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Optimal Capital Structure of Public-Private Partnerships

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Optimal Capital Structure of Public-Private Joint Ventures

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Abstract

This paper presents a model to assess the efficiency of the capital structure in public-private partnerships (PPP). A main argument supporting the PPP approach for investment projects is the transfer of know-how from the private partner to the public entity. The paper shows how different knowledge transfer schemes determine an optimal shareholding structure of the PPP. Under the assumption of lower capital cost of the public partner and lower development outlays when the investment is carried out by a private investor, an optimal capital structure is achieved with both the public and the private parties as shareholders.

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I. INTRODUCTION

The provision of public goods provides a strong rationale for public-private partnerships (PPPs) that can efficiently carry out public investment projects. The key justifications for pursuing PPPs as quoted in the literature are lower costs than in sole private investments and higher quality than in the sole public provision of the public good.[2] The lower costs of PPPs result from lower cost of capital of the public partner, while higher quality is achieved due to the transfer of know-how from the private to the public partner.

In the case of PPP projects in infrastructure, empirical research carried out mostly in the U.K. and the U.S. shows that the private sector is indeed able to build infrastructure cheaper than the public sector.[3] The savings amount to 15-30 percent[4] and can be attributed to more efficient project management by the private investor, shorter construction time, as well as lower administrative expenses. On the other hand, in developed markets the cost of capital for the private sector is on average 100-300 basis points higher than for the public sector.[5]

PPPs are often undertaken by joint venture companies (special purpose vehicles, SPV) with equity contributed by the private and public sectors. The share in equity of the SPV is usually reflected in the voting power of the partners. To be attractive and viable, the shareholding structure of the SPV should secure the interest of both the public and private partner, namely providing enough public capital and sufficient private sector know-how. Efficient financing of public investments by the private sector also requires that the higher financing cost of the private sector must be offset by the savings of development outlays due to the transfer of know-how from the private sector. Some authors do not acknowledge a continuum between sole public or sole private shareholding for determining the optimal capital structure.[6] The model presented below will show that the project may be optimally financed with the mixed public-private shareholding.

The literature on financing public investments by private capital compares higher outlays on construction for the public sector with the higher cost of capital for a private investor.[7]

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[2] See Vaillancourt-Rosenau (2000).

[3] See Wright (1987), pp. 143–216, and Viscusi et al. (2000), pp. 448-449.

[4] Wallance and Junk (1970, quotation from Viscusi et al., 2000, p. 448) even claim that public enterprises have investment outlays 40 percent higher than private ones.

[5] See American Chamber of Commerce in Poland (2002), p. 20.

[6] For example Grout (1997), pp. 53–66; Grout (2003), pp. 62–68; Zysnarski (2003), and American Chamber of Commerce in Poland (2002).

[7] For the so-called Public Sector Comparator (PSC), see e.g., Broadbent and Laughlin (2003), pp. 332-341; UK National Audit Office: www.nao.org.uk/guidance/focus/000154_pp5-6.pdf.

However, very few authors take account of the continuum between these two cost drivers and implications for the capital structure.[8]

This paper analyzes the conditions for PPPs which will provide for a Pareto-efficient development of public utilities infrastructure. Pareto optimality refers to achieving the same quality of service at a lower cost or better quality at the same cost for publicly developed or privately developed public investments. It will also evaluate how different forms of know-how transfer determine an optimal capital structure of the SPV. We find that if the cost of capital is lower for public entities and the outlays on building infrastructure are lower when the investment is made by a private investor, it is possible to reach the lowest total cost of construction with both public and private capital as part of the shareholding.

The paper is organized as follows. Section II lays out the relationships between the level of quality, the required investments in infrastructure, and the cost of public utilities' services. Section III presents a model of knowledge transfer (initially a discrete model, then a continuous one) to describe the optimal public-private capital structure in PPPs for the provision of public utilities infrastructure. It also includes practical examples of existing PPPs in the public utilities sector. Section IV concludes with policy advice on the applicability of the model solution.

II. The Relationships Within the Model

The amount of capital expenditures on infrastructure is determined by the required quality of public service supplied by the SPV. Consider a newly formed SPV that has to invest during the development phase and – after the investment phase – operates the infrastructure and provides the public good. Further assume that during the operational phase of the project the public service is provided by the SPV at the cost that reflects a fixed fee which covers the amortization of the initial investment outlays and a variable fee that covers the current cost of service. This assumption requires that the capital expenditure $I(q)$ required to satisfy the demand at the quality level q should be equal to the present value of fixed fees paid to the SPV $f(q)$ over the life of the project t:

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

For a sufficiently long life of the project (for $t \rightarrow \infty$) this can be expressed as:

[8] Gerrard (2001) refers to mixed public and private ownership in water supply utilities and Hammami et al. (2006) give two examples of 'semi-private' ownership of public utilities.

