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Moszoro, Marian

SGH Warsaw School of Economics

March 2014

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Marian W. Moszoro*

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*Annals of Public and Cooperative Economics* 85(1): 103–126

**Abstract**

This paper presents a rationale for hybrid public-private capital structures in public utilities. The public sector can borrow money cheaper, while private investors can spawn life-cycle cost savings. When investment vehicles enable the internalization of the financial advantage of the public sector and the managerial advantage of the private sector, a Pareto-efficient capital structure is achieved with both the public and private parties as shareholders. I show how different knowledge transfer schemes determine the optimal shareholding structure for the utility company.

*JEL Classification:* G32, H43, H54, L32, L95

*Keywords:* Public-Private Partnerships, Ownership Structures, Public Investment Policy, Knowledge Transfer, Water Utilities

*IESE Business School, Barcelona, Spain and Kozminski University, Warsaw, Poland. This is an extensively revised version during my visit at the Haas School of Business, University of California, Berkeley in 20092011, of an earlier paper that circulated as Optimal Capital Structure of Public-Private Partnerships, IMF Working Paper WP/08/1. It benefited from the participants in the presentations made at the World Bank (Washington, DC), Universidad Austral (Rosario, Argentina), World Finance Conference (Rio de Janeiro, Brazil), and KNF – Financial Supervision Authority (Warsaw, Poland). I particularly thank Andrew Feltenstein, Pawel Gasiorowski, Thomas Moser, and René Weber from the IMF for their comments and Paul Soto for research assistance. E-mail: mmoszoro@iese.edu.

Public agents have limited financial resources to face large (and increasing) quality standards. A key justification for pursuing public-private partnerships (PPP) are lower costs than in solely private investments and higher quality than in the solely public provision of public goods (Vaillancourt-Rosenau 2000), due to the public agent's lower cost of capital (London Energy Partnership, 2007; (Grout 2003), and the investor's managerial skills (Linder 1999) and industry-specific know-how (Hennart 1988), particularly with complex goods (Saussier, Staropoli, and Yvrande-Billon 2009). PPPs can increase quality to meet higher standards at the same level of capital expenditures or - keeping quality standards constant - free resources for the provision of other public goods.

The World Bank's Private Participation in Infrastructure Projects Database provides information on more than 4,000 infrastructure projects in developing countries dating from 1984 to 2010. In 713 PPP water projects amounting total investments of 41 billion US dollars, prevailingly in East Asia-Pacific and Latin America-Caribbean regions (see Table 1, Panel A), private ownership averages 87% (see Panel B). Interestingly, one quarter of all PPPs present hybrid public-private capital structures with private ownership between 20% and 80% (see Panel C).

Public-private hybrids are a common governance practice in Western countries. Table 2 depicts examples of PPPs with mixed public-private capital structures in the utilities sector in various European countries [1]. Referring to government-sponsored enterprises, Jaffee and Quigley (2009) sustain that "there is little reason to presume that the evolution of these enterprises represented the best method of providing services". Thus the question is under which conditions PPPs with mixed public-private capital can provide a more efficient governance structure than solely public or entirely private. This paper presents a simple model to assess the efficiency of public-private capital structures.

PPPs are often undertaken by joint venture companies or special purpose vehicles (SPV) with equity contributed by private investors and the public sector(European Commission and Others 2004; Corbacho and Schwartz 2008; Weber and Alfen 2010; Schaeffer and Loveridge 2002. The share in equity of the SPV is reflected in the shareholders' voting power and management involvement. To be compelling, the shareholding structure of the PPP-SPV

[1] Weber and Alfen (2010) show that two out of the ten largest international airports by passengers worldwide (Paris CDG and Frankfurt) have a mixed public-private ownership structure. See also, e.g., European Commission and Others (2004) and PricewaterhouseCoopers (2006).

should secure the interest of both types of shareholders by providing room for public financing and private sector managerial discretion.

The rationale for hybrid solutions presented in this paper is similar to Rangan, Samii, and Van Wassenhove's (2006), but differs in the drivers. Efficient financing of public investments by the private sector requires that the higher financing cost of the private sector be offset by life-cycle cost savings due to the transfer of skills and know-how from the private sector.

The main thrust of the paper is that it may be optimal for the public agent to become a shareholder in public utilities SPV. In markets with a long and reliable tradition of public procurement, such a statement sounds counterintuitive[2]. The existence of market failures, however, especially in the case of transition and emerging economies, justifies the government's involvement in the SPV to correct market failures which result in the inability of the marketplace to provide public goods (Jevčák and Keereman 2008; Tandberg 2008).

The remaining of the paper is organized as follows. Section 1 presents the literature related to mixed public-private partnerships. Section 2 introduces the premises on the public sector's financial advantage and private sector's managerial advantage. Section 3 outlines the relationships between expected quality, required investments in infrastructure, and life-cycle costs. Section 4 presents a discrete and a continuous model of skills transfer to describe the optimal public-private capital structure in PPPs for the provision of public utilities infrastructure. Section 5 concludes with policy advice.

# 1 Related Literature

The first public-private cooperation sets were concessions. Mixed public-private ownership is rather a novel concept.[3] In Linder's (1999) taxonomy of public-private partnerships, hybrid governance structures are defined as 'risk-shifting' and 'power-sharing' PPPs. Weber and Alfen (2010) refer to these solutions as 'horizontal' or 'institutional' PPPs (as opposed to 'vertical' or 'contractual' PPPs). Schaeffer and Loveridge (2002) state that public and the private sectors have complementary powers and thus each can help the other accomplish things that may otherwise not be feasible.

[2] This paper is not intended to advocate government intervention in private companies. Nonetheless, recent bailouts by governments worldwide during the period 2008-2010 have made the idea of governments taking a stake in private businesses less outrageous.

[3] A concise historic background of PPP can be found in Grimsey and Lewis (2004, 2005).

