Government Financial Support Programmes in Project Finance Investments *

Van Son Lai and Issouf Soumaré †

August 27, 2008

*We acknowledge financial support from the Institut de Finance Mathématique of Montreal, the Fonds Québecois de la Recherche sur la Société et la Culture (FQRSC), the Social Sciences and Humanities Research Council of Canada (SSHRC) and the Fonds de soutien à la recherche (SAR) of the Faculty of Business Administration at Laval University. All errors are the authors' sole responsibility.

†Laval University, Faculty of Business Administration, Department of Finance and Insurance, Quebec (Quebec), Canada G1V 0A6; Tel: 1-418-656-2131; Fax: 1-418-656-2624; Email: vanson.lai@fsa.ulaval.ca, issouf.soumare@fsa.ulaval.ca.

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Abstract

This paper studies the capital budgeting decision of project financed investments with the financial support of the government in the form of either (i) loan insurance and/or (ii) direct investment. The government direct investment can be in the form of either an investment subsidy or a joint equity participation in the form of a public-private partnership. The loan insurance programme seems to be more effective in reducing the borrowing cost compared to the direct investment. However, if there is scarcity of external debt financing, the direct investment subsidy will be a good alternative. When coupled with joint equity participation, the direct investment provides additional wealth to the government, which makes this form of support programme very attractive as frequently observed nowadays.

Keywords: Project finance, government financial support, loan insurance, investment subsidy, public-private partnership (PPP).
JEL Classification: G11, G14, G31, G38.

1 Introduction

The last decades have seen an unprecedent increase in the implementation of projects worldwide financed mainly through corporate financing known as project finance. Project-financed investments have grown at a compound rate of almost 20 percent (Esty, 2004)[1]. Project finance is an arrangement where one or more sponsors (shareholders) create a new project company with a view to repaying the lender largely out of the project's future cash flow. Under this form of financing, creditors usually rely on the project cash flows for reimbursement of their loan. In that respect, the project is set as a special purpose vehicle (SPV).

The literature raises many advantages associated with the use of project finance companies to structure investment projects such as the mitigation of the underinvestment problem, the reduction of the agency costs of free cash flows, the reduction of the information asymmetry and the signal costs, the efficiency of structuring the debt, the effective corporate organization and management compensation and better corporate governance (e.g. Finnerty (2007), Gatti (2008) and Subramanian, Tung and Wang (2007)). Since project-financed investments involve huge amounts of financing and are highly levered (e.g., Brealey, Cooper and Habib (1996), Esty (2003, 2004), Kleimeier and Megginson (2001) and Shah and Thakor (1987)), projects' sponsors usually resort to government supports to improve their credit rating and debt capacity, therefore have access to funds at lower costs.

In this paper, we explore two governmental support programmes, loan insurance and direct investment, in the financing and investment decisions of project financed companies. Government loan insurance consists of a promise from the government or public-related institutions like export credit agencies (ECA) or multilateral organizations to make good on payments to creditors when the project company defaults.[2] The

[1]In 2004, project finance fueled a total of \$234 billion in capital spending, up from \$172 billion in 2003. Recent examples include the Eurotunnel between France and the United Kingdom, the Dabhol power project in India, and the Chad-Cameroon pipeline in Central Africa.

[2]Export credit agencies (e.g., US Ex-Im Bank, UK Export Credits Guarantee Department (ECGD), Export Development Canada (EDC), COFACE-France) and multilateral development banks (e.g., African Development Bank, Asian Development Bank, Inter-American Development Bank, World Bank MIGA) are some of the main providers of financial guarantees, especially to back large-scale projects financing (see for example Dailami and Leipziger (1998), Ehrhardt and Irwin (2004), Garcia-Alonso,

government direct investment consists of the direct participation by the government to the project investment by fund injection. The fund infused by the government reduces the project's external financing need, which in turn reduces its borrowing cost. This governmental participation can either be in the form of an investment subsidy or a joint equity participation in the project. The later case can be assimilated to a public-private partnership (PPP)[3] where the supporting government becomes an equity holder in the project and shares the residual cash flows of the project with the project sponsors.

The two governmental support programmes described above (loan insurance and direct investment) are incentive devices to help the project get implemented. However, since the government is not a charitable organization, by supporting the project implementation, the government expects to get some (social) benefit. In our economic setup, the government gains from the project success by receiving tax revenues and share of the residual profit (in the case of a joint equity participation). Therefore, this paper extends previous studies on the role of government loan insurance in the capital budgeting decision of project companies (e.g., Chaney and Thakor (1985), Lai and Soumaré (2005)). In many project financing, the entrepreneurs are well informed than the host government. This is referred in the literature as the plumb problem (e.g. Chen (2005)) as opposed to the lemons problem. We account for this reality by introducing an informational asymmetry between the government and the other stakeholders. We assume that the government knows the distribution of the project risk but not its exact value, while lenders and project sponsors are perfectly informed about the project risk.

As expected, all the governmental support programmes enhance the debt capacity and improve the borrowing cost of the project company. However, loan insurance seems to be more effective in reducing the borrowing cost when compare to the direct investment programme. However, when equity participation is allowed for the government, the government benefits enormously from the project when it participates in the form of a direct investment and this justifies the popularity of PPPs.

Levine and Morga (2004)).

[3]Public-private partnerships (PPPs) can take different forms such as build-operate-transfer (BOT), build-transfer-operate (BTO), build-own-operate (BOO), buy-build-operate (BBO), design-build-operate (DBO), among others (e.g., Esty (2004), Finnerty (2007), Yescombe (2007)). Since the focus is not the study per se of the different forms of PPP, we leave these interesting issues for future research.

The remainder of the paper is structured as follows. Section 2 presents the model. In this section, the players (shareholders, government and creditors) utilities are derived. We also introduce the support programmes from the government and discuss their potential impacts on the stakeholders. Section 3 provides a general discussion of the findings through several numerical experiments. Section 4 concludes. The proofs are presented in the appendix.