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

This conclusion can be also derived from the market-clearing condition. In the two-part tariff system, for a given quality of service q and demand function $P(x,q)$, the fee for consumption of x units of the service should include a fixed fee $f(q)$ and a variable fee $p(x,q)$.

$$P(x,q) \cdot x = f(q) + p(x,q) \cdot x \tag{3}$$

From formula (3) the demand function is:

$$P(x,q) = \frac{f(q)}{x} + p(x,q) \tag{4}$$

On the supply side, for each level of service provision x, total revenues must include amortization of the investment outlays and a unit price at least equal to the marginal cost of service. This leads to the following supply function:

$$S(x,q) = \frac{I(q) \cdot r}{x} + \mathrm{MC}(x,q) \tag{5}$$

Market clearing condition requires $P(x,q)$ for a given x and q to be equal to $S(x,q)$

$$P(x,q) = S(x,q) \tag{6}$$

$$\frac{f(q)}{x} + p(x,q) = \frac{I(q) \cdot r}{x} + \mathrm{MC}(x,q) \tag{7}$$

$$f(q) = I(q) \cdot r \tag{8}$$

III. Determining the Optimal Public-Private Capital Structure

As stated above, it is assumed that the private sector is able to execute the PPP project cheaper than the public sector. Let us denote by $J(q)$ the amount by which development outlays (without financial costs) for a privately executed project are lower than the outlays for a publicly executed one.

Assume also that the transfer of the idiosyncratic assets of the private partner (such as know-how) to be transferred to the SPV materializes when the private share in the partnership's capital achieves a minimum of e. Then, as in equation (8), one may determine the level of fixed fees for mixed public-private financing from the following:

$$f(q) = \theta \cdot I(q) \cdot r_{pr} + (1-\theta) \cdot \left(I(q) + (1-\beta) \cdot J(q)\right) \cdot r_{pu} \tag{9}$$

where:

r_{pr} – interest (discount) rate for a private investor,

r_{pu} – interest (discount) rate for the public sector, $r_{pr} > r_{pu}$ [9]
θ – share of a private investor in the joint venture, θ ∈<0,1>
β – discrete variable reflecting the existence of know-how in project execution, so that:

$$\beta = \begin{cases} 0 & \text{when there is no know-how transfer} (\theta < \mathrm{e}) \\ 1 & \text{when there is know-how transfer} (\theta \geq \mathrm{e}) \end{cases}$$

Thus the condition for a PPP to execute the investment at a lower cost than the public partner can be written as:

$$\theta \cdot I(q) \cdot r_{pr} + (1-\theta) \cdot I(q) \cdot r_{pu} < \left(I(q) + (1-\beta) \cdot J(q)\right) \cdot r_{pu} \qquad (10)$$

Sorting and arranging with regard to θ one obtains:

$$\theta \left(\frac{r_{pr}}{r_{pu}} - 1 \right) < \frac{(1-\beta) \cdot J(q)}{I(q)}$$

or (11)

$$\theta < \frac{(1-\beta) \cdot J(q)}{I(q)} \Bigg/ \left(\frac{r_{pr}}{r_{pu}} - 1 \right)$$

Condition (11) shows that the project should be fully realized by the public entity if either the private partner does not contribute by allowing savings related to its knowledge, i.e., $J(q) = 0$, or the savings are relatively small compared with the difference in financial costs.

Provided there is know-how transfer from the private to the public sector (i.e., $\beta = 1$), a PPP (interior solution of inequality (11)) is more efficient than the total public or private financing (boundary solution), if the following condition is met:

$$\theta \cdot I(q) \cdot r_{pr} + (1-\theta) \cdot I(q) \cdot r_{pu} < \min\left(I(q) \cdot r_{pr} ; \left(I(q) + J(q)\right) \cdot r_{pu}\right) \qquad (12)$$

The first part of condition (12), i.e., when $\theta \cdot I(q) \cdot r_{pr} + (1-\theta) \cdot I(q) \cdot r_{pu} < I(q) \cdot r_{pr}$ yields:

$$\theta \cdot r_{pr} + (1-\theta) \cdot r_{pu} < r_{pr} \qquad (13)$$

$$(1-\theta)(r_{pu} - r_{pr}) < 0 \qquad (14)$$

Inequality (14) holds for every θ ∈ [*e*, 1).