The literature on financing public investments by private capital compares higher capital expenditures for public financing with the higher availability payments for private financing (Irwin 2008)[4]. Most scholars (Grout 1997, 2003; Hart 2003; Hart, Shleifer, and Vishny 1997) focus on the dichotomy whether a public agency should provide a service in-house or contract out provision.

The European Commission and Others (2004) provides examples of mixed public-private ownership and risk sharing. Very few scholars have taken account of cost drivers continuum between the public and private sectors and implications for the governance structure. Beato and Vives (1996) acknowledge that "mixed cases share features of the pure cases", and therefore "they may be evaluated by using the relative participation of final consumers and the public agency in the private firm's revenues". Gerrard (2001) points out mixed public and private ownership in water supply utilities, and Hammami, Ruhashyankiko, and Yehoue (2006) give two examples of 'semi-private' ownership of public utilities. Schwartz, Corbacho, and Funke (2008) describe the pros and cons of mixed public-private structures. Rangan, Samii, and Van Wassenhove (2006) set the necessary conditions for economic opportunity realization of mixed public-private partnerships based on transaction cost economics and externalities theory. Gazley, Chang, and Bingham (2010) underline the relevancy of a stakeholder outlook on governance to the context of public-private partnerships because of its 'systems-centered' perspective on how constituent interests are represented. Rufín and Rivera-Santos (2012) compare PPPs with business-to-business alliances. They predict that PPPs will avoid equity structures and will rely, instead, on less complete and more complex alliance contracts, which contrasts with substantial empirical evidence. Cruz and Marques (2012) discuss the practicalities of governance of mixed ownership structures and, on the basis of in-depth cross-sector case studies, argue that mixed companies lead to poor welfare outcomes due to complex whole life-cycle management. Gautier and Yvrande-Billon (2013) present regulation type (cost-plus vs. fixed price) and ownership structure (private vs. mixed) efficiency outcomes in French urban public transportation and show that a mixed firm regulated by a cost-plus contract is the least efficient modality.

[4] For the so-called Public Sector Comparator (PSC) and Value for Money (VfM) methodologies, see Broadbent and Laughlin (2003) and HM Treasury (2003).

## 2 Public Financial Advantage and Private Managerial Advantage

In this section I analyze the conditions for Pareto-efficient public-private financing of infrastructure. Pareto efficiency refers here to achieving the same quality of service at a lower cost or better quality at the same cost for a PPP compared to solely government and solely private investments.

Domestic financial markets of emerging economies are not deep and efficient enough to provide reasonably priced capital to finance large public projects. On the one hand, governments aiming at infrastructure development have to use savings from the external sector. Current account deficits of Central and Eastern European countries in the last decade confirm this observation. On the other hand, the conservative approach to risk evaluation by foreign investors leads to an additional premium to cover an excess risk for uncertainty. The public sector's participation provides the necessary certainty to attract foreign capital and offset the additional premium, and can make investment in infrastructure an interesting business case. Public participation does not correct all market failures, but it reduces their impact.

The rationale behind public shareholding in the SPV points also to the principal-agent theory. In a PPP, the public and private sectors have conflicting interests regarding the project's cost and the quality of the public good delivered. Under most legislative systems, shareholders have more control over the company's activities than its contractors. Therefore, governments seeking high-quality and fairly-priced public goods would have better control over the project as shareholders. Again, the need for better internal control of quality and prices is more important in emerging and transition markets, where legal regulations are not entrenched strongly enough.

### Cost of Public Capital

Prestigious economists (Samuelson 1964; Vickrey 1964; Solow 1965; Baumol 1968; Arrow and Lind 1970), analyzing the social discount rate in the 1960's and 1970's, claimed that the discount rate for public entities should be lower than for the private sector. Other leading scholars (Hirshleifer 1964; Diamond 1967; Bailey and Jensen 1972; Dreze 1974; Kay 1993; Brealey, Cooper, and Habib 1997; Klein 1997) held that the social discount rate should be higher than the plain public borrowing cost, equaling both public and private discount rates.

They argued that the public sector's lower borrowing cost does not reflect a more efficient management of risk, but the fact that the public sector does not default and that it can levy taxes to repay debt. These arguments are applicable to the general case of public borrowing in a closed economy; they, however, should not apply to the PPPs in emerging and transition markets for the following reasons:

- The effective PPP scheme assumes the transfer of risks from the public sector to the private sector (Bondal 2005). Therefore, the public sector's cost of borrowing does not reflect the project's risks, as these risks are transferred out of the public sector. As the International Monetary Fund (2004) states, it is difficult to establish whether the transfer of risk out of the public sector is proportional to the difference in funding cost, but the public cost of lending is definitely lower.

- In case of investments which are not significant to the economy (low share in GDP), the discount rate for the public sector should be lower than for the private sector, because the public sector can better absorb and spread risks among a greater number of individuals (Arrow and Lind 1970; Fisher 1973).

- Private companies cannot internalize all externalities and their return on investment comes only from the project's cash flows. Flemming and Mayer (1997) show that private sector investments in public utilities depend on the policy applied in other sectors of the economy and create externalities leading to inefficient piece-meal decision making, when only the perspective of a single sector of the economy is taken into account.

- In the case of incomplete capital markets, investors and lenders are not able to protect themselves in these markets against the risk connected with securities that are financing the public or private investments and therefore apply various discount rates (Hirshleifer 1964; Bailey and Jensen 1972).

- Grout (2003) proved that even in a world without incomplete markets and distorting taxation, it is appropriate to apply a higher discount rate for private entities than for public ones. The argument is based on the differential in the beta (risk) for government payments under a PPP and the beta of government expenditures under the normal public provision of goods.

- Lind (1990) suggests that the government's long-term borrowing rate is a "good first candidate" for long-run intergenerational problems and that "for most government projects we should compute net benefits (from the project) using the government borrowing rate as the discount rate" (Spackman 2004).

Moreover, the concept of the social discount rate is based on the social time preference. It is justified to take into account a common social discount rate for projects financed in the domestic market. It would be difficult for any government, however, to consider the social discount rate of the external sector, which theoretically should be applied if projects are financed from the savings of the external sector.

