HOW DO CREDIT SPREADS AFFECT RISK ALLOCATION IN PUBLIC – PRIVATE PARTNERSHIPS?

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***Abstract**: The impact of funding cost is an important dimension in the design of risk allocation in public–private partnerships (PPP), given the relevant leverage of project financing. However, the academic literature has paid little attention to this issue. The aim of this paper is to measure to what extent a higher cost of funding affect the choice of risk transfer by grantor governments. During the Great Recession, developing PPPs with market risk was a difficult task and high credit spreads were applied to project finance loans. This paper analyzes the optimal risk allocation in a PPP by using two models in which the government has the option to transfer availability risk or demand risk to a private partner. The paper finds that the credit spreads of project finance loans significantly affect the decisions on which type of risk should be transferred to private-sector parties when governments use PPPs.*
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INTRODUCTION

Under a public–private partnership (PPP), several private sector partners form a consortium, the ‘special purpose vehicle’ (SPV), to deliver capital assets and/or services to a governmental agency on a long-term contract. A government using a PPP method may transfer the demand risk or only the availability risk to the private-sector party. After the start of the Great Recession in summer 2007, those banks specializing in project finance (PF) showed a greater preference for PPPs with availability risk than those with demand risk; a behavior that occurred even in those countries where sovereign risk was rapidly increasing. The results were a great difficulty in financing projects with market risk and the application of high credit spreads to loans financing this type of PPP. Risk allocation (RA) plays a critical role in privately financed infrastructure projects and public services, and the project performance is contingent on whether the adopted RA strategy is efficient. Regarding the use of PPPs as the procurement method for a social service, the academic literature has paid much attention to issues such as the impact of agency problems generated by asymmetric and incomplete information, whilst it has dealt less with the other aspect of PPPs: the reliance on private-sector finance. However, the impact of funding in RA is an important dimension given the relevant leverage of project financing. The aim of this paper is to measure to what extent a higher cost of funding affect the choice of risk transfer by grantor governments. We consider a PPP where a private partner builds a hospital and provides clinical and non-clinical services. The results, however, are generalizable to other types of PPPs. In our model, the public-sector party chooses between an availability risk scheme and an alternative one in which the market risk is shared with the private partner. The market risk for the private partner consists of receiving fewer revenues, because of the demand shortage (an insufficient number of patients). This takes place in a context in which the demand evolution follows a Brownian motion; and there is no hidden information for the players. To transfer demand risk to the private-sector party, the government is willing to pay a higher fee per patient, but this differential payment may not fully offset the impact on revenue arising from a shortage of demand. As a consequence, when market risk is transferred, lenders require higher credit spreads and shareholders higher equity premiums. The paper proceeds as follows. In section 2, we briefly address a number of issues regarding RA. In section 3, we propose a model in which credit spread plays a role in RA. We extend the models including a number of financial covenants. In section 4, a number of theoretical results are proposed. To contextualize those results, several numerical calculations are carried out as well. Section 5 concludes. The main finding of the paper is that the credit spreads significantly affect the decisions on which type of risk should be transferred to private partners when governments use PPP schemes.

THE ALLOCATION OF RISKS BETWEEN PUBLIC-SECTOR AND PRIVATE-SECTOR PARTIES

Risk sharing between governments and concessionaires is always a concern among practitioners and policy makers (see Engel et al., 2007) but, despite the existence of many complex risks that can interfere with the success of infrastructure projects, the private sector has been keen to take over the traditional role of the public sector in financing, procuring and managing infrastructure assets. However, even in the largest PPP projects, the risk management practices are often highly variable, intuitive, subjective and unsophisticated (Ng & Loosemore, 2007).The type, extent and allocation of risks in PPP contracts depend on the fundamentals of the arrangement, the contractual provisions and the degree to which the contract is enforceable. The infrastructure projects that are particularly subject to risk are those with large initial costs, high irreversibility (sunk costs), long-term durability of assets and complex management, as it is the case of hospitals.

There are basically two strands of relevant literature analyzing contract design and risk transfer in PPPs. On the one hand, the *new economics of regulation* stresses the trade-off between efficiency and rent extraction when the regulated firm has an information advantage. This approach is associated in particular with the book by Laffont and Tirole (1993), the paper by Schmidt (1996) and many subsequent works. On the other hand, the *incomplete contracting* literature emphasizes that market relations are problematic when the environment is complex due to the fear of ex-post *hold-ups* (greater investment by one party can trigger tougher ex-post bargaining by the other party).This literature is associated with the papers by Williamson (1975 and 1985), Grossman & Hart (1986), Hart & Moore (1990), Hart (1995) or Schmidt (1996) among many others. Typically, the process of RA between public and private sectors in infrastructure agreements is analyzed as a bargaining process. Each risk should be allocated to maximize the project value, taking account of moral hazard, adverse selection and risk-bearing preference. For the analysis of risk allocation in models with moral hazard in building and adverse selection in operation see Bentz et al. (2002) and Irwin (2003), among others. For models with moral hazard, in which the effort during the investment affects both the quality of the infrastructure and its operation cost, see for example Martimort & Pouyet (2006). Thus, RA is a means to provide the appropriate incentives for the private partner to perform according to the contract terms.