2 The model

We consider a project implemented through a special purpose vehicle (SPV) as a stand-alone firm, meaning that the project is an independent and separate entity. The project is owned by sponsors and its cash flows are used to pay the stakeholders of the project. In this financing framework, often referred to as non- or limited recourse project financing, creditors depend on the performance of the project itself for repayment rather than the credit of the sponsors. The only commitment from the project sponsors is their capital contribution.

The project invests an initial amount I and yields at time t assets A_t characterized by the following risk-neutral[4] stochastic process

$$\frac{dA_t}{A_t} = (r_f + g - \delta)dt + \sigma dZ_{A_t}, \tag{1}$$

where r_f is the risk-free interest rate in the economy assumed to be non stochastic, g is the externally financed project asset growth, δ is the assets payout rate, σ is the volatility of the project assets, and Z_{A_t} is the Wiener process under the risk neutral probability. This representation for the project assets should be interpreted as the present value of all expected future cash flows (e.g., Lucas and McDonald (2006)). One of the concerns from the practice is the uncertainty surrounding the valuation of future cash flows. We are aware of these issues, but since it is not the main focus of our study, we assume the present value of the total expected cash flows to follow a geometric Brownian motion process with risk level σ chosen or known by the project manager.

[4]See Harrison and Kreps (1979) and Merton (1974) for the use of contingent claims analysis (CCA) in pricing assets.

We assume a simple capital structure for the project, consisting of single debt and equity contracts. There are no dividend payments nor intermediate payments on the debt before it matures. The maturity of the project coincides with the maturity of its debt, i.e. T. We assume the existence of corporate taxes. We also assume the intervention of a public authority as it is the case in most project financing (see Kleimeier and Megginson (2001), Esty (2003, 2004), Finnerty (2007) for extensive reviews on project finance).

The government may intervene in several forms, here we will study two forms of government interventions: (i) loan insurance and/or (ii) direct investment. The loan insurance support consists of insuring the debt of the project. We assume that under the loan insurance agreement, the government agrees to cover the project debt up to the haircut level H. The direct investment support, instead, consists of contributing directly to the initial investment of the project. Under this support programme, we assume the government contributes the amount K in the project investment. The government direct investment can be either an investment subsidy or an equity participation. In the later case, the government and the project sponsors share the project residual cash flows.

Therefore, the project is financed with equity (owners contributed capital), debt (outside financing) and the government contribution if any. We denote by C the total capital contribution from the project sponsors, and D the total amount borrowed, which yields a total investment $I = C + K + D$. Note that K will be equal to zero under the loan insurance programme only.

We assume imperfect information, in the sense that the government knows less about the project than the sponsors, this is known in the literature as the plumb problem, e.g. Chen (2005). As in Mason (1998), we model the information asymmetry using the following stochastic variance process for the project assets:

$$d\sigma_t^2 = \psi\sigma_t^2 dt + \xi\sigma_t^2 dZ_{\sigma_t}, \tag{2}$$

where ψ is the drift of the process and ξ captures the degree of information asymmetry. For small values of ξ, the distribution has a small variance, therefore less informational asymmetry. Hull and White (1987) derive closed-form solutions for call and put options under stochastic volatility under the assumption that $\psi = 0$, ξ constant and $\text{corr}(Z_{A_t}, Z_{\sigma_t}) = 0$. The steps of their derivation are provided in the appendix.

At the maturity of the debt, if the project is successful, the after tax net profit from the project, P, is the total current cash flows net of the corporate taxes and the total payments on the debt:

$$P = E\Big[e^{-r_f T}\max\big(A_T - (1+R)D - \tau_c \max(A_T - RD - \lambda I, 0), 0\big)\Big], \tag{3}$$

where $E[.]$ is the expectation under the risk neutral probability, λ is the depreciation portion of the initial investment, and R is the financing cost of the debt. The first term $A_T - (1+R)D$ represents the net profit before taxes, the second term $\tau_c \max(A_T - RD - \lambda I, 0)$ represents the adjustment for taxes with τ_c the domestic corporate tax rate. The total tax paid is equivalent to a call option held by the government with underlying asset the assets value of the project and exercise price the total interest payment on the debt plus the capital depreciation. The project benefits from the tax shields on the interests paid on its debt and also from the depreciation of the initial investment. It is well known that loan insurance lowers the borrowing cost R of the project. Since the project benefits from tax shields on the interests paid on its debt, RD, the impact of loan insurance on the total tax shields will depend on the magnitude of changes of R. Assuming σ constant, we can use the Black-Scholes-Merton (1973) option pricing formula to find the explicit expression of equation (3) as follows

$$\begin{aligned} P &= \big[A_0 e^{(g-\delta)T} N(x) - e^{-r_f T}(1+R)DN(x - \sigma\sqrt{T})\big] \times 1_{\{D \leq \lambda I\}} \\ &\quad -\tau_c\big[A_0 e^{(g-\delta)T} N(y) - e^{-r_f T}(RD + \lambda I)N(y - \sigma\sqrt{T})\big] \times 1_{\{D \leq \lambda I\}}, \end{aligned} \tag{4}$$

where

$$x = \frac{\ln(A_0/(1+R)D) + (r_f + g - \delta + \sigma^2/2)T}{\sigma\sqrt{T}}$$

and

$$y = \frac{\ln(A_0/(RD + \lambda I)) + (r_f + g - \delta + \sigma^2/2)T}{\sigma\sqrt{T}}.$$

2.1 The creditors' participation constraint

The participation constraint of debtholders is obtained when the amount borrowed is lower or equal to the present value of the future payments to lenders. Similar to Merton

(1974), the value of a non-guaranteed risky debt is equal to the value of the risk-free debt minus a put option. Thus, in the presence of loan insurance, the maximum debt amount is equal to the value of the non-insured risky debt plus the value of the guarantee:

$$D = e^{-r_f T}(1+R)D - E\left[e^{-r_f T}\max((1+R)D - A_T, 0)\right] + G. \tag{5}$$