The two concepts: the cost of capital (i.e., a financial approach) and the social discount rate (i.e., a general equilibrium approach) should not be equaled. I base my proposition regarding the cost of capital on direct market evidence that the public sector can raise capital cheaper than the private sector[5] and, from these funds, it can finance different projects. I concentrate on the cost of resources engaged and did not discuss the social cost of capital. Whether public sector projects should be discounted at a lower rate than private sector projects is a highly contentious issue.

The amount of literature supporting the lower cost of capital for the public sector (starting from the Arrow-Lind theorem in 1970) is as large and strong as that supporting the approach according to which public projects should be discounted at the same rate (see for example: HM Treasury 2003; Engel, Fischer, and Galetovic 2008), irrespective of the source of financing (see discussion in section 2.4 in Grout 2005). Writing in the 1980s on public sector discount rates and their relation to private sector discount rates, Lind (1982) pointed out that "the profession was no closer to agreement on the theory, on a procedure for computing the discount rate, or on the rate itself than it was in 1966." The evidence is that the difference between the interest rates for governments and private investors is statistically significant; however, whether public projects should be discounted at the same or a different rate is not a positive, but a normative question.

[5] See Table 3. Kosar (2008) and Jaffee and Quigley (2009) state that GSEs borrow money at significantly lower interest rates than solely private peers because of the inferred government guarantee. In emerging economies, the bond market is not liquid enough to provide continuous data. Moreover, most of municipal and corporate bonds there are privately placed and their yields are not published. Moszoro (2005) support the hypothesis of lower interest rates for public entities than for private corporations based on listed municipal and corporate bonds in Poland.

### Life-Cycle Cost Savings

Empirical research carried out in the United Kingdom and in the United States shows that the private sector can develop infrastructure cheaper than the public sector (Wright 1987; Viscusi, Vernon, and Harrington 2000). Wallace and Junk (1970) even claim that the investment costs of public enterprises are 40% higher than those of private enterprises.

On one hand, PPPs involve sizable structuring and transaction costs, and force governments to develop expensive internal capacities: lawyers, engineers, and financial advisers (Tandberg 2008; Corbacho and Schwartz 2008). Conversely, savings can be attributed to more efficient project management by the private investor (Linder 1999), shortened construction and development times (Ward and Chapman 1995; Saussier, Staropoli, and Yvrande-Billon 2009), higher cost of innovation efforts under private ownership of assets (Hart, Shleifer, and Vishny 1997), and lower administrative expenditures and less bureaucracy (Starr 1988; Goldsmith 1997). United Kingdom's National Audit Office (NAO) reports on PPPs (European Investment Bank 2004; Bondal 2005) presented the following statistics confirming the above-mentioned sources of savings:

(a) A report commissioned by the Treasury Taskforce found that the average percentage estimated saving against the Public Sector Comparator in PFI projects was 17%.

(b) HM Treasury research of 61 Private Finance Initiative (PFI) projects:

- 89% of projects were delivered on time or early;
- All PFI projects in the HM Treasury sample were delivered within public sector budgets;
- No PFI project was found where the unitary charge had changed following contract signature other than where user requirements changed;
- 77% of public sector managers stated that their project was meeting their initial expectations.

(c) Four Design-Build-Finance-Operate (DBFO) road contracts appear likely to generate net quantifiable savings of around £100 million (13%)

(d) Out of 98 projects surveyed by the NAO in 2001 on public authorities' perceptions of Value For Money:

- 81% believed that PFI projects are achieving satisfactory or better Value For Money—only 4% described Value For Money as 'poor';
- 75% of PFI projects were delivered on time or early, and in no case did the public sector bear the cost of construction overruns, a significant improvement on previous non-PFI experience.

(e) The contract for the Private sector Resource Initiative for the Management of the Estate, a project comprising transfer of the Department of Social Security estate to the private sector, is estimated to deliver savings of £560 million, 22%, over 20 years.

Capital expenditures are not always higher under the public sector's governance (Ahadzi and Bowles 2004). Vast evidence of cases of lower capital expenditures under private governance, however, deserves analysis for its implications in the organization of PPPs.

The mainstream PPP literature suggests that the key issues involved in the governance structure are the bundling of the project's construction and operation and efficient risk allocation between the public agent and private investors (Rangan, Samii, and Van Wassenhove 2006), regardless of the capital structure. Contract bundling is not in contradiction to the proposition of lower capital expenditures due to the private sector's participation in the SPV—it reinforces it. What the private sector does when bundling is a 'package selling' of: construction, insurance, and financing for a lower price than when contracted independently by the public sector. I sustain that when the private capital's share is large enough, the advantages of this bundling may be realized because of the economic incentives for the private investor (Hennart 1988).

When the private contractor only constructs the infrastructure without residual claims (i.e., no shares in the SPV), it has no incentives to build cheaply, but to bid low to win the tender. Where competition is low and the public sector does not have the resources to organize repetitive tenders, it may happen that:

(a) There is price collusion or bid rigging (Buccirossi 2008; Laffont and Tirole 1993)

(b) After bidding low and winning the tender, the private contractor renegotiates the contracts (see asymmetric collusion in Laffont and Tirole 1993).

(c) When public-private relations are ex ante less flexible and subject to ex post higher accountability (Wang and Bunn 2004), the private contractor charges a higher price than in a private-to-private relational contract (Moszoro and Spiller 2014).

(d) While the question on the appropriate discount rate is normative, why knowledge transfer requires private sector's (partial) equity ownership in the project is a positive question subject to the institutional and judicial environment. The corollary is that when a private investor has an equity stake in the project, residual control rights are more properly protected and the private investor has economic incentives to transfer managerial skills and know-how to innovate in cost and quality (Hart, Shleifer, and Vishny 1997).

