Procurement Contracts: *Traditional Versus PPPs*

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1 Introduction

Objective: In this paper, we

- compare the incentive structures generated by PPP contracts with the one induced by Tradition Procurement (TP) contracts.
- Besides, we study the *actual* construction costs under the PPP contracts with those under TP contracts.

Main Claims: We argue that

- PPP Contracts encourage life-cycle approach toward total project costs.
- PPP projects experience relatively **high** construction costs
- Relatively high construction costs for PPP projects are attributable to *non-contractible quality* investments/efforts on the part of the contractor.

The above claims are corroborated by showing that:

- *Ceteris paribus*, $\frac{C^a}{C^e}$ is significantly higher for PPP projects.
- *Ceteris paribus*, $\frac{T^a}{T^e}$ is significantly lower for PPPs projects.

where

$$CO = \frac{C^a}{C^e} = \frac{\text{Actual construction cost}}{\text{Estimated construction cost}}$$

and

$$TO = \frac{T^a}{T^e} = \frac{\text{Actual construction time}}{\text{Estimated construction time}}$$

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Literature:

- There is no existing empirical work on the subject comparing the actual construction costs under PPPs with those under TP contracts. Blanc-Brude, Goldsmith and Valila (2009) compare costs for PPP and TP projects. This work shows that the *ex-ante* construction costs are higher for PPP projects. The question, however, is whether the relatively high expected costs for PPPs are on account of the higher risk-premium charged by the PPPs contractor (since, PPPs allocate relatively high risk to contractors), or due to higher quality of construction under PPPs? The paper does not address and answer this question satisfactorily.

- Theoretical papers on PPPs have not adequately addressed the relationship between construction costs and the operation and maintenance, ($O\&M$), costs in view of the across-phase externalizes.

- There is large literature on construction costs (See (Laffont and Tirole (1993), Bajari and Tadelis (2001), Ganuza (1997,2007), Bajari and Tadelis (2001), Chen and Smith(2001), Arvan and Leite (1990), and Gaspar and Leite (1989);. But, it
  - focuses on Cost-plus and Fixed price contracts, and
  - ignores traditionally used Unit-rate contracts as well as PPPs/PFIs.
  - totally ignores the $O\&M$ costs and the across phase externalities.

- Our model life-cycle costs. Our model builds on Hart et al (1997), Hart (2003), and Benette and Iossa (2006).

2 Model

Provisioning of public goods and services typically requires building of assets. For example, provision of road services requires construction of roads. Therefore, procurement of these services starts with procurement of the relevant assets. A procurement contract is between the government and a contractor for construction of the assets needed for the purpose. The signing of a procurement contractor is preceded by what is called 'scoping' of the project by the government department concerned. The scope of project specifies the 'output' features that the assets should possess. For example, for an expressway project, the scope will specify number of traffic lanes, number and location of cross-section, by passes, under-passes, over-passes, cross-section, toll-plazas, major, medium and small bridges, service roads, etc. Besides, the project sponsoring department provides estimates of the works/tasks required to build the project assets, and their expected costs.[1] For a given project, let

[1] It is the government (the buyer) who decides the output features of the assets. It also provides estimates of the work-items and their costs. However, depending on the procurement contract to be

C^e denote the expected construction costs.

C^e is derived from the estimates of quantities of work-items and their per-unit costs.[2] We model these issues in Appendix. For infrastructure projects, the number of the works can be really large. [3] Therefore, complete identification and description of project works is a complex activity inherently prone to errors. As the empirical literature on the subject reveals, some of the relevant works invariably get left out of the initial design.

C^e is the estimated cost of works covered by the initial design, which is a subset of all relevant works. The leftover works are identified and incorporated in the design once the construction phase starts. Let

C^a denote the *actual* construction costs.

Remark 1 *C^a is borne by the builder contractor. The mode of compensation to the contractor for C^a differs across contracts.*

For the reasons discussed below, C^a typically turns out to be different from the estimated cost C^e. Some of the leading causes are discussed below. However, the actual construction costs, C^a, depend on

- the cost of inputs (material, labour, capital, etc), and
- on various *non-contractible* efforts/investment made by the builder contractor.

