private owners have better safeguards for their property. Therefore, projects developed in states having values of property rights index were expected to have higher overruns.
3. District Infrastructure Index, *InfraIndex*: The level of infrastructure within the district is captured by this variable. Better infrastructure is very effective in garnering adequate resources to the project development site thereby reducing the expected overrun. On the other hand, better infrastructure hikes the land rates, which may prove detrimental to the land acquisition process through expensive and long litigations, thereby, increasing the expected overrun.

The estimated parameters of an OLS regression equation are unbiased, efficient and consistent provided there is a linear relationship between the dependent and independent variables and the variables are normally distributed. We checked for the linearity of the OLS equations by plotting the estimated residuals of both the equations with that of the predicted values of their respective dependent variables. The resulting scatter plot of the residuals did not show any significant relationship pattern or curves, which indicated the presence of a linear relationship between the dependent and independent variables. To check for normality of the equations we plotted the fractiles of error distribution versus the fractiles of a normal distribution. There was no significant parabolic or S shaped pattern to indicate the presence of skewness or kurtosis in the data set. Hence the distribution of the error term was normal. To check for multicollinearity, a correlation coefficient analysis was done. Though some values in the resultant correlation coefficient matrix were higher as expected (such as the correlation between road length and estimated cost, which was 0.7168), the overall results were acceptable.

3 SLS Regression

Given the possibility of simultaneity bias between cost overrun and time overrun we did Durbin-Wu-Hausman (DWH) chi-square test to check for endogeneity using Instrumental Variables (IV). Cost/km/lane was used as an instrumental variable for cost overrun and Infrastructure Index was used as an instrumental variable for time overrun. Infrastructure index indicated the presence of robust institutional structure to facilitate and develop infrastructure projects. Projects in those states that have high infrastructure index values would have comparatively lower time overruns. Therefore, we used infrastructure index variable to instrument time overrun. Similarly, we used cost/km/lane to instrument cost overrun, as the former is an indication of project complexity which can lead to cost overruns. The test using the IV indicated the endogeneity of time overrun in the cost overrun equation and vice versa. Therefore a 3 SLS estimate was adopted for a more unbiased and efficient estimation of the simultaneous equations. Equations (6) and (7) give the 3SLS estimations.

$$\begin{aligned}\text{costoverrun} = {} & \beta_{c0} + \lambda_{c1}\text{timeoverrun} + \beta_{c2}\text{RoadLength} \\ & + \beta_{c3}D\_\text{Lanes} + \beta_{c4}\text{ProjectDuration} \\ & + \beta_{c5}D\_\text{Terrain} + \beta_{c6}D\_\text{Consultant} \\ & + \beta_{c7}\text{CostKmLane} + \beta_{c8}\text{Contractor} \\ & + \beta_{c9}\text{Estimate} + \beta_{c10}D\_\text{Multilateral\_Banks} \\ & + \beta_{c11}D\_PPP + \beta_{c12}D\_\text{Land\_Use} \\ & + \beta_{c13}D\_\text{Category} + \beta_{c14}D\_\text{Multi\_State} \\ & + \beta_{c15}\text{TimeLapse} + \beta_{c16}\text{PerCapitaStateGDP} \\ & + \beta_{c17}\text{PropertyRightsIndex} + \varepsilon_i \end{aligned} \quad (6)$$

$$\begin{aligned}\text{Timeoverrun} = {} & \beta_{t0} + \lambda_{t1}\text{costoverrun} + \beta_{t2}\text{RoadLength} \\ & + \beta_{t3}D\_\text{Lanes} + \beta_{t4}\text{ProjectDuration} \\ & + \beta_{t5}D\_\text{Terrain} + \beta_{t6}D\_\text{Consultant} \\ & + \beta_{t7}\text{Contractor} + \beta_{t8}\text{Estimate} \\ & + \beta_{t9}D\_\text{Multilateral\_Banks} + \beta_{t10}D\_\text{PPP} \\ & + \beta_{t11}D\_\text{Land\_Use} + \beta_{t12}D\_\text{Category} \\ & + \beta_{t13}D\_\text{Multi\_State} + \beta_{t14}\text{TimeLapse} \\ & + \beta_{t15}\text{PerCapitaStateGDP} \\ & + \beta_{t16}\text{PropertyRightsIndex} + \beta_{t17}\text{InfraIndex} + \upsilon_i \end{aligned} \quad (7)$$

where β_{c0} and β_{t0} are constant terms; β's are vectors of estimable parameters; λ's are estimable scalars of the endogenous covariates, and ε_i's and υ_i's are disturbance or error terms that capture unobserved effects