An important part of the literature considers that the public-sector party is less risk averse than the private-sector party because of its wider possibilities to diversify risk. The assumption of risk neutrality for the government provides a simple benchmark and can be an acceptable assumption if the PPP project does not represent a large share of the budget. Lewis & Sappington (1995) and Martimort & Sand-Zantman (2006) analyse the consequences of having risk-averse governments. In principal–agent models, a risk-averse firm is a short cut for agency problems preventing risk diversification. On the other hand, Martimort & Pouyet (2006) and others assume risk-averse concessionaires. Authors such as Klein (1997) and Hemming (2006) point out, however, that private firms can use capital markets to diversify risks at least as well as the government. Nevertheless, the academic literature has established the following criteria for RA: i) the public-sector party should bear risks that the private sector cannot control (or cannot control as well as the public-sector party) either in terms of likelihood of occurrence or in terms of impact; ii) the private-sector party should bear risks that the public sector can control (or can control better than the private-sector party) both in terms of likelihood of occurrence and in terms of impact; iii) the public-sector party and the private-sector party should share risks that the private sector can control in terms of impact but cannot control (or cannot control as well as the public-sector party) in terms of likelihood of occurrence; and iv) risk sharing may also be appropriate when risk is difficult to forecast and transferring risk to the private-sector party may result in an excessive risk premium (i.e. a high cost of capital).

Regarding this last issue, in many sectors the demand is difficult to predict accurately and the market risk is high. This is often the case when the expected revenues are calculated using forecasts of the future demand. In those cases, a full transfer of demand risk to the private-sector party might raise the cost of capital and funding substantially. To reduce the risk premiums and credit spreads, it might be desirable to cap the level of risk that the private-sector party bears; introducing some sort of risk sharing. The public-sector party may be in a better position than the private-sector party to acquire information on the likelihood of changes in users' needs. Furthermore, changes in public needs can be indirectly affected by changes in public sector policy. Thus, the risk of changes in public needs should generally be borne by the public-sector party, but optimal RA should also provide incentives for the private-sector party to make the requested changes in the service provision at a reasonable cost to control the impact of risk. Whilst the private-sector party should be contractually obliged to provide the extra service, changes in public needs can be very costly for the public sector because of the strong bargaining position of the private-sector party locked into the contract, and because of the lack of accessible alternatives and cost benchmarks. This may make it preferable to introduce some sort of risk-sharing agreement between the private partner and the public partner. Risk sharing can also help to provide incentives for the private-sector party to acquire information on the cost of changes in the service and thus inform the decision on whether those changes are indeed necessary. This is also important since the private partner is often in a better position to identify the most appropriate means to satisfy the needs of the public sector services (regarding healthcare services, for example, see Nikolic & Maikisch, 2006).

Our analysis focuses on the impact of project financing on the optimal design of a project under a PPP scheme, but the route that we follow is different from the one that is usually discussed in the literature. We analyze the impact of credit spreads on the optimal RA between the government and the contractor, while the literature discusses a number of related but different topics. First, a body of the literature on financing public investments by private capital compares the higher outlays on construction for the public sector with the higher payments for a private investor (see Broadbent & Laughlin, 2003 and Irwin, 2008). Second, some papers investigate the benefit of using PPPs as a procurement method since they might bring in the expertise of outside financiers in evaluating risks. In this respect, bundling the tasks of looking for outside finance and operating assets could improve on the more traditional model of procurement, in which the cost of investment is paid through taxation and investment is not backed up by such a level of expertise within the public sphere. Often, this analysis takes place in a context involving moral hazard and in which bundling private finance and operation is optimal since outside financiers have access to some informative signals on the operator's effort level. The intuition for this result is that relying on outside finance makes the operator less risk averse, even though outside finance may exacerbate the moral hazard by introducing further risk sharing. The point is that, as the financial contract is made under a better information structure, the extra round of contracting with financiers has more benefits in terms of improved incentives than costs in terms of modified risk sharing. Third, the literature analyzes the distortionary cost of taxation as a rationale for the usage of PPPs in scenarios in which the government is or is not credit constrained (see Iossa & Martimort, 2009). Fourth, the comparative effects of subsidy finance, revenue guarantees and user-fee finance are also analyzed in the academic literature (see Engel et al., 2007).Fifth, some papers focus on the possible negative effect of external finance. It may arise a new agency problem between the consortium and the external investor, acting as equity provider (see Dewatripont & Legros, 2005).Sixth, in discussing the downsides of external financing for PPPs, some papers focus on the control rights when creditors may access the property in the case of default by borrowers (see Aghion & Bolton, 1992). Seventh, the literature also discusses whether the risk of bankruptcy is internalized if contractors are financially constrained when contracts are awarded. If the answer is negative, it can lead to aggressive bidding and success at the auctions, with the government paying the consequences later. In a scenario of projects that are *too important to fail*, as typically occurs in healthcare projects, the government may find it optimal ex post to rescue the project financially. The anticipation of such *soft budget constraints* (SBCs) would contribute to a further distortion at the auction. SBCs are an illustration of a lack of commitment or lack of completeness of contracts. Finally, some authors focus on the implications of financing costs and efficiency improvement on the capital structure of the companies running PPPs (see Gerrard, 2001; Schwartz et al., 2008 or Moszoro, 2010).The underlying assumption in some of these papers is that it might be optimal for the public partner to become a shareholder in the SPV if the domestic capital markets are well developed such that the public sector's participation may mitigate the cost premium.

