The Basic Public Finance
of Public-Private Partnerships

Eduardo Engel, Ronald Fischer and Alexander Galetovic

Yale University, Universidad de Chile and Universidad de los Andes

LCR Economics Seminar Series
World Bank — November 17, 2009
Motivation

- Privatization is increasingly unpopular...

- ...while Public-Private Partnerships are on the rise

- Are PPPs really the “third way”?
  - the best of both worlds?

  or

- the worst of both worlds?
Basics

- Roads, bridges, tunnels, water and sewerage, seaports, airports, hospitals, schools, jails,...
- Most money spent on roads
- Many contractual forms: BLT, BLTM, BOT, DBOT, DBFO, DBFO/M, ROT, JV, ...
Public provision – PPPs – private provision

- All: private firms build (often also maintain)
- Incentives:
  - bundling?
  - control of assets?
  - residual claimant?
- Ties to the budget?
  - public provision: evidently yes
  - privatization: evidently no
  - PPP: ?
Public-private partnerships (PPPs)

- Same firm invests and provides service (‘bundling’)
- Long term contract: 20, 30, 99 years
- Assigned in a competitive (Demsetz) auction or via bilateral negotiation
- During the contract: concessionaire manages and controls the assets
- Revenue sources: user fees, government transfers (subsidies, guarantees, shadow fees, availability payments)
- At the end of the contract: assets revert to government
- Considerable amount of public planning
Investment in PPPs

Year 1990-2006

- Energy
- Telecoms
- Transport
- Water and sewerage
- Total

Eduardo Engel (Yale)  
Public Finance of PPPs  
World Bank - LCR Seminar
Investment in PPPs

Europe:
- UK, Portugal: 20% of public investment via PPPs
- 2002-2006: EUR 114 billion, three times annual average over preceding decade

US - Highways:
- 2006-08 vs. 1996-2005: tenfold (annual) increase
- Pennsylvania Turnpike, Texas SH 130, Indiana Toll Road, Virginia’s Pocahontas Parkway, Chicago Skyway.
Real World Contracts

- Fixed term: e.g., 20, 30, 75 or 99 years
- Minimum income guarantees and subsidies
- Revenue sharing if revenues/profit above a certain threshold
- Bidding variables: lowest price, lowest subsidy, largest up front transfer
- Big debate on whether PPPs are public debt
Economic Characteristics of PPPs

- Large upfront investment
- Bundling of infrastructure finance and service
- Temporal asset ownership by firm
- Control rights given to the provider
- High demand uncertainty
## High Demand Uncertainty: Chile

<table>
<thead>
<tr>
<th></th>
<th>'86</th>
<th>'87</th>
<th>'88</th>
<th>'89</th>
<th>'90</th>
<th>'91</th>
<th>'92</th>
<th>'93</th>
<th>'94</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angost.:</td>
<td>8.8</td>
<td>15.0</td>
<td>11.7</td>
<td>4.5</td>
<td>8.7</td>
<td>12.4</td>
<td>6.7</td>
<td>7.8</td>
<td>9.4</td>
</tr>
<tr>
<td>Zapata:</td>
<td>21.5</td>
<td>14.4</td>
<td>13.1</td>
<td>8.1</td>
<td>7.2</td>
<td>5.2</td>
<td>2.9</td>
<td>3.9</td>
<td>4.9</td>
</tr>
<tr>
<td>Lampa:</td>
<td>3.8</td>
<td>13.4</td>
<td>15.9</td>
<td>8.9</td>
<td>6.8</td>
<td>18.0</td>
<td>8.8</td>
<td>16.2</td>
<td>12.5</td>
</tr>
</tbody>
</table>
High demand uncertainty: Dulles Greenway

14 miles, joins Leesburg in Virginia with Western end of the Dulles toll road
High demand uncertainty

Traffic projection in 1996:
- Estimated: 35,000 daily vehicles for toll of $1.75
- Initially: 8,500 daily vehicles
- State of Virginia widened Route 7 (untolled)

Trouble:
- Ridership increases to 22,000/day after tolls are lowered to $1
- Concessionaire defaults in 1999, contract is renegotiated
- Term extended by 20 years, and tolls raised

