Procurement Contracts for Public Goods

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Procurement Contracts

- Procurement Contracts are used for provisions of public goods such as road and railways services, school
- Provision public goods requires procurement/building of assets - road, school building, etc.
- A Procurement Contract
  - Specifies responsibilities, rights and compensation mode for the contractor
  - Allocates construction, maintenance, and commercial risks between contracting parties.
- Procurement Contracts differ in terms of delegation of decision making power and risk allocation b/w public and private sector.

Traditional Contracts Vs PPPs: Risk Allocations

- Traditional Procurement :
  - 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
- PPP:
  - Contractor designs, builds and maintains the good (e.g., D-B-F-O-M; BOT)
  - All of Construction cost related risks are borne by contractor by contractor
  - Contractor bears all O/M costs are risks risk
- PPP delegates more decision rights to the contractor

Incomplete Contracts

Public Goods:

- Have output features
  - Number of traffic lanes, capacity of an airport, design of the road, or the station building
- Quality of the assets/services
  - roads without potholes, waiting time at toll plaza, building without cracks, passenger services at the station, etc.

We assume

- Output features are verifiable/contractible
- Quality is not
  - quality shows up after several years of construction,
  - corruption can make the quality 'non-verifiable'

Traditional Contracts Vs PPPs: Comparison of Outcomes

We

- Compare the incentive structures generated by PPP contracts with the one induced by Tradition Procurement Contracts
- Compare the actual construction cost for PPP contracts with Non-PPP Contracts

Main Claims

- PPP Contracts induce **lower** Life-cycle costs of project
- PPP Contracts induce relatively **high** Construction Costs
- Relatively high Construction Costs in PPP projects are attributable to non-contractible **quality** investments/efforts

Approach

- We model construction costs under PPPs and TP contracts
- we compare the costs ratio

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

The above claims are corroborated by showing that:

- *Ceteris paribus*, $\frac{C^a}{C^e}$ is significantly higher for PPPs

Project Design and Costs I

Project Design requires three tasks:

- Description of 'output' features of the project facility/assets
- Description/listing of the work-items
- Estimation of the number of the quantities of the work-items and their per-unit cost

For a given project, let

- d denote the effort in project designing
- $[0, \overline{W}]$, $0 < \overline{W}$ be the set of **total** work-items needed to be performed
- W be the number of works covered by the **initial** design; $W = W(\tau, I, d)$, where
- I denotes experience of the designers with project planning; and
- τ denotes technical complexity of the project.

Project Design and Costs II

- $W(\tau, l, 0) = 0$, $W(\tau, l, \infty) = \overline{W}$,
- $\frac{\partial W(\tau,l,d)}{\partial d} > 0$
- $\frac{\partial W(\tau,l,d)}{\partial l} > 0$
- $\frac{\partial W(\tau,l,d)}{\partial \tau} < 0$

As a result of d, the designer

- specifies works $[0, W]$, and
- gets $C^e_{[0,W]}$ as the signals of $C^a_{[0,W]}$, where

$$C^a_{[0,W]} = C^e_{[0,W]} + \epsilon$$

Assume

$$E(\epsilon) = 0 \qquad (0.1)$$

Actual Costs I

The actual Construction Cost depends on

- the cost of inputs (material, labour, capital, etc); and
- various *non-contractible* efforts/investment made by the builder contractor
  - a organizational effort before construction starts
  - e cost reducing but quality-shading effort
  - i quality improving effort
- e and i are put during construction.