RISK ALLOCATION IN A MODEL WITH VARIABLE CREDIT SPREADS

In this paper a governmental agency enters a long-term contractual arrangement with a private firm to deliver a healthcare service to society, according to which the agency pays a fee to a private partner managing a hospital, while patients do not pay for the healthcare services. The private partner takes responsibility for all clinical services. In this context, we compare two alternatives. In the first, the availability risk scheme (AR), the private partner signs an agreement in which the number of patients to treat is determined and the demand risk is fully retained by the public-sector party. In the second, the market risk scheme (MR), the private party takes the risk of demand. In the model there are three players: a risk-neutral agency of the government *G*, a private concessionaire firm *F* incorporated as a SPV and a syndicate of financial institutions *S*. For the provision of the services the construction of a hospital, with a cost of *H*, is required. We shall assume that the investment is upfront and there is no further capex. Instead of using the unbundled contracting method, according to which the government approaches a builder first and then a separate operator, *G* decides to tender a PPP, bundling various phases of contracting. The winner of the bid assumes responsibility for designing and building the hospital and for meeting the specified output; finances the investment and then operates the facility: the DBFO model. Usually the concessionaire also maintains the asset and the public sector retains ownership of it when the contract expires. To simplify, in our model, maintenance costs are included in the operating costs; at the end of the concession period, the hospital returns to the control and ownership of the public sector in good state. Frequently, to provide incentives for the private-sector party to look after the facility during the contract life and particularly towards the end of the contract, contract clauses provide for a final compensation payable to the private partner conditional on the state of the facility, once the contract expires. In our model, however, there is no such final compensation fee. We assume that the government, a benevolent social planner, retains the statutory risk, designs the contract, specifies the output requirements, designs the payment mechanism and decides the contract duration. In this regard, the government specifies that the winner of the bid *F* will undertake the investment in the hospital, and bear the financial risk, with the expectation of achieving a given level of return on the invested capital. In our model, the public-sector party does not provide the project with capital grants, guarantees, equity or subordinated loans. Finally, the government assumes that a syndicate of financial institutions *S* will give a single, senior and amortizing project finance loan to *F*, and will decide on its credit spread. The government runs a competitive auction to attract service providers and has two alternative tendering options, the availability risk scheme and the market risk scheme. Thus, the decision of the government refers to RA and it is assumed to be made in a context in which the government is able to allocate patients to different service centers to ensure compliance with the agreement in the case of availability risk scheme, but cannot control the healthcare demand in the market risk scheme. In addition, it is assumed that there is no hidden information regarding the operational cost or about the effort level applied by the private operator. Moreover, for simplicity, we assume that the service standards related to the output specifications are translated into measurable output indicators that can be verified by all the parties at a low monitoring cost; that the private operator meets the contract strictly; and that there are no bonus payments or penalties linked to the quality of the service provided. Finally, we assume that both the government and the concessionaire know the rules followed by the lenders when pricing the loan.

STOCHASTIC MODELING OF THE PUBLIC SERVICE DEMAND

The comparative analysis of concessions with and without market risk requires probabilistic modeling of demand D_t (treated patients in period t). Consider that D_t follows a Brownian motion such that

$$d\ln D_t = \mu dt + \sigma dW_t \quad (1)$$

Where μ represents the average growth in each period and σ the expected volatility of the demand growth. D_t^e becomes a mean value of the distribution of values of the demand in period *t*, D_t^h is the mean value of the distribution of all the demand values greater than D_t^e and D_t^l is the mean value of the distribution of all the demand values lower than D_t^f. Thus, D_t^e can be estimated by:

$$D_t^e = D_0 e^{\left(\mu + \frac{\sigma^2}{2}\right)t} \quad (2)$$

Where D_0 is the value of the demand at t = 0. Under these assumptions

$$p_t = \mathcal{N}\left(-\frac{\sigma\sqrt{t}}{2}\right) and \ 1 - p_t = \mathcal{N}\left(\frac{\sigma\sqrt{t}}{2}\right) \quad (3)$$

Where p_t is the probability of facing a high demand D_t^h and where $1\text{-}p_t$ is the probability of facing a low demandD_t^l.

$\mathcal{N}$(x) is the probability of normal cumulative distribution up to value x.

Meanwhile, the value of D_t^hcan be estimated by

$$D_t^h = (1 + \omega_t)D_t^e = D_t^e \frac{\mathcal{N}\left(\frac{\sigma\sqrt{t}}{2}\right)}{\mathcal{N}\left(-\frac{\sigma\sqrt{t}}{2}\right)} \quad (4)$$

Similarly

$$D_t^l = \frac{D_t^e}{1+\omega_t} = D_t^e \frac{\mathcal{N}\left(-\frac{\sigma\sqrt{t}}{2}\right)}{\mathcal{N}\left(\frac{\sigma\sqrt{t}}{2}\right)} \quad (5)$$

We note that (ω_t) is given by [6] and it holds that $\omega \geq 0$:

$$\omega_t = \frac{\mathcal{N}\left(\frac{\sigma\sqrt{t}}{2}\right) - \mathcal{N}\left(-\frac{\sigma\sqrt{t}}{2}\right)}{\mathcal{N}\left(-\frac{\sigma\sqrt{t}}{2}\right)} \quad (6)$$

Combining the above expressions, we obtain

$$p_t\left(D_t^h - D_t^e\right) = D_t^e\left\{\mathcal{N}\left(\frac{\sigma\sqrt{t}}{2}\right) - \mathcal{N}\left(-\frac{\sigma\sqrt{t}}{2}\right)\right\} \quad (7)$$

and it obviously holds that

$$p_t D_t^h + (1-p_t) D_t^l = D_t^e \quad (7')$$

The availability risk scheme

In the availability risk scheme *AR*, the utility function of the government $U^G(AR)_t$ is given by [8]:

$$U^G(AR)_t = (u-m)D_t^f - \alpha H + \tau \Pi_t^{AR} \quad (8)$$

where u is the unitary social benefit of the healthcare service; m is the unitary payment per recorded service; D_t^f is the agreed number of patient to be treated; α reflects the parameter of a second government payment; τ is the corporate tax rate (for simplification it is assumed to be constant over time); and Π_t^{AR} is the pre-tax profit of the concessionaire. In addition we assume that

$$D_t^f = (1-d)D_t^e = D_0 e^{\left(\mu+\frac{\sigma^2}{2}\right)t} \quad (9)$$

Where D_0 is an initial demand level; μ is the historic average growth of the demand for a determined period, σ is the historic volatility of the demand for the same period, and d is a discount factor, such that the four parameters are agreed between the government and the private-sector party at the beginning of the contract. Consequently, in this scheme, the future path of demand is deterministic. Those terms that do not use the subscript (t) are assumed to be equal for all periods.