Flyvbjerg et al.: systematic evidence on large forecast errors
When PPPs?: Previous academic work

- Bundling has many attributes that bring PPPs close to privatization:
  - temporary ownership of assets
  - can unilaterally implement cost-saving measures
  - can collect user fees

- Incomplete contracts/asymmetric information models:
  - Grout (1997)
  - Bentz, Grout and Halonen (2002)
  - Bennett and Iossa (2006)
  - Martimort and Pouyet (2006)
When PPPs?: Practitioners

- When public funds are saved:

  “One year ago, Indiana faced twin deficits: a fiscal deficit stemming from years of government outspending its means, and an infrastructure deficit, a $3 billion shortfall between the cost of needed transportation projects and the dollars due to come in. [...] Today, state government is operating on a balanced budget, and is on its way to paying back its debts to schools and local governments.”

  Governor Mitch Daniels’ statement the day he announced the winner of the Indiana Toll Road, January 2006.

- When productivity is enhanced
A public finance perspective

- Large upfront investment
- Large, exogenous demand risk
- Intertemporal nature of PPP: “two” periods of variable length
This paper: Main Results

- The lower cost of private funds arguments does not justify PPPs
- When PPPs?: Productive efficiency
- Optimal contract:
  - minimum income guarantee
  - a cap on the firm’s profits
  - can be implemented with a competitive auction with realistic informational requirements

Different from real-world contracts:
- contract term shorter when profit cap binding
- revenue “sharing”: government collects 100%

Budgetary accounting: PPPs closer to public provision
Outline

1. Motivation
2. Model and irrelevance result
3. Productive efficiency and optimal contract
4. Accounting for PPPs
5. Implementation with an auction
6. Extensions
7. Conclusion
2. Model and irrelevance result

Assumptions

- Infrastructure costs $I$ to firms, does not depreciate, no maintenance or operations costs
- Present value of user-fee revenue described by $f(v)$, c.d.f. $F(v)$:
  \[ v_{\text{min}} \leq v \leq v_{\text{max}} \]
- Risk neutral planner maximizes social surplus:
  - revenue in state $v$: $R(v) \in [0, v]$
  - subsidy in state $v$: $S(v) \geq 0$
- Risk averse firm, VNM utility $u(\cdot)$, outside option $u(0)$
- Cost of public funds: $1 + \lambda > 1$
- Relative weight on producer surplus: $\alpha \in [0, 1]$
Planner’s Problem

\[
\max_{\{R(v), S(v)\}} \int [CS(v) + \alpha PS(v)]f(v) \, dv
\]

s.t. \[
\int u(R(v) + S(v) - I)f(v) \, dv \geq u(0),
\]

\[
0 \leq R(v) \leq v,
\]

\[
S(v) \geq 0.
\]
Consumer and Producer Surplus

\[ PS(v) = R(v) + S(v) - I, \]

\[ CS(v) = \left[ v - R(v) - (1 + \lambda)S(v) \right] + \lambda [v - R(v)] \]

net consumer surplus distortionary taxes saved

\[ = (1 + \lambda) [v - R(v) - S(v)]. \]

Hence the planner’s objective is equivalent to:

\[ \min_{\{R(v), S(v)\}} (1 + \lambda - \alpha) \int [R(v) + S(v)] f(v) dv. \]

I.e., minimizes firm’s expected revenue.
Properties of the Optimal Contract

- Full insurance: \( R(v) + S(v) = I \) for all \( v \)
- Revenue-subsidy combination irrelevant
- No surplus for the firm: \( 1 + \lambda - \alpha > 0 \) even when \( \alpha = 1 \)
Irrelevance Result: Intuition

The private sector invests $1:

- the government saves $1 in current public investment
- and therefore saves $1 in taxes
- and therefore saves $1 + \lambda > 1$ to society

Hence: private investment is cheaper
Irrelevance Result: Intuition

But the public sector has to forego $1 in (present value of) user fee revenue:

- therefore must raise $1 in additional taxes
- which costs society $1 + \lambda > 1

Public and private financing are perfect substitutes at the margin

Savings at the beginning are equal to foregone revenue later on
3. Why PPPs?: Productive Efficiency