Hybrids public-private structures unveil severe governance problems. Cruz and Marques (2012) present empirical evidence on mixed companies from Portugal and discuss the hindrances to achieve internal regulation and relational agreement along the life-cycle. Gautier and Yvrande-Billon (2013) observe that, although mixed companies have a higher probability of contract renewal, they present the least efficient outcome.

This paper presents first-best comparative statics and is not intended to vindicate mixed ownership PPP. At the risk of oversimplifying, I model specific key drivers of PPP, namely: cost of capital and managerial expertise as functions of continuous public-private ownership. In particular institutional settings, the relevance of these drivers is subdued to governance, contractual, and political constraints. In general, however, they do matter and hence should be factored in.

# 3 Model Setup

Consider a partial equilibrium setup with a monopoly utilities provider - public, private, or mixed - and a representative consumer.

The amount of capital expenditures on the utilities infrastructure is determined by the required quality of the public goods or service supplied. Consider a newly formed SPV that invests during the development phase and then operates the infrastructure based on a two-part tariff: a fixed fee that covers investment outlays and a variable fee that covers the variable cost of service (Coase 1946). This proposition requires that capital expenditures $I(q)$ necessary to satisfy demand at quality level q should be equal to the present value of fixed fees $f(q)$ paid to the SPV over the lifetime t of the infrastructure:

$$I(q) = f(q)\frac{1-(1+r)^{-t}}{r} \tag{1}$$

For a sufficiently long life of the project, this can be expressed as:

$$I(q) = \frac{f(q)}{r} \tag{2}$$

The public sector's discount rate $r_{pu}$ is lower than the private sector's discount rate $r_{pr}$.

Capital expenditures (without financial costs) for publicly executed projects are higher by $J(q)$than capital expenditures for privately executed ones.

Finally, $\theta \in [0, 1]$ is the private investor's share in the SPV.

# 4 Optimal Public-Private Capital Structures

In this section, I show how different know-how transfer schemes determine the optimal capital structure of the SPV. When the cost of capital is lower for public entities and capital expenditures are lower for investment carried by private investors, it is possible to reach the lowest total financial and development cost with mixed public and private shareholding that enables the internalization of both the public sector's cost of capital advantage and the private sector's managerial advantage.

### Discrete Knowledge Transfer Scheme

Let us assume that the transfer of the private investor's know-how - i.e., idiosyncratic industry-specific knowledge and skills in infrastructure engineering, capital allocation, and risk management (Rangan, Samii, and Van Wassenhove 2006) - to the SPV materializes when the private share in the SPV achieves a minimum $\theta \geq e$ [6]. From equation 2, fixed fees for mixed public-private financing is given by:

$$f(n) = \begin{cases} \theta \cdot I(q) \cdot r_{pr} + (1-\theta) \cdot [I(q) + J(q)] \cdot r_{pu} & for\ \theta < e \\ \theta \cdot I(q) \cdot r_{pr} + (1-\theta) \cdot I(q) \cdot r_{pu} & for\ \theta \geq e \end{cases} \tag{3}$$

It remains discussable the extent to which cost saving and quality innovation effort is intrinsic and exclusive to the private sector (Hart, Shleifer, and Vishny 1997). In the discrete model, I assume that if the private investor holds residual control rights greater or equal to a certain threshold $e \in (0, 1)$, then cost-saving know-how transfer to the SPV is realized as described by Eaton, Akbiyikli, Akintoye, and Beck (2009).

[6] As Hennart (1988) points out, some knowledge types are firm-specific assets, i.e., they cannot be acquired separately from the firm.

For $\theta \geq e$, mixed public-private ownership is superior to public ownership when:

$$\theta \cdot I(q) \cdot r_{pr} + (1-\theta) \cdot I(q) \cdot r_{pu} < [I(q) + J(q)] \cdot r_{pu} \tag{4}$$

Solving for $\theta$ we obtain:

$$\theta < \frac{J(q)}{I(q)} \bigg/ \left( \frac{r_{pr}}{r_{pu}} - 1 \right) \tag{5}$$

Condition 5 shows that the project should be fully realized by the public sector if either there are no savings from private know-how (i.e., $J(q) = 0$) or savings are relatively small compared with the difference in financial costs.

Provided there is know-how transfer from the private to the public sector ($\theta \geq e$), PPP (interior solution of inequality 5) is more efficient than entirely public or private financing (boundary solutions) when:

$$\theta \cdot I(q) \cdot r_{pr} + (1-\theta) \cdot I(q) \cdot r_{pu} < min\{I(q) \cdot r_{pr}; [I(q) + J(q)] \cdot r_{pu}\} \tag{6}$$

For $I(q) \cdot r_{pr} < [I(q) + J(q)] \cdot r_{pu}$:

$$\theta \cdot r_{pr} + (1-\theta) \cdot r_{pu} < r_{pr} \tag{7}$$

$$(1-\theta)(r_{pu} - r_{pr}) < 0 \tag{8}$$

with inequality 8 holding for every $\theta \in [e, 1)$.

For $I(q) \cdot r_{pr} > [I(q) + J(q)] \cdot r_{pu}$:

$$\theta \cdot I(q) \cdot r_{pr} + (1-\theta) \cdot I(q) \cdot r_{pu} < [I(q) + J(q)] \cdot r_{pu}$$

can be simplified to:

$$\theta \cdot r_{pr} + (1-\theta) \cdot r_{pu} - r_{pu} < \frac{J(q)}{I(q)} r_{pu} \tag{9}$$

$$\theta < \frac{J(q)}{I(q)} \left( \frac{r_{pu}}{r_{pr} - r_{pu}} \right) \tag{10}$$

Condition 10 implies that the private investor's share in the SPV is determined by the relative savings from private know-how and the interest rate spread between the public and private sectors.

Setting $\theta = 1$, we obtain $(r_{pr} - r_{pu})/r_{pu} < J(q)/I(q)$. Therefore, the private investor should be the sole shareholder if relative savings on capital expenditures are bigger than the relative spread between discount rates.