The first two terms of expression (5) represent the value of the risky debt without guarantee. The third term, G, is equal to the value of the guarantee. In presence of loan insurance, when the guarantee is large enough, the debt becomes risk-free, i.e. $1+R = e^{r_f T}$. Assuming σ constant, the expression of D becomes

$$D = e^{-r_f T}(1+R)DN(x - \sigma\sqrt{T}) + A_0 e^{(g-\delta)T}N(-x) + G, \tag{6}$$

where

$$x = \frac{\ln(A_0/(1+R)D) + (r_f + g - \delta + \sigma^2/2)T}{\sigma\sqrt{T}}.$$

In equilibrium, the participation constraint of debtholders is

$$D = I - C - K. \tag{7}$$

Converting the borrowing rate, R, into a continuous rate, r, as follows, $1+R = e^{rT}$, and using expression (6) and the equilibrium condition (7), we obtain the following expression for the credit spread:

$$r - r_f = \frac{1}{T}\ln\left(\frac{1 - N(-x)A_0 e^{(g-\delta)T}/(I-C-K) - G/(I-C-K)}{N(x-\sigma\sqrt{T})}\right). \tag{8}$$

It becomes apparent from this expression that, all else being equal, the credit spread $r - r_f$ decreases when K and/or G increase. The government support programmes alleviate the debt burden.

2.2 The government participation constraint

As we have mentioned above, the government supports the project implementation by providing loan insurance and/or direct investment. To obtain the cost of the loan insurance for the government, we use the option pricing approach of Merton (1977), who establishes a parallel between a financial guarantee and a put option written by the guarantor and granted to the bondholder. Since we consider a zero coupon bond with bankruptcy occurring at the maturity of the debt, the cost of the guarantee to the government is equal to the present value of the future expected claim payments by the government when default occurs:[5]

$$G = E\left[e^{-r_f T}\max(\min(H,(1+R)D) - A_T, 0)\right]. \tag{9}$$

Assuming σ constant, this expression yields

$$G = e^{-r_f T}\min(H,(1+R)D)N(-z+\sigma\sqrt{T}) - A_0 e^{(g-\delta)T}N(-z), \tag{10}$$

where

$$z = \frac{\ln(A_0/\min(H,(1+R)D)) + (r_f + g - \delta + \sigma^2/2)T}{\sigma\sqrt{T}}.$$

Note that, the project does not pay explicitly a fee to the government to insure its loan. However, if the project is successful, the government gets tax revenues which compensate for the guarantee cost. The government by intervening in the project expects to gain tax revenues and shares of the project profit (under the direct investment with joint equity participation). We assume that under the direct investment support with joint equity participation, the government is granted α portion of the project shares. Therefore, the net gain to the local government is

$$W = \tau_c E\left[e^{-r_f T}\max(A_T - RD - \lambda I, 0)\right] + \alpha P - (G+K), \tag{11}$$

where τ_c is the corporate tax rate, G is the cost of the loan insurance, K is the amount of the government direct investment, and α is the portion of the project shares granted to the government under the equity participation programme. Here we assume $\alpha = \frac{K}{I}$. However, this allocation rule will be negotiated between the government and the sponsors. Under the government investment subsidy programme, $\alpha = 0$ since no shares are granted

[5]Note that, instead of having a haircut amount, the government could offer a guarantee on proportion of the face value of the loan, i.e., the government covers up to a given percentage ω of the debt face value: $\omega(1+R)D$. In that case, the cost of the guarantee to the government is $G = E\left[e^{-r_f T}\max(\omega(1+R)D - A_T, 0)\right]$. Without loss of generality, this formulation will give similar qualitative implications as the ones obtained with haircut guarantee contract.

to the government. The special case of loan insurance support alone is obtained with $K = 0$ and that of the direct investment alone with $H = 0$ implying $G = 0$.

By guaranteeing the debt, the government expects to gain from the project. In the government net gain equation (11), higher interest rate, R, or larger amount of debt, D, implies less tax payment. However, with loan insurance, the interest rate decreases, therefore, all else being equal, the total interests paid on the debt, RD, decreases. The government by guaranteeing the debt insures itself more future tax revenues. Investing directly in the project reduces the external fund need, therefore less tax shields from interest payments, thus more tax revenues for the government.

Since both the loan insurance and the direct investment support programmes are costly for the government, the participation constraint of the government is obtained when its net gain is positive, i.e. $W \geq 0$. Ideally, the guarantee haircut$H$ and/or the direct investment amount K will be chosen by the government so as to maximize its net-wealth W from the project. However, this will not always happen since the government will make compromises in order for the project to go ahead. Indeed, if the sponsors are not gaining from the project, they will abandon it even if it is better for the government. The government support alleviates the external financing constraint of the project, and thus render it financially viable from the viewpoint of the sponsors. In either cases, the capital contribution from the government alleviates the external financing need of the project. All else being equal, for given investment requirement, the total debt amount D is lower under government direct investment than under loan insurance. Note that equation (11) is a simplified version of the social objective of the government. Indeed, there are intangible social benefits taken into account by the public authority. We assume the tax rate τ_c to proxy for all these features.

Later, we compare the impacts of the two governmental support programmes (loan insurance versus direct investment) and evaluate their effects on the players utilities, especially sponsors and government.

2.3 The value to the project sponsors

In the direct investment with joint equity participation (or PPP), the government receives portion of the net-profit of the project, αP, and the remaining portion goes to the project sponsors. Therefore, the net-wealth to the sponsors is

$$S = (1 - \alpha)P - C. \tag{12}$$

This expression states that the net-wealth to the project sponsors is equal to their share of the residual profit minus their initial capital investment in the project.

On the one hand, the value of the guarantee haircut H and/or the investment amount K are obtained from the government participation constraint. The government chooses H and/or K in order to generate net positive wealth. On the other hand, the borrowing cost R (or rT in continuous time) is obtained from the participation constraint of debtholders. Therefore, the project's manager makes its financing and investment decisions under the participation constraints of both debtholders and government, i.e. $\max S$ under the constraints $W \geq 0$ and $D = I - C - K$.