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[9] The condition on higher interest rate for the private sector than the interest rate for the public sector may hold in the context of a partial equilibrium, when the public sector is characterized by lower risk. For a general equilibrium context see e.g. Feltenstein and Ha (1999).

The second part of condition (12):

$$\theta \cdot r_{pr} + (1-\theta) \cdot r_{pu} - r_{pu} < \frac{J(q)}{I(q)} r_{pu} \tag{15}$$

can be transformed to obtain the condition on θ :

$$\theta < \frac{J(q)}{I(q)} \left(\frac{r_{pu}}{r_{pr} - r_{pu}} \right) \tag{16}$$

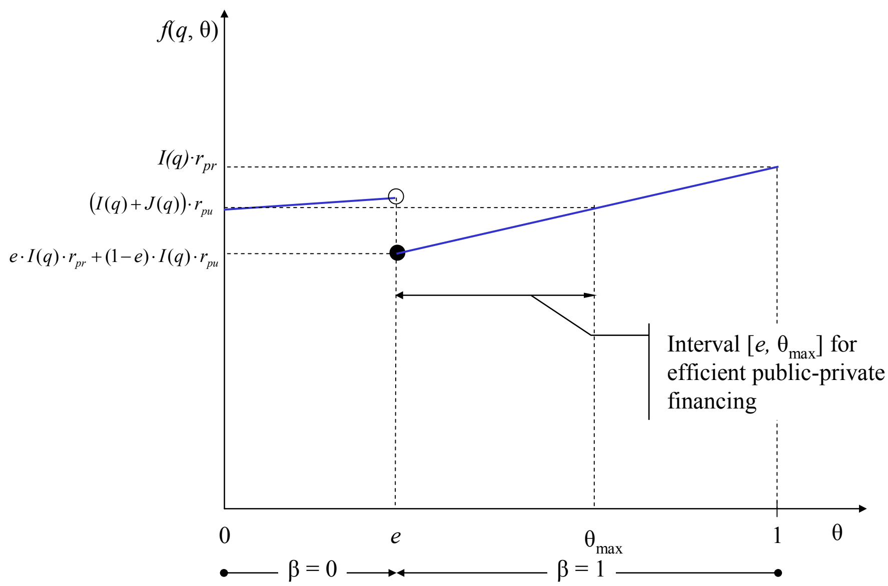
Condition (16) implies that the capital share of the private partner in the partnership is determined by the percentage of savings achieved on the investment thanks to the private sector participation in the project and the interest rate spread of the private sector over the rate available to the public sector.
Condition (16) also allows to determine when the project should be executed by the private partner only. Setting the right hand side of the inequality to be larger or equal to unity we obtain $J(q)/I(q) \geq (r_{pr} - r_{pu})/r_{pu}$. Therefore, the private partner should be the sole shareholder if the savings on the development outlays (in relation to *I(q)*) are higher than the relative spread between private and public rates.

Example 1:
The relationship presented in condition (16) can be used to present the following stylized facts. One can assume *J*(*q*) in relation to *I*(*q*) to equal 20 percent.[10] If private sector interest rates are assumed at 8.50 percent and an interest rate of long-term commercial loans for related government units at 7 percent, the PPP would be efficient in (in the sense of a tradeoff between cost and efficiency) when $\theta < 0.2(0.07/0.015)$, i.e., when $\theta < 93$ percent and $\theta \geq e$. Increasing the spread between the rates to 300 basis points yields a reduced private shareholding in the PPP to a maximum of 47 percent of total capital. Therefore, the bigger the difference between the interest rates for the public and private partners, the smaller the room for negotiation on capital participation between the parties.

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 $r_{pr}/r_{pu} > 1 + J(q)/I(q)$.

[10] Both Zysnarski (2003) and the American Chamber of Commerce (2002, p. 23), quoting British research (not providing the original source) claim that the savings from executing the investment by a private company equal 17 percent. If $\frac{(I+J)-I}{I+J} = 17\%$ then $J/I = 0.17/0.83 \approx 20$ percent.

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



As can be seen from Figure 1, the level of the fixed fee $f(q, \theta)$ rises starting from the point where the project is realized only by the public sector ($\theta = 0$). The $f(q, \theta)$ increases as a result of the increase of the share of the more expensive private capital in the partnership. The rate of increase for ($\theta < e$) equals $I(q)\ (r_{pr}\text{-}r_{pu}) - J(q)\cdot r_{pu}$. At $\theta = e$ the transfer of knowledge occurs and the $f(q, \theta)$ drops by (1-e)$J\cdot r_{pu}$. For $\theta \geq e$ the $f(q, \theta)$ increases at the rate of $I(q)\cdot(r_{pr} - r_{pu})$. At θ_{max} the fixed fee $f(q, \theta)$ is equal to the fixed fee in a project without private sector participation; and at $\theta = 1$, with private-only shareholding, the fee equals $I(q)r_{pr}$. Therefore, the larger the private share that is needed in the capital for the transfer of knowledge, the smaller the potential savings from private sector participation.