The equations were uniquely identified by ensuring that the number of exogenous variables excluded from each of the equations was equal to the number of endogenous variable included in the right hand side of the equation. The 3SLS method of estimation was done in STATA using the reg3 command.

Data Description

Quarterly reports from the Ministry of Statistics and Program Implementation (MOSPI) provided data for all infrastructure projects that are undertaken by the government. The reports covered over 600 projects over the study period (2004–11), both completed and ongoing. Out of these, there were 186 completed projects, including PPP and non-PPP projects that had begun operations by 2011. Data from these 186 projects formed the sample for our study. The data was cross-checked with alternative data sources, such as the National Highways Authority of India and Central Statistical Organization website, and the inconsistent data points were removed. This left a total of 145 projects, out of which 42 were PPP projects and the remaining 103 being non-PPP projects.

Table 2 provides the descriptive statistics for the data sample. Table 3 provides the mean values of key project features separately for PPP and non-PPP projects. The results indicated that there are significant differences in characteristics between the two types of projects.

Table 2. Descriptive Data for the Variables (N = 145)

Variables	Mean	Median	Standard deviation	Minimum	Maximum
Cost overrun (in crore INR)	47.32	27.31	98.94	−184.88	515
Time overrun (in months)	20.41	16	18.64	−7	83
Technical variables					
Road length (in km)	51.09	48	21.49	10	118
Economic variables					
Estimated cost (in crore INR)	291.13	267.20	140.18	33.78	660
Cost/km/lane (in Crore/km/lane)	1.42	1.27	0.56	0.73	3.75
Project duration (in months)	49.55	50	13.61	5	100
Time lapse (in months)	22.37	35	20.54	3	94
District/state specific variables					
Per capita real GDP (in $/person)	1,163.96	1,057	454.21	436	1,959
Infrastructure index	107.78	98.57	49.54	66.41	472.48
Property rights index (PRI)	0.47	0.54	0.23	0.11	0.90

Note: Currency conversion rate: 50 INR = 1$.

Table 3. Mean Comparison Analysis for Different Variables

Variables	Mean		P-Value (Wilcoxon rank-sum test)
	PPP Sample size = 42	Non-PPP Sample size = 103	
Cost overrun (in crore INR)	104.66	23.94	0.00[a]
Average percentage of cost overruns	27.32%	8.43%	0.00[a]
Time overrun (in months)	6.43	26.12	0.00[a]
Average percentage of time overruns	12.98%	75.56%	0.00[a]
Technical variables			
Road length (in km)	61.86	46.71	0.002[a]
Economic variables			
Project duration (in months)	53.57	47.91	0.005[a]
Cost/km/lane (in Crore/km/lane)	1.51	1.39	0.009[a]
Estimated cost (in crore INR)	382.46	253.89	0.00[a]
Time lapse (in months)	38.33	15.86	0.00[a]
District/state specific variables			
Per capita real GDP (in $/person)	1,392.81	1,070.64	0.00[a]
Infrastructure index	104.20	109.24	0.908
Property rights index (PRI)	0.55	0.44	0.002[a]

Note: Currency conversion rate: 50 INR = 1$.
[a]Significant at 1% level of significance.

Results

Comparison of Means

Table 4 and 5 provides the results from comparison of means analysis on cost overrun and time overrun respectively. Table 4 indicates that the mean cost overrun for PPP projects is INR 104.66 crore (about USD 20.93 million) whereas for the non-PPP projects, it is INR 23.94 crore (about USD 4.79 million). The difference in means is significant at the 0.1% level. As a robustness check of the unmatched sample results, the mean cost overrun between the two types of projects was also compared after matching the projects on different parameters such as road length, number of lanes, and project duration. The difference persisted for all the matching criterion. Since the N values do not differ significantly for the different matching variables, it can be considered that the original unmatched sample is also fairly balanced for both types of projects.