3 General discussion

3.1 Parameters estimation

The parameters values are set based on empirical evidence on the characteristics of project finance (e.g., Kleimeier and Megginson (2001), Esty (2003, 2004), Finnerty (2007)). The baseline parameters values are: $r_f = 5\%$ for the risk-free interest rate, $\delta = 0\%$ for the payout rate, $\lambda = 0.95$ for the depreciation code allowance, and $\tau_c = 30\%$ for the corporate tax rate. The project debt maturity is $T = 8$ years, which corresponds to the observed project finance average debt maturity of 8 to 12 years. We assume a constant return to scale production technology for the total assets value of the project $A_t = p_t I^\gamma$, where $\gamma = 1.00$ and p_t is a random variable capturing the stochastic nature of the assets with initial value $p_0 = 1.5$. The externally financed project asset growth rate is $g = 0$. The annualized assets volatility is $\sigma = 50\%$. For the stochastic volatility, we use $\psi = 0$ and $\xi = 0.10$ as baseline values. The baseline parameters values are summarized in Table 1.

Below, we run our numerical experiments and analyze the results. We also conduct several sensitivity analyzes with respect to our parameters values.

3.2 Government and sponsors' wealths sensitivity to H and K

In Panel a of Figure 1, we plot the cost of the loan insurance to the government (left) and the borrowing interest rate (right) as a function of H (guarantee haircut) and K (government direct investment amount). Not surprising, the cost of the loan insurance G increases with the level of H and decreases with K. Indeed, since $D = I - C - K$, when K increases, the demand for debt financing decreases, therefore less need for guarantee. The borrowing interest rate obtained from the participation constraint of lenders decreases faster with H than with K. However, to make a fair comparison of the two governmental support programmes, we need to use the same cost base, i.e. $G = K$, we explore that in more details in the next section.

In Panels b and c of Figure 1, we plot the government and sponsors wealths obtained from the project as a function of H and K. In Panel b, the direct investment provided by the government is done in the form of an investment subsidy ($\alpha = 0$), while in Panel c, it is an equity participation ($\alpha = K/I$). In absence of equity participation, we observe from Panel b that the government wealth W decreases with both H and K. The reason for this decreasing trend is the high cost associated with these support programmes. For the sponsors, we observe instead the inverse trend, i.e. their net-wealth S increases with both H and K.

However, when the government direct investment is done in the form of a joint equity participation instead of an investment subsidy, it receives $\alpha = \frac{K}{I}$ portion of the project profit. In that context, as shown by Panel c, the government wealth is still decreasing with the guarantee haircut level H and can even become negative since loan insurance is costly. But, for the investment level, the trend is ambiguous and depend on the level of H. For example, for small values of H, W displays a U shape relationship with respect to K, where high values of W are obtained with small and large values of K and low values of W are obtained with intermediate investment level K. When H becomes large, W is an increasing function of K since the government share of the project profit increases, and that gain outweighs the cost associated with the support programme. For the sponsors' wealth, with small values of H, we observe an inverse U shape relationship with respect to K, which implies the existence of an optimum value of K. But for big values of H, the sponsors' wealth S increases with H, but decreases with K as more shares of the profit go to the government.

In sum, the graphs show that with investment subsidy, the sponsors' wealth is an increasing function of both H and K. With the joint equity participation, however, the sponsors reach their optimal wealth when H is very high and K very low, and that because the government direct investment transfers wealth to the government. For low pledged guarantee amount, there is an optimal level of K from the viewpoint of the project sponsors if the government is to share the profit with them.

3.3 Comparison of the government support programmes

We compare the two governmental support programmes (loan insurance versus direct investment) using the same cost comparison base. Under the loan insurance programme, for given level of H, we compute the corresponding cost G and generate the borrowing interest rate, government and sponsors' wealths. Under the direct investment programmes (subsidy or equity participation), we assume the same cost for the government as in the loan insurance, therefore we set $K = G$.

In Table 2, we report the results with the government support programmes taken separately. Panel a reports the results when the government supports the project by loan insurance alone. To obtain the results, we vary H from 0 to 140 and calculate the other quantities. Panel b reports the results when the government supports the project by direct investment. For each column, we set K equal to the corresponding G in order to have the same cost comparison base. Since we consider two forms of direct investments, we report the government and sponsors wealths under the two forms of governmental support (investment subsidy and investment with equity participation). The same results are plotted in Figure 2, where we plot the debt value, the borrowing interest rate, the government and sponsors' wealths as a function of H (for the loan insurance) or K (for the direct investment).

We observe that loan insurance is more effective in reducing the cost of borrowing of the SPV. Thus, if there is credit rationing with a cap $\bar{R}$ on the borrowing interest rate, i.e. lenders aren't willing to lend beyond $\bar{R}$, loan insurance is less costly for the government to overcome this credit rationing constraint than the direct investment. For example, to maintain the borrowing cost below the interest rate cap of $\bar{R} = 15\%$, it takes a maximum guarantee haircut of $H = 55$ or a maximum guarantee cost of $G = 7.60$ with the loan insurance programme. The same level of interest rate is maintain with the direct investment support with a maximum investment amount of $K = 13.04$, almost the double of the cost of the guarantee. To maintain a rate below the cap of $\bar{R} = 10\%$, with loan insurance it takes a maximum level of guarantee haircut equals to $H = 100$ which corresponds to a today maximum guarantee cost of $G = 22.05$. The same level of interest rate will be obtained under the direct investment with an investment cost of more than 35.77. Therefore, to support the project obtain debt financing at some desirable interest rate level, loan insurance is more cost effective for the government than direct investment.

We also observe that the direct investment in the form of a subsidy is the preferred mode of governmental intervention programme from the viewpoint of the sponsors, but generates the lowest wealth level for the government among the support programmes. The direct investment with joint equity participation is worst in terms of wealth for the sponsors. For the government instead, the direct investment with joint equity participation gives the highest wealth followed by the loan insurance programme. The intuitions are as follows. Indeed, the direct investment subsidy lowers the financing need of the project, but the interest rate obtained from the debtholders equilibrium remains relatively high. And since the project does not pay explicitly the cost for this government intervention, the project will be able to deduct more tax shields, which increases the net wealth to the sponsors. Loan insurance, however, decreases considerably the interest payments on the loan, therefore less tax shields and the project pays more taxes to the government. We compute the debt face values from the results of the Table and found that they are the same under two equivalent programmes (same cost to the government), which means that, on the one hand, with subsidy the interest rate is much higher than with loan insurance, and on the other hand, the amount borrowed under the loan insurance programme is much higher than the one under the direct investments. Thus, the impact on the government and sponsors wealths under either the loan insurance or the direct investment subsidy programmes, comes from the magnitude of the collected tax revenues.