We model three types of *non-contractible* efforts/investment by the builder contractor after the award of contract date and before the completion of construction date. The time-line runs as follows: at $t = 0$ the scope and the cost estimates are derived. Assume the procurement contract is signed at $t = 0$ itself. Construction starts at $t = 1$ and ends at $t = 2$. The $O\&M$ phase starts at $t = 2$ and ends at $t = 3$. The project assets have no value after $t = 3$. Let,

a denote the construction costs reducing effort put in at $t = \frac{1}{2}$.

We interpret a as the expenditure or efforts in organizing of works, searching for most suitable design, securing supply of inputs, manpower, etc.[4] If implemented, a

used, the detail designing - that is detailed identification the work-items and their quantities may be done by the contractor.

[2]A typical road project requires many works such as, construction of embankment, construction of subgrade, building of earthen and concrete shoulders, fixing of drainage spouts, laying of boulder apron, among many others. Quantities are defined in terms of area (sq feet), or length (feet), depending on the nature of the work-item.

[3]Even a road bridge needs as many as 78 major and 26 minor activities/work items to be performed.

[4]The literature suggests that organization of project works is crucial for the construction costs. See....

reduces construction costs by improving the design and management of construction related works. Specifically, a can reduce construction costs by $\kappa^1(a)$.

Remark 2 *Effort a is implemented before construction starts. Moreover, this effort reduces construction costs without diluting the quality or standards of the construction. However, the actual reduction in construction costs enjoyed by the contractor depends on the degree of decision rights delegated to him.*

However, the contractor may not be able to appropriate all the benefits resulting from a. For any given project work, the contractor can enjoy the entire saving in construction costs only if the decision right w.r.t. that work has been contractually delegated to him; otherwise, he will have to negotiate the required changes with the government thereby yielding some of the benefits. Let, the actual reduction in construction costs enjoyed by the contractor be

$$\alpha\kappa^1(a),$$

where α in an increasing function of the degree of delegation of decision rights. Assume $0 \leq \alpha \leq 1$. Of course, α will vary across contracts. Between PPP and TP, α is higher for PPPs, since the degree of delegation is higher under PPPs. A PPP contracts specifies only the output features. Most decisions related to 'how to build' the assets are delegated to the contractor. For instance, the contractor can use his own design, allowing him to appropriate all the savings due to designs innovations. On the other hand, under a TP contract, the output as well as most of the input -'how to build'- related decisions, including the design are taken by the government department. These decisions are specified in the contract and cannot be altered by the contractor.

Next, we model efforts/investments that affect quality of construction as well the Operation and Maintenance, $O\&M$, costs. Let,

e denote the quality shading effort.

e is put in by the constructor during the construction phase Being quality shading in nature, e reduces construction costs at the expanse of quality. A decrease in construction quality leads to higher $O\&M$ costs. The scope for e depends on whether deviations from the contractually-specified work standards are easily detectable or not. Several factors like non-verifiability of output standards, corruption, etc., can increase the scope for e. Suppose e reduces construction costs by $\kappa^2(e)$.

Finally, we allow for a quality improving effort; i. Alternatively, i can be thought of as investment to improve quality of construction works. This innovation/investment reduces the $O\&M$ costs. If implemented, i increases construction costs by $\kappa^3(i) \geq 0$.

Both e and i are possible during the construction phase, say at $t = \frac{3}{2}$, and can be implemented by the contractor without violating the letter of the contract.