On the other hand, Π^{AR}, assuming availability risk, is given by

$$\Pi_t^{AR} = \alpha H + (m-\beta)D_t^f - L_{t-1}(i+\gamma) - \frac{H}{n} \quad (10)$$

where L the outstanding project finance loan; i the risk-free rate for the relevant project finance maturity; γ the credit spread of the loan; $(\frac{H}{n})$ is the annual depreciation of the asset, such that n is the concession length; the operational costs are proportional to the demand of the project: β reflects the observable unitary operating cost, such that $m > \beta$.

Note that, unlike other models that include potential externalities (improving the quality of the infrastructure may reduce or increase the operational cost of the operator), here the unitary operational cost depends only on the demand.

The credit spread can be proxied by

$$\gamma = \lambda \left(\sum_{1}^{n} (1+i')^{-t}\right)^{-1} \sum_{1}^{n} (1+i')^{-t} \frac{L_{t-1}}{\alpha H + (m-\beta) D_t^f} \tag{11}$$

where we assume that λ is a constant, indicating the risk price based on both the credit quality of the concessionaire and capitalization requirements of the lenders group. See Kleimeier & Megginson (2000), Blanc-Brude & Stranger (2007), Dailmani & Hauswald (2007), Kong et al.(2008), Sorge & Gadanecz (2008), Corielli et al. (2010), Girardone & Snaith (2011) or Sorge (2011) on the determinants of credit spreads in project finance.

3.3. The market risk scheme

As its second option, the government can tender the PPP through a market risk scheme *MR*, in which the concessionaire shares the demand risk with the government. It may happen that the demand takes levels substantially lower than those set for the case of the availability risk scheme. To compensate the private operator for thisrisk,the government decides to use a different payment system ($m' D_t$). The utility function of the government $\widehat{U}^G(MR)_t$ is given by

$$\widehat{U}^G(MR)_t = p_t[(u-m')D_t^h] + (1-p_t)[(u-m')D_t^l] - \alpha H + \tau \widehat{\Pi}_t^{MR1} \tag{12}$$

where p_t is the probability of facing a high demand D^h. Given that $D_t^e = p_t D_t^h + (1-p_t) D_t^l$, then [12] can be rewritten as

$$\widehat{U}^G(MR)_t = (u-m')D_t^e - \alpha H + \tau \widehat{\Pi}_t^{MR1} \tag{12'}$$

In a scenario with market risk, the annual expected profit of *F* is given by:

$$\widehat{\Pi}_t^{MR} = p_t\left[(m'-\beta)D_t^h + \alpha H - L_{t-1}(i+\gamma') - \frac{H}{n}\right] + (1-p_t)\left[(m'-\beta)D_t^l + \alpha H - L_{t-1}(i+\gamma') - \frac{H}{n}\right] \tag{13}$$

Equivalently,

$$\widehat{\Pi}_t^{MR} = (m'-\beta)D_t^e + \alpha H - L_{t-1}(i+\gamma') - \frac{H}{n} \tag{13'}$$

Now, the credit spread can be proxied by

$$\gamma' = \lambda' \left(\sum_{1}^{n} (1+i')^{-t}\right)^{-1} \sum_{1}^{n} (1+i')^{-t} \frac{L_{t-1}}{\alpha H + (m'-\beta) D_t^e} \tag{14}$$

Such that $\lambda' > \lambda$, where that λ' can be expressed as

$$\lambda' = \lambda(1 + k\sigma) \tag{15}$$

where $k > 0$. The scheme with demand risk incorporates an additional risk with respect to the availability risk scheme because of the random feature of the demand. This impact can be represented by a multiplier *k* of the demand volatility. Given that $\prod_t^{MR}$ may be less than $\prod_t^{AR}$ when $(m'-\beta)D_t - (m-\beta)D_t^f < L_{t-1}(\gamma' - \gamma)$, lending to this type of project is riskier, and lenders *S* charge a higher credit spread. The intuition is straightforward: the profit of the concessionaire is less for those scenarios in which the difference of revenues is negative or if it is positive but insufficient to offset the higher financing costs of the concessionaire.