Under very strict credit rationing, i.e. $\bar{R}$ low, the government may prefer loan insurance and even refuse to engage in direct investment in the form of subsidy unless it consists of joint equity participation. Indeed, maintaining for example the borrowing rate under 13%, the government net-wealth is negative under the direct investment subsidy support since the tax revenue gain doesn't compensate for the cost of the investment support.

3.4 Sensitivity to the degree of informational asymmetry

The degree of the information asymmetry has an impact on the government decision as shown by the graphs of Figure 3 especially the decisions to provide large haircuts H under the loan insurance support programme or invest large amounts K under the direct investment support programmes. The degree of informational asymmetry is measured by ξ with more asymmetry of information when ξ is high.

With loan insurance, from the first graph of Figure 3, we observe two areas with respect to the level of H. The first area corresponds to small values of guarantee haircut (i.e. $H \leq 60$), where the government overestimates its wealth when it faces higher degree of information asymmetry. While for larger values of guarantee haircut (i.e. $H \geq 60$), the government underestimates its gain from the project. For example, when $\xi = 40\%$, the guarantee haircut H will not exceed 100 from the viewpoint of the government, while with $\xi = 10\%$, the maximum value of H will be around 110 to maintain the government wealth positive, i.e. $W \geq 0$. Thus, the degree of uncertainty faced by the government will translate into the government under/over-estimation of its net-wealth from the project, thereby impacting on the level of support it will be willing to provide.

The last two graphs of Figure 3 are for direct investment: subsidy and joint equity participation. The second graph plots the results for the investment subsidy. As we observe in the graph, the impact of the information asymmetry seems to be less perceptible. It takes large values of government investment subsidy K to observe the impact of the degree of the information asymmetry on the government assessment of its own wealth. When K is large enough, we observe a relatively slight overestimation by the government of its net-wealth from the project. Finally, when the government invests in the project with joint equity participation, the results plotted in the third graph exhibits two interesting regions with respect to the level of investment K. Indeed, for small values of K (less than 25 in our experiment), the government tends to underestimate its net wealth as it faces more information asymmetry. While, for large values of K (more than 25), the government tends to overestimate its projected wealth from the project. Therefore, in the presence of a higher degree of uncertainty about the project risk, the government will be willing to provide more capital support especially if it can capture more shares of the project. We can assimilate that to an option, where its value increases for its holder with the degree of uncertainty, even though it is not the case. The government wealth curve is shifted toward the left with more information asymmetry, so from the viewpoint of the government, it takes less capital to reach a desired wealth level compared to the case with less degree of information asymmetry.

4 Conclusion

This paper studies the role of the government financial support in the financing and investment decisions of a pure private project finance or a pubic-private partnership (PPP). We consider two general forms of governmental financial support programmes: loan insurance and direct investment. The direct investment programme can either be an investment subsidy or an investment with joint equity participation. In the later case, the government is granted shares of the project profits proportional to its contribution to the project's total investment. This form of government collaboration with private entrepreneurs is well known as public-private partnership. All else being equal, loan insurance is more effective in reducing the borrowing cost of the project and provides more tax revenues to the government. However, the direct investment with joint equity participation provides more positive gains to the government as it shares the project profits with other shareholders.

Appendix

Appendix 1: Hull and White (1987) derivation of option prices under stochastic volatility

We assume the following processes for A_t and σ_t

$$\begin{aligned} dA_t &= (r+g-\delta)A_t dt + \sigma_t A_t dZ_{At}, \\ d\sigma_t^2 &= \psi\sigma_t^2 dt + \xi\sigma_t^2 dZ_{\sigma t}, \end{aligned}$$

with $\operatorname{corr}(Z_{At}, Z_{\sigma t}) = 0$, $\psi = 0$ and r, g, δ and ξ are constant parameters. Under these assumptions, Hull and White (1987) propose a closed-form solution for call and put options with underlying asset A under a stochastic volatility regime. The value of the option is the Black-Scholes formula augmented by the Taylor series expansion containing the stochastic volatility diffusion parameters. To alleviate the notation, lets denote by $V_t = \sigma_t^2$. Thus, the process of the volatility becomes:

$$dV_t = \xi V_t dZ_{\sigma t}.$$

Recall, under constant variance $\bar{V} = \frac{1}{T}\int_0^T \sigma_t^2 dt$, the Black-Scholes pricing formula for call and put options with underlying asset A and exercise price X is

$$\begin{aligned} \text{Call}(A, X, \bar{V}) &= e^{(g-\delta)T} AN(d_1) - e^{-rT} XN(d_2), \\ \text{Put}(A, X, \bar{V}) &= e^{-rT} XN(-d_2) - e^{(g-\delta)T} AN(-d_1), \end{aligned}$$

with $d_1 = \frac{\ln(A/X)+(r+g-\delta+\bar{V}/2)T}{\sqrt{\bar{V}T}}$ and $d_2 = d_1 - \sqrt{\bar{V}T}$. Under the above assumptions for the stochastic processes parameters, Hull and White (1987) shows that the value of a call option is

$$\widetilde{\text{Call}}(A, X, \sigma^2) = E\big[\text{Call}(A, X, \bar{V})\big] = \int \text{Call}(A, X, \bar{V}) f(\bar{V}/\sigma^2) d\bar{V}.$$

Below, we follow the Hull and White (1987) approach to obtain the closed form. Indeed, with $\psi = 0$, we can compute the first three moments of $\bar{V}$ as follows:

$$\begin{aligned} E[\bar{V}] &= V_0 = \sigma^2, \\ E[\bar{V}^2] &= \frac{2(e^{\xi^2 T} - \xi^2 T - 1)}{\xi^4 T^2} V_0^2, \\ E[\bar{V}^3] &= \frac{e^{3\xi^2 T} - 9e^{\xi^2 T} + 6\xi^2 T + 8}{3\xi^6 T^3} V_0^3. \end{aligned}$$

