Risk Allocation and the Costs and Benefits of Public-Private Partnerships

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Most public projects: Infrastructure + Management

Public Private Partnerships: Bundling: Builder U Operator

PPP for traditional services (transport, energy, gas)

PPP for new services (prisons, schools, waste recycling plants, undergrounds)
- No precedent service model for new services
- London Underground:
  "Hard to determine whether [the performance measures were] easy or difficult to achieve, and whether they [were] sufficiently aggressive" (NAO, 2004)
- Electronic monitoring system for Home Detention: totally new system
  - Uncertain mapping design effort and operational performance
Why does this uncertainty matter?

- A frequently heard argument: complexity makes PPP unsuitable
- PPP performance: mixed evidence
- UK Treasury recommends against PPP for complex services (Complex IT, recycling plants)
Related literature and uncertainty


- With positive externality, incentive problem easier under bundling

- No role for uncertain mapping
This paper

- Multitask delegation problem (build + manage); sequential tasks
- Bundling vs Unbundling
- Positive externality from design to operations
- **Uncertain mapping** design effort-operational performance
Three cases

- **Early Phase of Delegation:**
  Uncertainty at operational stage; shocks noncontractible
  → Benefit of bundling

- **Mature Phase of Delegation:**
  Shocks contractible and observable
  → More complete contracting possible
  → Even greater benefit of bundling

- **Complex Projects:**
  Asymmetric information on productivity shocks
  → Possible case for unbundling
The model

- Design effort \( a \); operational effort \( e \)
- Verifiable Revenues \( R = e + \zeta \)
- Verifiable Infrastructure Quality index \( Q = a + \varepsilon \)
- Cost of \( a \) is \( a^2 / 2 \)
- **Uncertain mapping:** cost of \( e \) is
  \[
  (e - a - \theta)^2 / 2
  \]
- Shocks \( \zeta \sim N(0, \eta^2) \); \( \varepsilon \sim N(0, \sigma^2) \); \( \theta \sim N(0, \vartheta^2) \)
- Builder and Operator risk averse (CARA)
- Principal max \( R - t \)
Incentive instruments

- Sharing of Revenues $R$
- Quality index $Q$

Unbundling

\[ t_B(Q) = \alpha_B + \beta Q + (\gamma R) ; \]
\[ t_O(Q) = \alpha_R + \gamma R + (\beta Q) \]

No gain from paying B on $R$ and O on $Q$

Bundling

\[ t(Q, R) = \alpha + \beta Q + \gamma R \]
Benchmark: contractible efforts and shocks

- Organizational form irrelevant

- Full insurance

- Efficient efforts

\[
\max E_\theta \left( e - \frac{(e - a - \theta)^2}{2} \right) - \frac{a^2}{2}
\]

\[\Downarrow\]

\[a^* = 1\]

\[e^* (a, \theta) = a + \theta + 1\]

- Positive externality: efforts "comove" but operational effort \(e\) depends on productivity shock \(\theta\).
1. Early phase of delegation:

- New services/services traditionally in public sector; no past data
- Unforeseen shocks $\rightarrow \theta$ not contractible;

- Unbundling:

\[
\text{Builder: } \max_a \alpha_B + \frac{\beta a}{\beta Q} - \frac{a^2}{2} - \frac{r \beta^2 \sigma^2}{2} \\
\downarrow \\
\alpha_U = \beta_U
\]

\[
\text{Operator: } \max_e \alpha_O + \frac{\gamma e}{\gamma R} - \frac{1}{2} (e - a - \theta)^2 - \frac{r \gamma^2 \eta^2}{2} \\
\downarrow \\
e_B = a_U + \theta + \gamma U
\]
Bundling

\[
\max_{a, e} \alpha + \beta a + \gamma e - \frac{a^2}{2} - \frac{(e - a - \theta)^2}{2} - \frac{r\beta^2\sigma^2}{2} - \frac{r\gamma^2\eta^2}{2}
\]

\[
\beta Q + \gamma R
\]

\[
\downarrow
\]

\[
a_B = \beta_U + \gamma_U
\]

\[
e_B = a_B + \theta + \gamma_B
\]

Bundling is optimal

- Internalized effect of design effort \(a\) on cost of operational effort, and thus revenues \(R\)

- Revenue-risk transfer more effective on incentives

→ Better “risk/efficiency” trade-off

→ More revenue sharing

\[
1 > \gamma_B > \gamma_U
\]
2: Mature Phase of Delegation

- Past data available $\rightarrow \theta$ contractible and verifiable ex post; $a, e$ unobservable
- Now more complete contracting: menu $\alpha(\theta), \gamma(\theta)$
- In practice: "compensation events" /revenue guarantees/risk matrix:
Full insurance optimal

\[ U(\bar{\theta}, a) = U(\theta, a) \]

How?

Through monetary compensation:

\[ \alpha(\theta) - \alpha(\bar{\theta}) = \gamma \Delta \theta \]

Instead revenue share independent of productivity shocks:

\[ \gamma(\theta) = \gamma(\bar{\theta}) \]

\[ \Rightarrow \text{Revenue sharing schemes now more effective on incentives} \]

\[ \Rightarrow \text{Gain from bundling increases} \]
3: Complex projects

- Now $\theta$ is the operator’s private information
- Feasible mechanisms must induce truthtelling

Unbundling:

\[ IC : \ U(\bar{\theta}, a) \geq U(\theta, a) + \Delta \theta \gamma(\theta) \]

- Incentive to claim a bad shock to receive monetary compensation
- Need extra risk $\Delta \theta \gamma(\theta)$ on operator to induce truthtelling
- Cost of truth-telling: reduce $\gamma(\theta)$ and thus also $e(\theta)$
Bundling:

\[ IC : U(\bar{\theta}, a) \geq U(\theta, a) + \Delta \theta \gamma(\theta) + \xi(\gamma(\theta), \Delta \gamma) \]

Double deviation: may deviate in design stage, choose lower \( a \), and underreport \( \theta \)

Extra slack \( \xi(\gamma(\theta), \Delta \gamma) > 0 \) iff \( \Delta \gamma > 0 \)

If lower \( \gamma(\theta) \) to reduce rent, then \( \Delta \gamma > 0 \), and lower benefit from design effort if misreport.
What is the cost of the extra slack to avoid double deviation under bundling?

Mechanism not Renegotiation-Proof:

Once a chosen, extra risk on payoff $U(\theta; a)$ should be renegotiated away.

Renegotiation-Proof contract has $\Delta \gamma = 0$, no extra slack.
Main Result

- **When $\Delta \theta$ small, bundling dominates**

The principal loses little with pooling contract under bundling
No slack, $\Delta \gamma = 0$, no cost of double deviation *per se*.

- **When $\Delta \theta$ large and renegotiation is a concern, unbundling dominates.**

Strong efficiency loss with pooling under bundling (zero effort at the operation stage)
Lender observes $\theta$

Govt offers to consortium

$$t(R) = \alpha_B + \gamma_B R$$

Lender offers to consortium

$$z(\theta) = \delta_B + \gamma_B \theta$$

One more layer of contracting, but govt first mover advantage. Gains from bundling re-established.
Summing Up

- PPPs dominates when uncertainty is limited or where sufficient past experience exists.
- Gain from PPP should increase over time for not too complex services.
- Unbundling dominates for complex projects where operational risks are high and there are informational asymmetries.
- Gain from bundling also private finance if lender have expertise to observe $\theta$: "Lender expertise helps risk allocation and increases the benefit of PPP"