On the one hand, in this model, the government determines *m* and m´ and chooses to tender a PPP with demand risk when

$$\sum_{1}^{n}(1+i')^{-t}[\widetilde{U}^G(MR)_t - U^G(AR)_t] > 0 \qquad (16)$$

Note that the rate used to discount the flows (i´) may or may not coincide with the risk-free rate (i). For a recent analysis of the impact of discount rates on PPPs, see Contreras (2014).Alternatively, in this particular case we can rewrite (16) as,

$$\sum_{1}^{n}(1+i')^{-t}\{[(1-\tau)(m-\beta)-(u-\beta)](D_t^f - D_t^g) - (1-\tau)(m'-m)D_t^g - \tau(\gamma'-\gamma)L_{t-1}\} > 0 \qquad (17)$$

Equivalently,

$$\sum_{1}^{n}(1+i')^{-t}\left\{[(1-\tau)(m-\beta)-(u-\beta)](D_t^f - D_t^g) - (1-\tau)(m'-m)D_t^g - \tau \lambda L_{t-1}\left[\left(\sum_{1}^{n}(1+i')^{-j}\right)^{-1}\sum_{1}^{n}(1+i')^{-j}L_{j-1}\left\{\frac{1+k\sigma}{\alpha H+(m'-\beta)D_j^g} - \frac{1}{\alpha H+(m-\beta)D_j^f}\right\}\right]\right\} > 0 \qquad (17')$$

On the other hand, private agents bidding for the project know the conditions ultimately included in the tender by *G* once the choice regarding the type of PPP has been adopted. When setting their bid, *α*, *m* and *m´* the candidates aim to achieve a minimum return on their equity investment (v) such that

$$\nu(AR) = (i + \Gamma^{AR}) \qquad (18)$$

$$\hat{\nu}(MR) = [i + \Gamma^{AR}(1+g)] \qquad (19)$$

Where *Γ* is the equity premium. It is assumed that *g*> 0, and that *v* is calculated as the internal rate of return of the cash flows, which include, as a negative flow, the initial equity contribution (H-L) and, as positive ones, all the dividends paid by the SPV to the shareholders during the concession period, as well as a final extraordinary dividend (*ed*) such that

$$CF_t^{AR} = -(H-L)_0 + d_1^{AR} + d_2^{AR} + \cdots + d_n^{AR} + ed_n^{AR} \qquad (20)$$

$$\widetilde{CF}_t^{MR} = -(H-L)_0 + \tilde{d}_1^{MR} + \tilde{d}_2^{MR} + \cdots + \tilde{d}_n^{MR} + \widetilde{ed}_n^{MR} \qquad (21)$$

In a model without financial covenants, the annual dividends paid match the net income:

$$d_t^{AR} = (1-\tau)\Pi_t^{AR} \qquad (22)$$

$$\tilde{d}_t^{MR} = (1-\tau)\tilde{\Pi}_t^{MR} \qquad (22')$$

The extraordinary dividends paid at the end of the concession period, once all the debt has been repaid, are given by

$$ed_n^{AR} = \sum_{1}^{n}[(1-\tau)\left[\alpha H - (m-\beta)D_t^f - L_{t-1}(i+\gamma) - \frac{L}{n}\right] - d_t^{AR}] \qquad (23)$$

$$\widetilde{ed}_n^{MR} = \sum_{1}^{n}[(1-\tau)\left[\alpha H - (m'-\beta)D_t^g - L_{t-1}(i+\gamma b) - \frac{L}{n}\right] - d_t^{MR}] \qquad (23')$$

The model extended with financial covenants

In practice, project finance is the preferred financial technique for large infrastructures, when the private sector is involved. Typically the sponsors commit an amount of capital to obtain additional sources: non-recourse or limited recourse debt provided by lenders or by bondholders. The repayment of these financial facilities depends primarily on the cash flow generated by the asset being financed. The SPV pledges the income stream as collateral to borrow the funds; and its dividend policy is habitually affected by some requirements imposed by the lenders. Thus, the payout policy is subject to at least five financial covenants, represented by $\theta_1, \theta_2, \theta_3, \theta_4$ and θ_5. Most of the project finance contracts include cash sweep clauses, which regulate the mandatory use of excess free cash flows to pay down outstanding debt rather than distributing it to shareholders. In our model, the required covenants are identical for the cases of availability risk and market risk, while the difference in the loan contract is reflected in the credit spread. The initial gearing ratio (θ_1) measures the degree to which the SPV is funded by the owner's funds versus the creditor's funds and must be equal to or lower than a given value:

$$\frac{L}{H} \leq \theta_1 \tag{24}$$

The debt/EBITDA ratio must be equal to or lower than a given value such that:

$$\frac{L_{t-1}}{\alpha H + (m - \beta)D_t^f} \leq \theta_2^{AR} \tag{25}$$

$$\frac{L_{t-1}}{\alpha H + (m' - \beta)D_t^e} \leq \theta_2^{MR} \tag{25'}$$

The debt service cover ratio (DSCR) must be equal to or higher than a given value. This ratio provides a snapshot of the ability to pay in the short term. It is calculated as the quotient of the free cash flow available to repay debt (FCF) divided by the amount of debt service (DS) such that

$$\frac{FCF_t}{DS_t} \geq \theta_3 \tag{26}$$

where

$$FCF_t^{AR} = (1-\tau)\left[\alpha H - (m - \beta)D_t^f - L_{t-1}(i + \gamma) - \frac{L}{n}\right] \tag{27}$$

$$\widetilde{FCF}_t^{MR} = (1-\tau)\left[\alpha H - (m' - \beta)D_t^e - L_{t-1}(i + \gamma b) - \frac{L}{n}\right] \tag{27'}$$

and

$$DS_t^{AR} = \left[L_{t-1}(i + \gamma) + \frac{L}{n}\right] \tag{28}$$

$$\widetilde{DS}_t^{MR} = \left[L_{t-1}(i + \gamma b) + \frac{L}{n}\right] \tag{28'}$$

where $\left(\frac{L}{n}\right)$ is the annual loan repayment.