This gives us the second and third central moments as follows

$$
\begin{aligned}
E[(\bar{V}-E[\bar{V}])^2] &= \frac{2(e^{\xi^2 T}-\xi^2 T-1)-\xi^4 T^2}{\xi^4 T^2} V_0^2, \\
E[(\bar{V}-E[\bar{V}])^3] &= \frac{e^{3\xi^2 T}-(9+18\xi^2 T)e^{\xi^2 T}+(8+24\xi^2 T+18\xi^4 T^2+6\xi^6 T^3)}{3\xi^6 T^3} V_0^3.
\end{aligned}
$$

The Taylor series expansion of $\text{Call}(A, X, \bar{V})$ with respect to $E[\bar{V}]$ is

$$
\begin{aligned}
\text{Call}(A, X, \bar{V}) &= \text{Call}(A, X, E[\bar{V}]) + \left.\frac{\partial \text{Call}}{\partial \bar{V}}\right|_{\bar{V}=E[\bar{V}]} \times (\bar{V}-E[\bar{V}]) \\
&+ \frac{1}{2}\left.\frac{\partial^2 \text{Call}}{\partial \bar{V}^2}\right|_{\bar{V}=E[\bar{V}]} \times (\bar{V}-E[\bar{V}])^2 \\
&+ \frac{1}{6}\left.\frac{\partial^3 \text{Call}}{\partial \bar{V}^3}\right|_{\bar{V}=E[\bar{V}]} \times (\bar{V}-E[\bar{V}])^3 + \ldots
\end{aligned}
$$

Hull and White (1987) claim that this series converges very quickly for sufficiently small $\xi^2 T$. Using the following derivatives of the call

$$
\begin{aligned}
\frac{\partial \text{Call}}{\partial \bar{V}} &= A e^{(g-\delta)T} N'(d_1) \frac{1}{2\sqrt{VT}}, \\
\frac{\partial^2 \text{Call}}{\partial \bar{V}^2} &= A e^{(g-\delta)T} N'(d_1) \frac{(d_1 d_2 - 1)}{4V^{3/2}} \sqrt{T}, \\
\frac{\partial^3 \text{Call}}{\partial \bar{V}^3} &= A e^{(g-\delta)T} N'(d_1) \frac{(d_1 d_2 - 1)(d_1 d_2 - 3) - (d_1^2 + d_2^2)}{8V^{5/2}} \sqrt{T},
\end{aligned}
$$

and taking the expectation, the Taylor expansion yields the following closed-form for the call option:

$$
\begin{aligned}
\widetilde{\text{Call}}(A, X, \sigma^2) &= \text{Call}(A, X, \sigma^2) \\
&+ A e^{(g-\delta)T} N'(d_1) \frac{(d_1 d_2 - 1)}{8} \left(\frac{2(e^{\xi^2 T}-\xi^2 T-1)}{\xi^4 T^2} - 1\right)\sigma\sqrt{T} \\
&+ A e^{(g-\delta)T} N'(d_1) \frac{(d_1 d_2 - 1)(d_1 d_2 - 3) - (d_1^2 + d_2^2)}{48} \\
&\times \frac{e^{3\xi^2 T}-(9+18\xi^2 T)e^{\xi^2 T}+(8+24\xi^2 T+18\xi^4 T^2+6\xi^6 T^3)}{3\xi^6 T^3} \sigma\sqrt{T} + \ldots
\end{aligned}
$$

Analogously, for the put option, we have

$$
\begin{aligned}
\widetilde{\text{Put}}(A, X, \sigma^2) &= \text{Put}(A, X, \sigma^2) \\
&+ A e^{(g-\delta)T} N'(d_1) \frac{(d_1 d_2 - 1)}{8} \left(\frac{2(e^{\xi^2 T}-\xi^2 T-1)}{\xi^4 T^2} - 1\right)\sigma\sqrt{T} \\
&+ A e^{(g-\delta)T} N'(d_1) \frac{(d_1 d_2 - 1)(d_1 d_2 - 3) - (d_1^2 + d_2^2)}{48} \\
&\times \frac{e^{3\xi^2 T}-(9+18\xi^2 T)e^{\xi^2 T}+(8+24\xi^2 T+18\xi^4 T^2+6\xi^6 T^3)}{3\xi^6 T^3} \sigma\sqrt{T} + \ldots
\end{aligned}
$$

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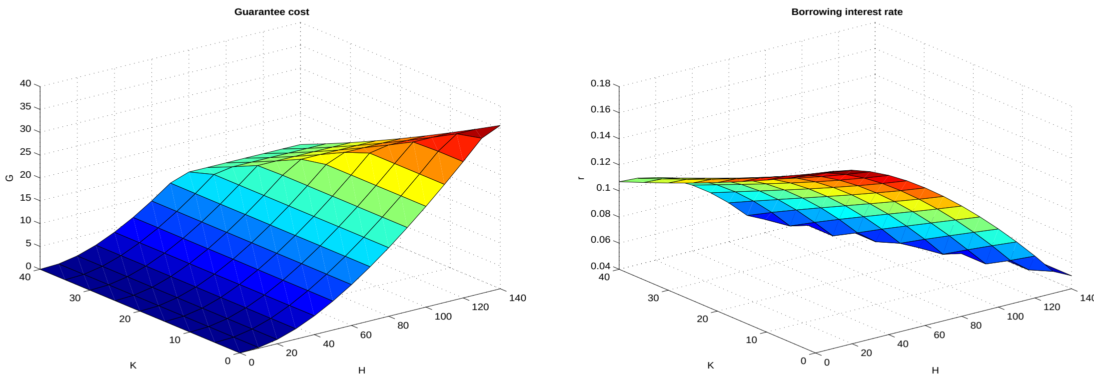
Table 1: **Baseline parameters values.**

Variable	**Description**	**Value**
r_f	Risk-free interest rate	0.05
g	Externally financed project asset growth rate	0.00
δ	Project payout rate	0.00
τ_c	Corporate tax rate	0.30
λ	Depreciation code allowance	0.95
T	Project debt maturity (in years)	8
γ	Coefficient of the production technology (elasticity)	1.00
p_0	Initial output price	1.5
σ	Annualized project assets volatility	0.50
ψ	Drift of the volatility process	0
ξ	Diffusion coefficient of the volatility process	0.10