Actual Costs II

For give a, e and i,

$$C^a_{[0,\overline{W}]}(a,e,i) = C^0_{[0,\overline{W}]} - \kappa^1(a) - \kappa^2(e) + \kappa^3(i),$$

where

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

$$\frac{\partial\kappa^2(e)}{\partial e} > 0, \ \& \ \frac{\partial^2\kappa^2(e)}{\partial e^2} < 0.$$

$$\frac{\partial\kappa^3(i)}{\partial i} \geq 0, \ \& \ \frac{\partial^2\kappa^3(i)}{\partial i^2} \geq 0.$$

Actual Costs III

For any given level of *a*, *e* and *i*, the actual construction costs of all works, $C^a_{[0,\overline{W}]}$, is given by

$$C^a_{[0,\overline{W}]} = C^a_{[0,W]} + C^a_{(W,\overline{W}]} \tag{0.2}$$

So,

$$\frac{C^a_{[0,\overline{W}]}}{C^e_{[0,W]}} = \frac{C^a_{[0,W]}}{C^e_{[0,W]}} + \frac{C^a_{(W,\overline{W}]}}{C^e_{[0,W]}} \tag{0.3}$$

In view of (0.1), for given $C^e_{[0,W]}$,

$$E\left[\frac{C^a_{[0,\overline{W}]}}{C^e_{[0,W]}}\right] = 1 + \frac{C^e_{(W,\overline{W}]}}{C^e_{[0,W]}} \tag{0.4}$$

Actual Costs IV

Proposition

- $E\left[\frac{C^a_{[1,\overline{W}]}}{C^e_{[1,W]}}\right] \geq 1.$
- $\frac{\partial E\left[\frac{C^a_{[1,\bar{W}]}}{C^e_{[1,W]}}\right]}{\partial d} < 0.,\ \frac{\partial E\left[\frac{C^a_{[1,\bar{W}]}}{C^e_{[1,W]}}\right]}{\partial I} < 0,\ \frac{\partial E\left[\frac{C^a_{[1,\bar{W}]}}{C^e_{[1,W]}}\right]}{\partial \tau} > 0.$

Suppose, for given I and τ,

$$\left(\frac{C^a_{[1,\overline{W}]}}{C^e_{[1,W]}}\right)^{PPP} > \left(\frac{C^a_{[1,\overline{W}]}}{C^e_{[1,W]}}\right)^{TP}.$$

It can hold because

- Either d is lower for PPPs;
- Or, on account of differences in a, e and i

Actual Costs V

The total Construction costs is

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

Let

- $\Phi(e, i)$ denote the O/M costs.

The total life cycle costs -total cost construction cost plus *O&M* cost- will be

$$
\begin{aligned}
\mathfrak{C}_{[0,\overline{W}]} &= C^{a}_{[0,\overline{W}]} + \Phi(e, i) \\
&= [C^{0}_{[0,\overline{W}]} - \kappa^{1}(a) - \kappa^{2}(e) + \kappa^{3}(i)] + \Phi(e, i) \\
&+ a + e + i \qquad (0.5)
\end{aligned}
$$

Optimization Problems I

For any given d and $C^e_{[1,W]}$, the total cost (construction plus $O\&M$) minimization problem is:

$$\min_{a,e,i}\{\Phi(e,i) \quad - \quad [\kappa^1(a)+\kappa^2(e)-\kappa^3(i)]+a+e+i\}.$$

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

$$\frac{\partial\kappa^1(a)}{\partial a} \leq 1 \tag{0.6}$$

$$\frac{\partial\kappa^2(e)}{\partial e} - \frac{\partial\Phi(e,i)}{\partial e} \leq 1 \tag{0.7}$$

$$-\frac{\partial\kappa^3(i)}{\partial i} - \frac{\partial\Phi(e,i)}{\partial i} \leq 1. \tag{0.8}$$

Optimization Problems II

We assume

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

On the other hand, a construction cost minimization problem is

$$\min_{a,e,i}\{-[\kappa^1(a) + \kappa^2(e) - \kappa^3(i)] + a + e + i\} \tag{0.9}$$

Let (a^{**}, e^{**}, i^{**}) be solution to the above optimization problem. Now, it can be seen that $i^{**} = 0$, and a^{**} and e^{**} will solve the following first order conditions:

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

Clearly, $a^{**} = a^*$. Assume $e^{**} > 0$.