Table 5 indicates that the mean time overrun for PPP projects is 6.43 months whereas for the non-PPP projects, it is 26.11 months. This difference in means is significant at the 0.1% level. The difference was consistent even after matching the projects on various parameters. The results from the means analysis show an opposing trend on cost and time overrun. While PPP projects have a higher cost overrun as compared to non PPP projects, it was the reverse in the case of time overrun.

Though the means analysis indicates a difference in the variables of interest between the two types of projects, it cannot be said for certain that this difference can be attributed to the treatment effect. We use regression (OLS and 3SLS) methods to estimate the impact of PPP on cost and time overruns.

Table 4. Match Pair Sampling Results for Cost Overrun (in Crore INR)

Type of project	Descriptive statistics	Variables used for matching			
		Unmatched sample	Road length (km)	Number of lanes	Project duration (in months)
PPP	Mean	104.66	96.74	104.66	104.66
	N	42	40	42	42
Non-PPP	Mean	23.94	23.94	23.94	20.13
	N	103	103	103	96
	P-value	0.00[a]	0.00[a]	0.00[a]	0.00[a]

Note: Currency conversion rate: 50 INR = 1$.
[a]Significant at 0.1% level of significance.

Table 5. Match Pair Sampling Results For Estimated Time Overrun (in Months)

Type of project	Descriptive statistics	Variables used for matching			
		Unmatched sample	Road length (km)	Number of lanes	Project duration (in months)
PPP	Mean	6.43	6.05	6.43	6.43
	N	42	40	42	42
Non-PPP	Mean	26.11	26.12	26.12	25.35
	N	103	103	103	96
	P-value	0.00[a]	0.00[a]	0.00[a]	0.00[a]

[a]Significant at 0.1% level of significance.

Table 6. OLS Regression Results ($N = 145$)

Independent variables	Dependent variable = *CostOverrun* ($R^2 = 0.3790$, P-value = 0.00) Coefficient (standard error)	P-Value	Dependent variable = *TimeOverrun* ($R^2 = 0.4723$, P-value = 0.00) Coefficient (standard error)	P-value
TimeOverrun	1.31 (0.50)	0.010[a]	—	—
CostOverrun	—	—	0.03 (0.02)	0.040[b]
RoadLength	−1.04 (1.21)	0.389	−0.14 (0.10)	0.145
Project duration	1.78 (0.68)	0.009[a]	−0.39 (0.11)	0.001[a]
CostKmlane	−27.79 (38.63)	0.473	—	—
D_Lanes	73.43 (41.41)	0.077[c]	4.87 (5.23)	0.353
D_Consultant	−23.77 (16.89)	0.161	−1.68 (2.95)	0.571
D_Terrain	1.95 (18.32)	0.916	3.34 (3.26)	0.306
Contractor	−9.36 (5.41)	0.085[c]	0.83 (0.96)	0.387
Estimate	0.24 (0.21)	0.252	0.03 (0.01)	0.032[b]
D_Multilateral_Banks	10.65 (21.03)	0.613	9.21 (3.60)	0.011[a]
D_PPP	65.37 (24.53)	0.008[a]	−11.59 (4.26)	0.007[a]
D_Land_Use	−31.85 (23.49)	0.176	−1.44 (4.11)	0.726
D_Category	−78.14 (26.66)	0.004[a]	−0.59 (4.84)	0.902
D_Multi_State	−78.41 (36.36)	0.032[b]	1.98 (6.45)	0.759
TimeLapse	0.08 (0.57)	0.884	−0.17 (0.10)	0.073[c]
PerCapitaStat GDP	−0.01 (0.02)	0.461	−0.003 (0.00)	0.385
PropertyRightsIndex	1.10 (38.33)	0.977	−20.22 (7.00)	0.004[a]
InfraIndex	—	—	0.05 (0.03)	0.088[c]
Constant	−5.89 (72.05)	0.935	41.54 (12.06)	0.001[a]

[a]Significant at 1% level of significance.
[b]Significant at 5% level of significance.
[c]Significant at 10% level of significance.

