The Simple Micro-economics of Public Private Partnerships

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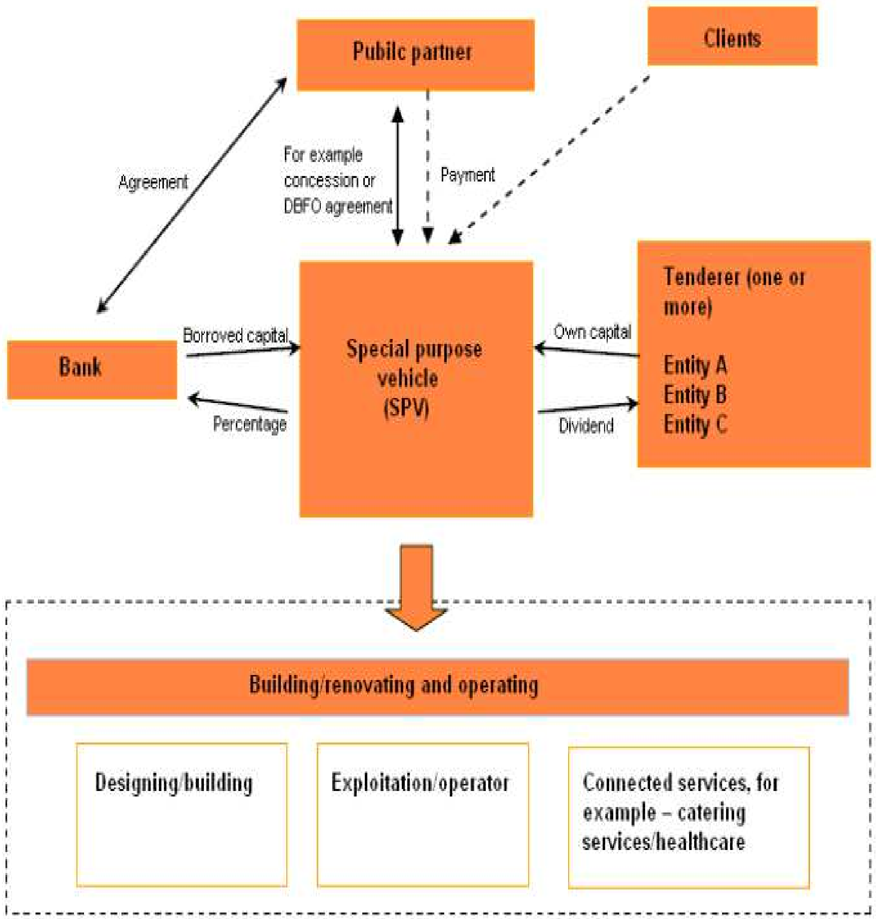
BACKGROUND

PPP: long-term contract btw public and private sector to Build, Operate, Maintain and Finance infrastructures for public services

- **Bundling** of project phases: DBFO, BOT models
- **High risk transfer**/ Output specifications
- **Long-term contract** 25-30 years
- **Private Finance**

Typical PPP transaction structure



Types of PPP/PFI projects:

1. Public sector as client (Schools, Hospitals, Prisons)

2. Financially free-standing, with users' fees (bridges, roads, leisure centres)

(3. Joint ventures)

Trend: increasing use of PPPs

- Old sectors: transport, water, gas, toll roads, highways

- New sectors: hospitals, schools, prisons, bridges, leisure centres, museums

UK leading example

- Since 1992, English Private Finance Initiative (PFI):
- 10-15% investment in public services
- 625 signed projects of £58.7b. 510 completed infrastructure
- 97 hospitals; 94 projects for 800 schools
- 43 transport; 300 plus defence projects, leisure, museums, housing and waste.

Also largely used in Italy, France, Spain, Portugal in Europe
India, Canada, Australia, LAC.

Italy: (**ANCE Jan-Aug 2009**)

- PPP 33% pubic investment in infrastructures (19,4% if we exclude works >500m)
- Steady rise from 13,9% in 2003 to 18,8% in 2008 (expt 2004)
- Use increases with value of project: 4,2% for projects <6m; 83% for projects > 500
- Local authorities most active (77% of projects)
- South regions most active (Campania, Sicilia, Lazio) for PPP with private initiative
- Lombardia, Toscania: most active for PPP with public initiative
- Photovoltaic networks, cemeteries, leisure centres, parking but also hospitals,
- Soon prisons, schools (?).