In view of the above, if a, e and i are implemented, the total construction costs (excluding cost of efforts themselves) will be

$$C^a(a, e, i) = C^0 - \kappa^1(a) - \kappa^2(e) + \kappa^3(i), \tag{1}$$

where C^0 denoted the total construction cost in the absence of efforts a, e and i. Assume

$$\frac{\partial \kappa^1(a)}{\partial a} > 0, \ \& \ \frac{\partial^2 \kappa^1(a)}{\partial a^2} < 0.$$
$$\frac{\partial \kappa^2(e)}{\partial e} > 0, \ \& \ \frac{\partial^2 \kappa^2(e)}{\partial e^2} < 0.$$
$$\frac{\partial \kappa^3(i)}{\partial i} \geq 0, \ \& \ \frac{\partial^2 \kappa^3(i)}{\partial i^2} \geq 0.$$

For any given level of a, e and i, the actual total construction costs is

$$\begin{aligned} &= C^a(a, e, i) + a + e + i \\ &= C^0 - \kappa^1(a) - \kappa^2(e) + \kappa^3(i) + a + e + i \end{aligned} \tag{2}$$

Let,

$\Phi(e, i)$ denote the expected $O\&M$ costs.

$O\&M$ costs are incurred during the operational phase of the project. In view of the above

$$\frac{\partial \Phi(e, i)}{\partial e} > 0, \ \& \ \frac{\partial \Phi(e, i)}{\partial i} < 0.$$

Further assume $\frac{\partial^2 \Phi(e,i)}{\partial e^2} > 0, \ \& \ \frac{\partial^2 \Phi(e,i)}{\partial i^2} > 0$. Assuming no-discounting, the life-cycle costs -total cost construction cost plus $O\&M$ cost- will be

$$\begin{aligned} \mathfrak{C}^a(a, e, i) &= C^a(a, e, i) + \Phi(e, i) + a + e + i \\ &= C^0 - \kappa^1(a) - \kappa^2(e) + \kappa^3(i) + \Phi(e, i) + a + e + i \end{aligned} \tag{3}$$

For any given C^e, the life-cycle costs minimization problem is:

$$\min_{a,e,i} \left\{ \Phi(e, i) - \kappa^1(a) - \kappa^2(e) + \kappa^3(i) + a + e + i \right\}. \tag{4}$$

The total cost minimizing efforts a^*, e^* and i^* solve the following necessary and sufficient first order conditions, respectively:

$$\frac{\partial \kappa^1}{\partial a} \leq 1 \qquad \text{with equality if } a^* > 0 \tag{5}$$

$$\frac{\partial \kappa^2(e)}{\partial e} - \frac{\partial \Phi(e,i)}{\partial e} \leq 1 \qquad \text{with equality if } e^* > 0 \tag{6}$$

$$-\frac{\kappa^3(i)}{\partial i} - \frac{\partial \Phi(e,i)}{\partial i} \leq 1 \qquad \text{with equality if } i^* > 0 \tag{7}$$

On the other hand, the construction cost minimization problem is

$$\min_{a,e,i} \left\{ -\kappa^1(a) - \kappa^2(e) + \kappa^3(i) + a + e + i \right\} \tag{8}$$

Let (a^{**}, e^{**}, i^{**}) be solution to the above optimization problem. From (8) it can be seen that $i^{**} = 0$. Moreover a^{**} will solve (5), but e^{**} will solve the following first order condition:

$$\frac{\partial \kappa^2(e)}{\partial e} = 1.$$

We assume functional forms that give us

$$a^* > 0,\ e^* = 0,\ \ i^* > 0,\ \&\ e^{**} > 0.$$

3 Contracts and Costs: *Comparison*

PPP and TP contracts have the following distinguishing features:

Traditional Procurement (Unit-rate Contracts):

- Contractor builds the pre-designed good
- *Per-unit* cost risk mostly borne by the contractor
- Work quantities related risk mostly borne by the Govt.
- Contractor does not bear any O/M cost and related risk
- Short-term contract; the relation ends with the construction phase
- Most decision rights are retained by the government

PPP Contracts:

- Specify only the output features
- Contractor design, builds, finances and maintains the good (D-B-F-O-M)