OLS Regression

Table 6 gives the OLS results for cost and time overruns estimated using Equation (4) and (5) respectively. It was seen that time overrun had a positive impact on cost overrun, and it was significant at the 1% level. Cost overrun too had a significant impact on time overrun, and was significant at the 5% level. This gives an indication of the simultaneity that can occur between the two variables of interest, which we try and address using the 3SLS regression subsequently.

The treatment variable, *PPP*, was also significant at the 1% level for both the estimations. However, consistent with the comparison of means analysis, the effect of PPP had an opposing effect on cost and time overrun. The coefficient of the PPP variable was positive in the estimation for cost overrun, which indicated that the incidence of PPP had an effect of increasing cost overrun. On the other hand, the coefficient of the PPP variable was negative in the estimation for time overrun, which indicated that PPP had an effect of decreasing time overrun.

In the cost overrun estimation, *project duration*, *lanes*, *contractor*, *D-category*, and *D_multi_state*, were significant. *Project duration* had a positive relationship with cost overrun, which indicated that as the duration of the projects increased, it had an impact of increasing cost overruns. Since long duration projects are exposed to a higher level of uncertainties, it had an effect of increasing cost overruns. *Lanes* had a positive relationship with cost overrun, i.e., as the number of lanes in the road projects increased, it had an effect of increasing cost overruns. This can be attributed to the fact that a higher number of lanes involved, among other things, getting right of way over a broader stretch and a higher land acquisition area. The uncertainties in these processes can lead to cost overruns. The coefficient for the *contractor* variable was negative, which is not as per expectation. Involvement of Grade 1 contractor should have had an effect of reducing cost overrun as compared to that Grade 3 contractor, given the superior capabilities and expertise of the former. However, our estimations indicated that Grade 3 contractors had a greater effect of reducing cost overruns as compared to that of Grade 1 contractor. One possible explanation behind this result could be Grade 1 contractors are involved in more complex projects as compared to that of Grade 3 contractors, and such projects are inherently more prone to be affected by cost overruns than the simpler projects. But, such an explanation also indicates that superior execution and management capabilities of the contractors do not play a significant role in influencing cost overruns. Further studies with alternate measurement variables for contractor capabilities can shed more insights on this.

The coefficient for variable *D-category* was negative, which indicated that political will and support for the projects can play an important role in reducing cost overruns. A strong interest from the political and executive leadership in the completion of the project can lead to quick clearances that can reduce cost overruns. An additional explanation for this trend could be such political attention results in these projects being staffed and managed with more capable people, who are able to reduce cost overruns. Seen in this perspective, this coefficient highlighted the positive impact of superior management practices in reducing project overruns. The coefficient of *D_Multi_state* was negative, which indicated that road projects that involved more than one state experienced lower cost overruns. This indicated that potential benefits from higher tax collections because of inter-state traffic could have resulted in more focus and oversight on such inter-state projects, resulting in lower cost overruns. In a way this was a surprising result, since it would have been expected that inter-state projects would result in co-ordination issues between different states that would increase

Table 7. DWH Test Results for Endogeneity

H_0 (null hypothesis)	DWH chi-square test statistic	P-value
TimeOverrun is exogenous	6.80, chi-sq(1)	0.01
CostOverrun is exogenous	5.43, chi-sq(1)	0.02

Table 8. 3SLS Regression Results ($N = 145$)