The transfer of know-how can also be described by a continuous function, where β is any continuous and differentiable function of θ. In the exemplary case of the linear function describing know-how transfer, function (9) can be written as:

$$f(q,\theta) = \theta \cdot I(q)\cdot r_{pr} + (1-\theta)\cdot\big(I(q) + (1-\theta)\cdot J(q)\big)\cdot r_{pu} \qquad (17)$$

where $(1 - \theta) \cdot J(q)$ reflects the linear increase in outlays resulting from lack of know-how, proportional to the public partner share.

The first-order conditions for a minimum of function (17) with respect to θ are:

$$\frac{\partial f}{\partial \theta} = I(q)\cdot r_{pr} - \big(I(q) + 2(1-\theta)\cdot J(q)\big)\cdot r_{pu} = 0 \qquad (18)$$

Therefore $f(q, \theta)$ has the minimum at such θ^* that:

$$\left(I(q)+2(1-\theta^{*})\cdot J(q)\right)\cdot r_{pu}=I(q)\cdot r_{pr} \qquad (19)$$

$$2(1-\theta^{*})\cdot J(q)=\frac{I(q)\cdot r_{pr}}{r_{pu}}-I(q) \qquad (20)$$

$$\theta^{*}=1-\frac{I(q)}{2J(q)}\left(\frac{r_{pr}}{r_{pu}}-1\right) \qquad (21)$$

Since the second derivative of (17) with respect to θ is positive for each $J(q) > 0$, then equation (21) determines the minimum of function (17).

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

Example 2:
Equation (21) can be used to determine the private partner's optimal shareholding for the same ratio of $I/J = 5$ as in Example 1. For the cases in which interest rates applicable to the private sector are on average 25 percent higher than the rates for the public sector ($r_{pr}/r_{pu} - 1 = 0.25$), function $f(q, \theta)$ reaches its minimum at $\theta^{*} = 0.375$. The optimal capital structure would then be a 62.5 percent share in capital owned by the public partner and 37.5 percent of the capital owned by the private partner.

PPP with mixed financing will be pareto-efficient under these assumptions if the following condition is met:

$$\theta\cdot I(q)\cdot r_{pr}+(1-\theta)\cdot\left(I(q)+(1-\theta)J(q)\right)\cdot r_{pu}<\min\left(I(q)\cdot r_{pr};\left(I(q)+J(q)\right)\cdot r_{pu}\right) \qquad (22)$$

For $I(q)\cdot r_{pr}<\left(I(q)+J(q)\right)\cdot r_{pu}$ (first part of condition (22)), the private partner share θ results from the solution of the condition:

$$\theta\cdot I(q)\cdot r_{pr}+(1-\theta)\cdot\left(I(q)+(1-\theta)\cdot J(q)\right)\cdot r_{pu}<I(q)\cdot r_{pr} \qquad (23)$$

$$I(q)\cdot r_{pr}-(1-\theta)\cdot I(q)\cdot r_{pr}+(1-\theta)\cdot I(q)\cdot r_{pu}+(1-\theta)^{2}\cdot J(q)\cdot r_{pu}<I(q)\cdot r_{pr} \qquad (24)$$

$$(1-\theta)\cdot I(q)\cdot(r_{pu}-r_{pr})+(1-\theta)^{2}\cdot J(q)\cdot r_{pu}<0 \qquad (25)$$

This condition is met for $1-\frac{I}{J}\left(\frac{r_{pr}}{r_{pu}}-1\right)<\theta<1$

For $I(q)\cdot r_{pr} > \big(I(q)+J(q)\big)\cdot r_{pu}$ (second part of condition (22)), the private partner share θ must meet the following condition:

$$I(q)\cdot r_{pr} - (1-\theta)I(q)\cdot r_{pr} + (1-\theta)I(q)\cdot r_{pu} + (1-\theta)^2 J(q)\cdot r_{pu} < \big(I(q)+J(q)\big)\cdot r_{pu} \qquad (26)$$

$$-I(q)\cdot(r_{pu}-r_{pr}) - J(q)\cdot r_{pu} + (1-\theta)I(q)\cdot(r_{pu}-r_{pr}) + (1-\theta)^2 J(q)\cdot r_{pu} < 0 \qquad (27)$$

This condition is met for:

$$0 < \theta < 2 - \frac{I}{J}\left(\frac{r_{pr}}{r_{pu}} - 1\right) \qquad (28)$$