Example: **hospitals**

- Public sector as client
- Design, building, managing non-core services (equipment, cleaning, patients catering, staff catering, IT), maintenance, financing
- (Finlombarda 2008) in 2008 72 projects for 4.2b (Nord 2.3b)
- Typically, core services provided by public sector (≠ in Portugal)
- 3 cases with also core services

Length of procedures: 15.8 months from tender

Public finance (public contribution to cost of capital): 54% of value

- Availability payment plus deductions for substandard
- Payment for non-core services linked to quality standards
- Profitable services charged to users (coffee bars, parking, news-agent)
- Risk sharing on exogenous events (force major, national strike, legislative risk)
- Design and construction risk transferred (?)
- Risks for timing planning permissions and other administrative risk or regulatory risk held by the public sector.

Motivation

- Ideology (but Megginson and Netter 2001 JEL)
- "Healthy" public accounts & tricks (but now Eurostat, 2004)
- Government indebtness & Private finance
- Political economy: "build now, pay later"

Performance: **UK**, **NAO** (**2003**):

22% of PFI projects over budget, whilst 73% under TP

24% of PFI projects delayed completion , whilst 70% under TP

PFI: Positive evidence for roads, bridges, prisons

Negative evidence for IT and non-core services

Mixed evidence for hospitals, schools

Our paper: Efficiency considerations looking at main characteristics

- Why **bundle** project phases into a single contract
- Why **transfer more risk**, e.g. demand and cost risk
- Why set **longer contract duration**
- Why rely on **private finance**

- Contract dynamics: risk allocation over time, contract flexibility
- The role of institutions: regulatory risk

- Simple model of procurement in moral hazard context.
- Moral hazard is key for PPPs:

    issue of agency cost of delegation

    issue of risk sharing between G and F

- Multi-tasking (DBFO)
- Combine optimal contracting with property right literature

THE BASIC MODEL

G and $F1,\ F2$

a : quality-improving investment by $F1$ in building stage

e : cost-reducing effort by $F2$ in operational stage

social benefit: $B = b_0$

cost of operations:

$$C = \theta_0 - e - \delta a + \varepsilon$$

$\delta > 0$ (positive externality);

$\delta < 0$ (negative externality)

Investments noncontractible; C contractible

G all bargaining power ex ante

Payoffs

G is risk neutral and max benefit minus cost minus payment

F1, F2 are risk averse and max profits (CARA)

Expected welfare

$$W = B - C - \frac{a^2}{2} - \frac{e^2}{2}$$

Benchmark:

a and e that max W:

$$b + \delta = a^{FB}$$
$$1 = e^{FB}$$

- a^{FB} : internalize effect on social benefit and cost at operation stage
- e^{FB} : internalize effect on cost at operation stage

Q: **Why bundle**?

Q: **Why more risk transfer**?

UNBUNDLING

$F1$ and $F2$ are separate

$F1$ bears no operational risk and max $\pi_1 = p - \frac{a^2}{2}$

$F2$ gets cost-reimbursement rule $t(C) = \alpha - \beta C \Rightarrow F2$ bears operational risk proportional to power of incentive scheme, β, and max $\pi_2 = t(C) - \frac{e^2}{2} - \frac{r\sigma^2\beta^2}{2}$

$\beta = 0$ (cost plus)

$\beta = 1$ (fixed price)

Consider F1: chooses $a = 0$

Consider F2:

$$\pi_2 = \alpha - \beta \overbrace{(\theta_0 - e - \delta a)}^{C} - \frac{e^2}{2} - \overbrace{\frac{r\sigma^2\beta^2}{2}}^{\text{risk premium}}$$

$$\Rightarrow e = \beta$$

Consider G. It max

$$\max_{\beta} -p - \alpha + B - (1-\beta)C$$

$$s.t.: \ \pi_1, \pi_2 \geq 0$$

$$e = \beta, a = 0,$$

which gives $p = 0$,

$$\alpha = \beta C + \frac{e^2}{2} + \frac{r\sigma^2\beta^2}{2},$$

and β solving

$$\max_{\beta} b_0 - (\theta_0 - \beta) - \frac{\beta^2}{2} - \frac{r\sigma^2\beta^2}{2},$$