Independent variables	Dependent variable = *CostOverrun* Coefficient (standard error)	*P*-value	Dependent variable = *TimeOverrun* Coefficient (standard error)	*P*-value
TimeOverrun	9.39 (5.45)	0.084[a]	—	—
CostOverrun	—	—	−0.43 (0.56)	0.445
RoadLength	−3.27 (2.46)	0.184	−0.25 (0.29)	0.389
Project duration	5.11 (2.48)	0.039[b]	0.21 (0.78)	0.790
CostKmlane	−160.03 (108.20)	0.139	—	—
D_Lanes	109.44 (71.47)	0.126	28.77 (32.20)	0.372
D_Consultant	3.87 (33.07)	0.907	−12.91 (15.74)	0.412
D_Terrain	−17.16 (32.38)	0.596	10.64 (12.39)	0.390
Contractor	−12.08 (8.98)	0.179	−1.87 (4.16)	0.653
Estimate	0.56 (0.41)	0.167	0.08 (0.07)	0.256
D_Multilateral_Banks	−61.09 (58.78)	0.299	21.68 (17.91)	0.226
D_PPP	133.74 (60.54)	0.027[b]	19.80 (39.80)	0.619
D_Land_ Use	−8.66 (41.20)	0.833	−18.64 (23.59)	0.429
D_Category	−41.51 (49.75)	0.404	−31.93 (40.21)	0.427
D_Multi_State	−88.06 (59.46)	0.139	−36.34 (49.64)	0.464
TimeLapse	2.14 (1.66)	0.196	−0.20 (0.26)	0.444
PerCapitaState GDP	0.01 (0.04)	0.704	−0.02 (0.02)	0.385
PropertyRightsIndex	128.40 (105.24)	0.222	−46.56 (37.02)	0.208
InfraIndex	—	—	0.26 (0.27)	0.328
Constant	−338.56 (250.69)	0.177	37.74 (32.31)	0.243

[a]Significant at 10% level of significance.
[b]Significant at 5% level of significance.

project overruns rather than reducing it. However, because of the commercial benefits of inter-state traffic, our estimates indicated that the states have been managing the coordination among themselves effectively.

In the time overrun equation, the other variables that were significant are *Projectduration*, *Estimate*, *D_multilateral_banks*, *Timelapse*, and *PropertyRightsIndex*. The coefficient of *Projectduration* was negative, indicating that long duration projects had lower time overruns. Though a bit surprising, it can be attributed to the reason that project planning for long duration projects could have incorporated appropriate buffer for delays in the project schedule. However, it is interesting to note that the effect of such detailed project planning have resulted in opposing effects—it increased cost overruns, but reduced time overruns. Additional studies are needed to investigate this further. The coefficient of *Estimate* was positive, which indicated that projects with higher costs had an effect of increasing time overruns. This was on expected lines—as the project size increased, the complexity increased, which had an effect of increasing time overruns. The coefficient of *D_multilateral_banks* had a positive coefficient, which indicated that projects with investment from multilateral banks had higher time overruns as compared to projects that did not. This can be attributed to the loan covenants of such institutions that require adherence to tighter project management processes (such as a strong rehabilitation policy for project affected people, use of international competitive bidding processes, etc.). The coefficient of *Timelapse* was negative, indicating that projects in recent years had experienced lower time overruns as compared to projects developed in earlier years. This showed that over time, because of the progress achieved in overall project management techniques, it has been possible to reduce the duration of time overruns. The coefficient of *PropertyRightsIndex* was positive, which indicated that the model estimated an increase in time overrun that offered higher protection for property rights. Road development projects invariably involved land acquisition. Projects that were implemented in states that reportedly provided better protection to property rights (and therefore having higher property index values) could have been subjected to a higher level of litigation from project affected people, which could have had an effect of increasing time overruns.

3SLS Regression

Given the possibility of simultaneity bias between cost and time overruns, the DWH test was used to check for endogeneity in the OLS regressions. The test results are given in Table 7.

Since the test results indicated endogeneity, a 3SLS regression was estimated for the variables of interest. Table 8 gives the regression results.

The results on cost overrun indicated that *PPP* had a significant impact on cost overrun. *Projectduration* and *Timeoverrun* also retained its significance. However, other variables that were significant in the OLS regression viz., *lanes*, *contractor*, *D-category*, and *D_multi_state*, were not significant in the 3SLS regression. However, it can be seen that the direction of these coefficients was consistent in both the regressions. The results on time overrun did not show any significance for any of the variables. *PPP*, which was significant in the OLS regression estimates on time overrun, was not seen as significant and the direction of the coefficient also changed. Similarly, the other variables, viz., *Costoverrun*, *Projectduration*, *Estimate*, *D_multilateral_banks*, *Timelapse*, and *PropertyRightsIndex*, were also not seen as significant. This showed that none of the variables used in this study had significant impact on time overrun. Additional robustness checks need with alternate instrumental variables in the case of time overrun, are needed to validate these results and can be considered as scope for future work.