Example 1:

The relationship presented in condition 10 can be used to present the following stylized example. Let us assume savings $J(q)/I(q)$ to equal 20%[7], private sector interest rate at 8.50% and interest rate of long-term loans for public sector entities at 7%. PPPs would be efficient (in terms of a tradeoff between financial and development cost) when $\theta < .2(.07/.015)$, i.e., when $e \leq \theta < 93\%$. Assuming an increase in the spread between the rates to 300 basis points would reduce private shareholding in the PPP to a maximum of 47% of the capital. Therefore, the bigger the spread between interest rates for the public agent and private investors, the less room there is for negotiation on capital participation between the parties.

In Apa Nova, Romania, Vivendi holds 84% of the shares (see Table 2). A large participation of the private sector responded to a lower capital advantage of the public sector, i.e., the spread between public and private interest rates was smaller than in other countries.

Figure 1 shows the level of the fixed fee as a function of the public-private capital structure and the interval of efficient public-private financing for the case where $r_{pr}/r_{pu} > 1 + J(q)/I(q)$.

Starting from sole public financing ($\theta = 0$), the fixed fee $f(q, \theta)$ increases in $\theta$ as a result of the larger share of the more expensive private capital. For $\theta < e$, the marginal increase of $f(q, \theta)$ equals $I(q) \cdot (r_{pr} r_{pu}) - J(q) \cdot r_{pu}$. At$0theta = e$, know-how transfer takes place and $f(q, )$ dropsby $(1e) \cdot J \cdot r_{pu}$. For $\theta \geq e$, $f(q, \theta)$ increases at the rate of $I(q) \cdot (r_{pr} r_{pu})$. At$\theta_a$, $f(q, \theta)$ equals the fixed fee in a publicly financed project; and at $= 1$ with private-only shareholding, the fixed fee equals $I(q) \cdot r_{pr}$. Therefore, the larger the private share that is needed for know-how transfer to take place, the smaller the potential savings from private sector participation.

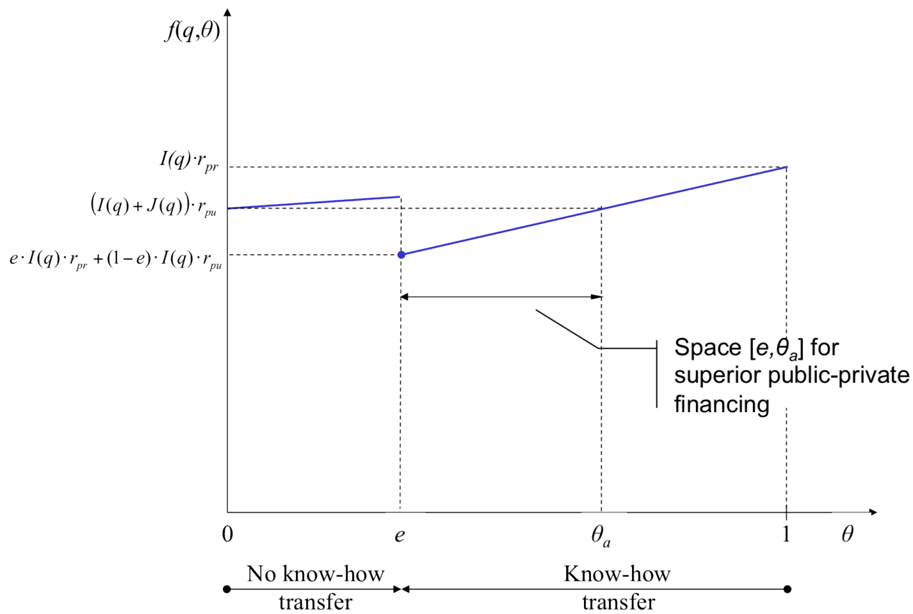
If the parameter space $[e, \theta_a)$ is not empty, then mixed public-private ownership dominates.

### Continuous Knowledge Transfer Scheme

Consider know-how transfer as a continuous, monotonically increasing, and differentiable function of private share$\theta$, i.e., private effort increases in private ownership and control rights. For simplicity, consider the case of linear know-how transfer. Equation 3 can be re-expressed as:

$$f(q, \theta) = \theta \cdot I(q) \cdot r_{pr} + (1 - \theta) \cdot [I(q) - (1 - \theta) \cdot J(q)] \cdot r_{pu} \tag{11}$$

**Figure 1:** Interval of efficient public-private financing (discrete model)




where $(1\theta) \cdot J(q)$ shows the linear decrease in capital expenditures resulting from know-how transfer proportional to the private investor's share.

The first-order condition for an extremum of function 11 with respect to $\theta$ is:

$$\frac{\delta f}{\delta\theta} = I(q) \cdot r_{pr} - [I(q) + 2(1-\theta) \cdot J(q)] \cdot r_{pu} = 0 \tag{12}$$

Therefore, $f(q, \theta)$ has an extremum at such $\theta^*$ that:

$$[I(q) + 2(1-\theta^*) \cdot J(q)] \cdot r_{pu} = I(q) \cdot r_{pr} \tag{13}$$

$$2(1-\theta^*) \cdot J(q) = \frac{I(q) \cdot r_{pr}}{r_{pu}} - I(q) \tag{14}$$

$$\theta^* = 1 - \frac{I(q)}{2J(q)} \left( \frac{r_{pr}}{r_{pu}} - 1 \right) \tag{15}$$

Since the second derivative of equation 11 with respect to $\theta$ is positive for each $J(q) > 0$, then equation 15 determines the minimum of function 11.

As $\theta$ ranges from zero to one, the condition for $\theta^*$ to be an interior minimum holds for $r_{pr} - r_{pu} > 0$ and $r_{pr}/r_{pu} - 1 < 2J(q)/I(q)$.

Example 2:

Equation 15 can be used to determine the private investor's optimal shareholding given expected savings and interest spreads. Assuming the same ratio of expected savings $J/I = .2$ as in Example 4 and interest rates applicable to the private sector on average 25% higher than to the public sector($r_{pr}/r_{pu} = 1.25$)[8], function $f(q, \theta)$ reaches its minimum at $\theta^* = 0.375$. The optimal capital structure would then be a 62.5% capital share owned by the public agent and 37.5% by the private investor.