- Entire Construction cost risk is borne by contractor by contractor; all increases in construction costs such as on account of incomplete design, cost of inputs etc., are borne by the contractor.
- Contractor bears all O/M costs are risks risk
- Long-term contract; the relation covers construction as well as maintenance phases
- Most decision rights, especially those related to construction, are delegated to the contractor

Under PPP, the contractor solves

$$\max_{a,e,i} \left\{ P^{PP} - [\Phi(e,i) - \alpha^{PP}\kappa^1(a) - \kappa^2(e) + \kappa^3(i) + a + e + i] \right\}, \tag{9}$$

where P^{PP} denoted the expected receipts for the contractor. Depending on the context, it is the expected value of the use-fee (in case PPP is a concession), or expected value of the payments contractually agreed by the government. Let, (a^{PP}, e^{PP}, i^{PP}) be solution to (9). From (4) and (9), it is clear that $e^{PP} = e^* = 0$ and $i^{PP} = i^*$. However, a^{PP} will solve

$$\alpha^{PP}\frac{\partial \kappa^1(a)}{\partial a} = 1. \tag{10}$$

That is $a^{PP} \leq a^*$.

Under TP, the contractor essentially solves the following:[5]

$$\max_{a,e,i} \left\{ P^{UR} - [\alpha^{TP}\kappa^1(a) + \kappa^2(e) - \kappa^3(i) + a + e + i] \right\} \tag{11}$$

So, the contractor will choose $e^{TP} = e^{**}$ and $i^{PP} = i^{**} = 0$. However, a^{TP} will solve

$$\alpha^{TP}\frac{\partial \kappa^1(a)}{\partial a} = 1. \tag{12}$$

In view of $\alpha^{TP} < \alpha^{PP}$, we have $a^{TP} < a^{PP}$. To sum up,

$$\begin{aligned} i^{PP} &= i^* > i^{TP} = 0 && (13)\\ e^{PP} &= e^* = 0 < e^{**} = e^{TP} && (14)\\ a^{TP} &\leq a^{PP} = a^*. && (15) \end{aligned}$$

Assuming competitive bidding, under PPP cost to the government is

[5] The details of contractor's optimization problem under TP are provided in Appendix.

$$P^{PP} = C^0 - \kappa^1(a^{PP}) - \kappa^2(e^{PP}) + \kappa^3(i^{PP}) + \Phi(e^{PP}, i^{PP}) + a^{PP} + e^{PP} + i^{PP}$$

On the other hand, under TP cost to the government is

$$P^{TP} + \Phi(e^{TP}, i^{TP})$$

where

$$P^{TP} = C^0 - \kappa^1(a^{TP}) - \kappa^2(e^{TP}) + \kappa^3(i^{TP}) + a^{TP} + e^{TP} + i^{TP}$$

The above analysis offers the following results:

Proposition 1 *For any given C^e and, ceteris paribus,*

$$\mathfrak{C}^a_{PP} < \mathfrak{C}^a_{TP}$$

Proposition 2 *For any given C^e and, ceteris paribus,*

$$[a^{TP} = a^{PP}] \Rightarrow [(\frac{C^a}{C^e})^{PP} > (\frac{C^a}{C^e})^{TP}]$$

But, $a^{PP} > a^{TP}$, therefore, the effect of i and e may dominate the effect of a, or *vice-versa*. That is, the cost ratio $\frac{C^a}{C^e}$ under a PPP can be greater or lower than this ratio under TP, i.e., $(\frac{C^a}{C^e})^{PP} > (\frac{C^a}{C^e})^{TP}$ or $(\frac{C^a}{C^e})^{PP} \leq (\frac{C^a}{C^e})^{TP}$ may hold.

However, in an empirical context if it turns out that $(\frac{C^a}{C^e})^{PP} > (\frac{C^a}{C^e})^{TP}$, the actual construction cost difference between PPP and TP - attributable to i and e - will be greater than the differences observable from data on construction costs (because of the higher a under PPPs).