Conclusions

Cost and time overruns in infrastructure projects are a common occurrence. The objective of this paper was to examine whether the use of PPP had any impact on these project overruns. It was found that use of PPP led to higher cost overruns, while it did not have significant impact on time overrun. These findings are contrary to the findings of the previous studies, which clearly indicate the superior performance of PPP projects. However, it must be noted that the sample size of the previous studies in general have been very limited. The findings of this study, atleast for cost overrun, persist with robustness checks and bias corrections.

The following reasons can be used to explain this trend. First, is the time period used for selecting the projects. Though there was experience of implementing PPP projects globally, these were the initial years in the country when PPP's were being actively considered for developing road projects. It was a learning phase and there was a lot of experimentation and learning in structuring and contracting PPP projects, which resulted in cost overruns in such projects. However, adequate support could not be found in our analysis for this argument since the cost overrun did not show a declining trend in recent years as compared to earlier years. Not only was the coefficient for the variable *TimeLapse* insignificant, it also had a positive sign. This indicated that, cost overruns increased in recent years, though the effect was not significant.

Second, the PPP contractual structure either provided an incentive for incurring cost overruns or did not discourage it adequately in terms of penalties. While additional studies that examined the PPP contracts are needed to verify this, it is not uncommon to have incidences of costs exaggeration by private sector where there is no risk in recovering such excess costs and along with corresponding returns (see for example Parikh (1995). This phenomenon of "gold-plating" was the central theme in the well known paper by Averch and Johnson (1962). The results of this paper clearly suggest the need for a thorough relook of the PPP agreements and make it tighter to reduce the incidence of cost overruns.

PPP projects did not have a significant impact on time overrun. In essence, PPP projects were no more or no less effective as compared to the non-PPP projects in reducing time overruns. Additional studies are needed to determine whether incentives could be provided to complete projects earlier than budgeted, without any corresponding impact on cost.

Incidence of time overrun was predicted with an increase in cost overrun, but not vice versa. This was on expected lines. A project progressing as planned with respect to time was unlikely to incur any cost overruns. But any deviation is likely to have a corresponding impact on cost over runs. In the estimation of cost overrun, it is important to note the positive co-relation with time overrun. Though not significant, it was however, interesting to note the negative sign for the cost overrun coefficient in the regression estimate for time overrun. This can be explained by the rationale that when project need to be completed before schedule (negative time overrun), additional costs need to be incurred that were not budgeted for (i.e., a positive cost overrun).

On the whole, our study indicated that PPP projects were worse off than non-PPP projects in managing project overruns. In the case of time overrun, they were as good as non-PPP projects, whereas in the case of cost overrun, PPP projects were predicted to result in an increase cost overrun. Several reasons could be advanced to explain the result. First, generally PPP projects were larger, and therefore probably involved greater complexity in construction. This complexity could be a reason for higher cost overruns in PPP projects. Better project planning with a more complete understanding of the ex-ante ground realities can help in reducing cost overruns. Second, the private sector seems more comfortable with a cost overrun in its balance sheet, when contracts are structured on the basis of cost recovery. Increased project costs have an impact on the entire project lifecycle (in terms of higher tolls or annuity payments by the government). Use of performance incentives which are based on deliverables rather than recovery of project cost can be more effective in reducing cost overruns.

The findings also imply that defective planning and contractual failures can lead to cost overruns and consequently for a wastage of public resources. Since long duration projects significantly increase cost overruns, structuring projects as smaller road stretches can be an effective way to reduce cost overrun. There is also a need to overhaul project planning and management. Rather than paying a higher cost later on, it is worth investing resources to have more precise initial estimates of project time and cost.