Mixed PPP is Pareto-efficient if:

$$\theta^* \cdot I(q) \cdot r_{pr} + (1-\theta^*)[I(q) + (1-\theta^*) \cdot J(q)] \cdot r_{pu} < min\{I(q) \cdot r_{pr}; [I(q) + J(q)] \cdot r_{pu}\} \quad (16)$$

For $I(q) \cdot r_{pr} < [I(q) + J(q)] \cdot r_{pu}$, the private investor's share $\theta^*$ results from solving:

$$\theta^* \cdot I(q) \cdot r_{pr} + (1-\theta^*)[I(q) + (1-\theta^*) \cdot J(q)] \cdot r_{pu} < I(q) \cdot r_{pr} \quad (17)$$

$$I(q) \cdot r_{pr} - (1-\theta^*) \cdot I(q) \cdot r_{pr} + (1-\theta^*) \cdot I(q) \cdot r_{pu} + (1-{}^*)^2 \cdot J(q) \cdot r_{pu} < I(q) \cdot r_{pr} \quad (18)$$

$$(1-\theta^*) \cdot I(q) \cdot (r_{pr} - r_{pu}) + (1-\theta^*)^2 \cdot J(q) \cdot r_{pu} < 0 \quad (19)$$

This condition is met for:

$$1 - \frac{I(q)}{J(q)} \left( \frac{r_{pr}}{r_{pu}} - 1 \right) < \theta^* < 1 \quad (20)$$

For I(q) $\cdot r_{pr} \geq [I(q) + J(q)] \cdot r_{pu}$, the private investor's share $\theta^*$ must meet the following condition:

$$I(q) \cdot r_{pr} - (1-\theta^*) \cdot I(q) \cdot r_{pr} + (1-\theta^*) \cdot I(q) \cdot r_{pu} + (1-\theta^*)^2 \cdot J(q) \cdot r_{pu} < [I(q) + J(q)] \cdot r_{pu} \quad (21)$$

$$-I(q) \cdot (r_{pu} - r_{pr}) - J(q) \cdot r_{pu} + (1-\theta^*) \cdot I(q) \cdot (r_{pu} - r_{pr}) + (1-\theta^*)^2 \cdot J(q) \cdot r_{pu} < 0 \quad (22)$$

This condition is met for:

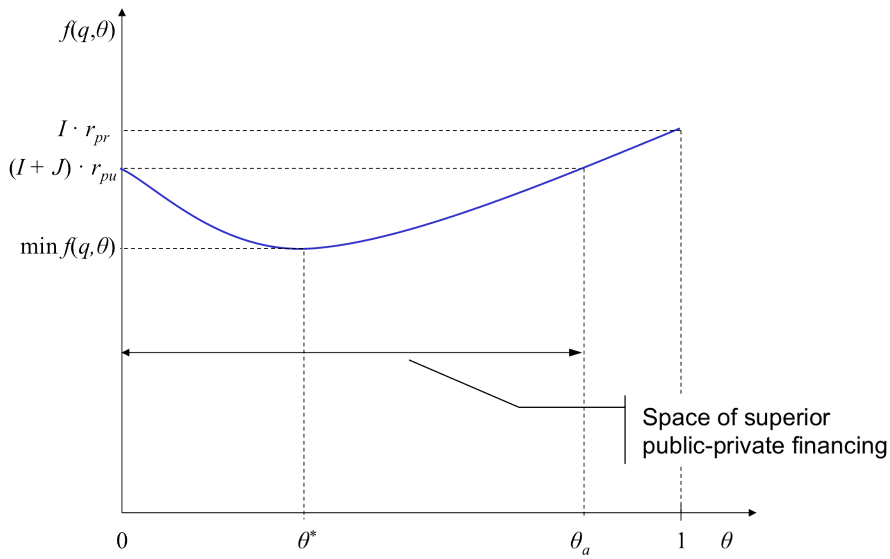
$$0 < \theta^* < 2 - \frac{I(q)}{J(q)} \left( \frac{r_{pr}}{r_{pu}} - 1 \right) \quad (23)$$

For $I(q) \cdot r_{pr} \geq [I(q) + J(q)] \cdot r_{pu}$, the private investor's share $\theta^*$ must meet the following condition:

$$max \left[ 0; 1 - \frac{I(q)}{J(q)} \left( \frac{r_{pr}}{r_{pu}} - 1 \right) \right] < \theta^* < min \left[ 2 - \frac{I(q)}{J(q)} \left( \frac{r_{pr}}{r_{pu}} - 1 \right); 1 \right] \quad (24)$$

mixed public-private capital will be the efficient form of financing public investments.

**Figure 2:** Interval of efficient public-private financing (continuous model)




Example 3:

Expected savings in capital expenditures due to the private sector's managerial advantage in existing joint venture partnerships can be inferred from condition (31) colorredesta mal la ref. In a sample of five public-private water supply and sewage companies in Poland (see Table 2), $\theta$ ranged between .33 and .64. For interest rates 20% higher for the private sector than for the public sector and assuming that the existing capital structures were optimal, expected savings in capital expenditures $J/(I+J)$ ranged 12.8 - 23.0%. On average, these results are similar to savings of 17% in capital expenditures found in British PFI (European Investment Bank 2004; Bondal 2005).

Figure 2 shows the space for Pareto-efficient public-private partnerships, assuming a linear decrease in development costs due to private know-how transfer.

Knowledge transfer begins even with a small private share in the shareholding. An efficient public-private capital structure is achieved in the interval $\theta \in (0, {}_a)$, where the fixed fee $f(q, \theta)$ is lower than in the cases of solely public or solely private investments. The fixed fee $f(q, \theta)$ achieves its minimum at $\theta^*$. Further increase of $\theta$ leads to an increase in $f(q, \theta)$ as a result of the higher share of more expensive private capital. As in Figure 1, at $= 1$ the fixed fee equals $I(q) \cdot r_{pr}$.