**Incorporating Productive Efficiency:**

- It is more efficient to finance the firm via user fees than via subsidies: 
  \[1 + \zeta > 1\]
  of subsidies needed to achieve the same as 
  \[1\] of user fees

- \(\zeta\): measures the inefficiency of transferring resources to the firm through the budget

- Opportunity cost of transferring a dollar to the firm:
  - Via user fees: \(1 + \lambda - \alpha\)
  - Via subsidies: \((1 + \lambda)(1 + \zeta) - \alpha\)

- We distinguish between inefficiencies in collecting taxes and spending them
Micro-Foundation for $\zeta$

- Optimal resource allocation across government agencies
- Surplus created if agency $i$ spends $G_i$ on its best projects: $S(G_i), i = 1, \ldots, n$. $S_i(0) = 0, S'_i \geq 0, S''_i < 0$.
- Agency $i$: achieving $G_i$ costs $G_i + Z_i(G_i)$, with $Z_i(0) = 0$, $Z'_i \equiv 1 + \zeta_i \geq 0$, and $\zeta'_i \geq 0$
- Then optimal government expenditures implies:

$$
\frac{S'_i}{1 + \zeta_i} = 1 + \lambda; \quad i = 1, \ldots, n.
$$

- Marginal surplus created by spending an additional dollar in a particular government agency adjusted by the agency’s relative marginal efficiency is constant across all agencies
- $\zeta$ marginal efficiency of agency in charge of PPPs
Planner’s Problem

\[ \begin{align*}
\min_{\{R(v), S(v)\}} & \quad \int \left[ (1 + \lambda - \alpha)R(v) + \{(1 + \lambda)(1 + \zeta) - \alpha\}S(v) \right] f(v) dv \\
\text{s.t.} & \quad \int u(R(v) + S(v) - I)f(v) dv \geq u(0), \\
& \quad 0 \leq R(v) \leq v, \\
& \quad S(v) \geq 0.
\end{align*} \]
Solving the Planner’s Problem

- Basic insight:
  - finance with subsidies only after running out of user fees
  - \( S(v) > 0 \implies R(v) = v \)

- High demand state:
  - no subsidies and finite contract length
  - \( R(v) < v, \quad S(v) = 0 \)

- Low demand state:
  - subsidies are paid out and the contract lasts indefinitely
  - \( R(v) = v, \quad S(v) > 0 \)

- Intermediate demand state:
  - no subsidies and infinite contract length
  - \( R(v) = v, \quad S(v) = 0 \)
## Classification of Demand States

<table>
<thead>
<tr>
<th>$S(v) = 0$</th>
<th>$R(v) &lt; v$</th>
<th>High demand</th>
<th>$R(v) = v$</th>
<th>Intermediate demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S(v) &gt; 0$</td>
<td>Never optimal</td>
<td></td>
<td>Low demand</td>
<td></td>
</tr>
</tbody>
</table>

Where $R(v)$ is the return and $S(v)$ is the supply.
Classification of Projects

Three types of infrastructure projects:

1. **High demand project**: \( v_{\text{min}} > l \)
   - Project can be financed with user fee revenue in all demand states

2. **Low demand project**: \( v_{\text{max}} < l \)
   - Project cannot be financed with revenue in any state

3. **Intermediate demand project**: \( v_{\text{min}} < l < v_{\text{max}} \)
   - Project self-financing in some states but not in all states
Distinction: Projects vs. Demand States

<table>
<thead>
<tr>
<th>Demand state</th>
<th>Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>High:</td>
<td>$R(v) &lt; v, S(v) = 0$</td>
</tr>
<tr>
<td>Intermediate:</td>
<td>$R(v) = v, S(v) = 0$</td>
</tr>
<tr>
<td>Low:</td>
<td>$R(v) = v, S(v) &gt; 0$</td>
</tr>
</tbody>
</table>
Optimal Contract: High Demand Project

- **Full insurance**: $R(v) = I$, $S(v) = 0$
- **All states**: high demand states
- **Contract term varies inversely with demand**
- **Opportunity cost of last dollar spent on the project**: $1 + \lambda$
Optimal Contract: Low Demand Project

- Full insurance: \( R(v) = v, S(v) = I - v \)
- All states: low demand states
- Indefinite contract in all states
- Opportunity cost of last dollar spent on the project:
  \[ (1 + \lambda)(1 + \zeta) \]
Can improve upon, $R(v) + S(v) \equiv I$, that is, upon

\[
\begin{align*}
    v < I & \implies R(v) = v, \quad S(v) = I - v, \\
    v > I & \implies R(v) = I, \quad S(v) = 0.
\end{align*}
\]

Reduce guarantee to $I - \Delta I$, increase revenue cap to $I + c\Delta I$, $c = F(I)/(1 - F(I))$ to leave firm’s expected revenue unchanged.