Our interaction with field officials indicated that, during the study period, construction contracts were generally awarded even before the required land for the project was acquired. Similarly, utilities were shifted only during the construction phase. Invariably, several departments are involved in approving and the actual shifting of power, water and sewer lines and other utilities. Government agencies rarely do what they were required to do, but can use a cobweb of complicated rules and procedures to pass on the blame for delays to one another. So much so that even if the delay is caused by the contractor it is almost impossible to punish him, since the contractor can easily prove a contributory negligence on the part of one or the other department (Singh 2010). This explained why contracts were rarely terminated, even when contractors caused prolonged delays. Quicker land acquisition and shifting of utilities through a more efficient government processes is critical. Moreover, a prerogative to allot land prior to construction which can enable the government to provide incentives for projects that deliver on time and quality should be exercised.

Policymakers seem to be keen to privatize the funding, management and ownership of infrastructure facilities. The problems of delays and cost overruns with the public delivery systems are being used to justify privatization of roads and other infrastructure sectors. However, the results imply that following a PPP route is bound to increase the cost overrun in the projects and thus, change in ownership in itself cannot mitigate all the problems with the supply and administration of infrastructure facilities.

The regression estimations used in this study has helped us to effectively understand the impact of PPP in managing project overruns. However, before ending it would be pertinent to outline scope for future work. First, including variables that account for additional project level differences that prevail between PPP and non-PPP projects can enrich our understanding even further. For instance, that there are substantial differences in the operating environments of PPP and non-PPP projects. Key differences could be obtained using surveys and interviews with relevant industry specialists and the government, which can then be incorporated in the estimations. Second, the dataset used for the study comprised of 145 projects, which were drawn from only the national road projects. It would be interesting to see the trend by including state level road projects also. Third, inclusion of the effects of the contracting method and extent of competition at the project bidding stage on overruns can also provide interesting insights. Fourth pertains to methodology—identification and use of alternate instrumental variables can help to improve the validity of the results.

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References

Arditi, D., Akan, G. T., and Gurdamar, S., (1985). "Cost overruns in public projects." *Int. J. Proj. Manage.*, 3(4), 218–224.

Attalla, M., and Hegazy, T., (2003). "Predicting cost deviation in reconstruction projects: Artificial neural networks versus regression." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)0733-9364(2003)129:4(405), 405–411.

Averch, H., and Johnson, I. L., (1962). "Behaviour of the firm under regulatory constraint." *Am. Econ. Rev.*, 52, 1052–1069.

Bain, R. (2007). "PPP construction risk: International evidence from the roads sector." *Proc., of the European Transport Conf.*, Association of European Transport, Noordwijkerhout, Netherlands.

Blackwell, M., Iacus, S., King, G., and Porro, G. (2009). "CEM: Coarsened exact matching in Stata." *STATA J.*, 9(4), 524–546.

Blanc-Brude, F., Goldsmith, H., and Välilä, T. (2009). "A comparison of construction contract prices for traditionally procured roads and public–private partnerships." *Rev. Ind. Organ.*, 35(1), 19–40.

Central Public Works Department (CPWD). (2012). "List of enlisted contractors." Class I—Class V ⟨http://www.cpwd.gov.in/⟩ (Mar. 17, 2012).

Central Statistics Office. (2012). "Per-capita Net State GDP (2011-2012), as on Mar. 1, 2012." Directorate of Economics and Statistics of individual states, ⟨http://mospi.nic.in/Mospi_New/upload/State_wise_SDP_2004-05_14mar12.pdf⟩ (Mar. 21, 2012).

Centre for Monitoring Indian Economy (CMIE). (2012). "Infrastructure development index, Annex -3, India." ADB/UNESCAP Concluding Workshop on Enhancing Social and Gender Statistics, Bangkok, ⟨http://www.unescap.org/stat/meet/esgs2/esgs2_india_an3.pdf⟩ (Mar. 15, 2012).

Chasey, A. D., Maddex, W. E., and Bansal, A. (2012). "Comparison of public-private partnerships and traditional procurement methods in North American highway construction." *Transportation Research Record: Journal of the Transportation Research Record, No. 2268*, Transportation Research Board of the National Academies, Washington, DC, 26–32.