## 5 Concluding Remarks

Efficiency considerations suggest that the ownership of utilities does not have to be dichotomically public or private. In particular cases, efficient investment in public infrastructure requires mixed public and private ownership and governance of the project. Given very likely parameters of interest rate spreads between the public and private sectors and potential savings from private management, the optimum share of private ownership $\theta^*$ is interior and a public-private capital structure will be more Pareto-efficient - i.e., provide higher quality for the same fee or lower fee for the same quality - than the solely public or solely private ownership. Furthermore, the smaller the difference between the interest rate spreads between the public and private sectors and the larger the savings resulting from private sector participation, the larger the room for negotiation of capital participation between the parties.

These conclusions have important policy implications. The economic motivations of the public agent and private investors differ and PPP contracts must be correspondingly designed. From the public sector's point of view, the transfer of managerial skills and knowledge that justifies the private investor's participation in the SPV should be well defined and secured in properly drafted and executable legal documents. From the private investor's point of view, the lower cost derived from public financing should be secured for the project's entire lifespan. This might not be problematic if the project's funding is provided upfront. However, if funding is required over the project's lifetime, the availability of cheaper financing would imply that the government involved maintains its creditworthiness and, accordingly, follows sound macroeconomic policies.

Therefore, PPPs may be most efficient in countries whose governments follow stability-oriented and predictable economic policies that are conducive to securing cheaper financing. An equally important advantage is a reliable legal system that provides the instruments to secure the interest of the public agent vis-à-vis the private investor. A lack of confidence between the partners, an insufficient legal framework, and the pursuit of other than stability-oriented macroeconomic policies would undermine the Pareto-efficient solution derived from the model. If any or all of these conditions are violated, the possible savings achieved with public-private mixed ownership diminish.

**Table 1:** Private participation water and sewerage projects in developing countries by types of contract and regions

**Panel A. Total investments in million of US dollars (number of projects in brackets)**

| | East Asia and Pacific | Europe and Central Asia | Latin America and the Caribbean | Middle East and North Africa | South Asia | Sub-Saharan Africa | Total |
|---|---|---|---|---|---|---|---|
| **Concession** | **8102 (134)** | **665 (9)** | **14583 (130)** | | **108 (3)** | **76 (2)** | **23535 (278)** |
| Build, rehabilitate, operate, and transfer | 1814 (32) | 352 (5) | 11268 (83) | | 99 (2) | 31 (1) | 13564 (123) |
| Rehabilitate, lease or rent, and transfer | 0 (0) | 29 (1) | 133 (3) | | 9 (1) | | 171 (5) |
| Rehabilitate, operate, and transfer | 6288 (102) | 284 (3) | 3182 (44) | | | 45 (1) | 9799 (150) |
| **Divestiture** | **520 (12)** | **437 (8)** | **2255 (12)** | | | | **3212 (32)** |
| Full | 1 (1) | 435 (2) | 73 (2) | | | | 509 (5) |
| Partial | 519 (11) | 2 (6) | 2182 (10) | | | | 2703 (27) |
| **Greenfield project** | **5176 (224)** | **1825 (7)** | **2109 (44)** | **3202 (11)** | **245 (4)** | **133 (2)** | **12689 (292)** |
| Build, operate, and transfer | 4474 (213) | 1825 (7) | 1965 (38) | 2692 (8) | 245 (4) | 133 (2) | 11334 (272) |
| Build, own, and operate | 702 (11) | 0 (0) | 144 (6) | 510 (3) | 0 (0) | 0 (0) | 1356 (20) |
| **Management and lease contract** | **126 (14)** | **1205 (30)** | **1 (31)** | **0 (9)** | **2 (5)** | **37 (22)** | **1372 (111)** |
| Lease contract | 93 (7) | 1205 (20) | 0 (17) | | | 37 (10) | 1336 (54) |
| Management contract | 33 (7) | 0 (10) | 1 (14) | 0 (9) | 2 (5) | 0 (12) | 36 (57) |
| **Total** | **13924 (384)** | **4133 (54)** | **18948 (217)** | **3202 (20)** | **355 (12)** | **246 (26)** | **40808 (713)** |

**Panel B. Average percent of private ownership**

| | East Asia and Pacific | Europe and Central Asia | Latin America and the Caribbean | Middle East and North Africa | South Asia | Sub-Saharan Africa | Total |
|---|---|---|---|---|---|---|---|
| **Concession** | **76** | **75** | **98** | | **100** | **100** | **87** |
| Build, rehabilitate, operate, and transfer | 70 | 56 | 98 | | 100 | 100 | 90 |
| Rehabilitate, lease or rent, and transfer | | 100 | 83 | | 100 | | 91 |
| Rehabilitate, operate, and transfer | 78 | 98 | 98 | | | 100 | 85 |
| **Divestiture** | **49** | **72** | **61** | | | | **60** |
| Full | 100 | 100 | 100 | | | | 100 |
| Partial | 45 | 63 | 54 | | | | 52 |
| **Greenfield project** | **88** | **94** | **99** | **61** | **79** | **75** | **89** |
| Build, operate, and transfer | 89 | 94 | 99 | 63 | 79 | 75 | 89 |
| Build, own, and operate | 79 | | 100 | 57 | | | 81 |
| **Management and lease contract** | **88** | **93** | **91** | **100** | **84** | **98** | **93** |
| Lease contract | 79 | 92 | 90 | | | 95 | 90 |
| Management contract | 100 | 95 | 93 | 100 | 84 | 100 | 96 |
| **Total** | **83** | **87** | **95** | **79** | **87** | **96** | **87** |