From the above analysis it turns out that for the section:

$$\max\left[0;1-\frac{I}{J}\left(\frac{r_{pr}}{r_{pu}}-1\right)\right] < \theta < \min\left[2-\frac{I}{J}\left(\frac{r_{pr}}{r_{pu}}-1\right);1\right] \qquad (29)$$

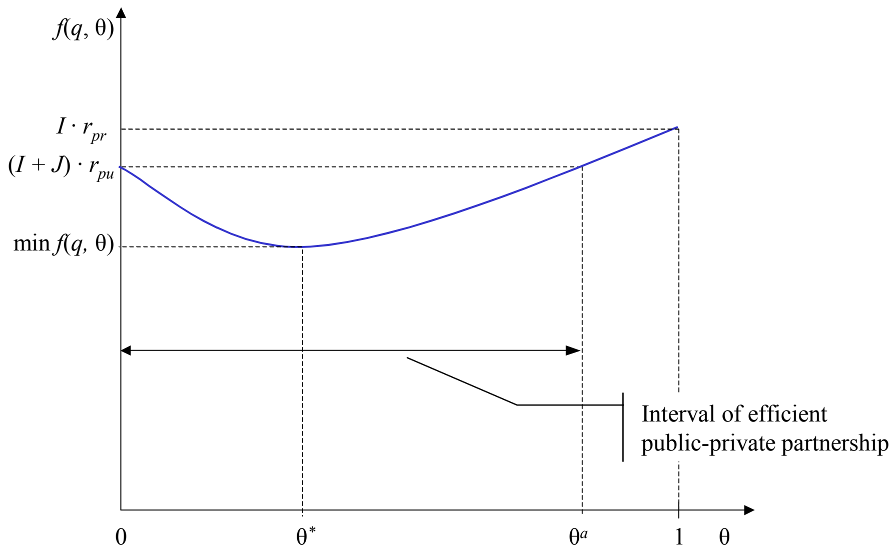
the PPP will be the efficient form of financing public investments.

Example 3:
The level of expected savings of development outlays in existing joint venture partnerships can be calculated based on condition (29). In a sample of five public-private water supply and sewage companies in Poland,[11] the level of θ was between 0.33 and 0.64. For interest rates that on average are 20 percent higher for the private sector than for the public sector, and assuming that the existing capital structures are at an optimum, we can conclude that the ratio *I*/*J* was expected to be between 3.35 and 6.8, which amounts to savings of development outlays up to 12.8–23.0 percent. On average, these results are similar to the savings of 17 percent quoted in the literature for the U.K.

Figure 2 shows the space for Pareto-efficient public-private partnerships assuming a linear function describing the increase of costs due to the lack of know-how in the public sector.

[11] See Moszoro (2005), p. 70.

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



The transfer of knowledge begins even with a small private share in the shareholding. An efficient public-private capital structure is achieved in the interval $\theta \in (0 , \theta^{a})$, where the fixed fee $f(q, \theta)$ is lower than in the case of a sole public or sole private investment. The minimum value of the fixed fee is obtained at θ^{*}, where all the know-how is transferred from the private partner to the PPP. Further increases of θ lead to an increasing $f(q, \theta)$ as a result of the higher share of more expensive private capital. As in Figure 1, at $\theta = 1$ the fee equals $I(q) \cdot r_{pr}$.

IV. Conclusions

The model-based analysis in this paper shows that PPPs may provide public services cheaper than a sole private or sole public entity. Efficiency considerations suggest that the ownership of the SPV providing the public service does not have to be exclusively public or private. An optimum investment in public infrastructure requires mixed public and private ownership of the project and knowledge transfer. If the optimum share of private ownership θ lies within the borders as defined by the interest rate spread and the potential savings from private management, a public-private capital structure will be more efficient in terms of lower fixed costs than a sole public or sole private ownership. Moreover, the larger the difference between the interest rates for the public and private partners and the smaller the savings resulting from private sector participation, the smaller the room for negotiation on capital participation between the parties.

This model-based conclusion has important policy implications. The economic motivations of the public and the private partners differ, which requires the legal framework of a PPP to be elaborate. From the point of view of the public partner, the transfer of knowledge that justifies the participation of the private partner in the SPV should be well defined and secured in a properly drafted and executable legal documentation. From the point of view of the private partner, the lower cost derived from the public financing should be secured for the entire lifespan of the project. This might not be problematic if the funding of the project is provided upfront. However, if the funding is required over the lifetime of the project, 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 macroeconomic 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 partner vis-à-vis the private partner. 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 the PPP scheme diminish.

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