Construction Week Online. (2012). "Top 30 infrastructure companies." ⟨http://www.constructionweekonline.in/article-7581-top_30_infrastructure_companies/⟩ (Mar. 26, 2012).

Debroy, B., Bibek, L., and Laveesh Bhandari, S. S. A. (2011). "Economic freedom of the States of India 2011." Academic Foundation, New Delhi, ⟨http://www.freetheworld.com/pdf/EconomicFreedomIndia-2011.pdf⟩ (May 12, 2013).

Dey, P. K., Tabucanon, M. T., and Ogunlana, S. O. (1994). "Planning for project control through risk analysis: A case of petroleum pipeline laying project." *Int. J. Proj. Manage.*, 12(1), 23–33.

Flyvbjerg, B., Bruzelius, N., and Rothengather, W. (2003a). *Megaprojects and risk: An anatomy of ambition*, Cambridge University Press, Cambridge, U.K.

Flyvbjerg, B., Holm, M. K. S., and Buhl, S. L., (2003b). "How common and how large are cost overruns in transport infrastructure projects?" *Transport Rev.*, 23(1), 71–88.

Flyvbjerg, B., Holm, M. K. S., and Buhl, S. L., (2004). "What causes cost overrun in transport infrastructure projects?" *Transport Rev.*, 24(1), 3–18.

Grimsey, D., and Lewis, M. (2007). "PPP and public procurement." *Agenda*, 14(2), 171–188.

Hampton, G., Baldwin, A. N., and Holt, G. (2012). "Project delays and cost Stakeholder perceptions of traditional v. PPP procurement." *J. Financ. Manage. Property Construct.*, 17(1), 73–91.

Hinze, J., Selstead, G., and Mahoney, J. P. (1992). "Cost overruns on state of Washington construction contracts." *Transport. Res.*, 1351, 87–93.

Iacobacci, M. (2010). *Dispelling the myths: A pan Canadian assessment of public-private partnerships for infrastructure investments*, Conference Board of Canada, Ottawa, Canada.

Infrastructure Partnerships Australia. (2007). Performance of PPP's and traditional procurement in Australia.

Ministry of Statistics and Programme Implementation (MOSPI). (2012). "Project implementation status report for central sector projects." Quarterly Reports, Mar. 2004–Jun. 2009 ⟨http://mospi.nic.in/Mospi_New/site/inner.aspx?status=3&menu_id=128⟩ (Feb. 10, 2012).

Odeck, J. (2004). "Cost overruns in road construction—what are their sizes and determinants?" *Transport Pol.*, 11, 43–53.

Parikh, K. S. (1995). "Enron episode: Lessons for power policy." *Econ. Polit. Wkly.*, 30(41–42), 2543–2546.

PPP Project Database. (2011a). "Master list of PPP projects, as on Jan. 31, 2011." ⟨http://www.pppindiadatabase.com/Uploads/Master%20List%20PPP%20Projects%20in%20India%20as%20on%20January%2031,2011.pdf⟩ (Mar. 9, 2012).

PPP Project Database. (2011b). "Status of PPP projects, as on Jul. 31, 2011." ⟨http://www.pppindiadatabase.com/Uploads/Status%20of%20PPP%20Projects%20as%20on%20July%2031,%202011.pdf⟩ (Mar. 9, 2012).

Sambasivan, M., and Soon, Y. W. (2006). "Causes and effects of delays in Malaysian construction industry." *Int. J. Proj. Manage.*, 25(20), 517–526.

Shaheen, A. A., Fayek, A. R., and AbouRizk, S. M. (2007). "Fuzzy numbers in cost range estimating." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)0733-9364(2007)133:4(325), 325–334.

Singh, R. (2010). "Delays and cost overruns in infrastructure projects: Extent, causes and remedies." *Econ. Polit. Wkly.*, 45(21), 43–54.

Swaminathan, A. K. (1999). *Study on delays due to pre-construction activities in national highway projects*, World Bank, New Delhi, India.

Vijayamohanan, P. N., and Kannan, K. P. (2003). "Time and cost over-runs of the power projects in Kerala." *WP No 320*, Centre for Development Studies, Thiruvananthapuram.