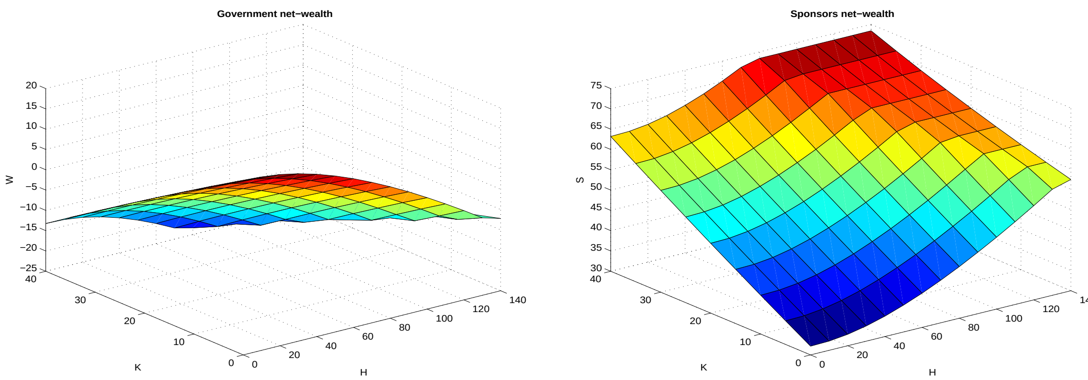
Figure 1: **Government and sponsors wealths sensitivity to H and K.**

These graphs plot the value of the guarantee, the borrowing interest rate, the government and sponsors wealths as a function of H and K. Panel a shows the cost of the guarantee and the borrowing interest rate. In Panel b, we plot the government and sponsors wealths for combinations of loan insurance and investment subsidy. In Panel c, we plot the government and sponsors wealths for combinations of loan insurance and joint equity participation. With investment subsidy, $\alpha = 0$ and with joint equity participation of the government, $\alpha = K/I$. We use the following parameters values: $I = 100$, $C = 10$, $A_0(I) = 1.5I$, $\tau_c = 0.30$, $\lambda = 0.95$, $r = 5\%$, $g = 0\%$, $\delta = 0\%$, $\sigma = 0.50$, $\psi = 0$ and $\xi = 0.10$.

a)- Cost of the guarantee and interest rate



b)- Loan insurance and investment subsidy ($\alpha = 0$)



c)- Loan insurance and joint equity participation ($\alpha = \frac{K}{I}$)

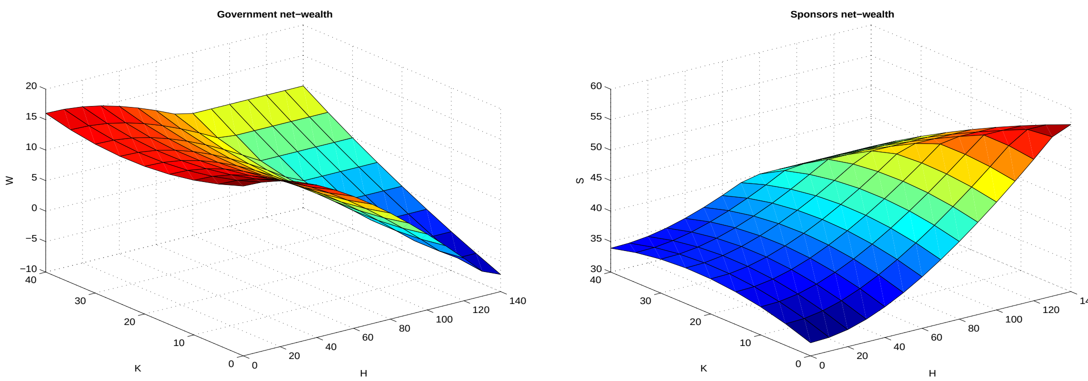


Table 2: **Comparison tables of the government support programmes.**

These tables show the government and sponsors net-wealths from the project as a function of the cost to the government G (loan insurance) or K (direct investment). In order to compare the impact of the diverse government programmes, the cost under the different programmes have been calibrated to be equal. To achieve that, we first vary H from 0 to 140 and compute G the guarantee cost under the loan insurance programme. For the direct investment programmes (subsidy or PPP), we use the obtained value of G as the value of the government direct investment amount K and calculate the other quantities. We use the following parameters values: $I = 100$, $C = 10$, $A_0(I) = 1.5I$, $\tau_c = 0.30$, $\lambda = 0.95$, $r = 5\%$, $g = 0\%$, $\delta = 0\%$, $\sigma = 0.50$, $\psi = 0$ and $\xi = 0.10$. Under the equity participation programme, we use $\alpha = K/I$. W and S are respectively the government and sponsors net-wealth.

a)- Loan insurance only

H	0	20	40	60	80	100	120	140
G	0.00	0.94	4.10	8.94	15.02	22.05	29.84	35.77
D	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00
r	0.1764	0.1731	0.1621	0.1454	0.1244	0.0999	0.0721	0.0500
W	17.85	17.19	15.00	11.63	7.39	2.46	-3.01	-7.19
S	32.14	32.81	35.04	38.45	42.74	47.70	53.20	57.40

b)- Direct investment

K	0.00	0.94	4.10	8.94	15.02	22.05	29.84	35.77
D	90.00	89.06	85.90	81.06	74.98	67.95	60.16	54.23
r	0.1764	0.1744	0.1679	0.1585	0.1473	0.1351	0.1225	0.1133
Investment subsidy								
W	17.85	17.16	14.83	11.22	6.62	1.18	-4.97	-9.77
S	32.14	32.84	35.17	38.77	43.37	48.80	54.95	59.74
Joint equity participation								
W	17.85	17.57	16.68	15.58	14.63	14.15	14.41	15.19
S	32.14	32.43	33.31	34.41	35.36	35.83	35.57	34.79

Figure 2: **Comparison graphs of the government support programmes.**

These graphs plot the debt market value, borrowing interest rate, government and sponsors' wealths as a function of H (in the case of loan insurance) or K (in the case of direct investment). In order to compare the impact of the diverse government programmes, the cost under the different programmes have been calibrated to be equal. To achieve that, we first vary H from 0 to 140 and compute G the guarantee cost under the loan insurance programme. For the direct investment programmes (subsidy or PPP), we use the obtained value of G as the value of the government direct investment amount K and calculate the other quantities. We use the following parameters values: $I = 100$, $C = 10$, $A_0(I) = 1.5I$, $\tau_c = 0.30$, $\lambda = 0.95$, $r = 5\%$, $g = 0\%$, $\delta = 0\%$, $\sigma = 0.50$, $\psi = 0$ and $\xi = 0.10$. Under the equity participation programme, we use $\alpha = K/I$.