$\Rightarrow$

$$\beta_u = \frac{1}{1 + r\sigma^2}.$$

Therefore welfare is

$$W_u = b_0 - \theta_0 + \beta - \frac{\beta^2(1 + r\sigma^2)}{2}$$

$$= b_0 - \theta_0 + \frac{1}{(1 + r\sigma^2)2}$$

To summarize:

$--$ Building stage: $F1\ a_u = 0$: Underinvestment: F1 has no incentive to take into account effect of building quality a on social benefit B and on operational cost C

$--$ Operational stage: $F2$ chooses: $e_u = \beta$, $\uparrow$ power of incentive scheme $\beta \Rightarrow \uparrow$ risk transfer to $F2 \Rightarrow\uparrow$ risk premium, but

$$e_u < e^{FB}$$

Underinvestment arises since transferring risk is costly

BUNDLING (PPP) with $\delta > 0$ (positive externality)

For simplicity let $\delta = 1.$ Now consortium F chooses both e, a. The consortium max:

$$\pi = \alpha - \beta \overbrace{(\theta_0 - e - a)}^{C} - \frac{e^2}{2} - \frac{a^2}{2} - \overbrace{\frac{r\sigma^2\beta^2}{2}}^{\text{risk premium}}$$

$\Rightarrow F$ internalizes effect of quality-enhancing investment a on the fraction of cost at operational stage

$$a = \beta$$

An increase in the power of incentive scheme β now raises BOTH efforts a and e.

Consider G. It max

$$\max_{\beta} -p - \alpha + B - (1-\beta)C$$

$$s.t. : \quad \pi \geq 0$$

$$e = \beta, a = gb$$

which gives

$$p = 0,$$

$$\alpha = \beta C + \frac{e^2}{2} + \frac{r\sigma^2\beta^2}{2}$$

and β solving

$$\max_{\beta} b_0 - \theta_0 + 2\beta - \frac{2\beta^2}{2} - \frac{r\sigma^2\beta^2}{2}$$

$\Rightarrow \beta_b = \frac{2}{(2+r\sigma^2)}$. Therefore welfare is

$$W_b = b_0 - \theta_0 + 2\beta - \frac{\beta^2(2 + r\sigma^2)}{2}$$

$$= b_0 - \theta_0 + \frac{2}{(2 + r\sigma^2)}$$

with $W_b > W_u$.

$\Rightarrow$ *Risk transfer more effective on incentives*

- Bundling increases BOTH efforts:

$$a_u < a_b < a^{FB} \text{ and } e_u < e_b < e^{FB}$$

- PPPs are associated with greater risk transfer (optimal with positive externality)

$$\beta_b > \beta_u$$

⇒ *Social welfare is higher under PPP than under traditional procurement*

ROBUSTNESS CHECK 1: **cost incentives**

Under unbundling now F1 receives a payment linked to operating cost in period 2: $t_B = \alpha_B - \beta_B C$

$\Rightarrow$ F1 has now incentives to exert effort: $a_u = \beta_B$

Bundling still better:

Two birds (building and managing incentives) with one stone (operating risk transfer).

ROBUSTNESS CHECK 2: Quality incentives

Suppose index q of quality of infrastructure available. Now F1 receives a payment that is linked to quality: $t_B = -\alpha_B + \beta_B q$

$\Rightarrow$ F1 has incentives to exert effort: $a_u = \beta_B$

Bundling still better: by bundling tasks, G can provide incentives with lower risk transfer.

Results generally consistent with evidence

• Enterprise LSE: Sample of PFI project: cost saving 17%

• NAO (97,03): innovative design on prisons → cost saving 30% (80% prisons costs are staff costs)

• HM Treasury (04) for highway projects: use of high modulus roadbases and stone mastic asphalt reduces maintenance costs and noise.

NEGATIVE EXTERNALITY ($\delta < 0$)

Now also with bundling $F1$ chooses $a_b = 0$ as under unbundling. Thus bundling and unbundling yield the same result.