4 Cost Comparisons: Other factors

Our data shows $E(\frac{C^a}{C^e})^{PP} > E(\frac{C^a}{C^e})^{TP}$. The above analysis attributes this outcome to the trade-off between construction costs and the $O\&M$ costs; more specifically, to the differences in the levels of non-contractible efforts e and i under the two types of contracts. However, $\frac{C^a}{C^e}$ can be higher for PPPs for the following additional reasons:

1. At Project Designing/Planning Stage:
   (a) Purposeful Under-estimation of C^e for PPPs
   (b) Choice of PPPs by Department
   (c) Choice of PPPs by contractors - Endogeneity
2. During Construction Stage:

(a) larger addition to ex-post works for PPP projects

(b) Trade off between Construction Costs and Deliver Time. The PPP contractor has incentive to expedite construction, since his revenue stream can start only after the construction is over. (PPP contractor can collect fee/annuity only after project is complete.) There is no such incentive for a TP contractors.

   i. So $\frac{T^a}{T^e}$ is expected to be lower for PPP. However,

   ii. Lower $\frac{T^a}{T^e}$ can increase $\frac{C^a}{C^e}$

   iii. But, lower $\frac{T^a}{T^e}$ can decrease $\frac{C^a}{C^e}$; inflation, etc

However, projects in our data set do not suffer from problems 1(a)-1(b) and 2(a) above, since

- For all projects, cost estimates were arrived at $t = 0$, before contractual choice was made.
- Since 2005, each is project was offered for PPPs. If no takers, then TP was used. (In our data, most PPPs are post-2005)
- 10 year Tax holiday for investors; so contractor does not benefit by escalating costs.
- Moreover, as per the contract (MCA), construction cost cannot be a basis for contract renegotiation.
- The upfront subsidy (VGF) is based on the estimated and not on actual costs.

Moreover, we are able to control for $\frac{T^a}{T^e}$, the issue in 2(b) above. However, we need to address the issue in 1(c).

Besides, for any given contract type, (in)completeness of the initial design has implications for the ratio $\frac{C^a}{C^e}$. It is pertinent to capture factors that have bearing on the completeness of the design and therefore the cost ratio. ????

Let,

l denotes the experience of the designers with project designing,
τ denotes the complexity of the project.

Proposition 3 $\frac{\partial E\left(\frac{C^a}{C^e}\right)}{\partial l} < 0$ *and* $\frac{\partial E\left(\frac{C^a}{C^e}\right)}{\partial \tau} > 0$.

Proof is provided in the appendix.

We have proxies for l and τ for our dataset. So, we are able to control for these factors while running regressions.

5 Empirical Framework and Results

We use the following model

$$\begin{aligned}
\frac{C^a}{C^e} &= \alpha_0 + \alpha_1 TIMELAPSE_t + \alpha_2 TIMELAPSE_t^2 + \alpha_3 INITIALCOST_t \\
&+ \alpha_4 IMPLPHASE_t + \alpha_5 DPPP_t + \alpha_6 PSGDP_t \\
&+ \alpha_7 (\frac{T^a}{T^e}) + \epsilon_{2t}
\end{aligned}$$

RESULTS:

Ceteris paribus, average cost overruns, i.e., $\frac{C^a}{C^e} = CO$

- are higher for PPP projects;
- decreases with TIMELAPSE. This variable captures the experience with project planning, i.e., l. It is defined as the time difference between the contract date for the project at hand and the contract date for the first (oldest) project in the data set. A later date means more experienced planning.
- increases with TIME-OVERRUN, i.e., $(\frac{T^a}{T^e})$;
- increases with IMPL-PHASE. It is T^e, as defined above. Ceteris-paribus, T^e measures the complexity of the project, i.e., τ - between two projects with equal estimated costs, the planners plausibly will keep longer T^e for the more complex project.

The coefficient of TIMELAPSE, and TIMELAPSESQ are of expected sign and are highly significant.

The coefficient of IMPLPHASE is positive and extremely significant at 1 percent.

The coefficient of PPP dummy is positive and extremely significant at 1 percent.