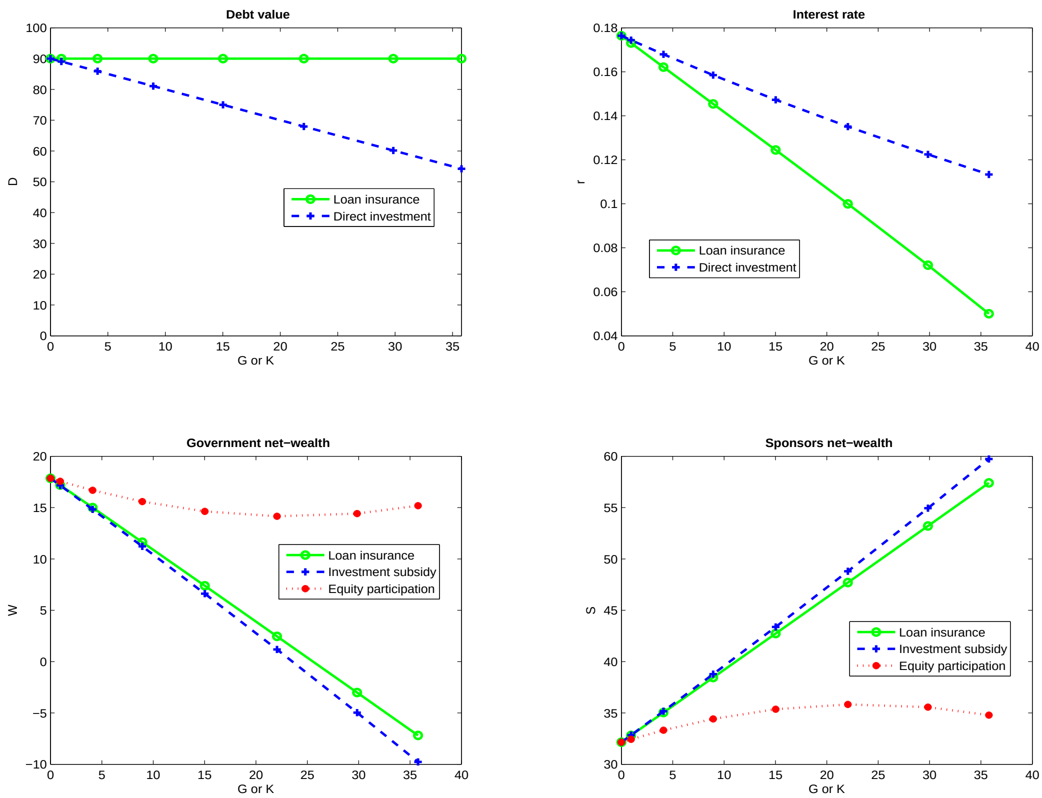
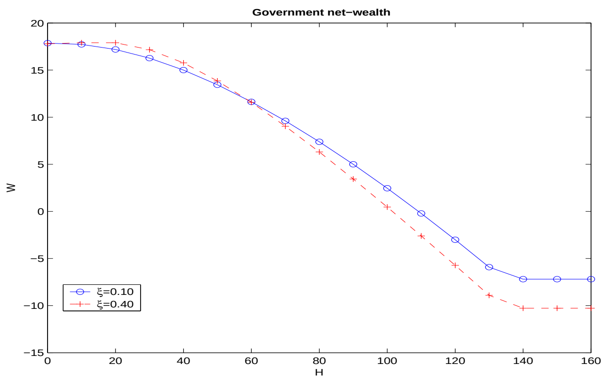


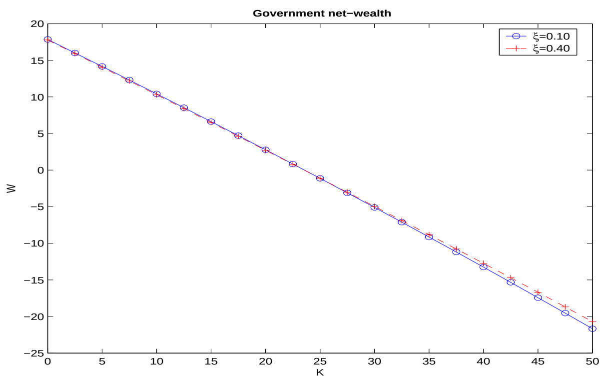
Figure 3: **Impact of the degree of information asymmetry on the government perception.**

These graphs plot the government assessment of its net-wealth for three governmental support programmes and under two degrees of information asymmetry. The degree of informational asymmetry is capture through the volatility coefficient ξ with $\xi = 0.10$ characterizing a low informational asymmetry environment and $\xi = 0.40$ a high informational asymmetry environment. We use the following parameters values: $I = 100$, $C = 10$, $A_0(I) = 1.5I$, $\tau_c = 0.30$, $\lambda = 0.95$, $r = 5\%$, $g = 0\%$, $\delta = 0\%$, $\sigma = 0.50$, $\psi = 0$. Under the loan insurance programme (top graph), $K = 0$ and H varies from 0 to 160. Under the direct investment programmes (investment subsidy and investment with joint equity participation), $H = 0$ and K varies from 0 to 50. Under the investment with joint equity participation, we set $\alpha = K/I$.

Loan insurance



Investment subsidy



Investment with equity participation