GENERAL MODEL

Social benefit affected also by e and a

$$B = b_0 + ba + de + \eta,$$

Indice su qualita del servizio

$$Q = B + \omega,$$

$$C = \theta_0 - \gamma e - \delta a + \varepsilon.$$

1. Contractible profits. The firm's profit $\Pi = B - C$ is observable and can be contracted upon. Optimal contracting calls for giving BO a linear profit-sharing rule $t(\Pi)$ of the form $t(\Pi) = \alpha + \beta\Pi$ so that BO obtains a net profit $t(\Pi) - \frac{a^2}{2} - \frac{e^2}{2}$.

The case $\beta = 0$ is akin to in-house provision of the service where BO actually acts as an employee of the public sector who has no particular incentives to raise profits. Instead, $\beta > 0$ holds when there is delegation to the private contractor who bears profit risk. When $\beta = 1$ all risks are transferred to BO.

2. Contractible revenues. The revenues from the service B is observable and can be contracted upon whereas costs may not be. The payment mechanism takes the form

$t(B) = \alpha + \beta B$ and BO's payoff becomes $t(B) - C - \frac{a^2}{2} - \frac{e^2}{2}$.

A payment mechanism solely based on user charges corresponds to $\alpha = 0$ and $\beta = 1$ so that the contractor bears all demand risk. In a payment mechanism based on availability, $\alpha > 0$ and $\beta = 0$ so that the contractor's reward is fixed and the government retains all demand risk. This payment scheme is typically used for PPPs in hospitals, schools and prisons (the so called PFI model) where users do not pay for the service. The revenues for BO then consist only of an 'availability payment' that G pays for making the service available to users.

3. Contractible costs. This is our baseline scenario. Operating cost C is observable and contracted upon. To simplify notation we assume that those costs are borne by G and that BO operates under a simple cost-reimbursement rule of the form $t(C) = \alpha - \beta C$ to get payoff $t(C) + B - \frac{a^2}{2} - \frac{e^2}{2}$ or $t(C) - \frac{a^2}{2} - \frac{e^2}{2}$ depending on whether users pay or not.

When a also affects social benefit (non-verifiable), it can be shown that

$$a_b \leq a_u < a^{FB} \text{ and } e_b \leq e_u < e^{FB}$$

Optimal NOT to internalize externality for it would exacerbate underinvestment problem due to b never internalized

Consistent with evidence of little design innovation, few windows, poor air quality and noise in schools (Audit Commission 04)

RELATED LITERATURE

Hart (03, EJ), Besley and Gatack (01 QJE); Bennett Iossa (06, JPubE); Francesconi Muthoo (06)

Bentz et al (01), Martimort and Pouyêt (07, IJIO)

BUT IS RISK TRANSFER ALWAYS FEASIBLE?

Essential services provision: G bears residual risk

Soft budget constraint problem

Example: Metronet for London Underground

But also hard budget: Jarvis

Re-tendering of PPP contracts often difficult because of lack of secondary market and alternative providers

SIDE EFFECTS OF BUNDLING

- Higher transaction costs:

5-10% cost of capital independently of project value (Yescombe, 2007)

- Longer tendering periods

(from OJ to financial closure): 34 months average

25 for schools

38 for hospitals

- 85 % projects in sample prior to 2004 attracted 3+ bids
- Recently tendered projects : 67 % with 3+ bids; 30% projects with only 2 bids (1.8 for hospitals in Italy)

- Top 10 constructors cover 63% of total sample
- Top 10 hard FM cover 56% of total sample

- Same advisors appointed by public and private sector in turns

- Insurance advisory market more concentrated than other advisory markets.

DEMAND RISK AND CONTRACT DURATION

Q: Why more transfer of demand risk and when?

Q: Implications for user charges and contract length

i) User charges; ii) usage payment; iii) availability.

Assume demand is inelastic for $p \leq p_0$:

$$D(p) = \begin{cases} d_0 + a + \eta & \text{if } p \leq p_0 \\ 0 & p > p_0. \end{cases}$$

$\eta \sim N(0, \sigma^2),$ and contract specifies revenue-sharing rule

$$t(R) = \alpha + \beta R$$

where β share of revenues $R = p_0(d_0 + a)$ left to F. For simplicity assume zero marginal cost.

α : fixed feee

β : revenue sharing rule.