The loan life coverage ratio (LLCR) must be equal to or above a given value. This ratio is a measure of the ability to pay over the life of a project finance loan. It is calculated as the present value of the FCF generated over the lifespan of the project divided by the outstanding debt in the project:

$$\frac{FCF^{PV}}{L} = \theta_4 \tag{29}$$

where

$$FCF^{PV}(AR) = \sum_{1}^{n} \frac{(1-\tau)}{(1+i')^{t}}\left[\alpha H + (m-\beta)D_t^f - L_{t-1}(i+\gamma) - \frac{L}{n}\right] \quad (30)$$

$$FCF^{PV}(MR) = \sum_{1}^{n} \frac{(1-\tau)}{(1+i')^{t}}\left[\alpha H + (m-\beta)D_t^g - L_{t-1}(i+\gamma b) - \frac{L}{n}\right] \quad (30')$$

Finally, the debt service reserve account (DSRA) must be equal to or higher than a given value. This covenant works as an additional security measure for lenders and is generally a deposited amount of money sufficient to cover the projected debt service obligations for a given number of months. These ratios are calculated by:

$$DSRA_t^{AR} = 12\left[\frac{\sum_1^n [FCF_t^{AR} - d_t^{AR}]}{DS_t^{AR}}\right] = \theta_5 \quad (31)$$

$$\widehat{DSRA}_t^{MR} = 12\left[\frac{\sum_1^n [\widehat{FCF}_t^{MR} - \widehat{d_t^{MR}}]}{\widehat{DS}_t^{MR}}\right] = \theta_5 \quad (31')$$

After the introduction of the described financial covenants, the choice of a PPP with market risk by the government is still driven by equation [14], but now the return on equity for the private investor is affected by these restrictions.

THEORETICAL AND NUMERICAL RESULTS

In the first part of this section we provide some theoretical results about the impact of various relevant parameters on the governmental decision to procure the healthcare services through one or another type of PPP. The government chooses the scheme with shared market risk when A $= \sum_1^n (1+i')^{-t}[\widehat{U}^G(MR)_t - U^G(AR)_t)] > 0$, as expressed in equation [18'], such that

$$A = \sum_1^n (1+i')^{-t}\left\{[(1-\tau)(m-\beta)-(u-\beta)](D_t^f - D_t^g) - (1-\tau)(m'-m)D_t^g - \tau\lambda L_{t-1}\left[\left(\sum_1^n (1+i')^{-j}\right)^{-1}\sum_1^n jL_{j-1}\left\{\frac{1+k\sigma}{\alpha H + (m'-\beta)D_j^g} - \frac{1}{\alpha H + (m-\beta)D_j^f}\right\}\right]\right\} \quad (32)$$

Denoting

$$\Delta = \frac{m' - m}{m} \quad (33)$$

$$\Omega = \frac{u - m}{m} \quad (34)$$

We can rewrite

$$A = -\sum_1^n (1+i')^{-t}\left\{[\tau(m-\beta) + m\Omega](D_t^f - D_t^g) + (1-\tau)\Delta m D_t^g + \tau\lambda L_{t-1}\left[\left(\sum_1^n (1+i')^{-j}\right)^{-1}\sum_1^n (1+i')^{-j} L_{j-1}\left\{\frac{1+k\sigma}{\alpha H + (m(1+\Delta)-\beta)D_j^g} - \frac{1}{\alpha H + (m-\beta)D_j^f}\right\}\right]\right\} \quad (35)$$

The sensitivity of A with respect to Δ is given by

$$\frac{\partial A}{\partial \Delta} = -\sum_1^n (1+i')^{-t}\left\{(1-\tau)mD_t^g - \tau\lambda L_{t-1}\left[\left(\sum_1^n (1+i')^{-j}\right)^{-1}\sum_1^n (1+i')^{-j}\frac{L_{j-1}(1+k\sigma)mD_j^g}{\left(\alpha H + (m(1+\Delta)-\beta)D_j^g\right)^2}\right]\right\} \quad (36)$$

Moreover, the sensitivity of A with respect to Ω is given by

$$\frac{\partial A}{\partial \Omega} = -m\sum_1^n (1+i')^{-t}\left(D_t^f - D_t^g\right) \quad (37)$$

In addition, the sensitivity of A with respect to μ and σ are given by

$$\frac{\partial A}{\partial \mu} = -\sum_1^n (1+i')^{-t}\left\{[\tau(m-\beta) + m\Omega](D_t^f - D_t^g) + (1-\tau)\Delta m D_t^g - \tau\lambda L_{t-1}\left[\left(\sum_1^n (1+i')^{-j}\right)^{-1}\sum_1^n (1+i')^{-j} L_{j-1}\left\{\frac{(1+k\sigma)(m(1+\Delta)-\beta)D_j^g}{\left(\alpha H + (m(1+\Delta)-\beta)D_j^g\right)^2} - \frac{(m-\beta)D_j^f}{\left(\alpha H + (m-\beta)D_j^f\right)^2}\right\}\right]\right\} \quad (38)$$

$$\frac{\partial A}{\partial \sigma}=\sigma\frac{\partial A}{\partial \mu}-\sum_{t}^{n}(1+i^{*})^{-t}t\left\{[\tau(m-\beta)+m\Omega](D_t^f-D_t^e)+(1-\tau)\Delta m D_t^e+\tau\lambda k L_{t-1}\left[\left(\sum_{t}^{n}(1+i^{*})^{-j}\right)^{-1}\sum_{t}^{n}\frac{(1+i^{*})^{-j}L_{j-1}}{\alpha H+(m(1+\Delta)-\beta)D_t^e}\right]\right\} \quad (39)$$

In the second part of this section we present an illustrative case example to demonstrate how assumptions about the credit spread determination affect the optimal allocation of risks. We use a number of assumptions to calibrate the model, such that the government is indifferent between the availability risk scheme and the market risk scheme. The main characteristic of the hypothetical hospital, are show in table 1. In Robinson & Luft, 1985 and Martín et al., 2012 can be found main economic parameters for a hospital.