The planner values:

- dollar saved in subsidies: $(1 + \lambda)(1 + \zeta) - \alpha$
- dollar lost due to higher revenue cap: $1 + \lambda - \alpha$

Hence: welfare improves at $(1 + \lambda)\zeta$ per dollar saved in subsidies.

Net effect: welfare increase proportional to $\Delta I$, while cost of additional risk is 2nd order in $\Delta I$. 
Optimal Contract: Intermediate Demand Project

Will have high-, intermediate- and low-demand states

Two threshold contract:

- Income guarantee: \( m \)
- Revenue cap, \( M \)
- \( m < M \)

<table>
<thead>
<tr>
<th>( v )</th>
<th>( R(v) )</th>
<th>contr. length</th>
<th>( S(v) )</th>
<th>( G(v) )</th>
<th>Opp. cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>( v &lt; m ):</td>
<td>( v )</td>
<td>infinite</td>
<td>( m - v )</td>
<td>( v - m )</td>
<td>( (1 + \lambda)(1 + \zeta) )</td>
</tr>
<tr>
<td>( v \in (m, M) ):</td>
<td>( v )</td>
<td>infinite</td>
<td>0</td>
<td>0</td>
<td>in between</td>
</tr>
<tr>
<td>( v &gt; M ):</td>
<td>( M )</td>
<td>finite</td>
<td>0</td>
<td>( v - M )</td>
<td>( 1 + \lambda )</td>
</tr>
</tbody>
</table>
Two threshold contract: the firm bears risk

- $m$ and $M$ determined by the participation constraint and:

$$u'(m - I) = \frac{\lambda \zeta - \alpha}{\lambda - \alpha} u'(M - I).$$
4. Accounting for PPPs

- PPP assets:
  - government owned?
  - non government owned?

- PPP assets contribute to the government deficit only if government-owned

- No uniform accounting rules across countries

- Some suspicion on government motivation for PPPs:
  
  "Cynics suspect that the government remains keen on PFI not because of the efficiencies it allegedly offers but because it allows ministers to perform a useful accounting trick."

  The Economist, July 2nd 2009.
Assets built by PPPs are classified as non-governmental assets (and therefore recorded off the balance sheet) if both of the following conditions are met:

1. private partner bears construction risk
2. private partner bears one of either availability or demand risk
**PPPs: public or private?**

- PPPs: the benefits of private ownership without the criticism?
- Consider a high demand project:

<table>
<thead>
<tr>
<th></th>
<th>Public provision</th>
<th>PPP</th>
<th>Privatization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upfront surplus:</td>
<td>$-I$</td>
<td>0</td>
<td>$E[v] - I - R.P.$</td>
</tr>
<tr>
<td>PV user fees:</td>
<td>$v$</td>
<td>$v - I$</td>
<td>0</td>
</tr>
<tr>
<td>Total:</td>
<td>$v - I$</td>
<td>$v - I$</td>
<td>$E[v] - I - R.P.$</td>
</tr>
</tbody>
</table>

- What matters is **intertemporal** risk profile
- Risk profile of government budget under PPPs the same as under public provision ... and should be treated that way
- Privatization: budget uncertainty resolved when privatizing
5. Implementation with an auction

Two-threshold auction:

- The government announces $f(v)$ and
  \[
  \zeta \equiv \frac{(1 + \lambda)(1 + \zeta) - \alpha}{1 + \lambda - \alpha}.
  \]