So $\alpha = 0, \beta = 1$, payment is based only on user charges

$\alpha > 0, \beta = 0$ payment is based on availability

- Transferring demand risk to the contractor helps incentives but raises risk premium

- Case of financially freestanding project: Optimal payment mechanism comes closer to user charges ($\alpha = 0, \beta \to 1$, high-powered incentives) when risk-aversion and demand risk are small.

- Case of non-financially freestanding project: Optimal payment mechanism moves towards being based on availability ($\alpha > 0, \beta \to 0$, low-powered incentives) when risk-aversion and demand uncertainty are large.

The contractor maximizes the certainty equivalent of his expected utility and his incentive constraint can be written as:

$$\max_{a} \alpha + \beta p_0(d_0 + a) - \frac{a^2}{2} - \frac{r\sigma^2\beta^2 p_0^2}{2}$$

$$\Rightarrow a = \beta p_0$$

The government then extracts all profit from the firm by setting

$$\alpha = -\beta p_0(d_0 + a) + \frac{a^2}{2} + \frac{r\sigma^2\beta^2 p_0^2}{2},$$

and then the government's chooses β to solve

$$\max_{\beta} p_0(d_0 + a) - \frac{a^2 + r\sigma^2\beta^2 p_0^2}{2}$$

$$s.t. a = \beta p_0$$

Immediate optimization yields the second-best value of the operating effort as:

$$a^{SB} = \frac{p_0}{1 + r\sigma^2} < p_0$$

$$\beta^{SB} = \frac{1}{1 + r\sigma^2} < 1$$

Case: financially free-standing projects: $\alpha = 0, \beta \to 1.$

Q: How to set contract length T?

Initial investment I must be covered through contract length

Incentives (a) must be provided through contract length

$$E_\eta\left(u\left(-I - \frac{a^2}{2} + \int_0^T p_0(d_0 + a + \eta)exp(-\rho t)dt\right)\right)$$

$$= u\left(-I - \frac{a^2}{2} + (1 - exp(-\rho T))p_0(d_0 + a) - \frac{p_0^2 r\sigma^2}{2}(1 - exp(-\rho T))^2\right)$$

where ρ is the interest rate.

The moral hazard constraint is then:

$$a = (1 - exp(-\rho T))p_0$$

The longer the duration of the contract T, the greater the firm's effort since its benefits accrues over a longer period. Note that the term $1 - exp(-\rho T)$ plays the same role as β.

Suppose first that the investment constraint above is slack. The second-best effort level is:

$$a^{SB} = \frac{p_0}{1 + r\sigma^2} = p_0(1 - exp(-\rho T^{SB})).$$

From which, we derive the optimal unconstrained length of the franchise as:

$$T^{SB} = \frac{1}{\rho} \ln\left[1 + \frac{1}{r\sigma^2}\right]$$

More demand risk and a greater degree of risk aversion both call for reducing the incentive power and for more insurance which is obtained by reducing the length of the contract.

However, with financially free-standing projects the length of the contract must be chosen so as to guarantee that the stream of expected revenues coming from user charges is sufficient to cover the firm's investment as well as the risk-premium.

Suppose that T^{SB} is such that investment constraint is not satisfied. The length of the contract has to be increased to ensure that the firm breaks even. so we ahve

- (BC not binding): Contract length is shorter in more uncertain environments (σ^2 greater), when users' willingness to pay is greater (p_0 greater).

- (BC binds): Contract length is longer when investment I is higher. $\Rightarrow$ Excessive risk transfer and distortion in incentives due to relying only on private finance)

In Engel et. al (01 JPE): optimal contract length in concessions but no moral hazard.

BUNDLING FINANCING AND OPERATION TASKS

Q: **What is the benefit of private finance**?

Financiers have expertise to get access to informative signal $y = e + \eta$ on F's operating effort.

Then given contract btw G and F, $t(C) = \alpha - \beta C$, F and L agree on risk sharing contract with repayment to L :

$$z(C,y) = E + (1-\gamma)(\alpha - \beta C) - \xi y$$

F now chooses e :

$$e = \beta\gamma + \xi y$$

- Only fraction γ of incentive power of G's contract ends up fostering $F's$ effort.
- L can improve incentives by conditioning $F's$ repayment on informative signal. F gets bonus if good signal
- Extra round of contracting introduces further risk sharing and exacerbates m.h. but information structure improves.