Table 1: Assumptions about the project

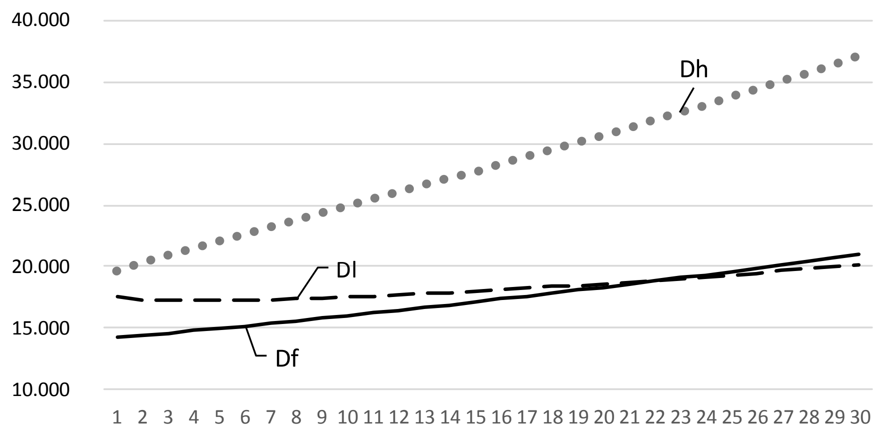
Variable	Concept	Amount	Unit
H	Construction cost of the hospital	150	€ million
n	Contract length	30	years
	Average investment per bed	0.5	€ million
	Hospital size (number of beds)	300	beds
	Average period of hospitalization	6.00	days
D_0	First year demand	18,250	patients
d	Demand discount for AR	23.34	%
D^f_0	Number of agreed patients	13,991	patients
α	Annual payment/H	4.0	%
β	Operating cost per patient	3,500	€
Ʊ	(u-m)/m	6.00	%
u	Social benefit per patient	4,468	€
m	Payment per patient in AR	4,215	€
Δ	(m -m')/m	2.5	%
m'	Payment per patient in MR	4,320	€
v (AR)	Return on equity in AR	8.1	%
v (MR)	Return on equity in MR	8.9	%

Main assumption about the market and the project finance are shown in table 2. Note that, according to the assumptions, in spite of the discount applied to the availability scheme in terms of number of patients to be treated, the lower part of the expected range in the market risk scheme falls below the path agreed in the availability scheme level. See figure 1.

Table 2 Assumptions about the market and the project finance loan

Variable	Concept	Amount	Unit
μ	Average growth of demand	1.1	%
σ	Volatility of demand growth	5.33	%
τ	Tax rate	25.0	%
i	Benchmark yield	3.00	%
Υ	Credit spread (AR)	2.66	%
Υ'	Credit spread (MR)	4.74	%
θ^1	Gearing ratio ≤	75	%
θ^2	Debt/Ebitda ≤	3.00	x
θ^3	Debt service coverage ratio (DSCR) ≥	1.15	x
θ^4	Loan life coverage ratio (LLCR) ≥	1.60	x
θ^5	Debt service reserve account (DSRA) ≥	9.00	months

Figure 1 Comparative evolution of the number of patients per year



For a better interpretation of the choice between a scheme with availability risk and a scheme with demand risk, we can rename the key parameter *A* (which is in absolute levels of Euros) into *B*. Now *B* is the sum of the present value of the difference between utilities obtained by the government in both schemes, in terms of the cost of building the hospital such that

$$B = \frac{\sum_1^n (1+i)^{-t}\left[\hat{U}^G(MR)_t - U^G(AR)_t\right]}{H} \quad [40]$$

The simulations we offer bellow have a two-fold objective. First, to determine the sensitivity of the risk allocation choice to differences in credit spreads that are required in availability and market risk schemes. Secondly, to test for the robustness of the results.

The main results of the numerical exercise are as follow:

- Each basis point in the difference of the relevant credit spreads (γ´- γ) implies 2.4 basis points in *B*. See table 3.

- For differences in credit spreads (γ´- γ) below 2.88% the market risk scheme would be preferred. See table 3.
- The consideration of alternative scenarios for the risk-free rate does not significantly affect the above results. See table 3.

Table 3: Sensitivity of the choice between availability risk and market risk to differences in credit spreads (various scenarios of risk-free rates)

i = 2.5%			i = 3.0%			i= 3.5%		
Y' - Y	(Ug^{AR}-UgMR)	Decision	Y' - Y	(Ug^{AR}-UgMR)	Decision	Y' - Y	(Ug^{AR}-UgMR)	Decision
1,43%	-3,44%	Market risk	1,46%	-3,06%	Market risk	1,50%	-2,72%	Market risk
1,78%	-2,66%		1,82%	-2,29%		1,86%	-1,97%	
2,12%	-1,88%		2,17%	-1,53%		2,22%	-1,22%	
2,47%	-1,09%		2,52%	-0,76%		2,58%	-0,47%	
2,81%	-0,31%		2,88%	0,00%	Indifference	2,94%	0,27%	Availability risk
3,16%	0,47%	Availability risk	3,23%	0,76%	Availability risk	3,30%	1,02%	
3,50%	1,26%		3,58%	1,53%		3,66%	1,77%	
3,85%	2,04%		3,93%	2,29%		4,02%	2,52%	
4,19%	2,82%		4,29%	3,06%		4,38%	3,26%	

Each percentage point of the excess of the payment per patient paid by the government in the market risk scheme relative to the payment in availability risk scheme (Δ) implies 8.6 percentage points in *B*. This ratio is not affected by the difference of the relevant credit spreads (γ´- γ). See table 4.