- Firms bid pairs $(m, M)$
- Lowest value of the scoring function

\[
W(M, m) = M(1 - F(M)) + \int_0^M vf(v)dv + \zeta \int_0^m (m - v)f(v)dv
\]

wins the auction
Claim: auction implements optimal contract

- Scoring function $\equiv$ social welfare function
- Denote by $m^*$ and $M^*$ the values for the optimal contract
- $(m^*, M^*)$ is feasible bid; a higher bid cannot be an equilibrium; a lower bid contradicts the optimality of $(m^*, M^*)$
Informational Requirements

- No need to know \( I \) or \( u(\cdot) \)

- Need to know \( f(v) \) and \( \bar{\zeta} \)

For high demand projects, the two-threshold auction reduces to a Present-Value-of-Revenue (PVR) auction:

- bid on PV of user fees
- lowest bid wins
- contract lasts until winning bid is collected
Implications: Minimum Subsidy Auctions

- Minimum subsidy auction of low demand projects is not optimal
- Optimal subsidy is demand-contingent
- Also: expected expenditure on subsidies lower under two-threshold project
Experience with Flexible Term Contracts
Experience with Flexible Term Contracts

UK, 1989: PVR contract, without the auction:

- Queen Elizabeth II Bridge at Dartford
- Beauty contest, chose best project
- Financed 100% via debt (BoA, Trafalgar, Prudential, Kleinwort-Benson)
- Concession ends when pay back debt and interest
- Cash flow: pay back debt and interest

Colombia, 1997: auction, without present value

Chile, 1998: first PVR auction

Chile, 2006: PVR auctions for all highway franchises
Experience with Flexible Term Contracts: Portugal

- Shadow toll concession program began in 1999
- Bill faced by transport authority by 2004-2007: EUR 650MM, equals total annual road budget
- Motivated move to concessions that do not involve public budget
- Litoral Centro: 98.4km highway from Marinha Grande to Mira
- Europe’s first variable-term toll concession
- Concession period depends on when (and whether) net present value (NPV) of toll revenue reaches the EUR 784 MM mark:
  - attained before year 22: 22 years
  - attained between years 22 and 30: ends when attained
  - concession ends in year 30 if not attained by then
- Eurofinance project of the year
- Portugal using flexible term franchises for all highway concessions

Eduardo Engel (Yale)
6. Extensions

A. Price-responsive demand

B. Moral hazard
A. Price Responsive Demand

- Allow for one price during the contract, another price after the contract.
- As before: optimal contract characterized by two thresholds.
- Prices are set to distort optimally when compared with the relevant margin:
  - high demand states: $1 + \lambda$
  - low demand states: $(1 + \lambda)(1 + \zeta)$
  - int demand states: in between
B. Moral Hazard

Planner’s Problem:

\[
\min \int [(1 + \lambda - \alpha)R(v) + ((1 + \lambda)(1 + \zeta) - \alpha)S(v) - (1 + \lambda)v] f(v, \epsilon) dv,
\]

s.t. \[
\int u(R(v) + S(v) - I) f(v, \epsilon) dv \geq u(0) + k\epsilon,
\]

\[
\epsilon = \arg\max_{\epsilon'} \int u(R(v) + S(v) - I) f(v, \epsilon') dv - k\epsilon',
\]

\[
0 \leq R(v) \leq v; \quad S(v) \geq 0.
\]

Assumptions:

- MLRP holds for \( f(v, \epsilon) \)
- Effort does not matter “too much”
Optimal Contract with Moral Hazard

\[ R(v), S(v) \]

Revenue for the government \((\lambda)\)

Subsidy \((\lambda \zeta)\)

Optimal Contract with Moral Hazard

Eduardo Engel (Yale)

Public Finance of PPPs
7. Conclusion

When PPPs?

- savings made early during the relationship are offset by revenue lost later $\Rightarrow$ cost of funds argument does not justify PPPs.
- we therefore focused on productive efficiency

High demand projects

- limited term privatization is optimal
- contract length is state-contingent

Intermediate and low demand projects

- when subsidies are paid, the contract lasts indefinitely
- optimal contract combines an income guarantee with a cap on profits, both in present value
Implementation

- the optimal contract can be implemented via a competitive two-threshold auction with realistic informational assumptions

Implications for budgetary accounting

- PPPs much closer to public provision than to privatization

What’s special about PPPs?

- temporary nature of PPP contract allows for state-contingent contract terms, making feasible risk allocations that are not available under privatization