Bundling private finance and operation is optimal when outside financiers have access to some informative signal on the operator's effort level. The power of incentives unambiguously raises and aggregate welfare improves with respect to public finance.

- PFI now completely dependent on banks. With more bargaining power, banks are asking for 2.5% higher return.

- Current options:

  1. Injecting public money into scheme
  2. Underwriting returns to lender

- But then circular process: banks lend to govt that guarantees returns to banks!

- Less incentives for banks to monitor which reduces value of private finance.

UNCERTAINTY AND FLEXIBILITY

Q: Are PPPs suitable in sectors with fast-evolving users' needs?

NAO (2003): 55% of PFI contracts have been changed after being signed

Suppose bundling contract is offered before γ realized

$$C = \theta_0 - \gamma e - \delta a + \varepsilon$$

With unbundling, delay contracting till γ realized $\Longrightarrow$ improve incentives for e but worsens incentives for a

If small externality δ and fast evolving user-needs, PPPs unsuitable

On cost of flexibility

- Bajari and Tadelis (03, RJE),
- Ellman (07)

Applications:

No PPP for IT in UK

Jamie Oliver’s and school food quality

CONTRACT DYNAMICS:

Q: **Risk allocation over time**?

Q: **How to prevent cost overruns**?

Twice-repeated basic model with investments in early periods that reduce cost in later periods

$$C_1 = \theta_0 - e_1 + \frac{a^2}{2} + \varepsilon_1 \quad \text{and} \quad C_2 = \theta_0 - e_2 - a + \varepsilon_2$$

To induce investment $\Longrightarrow$ G will offer non-stationary contract: $\Longrightarrow$ cost-plus in earlier periods and fixed-price in the sequel

$$\beta_1 < \beta_2$$

$\Rightarrow$ *Power of incentive scheme increases over time: investment in early periods and management strategies in later periods*.

COST OVERRUNS

Procurement cost $C = \theta_0 - e + \varepsilon$ highly uncertain

Flyvbjerg et al. (02), optimistic cost estimates

θ_0 privately observed by F ex post

Ex post asymmetric information: $U(\theta_0) = \alpha(\theta_0) + \beta(\theta_0)\theta_0 + \frac{(1-r\sigma^2)\beta^2}{2}$

For truthful cost revelation need give rent if low cost $\Longrightarrow$ add ex-post risk $\Longrightarrow$ additional risk premium $\Longrightarrow$ given less powered incentives to the less efficient firm and incomplete insurance vis a vis the realizations of innate cost levels

On intertemporal effort allocation

- Laffont and Tirole (1993): higher incentives over time; bias towards incumbent

- Lewis (1986): lower effort over time

REGULATORY RISK

Political environment often unstable;

$G1$ has limited commitment power

$G2$ does not take into account impact of contract on incentives in period 1

(recall that optimal contract calls for high risk transfer in period 2 to induce investment a in period 1)

$\Rightarrow$ renegotiation may occur: $G2$ calls for lower risk transfer to save on risk premium

$$\Downarrow$$

Anticipating this, F1's incentives to invest are lowered

$$a^0 < a^{SB}$$

Cost-reimbourcement rules are even more titled towards cost-plus contracts and efficiency loss

$$e_1^0 < e_1^{SB};\ e_2^0 < e_2^{SB}$$

PPP unsuitable when high regulatory risk

Related Literature and applications

- Laffont and Tirole (93), the ratchet effect induces worse information transmission and lowers incentives for cost reduction
- Aubert and Laffont (02), how G1 can affect G2's contracting
- Guash (04), Guash Laffont and Straub (06), most renegotiations occur during elections and, in LAC sample, experienced and independent regulator is important.
- PPP Units
- Political risk discourages investors (London Underground)
- Hammami (06), PPP found in countries with less corruption
- Guash and Spiller (1999) cost of regulatory risk ranges btw 2-6% to cost of capital

Concluding, **PPP suitable if**:

- Infrastructure quality key (e.g. transport, not schools)
- Large potential of whole-life costing (transport, water)
- Service quality index available and reliable
- Risk transfer feasible
- Service demand stable and predictable (e.g. water, not IT)
- Low investment, compared to size of the market.
- Low specificity of facility for public service
- Stable institutions (low regulatory risk)

NEXT

- Unknown mapping between effort and performance
- Informational linkages and the role of innovations