Table 4: Sensitivity of the choice between availability risk and market risk to differences in credit spreads (various payment scenarios)

	Excess of payment per patient in market risk scheme (Δ)						
γ' - γ	1,75%	2,00%	2,25%	2,50%	2,75%	3,00%	3,25%
1,46%	**-9,60%**	**-7,42%**	**-5,24%**	**-3,06%**	**-0,87%**	1,31%	3,50%
1,82%	**-8,82%**	**-6,64%**	**-4,47%**	**-2,29%**	**-0,12%**	2,06%	4,25%
2,17%	**-8,03%**	**-5,87%**	**-3,70%**	**-1,53%**	0,64%	2,81%	4,99%
2,52%	**-7,24%**	**-5,09%**	**-2,93%**	**-0,76%**	1,40%	3,56%	5,73%
2,88%	**-6,46%**	**-4,31%**	**-2,15%**	0,00%	2,16%	4,32%	6,48%
3,23%	**-5,67%**	**-3,53%**	**-1,38%**	0,76%	2,91%	5,07%	7,22%
3,58%	**-4,88%**	**-2,75%**	**-0,61%**	1,53%	3,67%	5,82%	7,96%
3,93%	**-4,10%**	**-1,97%**	0,16%	2,29%	4,43%	6,57%	8,71%
4,29%	**-3,31%**	**-1,19%**	0,93%	3,06%	5,19%	7,32%	9,45%

Each percentage point in the reduction concerning the number of treated patients in the availability risk scheme (where the demand is not affect by the volatility) implies 1.29 percentage points in *B*. This ratio is hardly affected by the difference of the relevant credit spreads (γ´- γ). See table 5.

Table 5: Sensitivity of the choice between availability risk and market risk to differences in credit spreads (various discount off the demand scenarios)

	D_o^f/D_o^e						
γ' - γ	25,30%	24,55%	23,80%	23,05%	22,30%	21,55%	20,80%
1,46%	**-5,59%**	**-4,62%**	**-3,66%**	**-2,69%**	**-1,72%**	**-0,76%**	0,21%
1,82%	**-4,83%**	**-3,86%**	**-2,89%**	**-1,93%**	**-0,96%**	0,01%	0,97%
2,17%	**-4,06%**	**-3,10%**	**-2,13%**	**-1,16%**	**-0,20%**	0,77%	1,74%
2,52%	**-3,30%**	**-2,33%**	**-1,36%**	**-0,40%**	0,57%	1,53%	2,50%
2,88%	**-2,53%**	**-1,57%**	**-0,60%**	0,37%	1,33%	2,30%	3,26%
3,23%	**-1,77%**	**-0,80%**	0,17%	1,13%	2,10%	3,06%	4,03%
3,58%	**-1,00%**	**-0,04%**	0,93%	1,90%	2,86%	3,83%	4,79%
3,93%	**-0,24%**	0,73%	1,69%	2,66%	3,63%	4,59%	5,56%
4,29%	0,53%	1,49%	2,46%	3,43%	4,39%	5,36%	6,32%

Each percentage point in the demand volatility implies between 0.6 and 1.4 percentage points in *B*. This ratio is affected by the difference of the relevant credit spreads (γ´- γ), such that an increase of each basis point amplifies the impact by 29 basis points. See table 6.

Table 6: Sensitivity of the choice between availability risk and market risk to differences in credit spreads (various volatility of demand scenarios)

	σ						
γ' - γ	4,00%	5,00%	6,00%	7,00%	8,00%	9,00%	10,00%
1,46%	**-4,86%**	**-4,24%**	**-3,64%**	**-3,06%**	**-2,49%**	**-1,95%**	**-1,42%**
1,82%	**-4,42%**	**-3,69%**	**-2,98%**	**-2,29%**	**-1,62%**	**-0,97%**	-0,35%
2,17%	**-3,98%**	**-3,14%**	**-2,33%**	**-1,53%**	**-0,75%**	0,00%	0,73%
2,52%	**-3,53%**	**-2,59%**	**-1,67%**	**-0,76%**	0,12%	0,97%	1,80%
2,88%	**-3,09%**	**-2,04%**	**-1,01%**	0,00%	0,99%	1,95%	2,88%
3,23%	**-2,65%**	**-1,49%**	**-0,35%**	0,76%	1,86%	2,92%	3,95%
3,58%	**-2,21%**	**-0,94%**	0,31%	1,53%	2,72%	3,89%	5,02%
3,93%	**-1,77%**	**-0,39%**	0,96%	2,29%	3,59%	4,86%	6,10%
4,29%	-1,33%	0,16%	1,62%	3,06%	4,46%	5,84%	7,17%

CONCLUSIONS

This paper analyzes the optimal risk allocation in a healthcare project consisting of the construction of a health facility and the going provision of its clinical and non-clinical services under a PPP scheme. We use a model in which the government has the option to transfer availability risk or demand risk to a private partner. When market risk is transferred, the possible negative impact on the concessionaire's profits implies that lenders require higher credit spreads. The paper finds, first that credit spreads of project finance loans significantly affect the optimal decision on the risk allocation in health PPP; and secondly, that these results appear to be robust to changes in key parameters of the model.

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