**Panel C. Percent of projects with private ownership between 20 and 80 percent**

| | East Asia and Pacific | Europe and Central Asia | Latin America and the Caribbean | Middle East and North Africa | South Asia | Sub-Saharan Africa | Total |
|---|---|---|---|---|---|---|---|
| **Concession** | **49** | **44** | **4** | | **0** | **0** | **27** |
| Build, rehabilitate, operate, and transfer | 53 | 80 | 2 | | 0 | 0 | 19 |
| Rehabilitate, lease or rent, and transfer | 0 | 0 | 33 | | 0 | | 20 |
| Rehabilitate, operate, and transfer | 48 | 0 | 5 | | | 0 | 34 |
| **Divestiture** | **67** | **50** | **75** | | | | **66** |
| Full | 0 | 0 | 0 | | | | 0 |
| Partial | 73 | 67 | 90 | | | | 78 |
| **Greenfield project** | **23** | **14** | **2** | **82** | **50** | **50** | **22** |
| Build, operate, and transfer | 23 | 14 | 3 | 75 | 50 | 50 | 22 |
| Build, own, and operate | 27 | 0 | 0 | 100 | | | 30 |
| **Management and lease contract** | **21** | **13** | **19** | **0** | **20** | **5** | **14** |
| Lease contract | 43 | 15 | 24 | | | 10 | 20 |
| Management contract | 0 | 10 | 14 | 0 | 20 | 0 | 7 |
| **Total** | **33** | **24** | **10** | **45** | **25** | **8** | **25** |

Source: World Bank and PPIAF, PPI Project Database (http://ppi.worldbank.org); retrieved September 2010.

**Table 2:** Examples of PPPs with joint public-private capital structures

| Company and location | Private investors | Private investors' share $\theta$ | Comments |
|---|---|---|---|
| | | **Panel A: Water companies** | |
| AQUA, Bielsko-Biala, Poland | United Utilities Europe | 21%, and then 33.18% | acquiring the shares of an existing company; 12 years of contractual commitments |
| Dabrowa Gornicza, Poland | RWE Aqua GmbH | 34% | acquiring the shares of an existing company; 20 years of contractual commitments |
| Glogow, Poland | Gelsen-Wasser AG | 46% | acquiring the shares of the existing company |
| SAUR Neptun, Gdansk, Poland | SAUR International | 51% | jv with the city in the operator company; 30 years of contractual commitments |
| Tarnowskie Gory/Miasteczko Slaskie, Poland | Veolia Water (Vivendi) | 33.85%; after increasing capitalization 64% | 25 years of contractual commitments |
| Stadtentwässerung Schwerte, Germany | RWE Umwelt Aqua | 48% | Reported investment costs 12% below the average of German cities |
| BerlinWasser, Germany | RWE Aqua (16.63%), Allianz Capital Partners (16.63%), Veolia Deutshland (16.63%) | 49,9% | |
| Scottish Water Solutions, UK | Stirling Water (24.5%), UUGM (24.5) | 49% | Stirling Water comprises Thames Water, KBR, Alfred McAlpine and MJ Gleeson; UUGM is formed by United Utilities, Galliford Try and Morgan Est |
| Apa Nova, Rumania | Vivendi | 84% | 25 years of contractual commitments |
| | | **Panel B: Solid Waste** | |
| Mülheimer Entsorgungsgesellschaft, Germany | Trienekens | 49,0% | |
| Szolnok, Hungary | Rethmann | 51% | 4% ownership by County and a regional association of municipalities, classified as public sector; Municipality will retain at least 25% of shares to be considered qualified minority investor under Hungarian law |
| Debrecen, Hungary | ASA | 51% | Municipality will retain at least 25% of shares to be considered qualified minority investor under Hungarian law |
| Varna, Bulgaria | RWE | 65% | |
| Kirklees, UK | United Waste Services | 81% | 25 years of contractual commitments |
| | | **Panel C: Airports** | |
| Charles De Gaulle Airport, Paris, France | Free float (29.6%), employees (2%) | 31,60% | Schiphol Group owns 8% of Paris CDG, a consortium of: State of Netherlands (69.8%), City of Amsterdam (20%), Aéroports de Paris (8%) and City of Rotterdam (2.2%), classified as a public entityand City of Rotterdam (2.2%), I classified it as a public entity |
| International Airport Hamburg, Germany | Hochtief AirPort, Aer Rianta International | initially 36%, then 40% | |
| Local Airport Kassel-Calden, Germany | IHK (chamber of commerce), FRAPORT (Transportation Company) | 50% | |
| Flughafen Dusserldof, Germany | HTA (20%), HTAC (10%), Aer Rianta (20%) | 50% | acquiring the shares of the existing company |
| Frankfurt Airport, Germany | Stadtwerke Frankfurt am Main Holding GmbH (20.16%), Julius Bar Holding AG (10.35%), Deutsche Lufthansa AG (9.94%), others (27.98%) | 68,43% | partial IPO to wide range of investors |

Source: Moszoro (2005), European Commission and Others (2004), Weber and Alfen (2010).

**Table 3:** Add caption

| Statistic | Corporate Bonds (%) | Municipal Bonds (%) | Treasury Bonds (%) | C-M Bond Yields Spread (%) | C/M Bond Yields Ratio | C-T Bond Yields Spread (%) | C/T Bond Yields Ratio |
|---|---|---|---|---|---|---|---|
| [1] | [2] | [3] | [4] | [5]=[2]-[3] | [6]=[2]/[3] | [7]=[2]-[4] | [8]=[2]/[4] |
| Minimum | 4,44 | 3,15 | 2,22 | 0,62 | 1,16 | 0,25 | 1,05 |
| Maximum | 6,82 | 4,40 | 5,03 | 2,42 | 1,72 | 2,85 | 2,15 |
| Mean | 5,18 | 3,74 | 3,93 | 1,44 | 1,39 | 1,25 | 1,37 |
| Median | 5,15 | 3,80 | 3,96 | 1,34 | 1,36 | 1,13 | 1,29 |
| Std. Deviation | 0,41 | 0,30 | 0,70 | 0,41 | 0,13 | 0,80 | 0,30 |

Source: Reuters.

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