Contracts and Equilibria I

Under PPP, the contractor solves

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

where
$0 \leq \alpha^{PP} \leq 1$ and depends on the decision rights delegated to the contractor.

We have $e^{PP} = e^*$ and $i^{PP} = i^*$, and a^{PP} solves the following first order condition:

$$\frac{\partial\kappa^1(a)}{\partial a} \leq 1$$

Contracts and Equilibria II

On the other hand, under TP, the contractor solves

$$\max_{a,e,i} \{p^{TP} - [\alpha^{TP}\kappa^1(a) + \kappa^2(e) - \kappa^3(i)] - [a + e + i]\} \tag{0.10}$$

Assume $\alpha^{TP} < \alpha^{PP}$.

$$\begin{cases} i^{PP} = i^* > i^{TP} = i^{**} = 0 & ; \\ e^{PP} = e^* = 0 < e^{**} = e^{TP} & . \\ a^{TP}(\alpha^{TP}) < a^{PP}(\alpha^{PP}) \leq a^* & . \end{cases} \tag{0.11}$$

Cost Comparisons I

Proposition

For any given d and $C^e_{[1,W]}$:

$$\mathfrak{C}^a_{PPP} < \mathfrak{C}^a_{UR}$$

Proposition

For any given d, and $C^e_{[1,W]}$:

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

$$e^{TP} = e^{PP} \text{ and } i^{TP} = i^{PP} \quad \Rightarrow \quad [(\frac{C^a}{C^e})^{PP} < (\frac{C^a}{C^e})^{TP}]$$

However, $a^{TP} < a^{PP}$, $e^{TP} > e^{PP}$ and $i^{TP} < i^{PP}$. Therefore,

Cost Comparisons II

- $(\frac{C^a}{C^e})^{PPP} >$ or $\leq (\frac{C^a}{C^e})^{TP}$ is possible
- But, if it turns out that $(\frac{C^a}{C^e})^{PPP} > (\frac{C^a}{C^e})^{TP}$ then it must be on account of differences in e and i
- Moreover, the actual cost difference b/w PPPs and TPs on account of e and i is greater than what data will show

DATA: NHAI

- National highways (NH) projects, sponsored by the National Highways Authority of India (NHAI);
- All over India;
- Completed 1995 onwards.
- All projects: 453
  - PPPs 176
  - Non-PPPs/IR 277
- Completed Projects: 195
  - PPPs 50
  - Non-PPPs/IR 145

Higher $\frac{C^a}{C^e}$ for PPPs : Other possible reasons

However, $\frac{C^a}{C^e}$ can be higher for PPPs for the following reasons:

- At Project Designing/Contracting Stage:
  - Purposeful Under-estimation of C^e for PPPs
  - Choice of PPPs by Department
  - Choice of PPPs by contractors - Endogeneity
- During Construction Stage:
  - Ex-post addition to works for PPP projects
  - Trade off between Construction Costs and completion Time;
    - Lower $\frac{T^a}{T^e}$ can increase $\frac{C^a}{C^e}$
    - Lower $\frac{T^a}{T^e}$ can decrease $\frac{C^a}{C^e}$; inflation, etc
- Trade-off between Construction Costs and $O\&M$ Costs

Empirical Framework

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

Hypothesis

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

- are higher for PPP projects;
- decrease with experience/TIMELAPSE, i.e., t;
- increase with TIME-OVERRUN, i.e., $TO = (\frac{T^a}{T^e})$;
- increase with IMPL-PHASE, i.e., τ;

Limitations

- We have ignored the fact the social benefit may depend on the design and the other efforts by the contractor
- If so, the choice of a under PPP may not be optimum
- Under Annuity PPPs, the service provided by the contractor may not be optimum

Moreover,

- PPP contracts are more complex than the TP contracts
- If the public sector does not have adequate capacity, contract may not deliver the value for money to the public sector.
- There is greater need for careful regulation during O/M phase