State Owned Firms: Private Debt, Cost Revelation and Welfare

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Abstract

In this paper we study the role of private debt financing in disciplining a state owned firm operating for a government that incurs a cost of public financing. We show that debt contracts allow the government to avoid socially costly subsidies by letting unprofitable state-owned firms default. Debt is never used when the firm and government share the same information about the firm. By contrast, when the state-owned firm has private information, the government has an incentive to use debt to reduce the firm's information rents. We identify the conditions under which a positive debt level benefits governments. They depend on the cost of public funds, the interbank funding rate, the share of foreign investors, the level and uncertainty of the firm's cost.

Keywords: State-owned firms, privatization, debt, information asymmetry.
JEL classification: L33, G32.

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1 Introduction

State-owned firms are of major economic importance in many countries. While they made up between 6-8% of total GDP across countries worldwide in the late nineties, increased purchases over the last decade has led governments to own approximately one fifth of global stock market capitalization. A particular feature of state-owned firms lies in the fact that they also raise significant levels of debt in the form of loans and bonds as a means to reduce government equity transfers. State-owned firms indeed usually incur debt levels much higher than a third of their assets and are responsible for the issuance of many bonds worldwide.[1] Given those facts, it seems important to understand the role of private debt financing in the relationship between state-owned firms and their governments.

This paper highlights the role of private debt financing as a disciplining device for state-owned firms when they operate for governments that lack information and incur a cost in financing their public funds. We examine the use of debt financing as an instrument to entice state-owned firms to reveal their private information and discuss the welfare costs and benefits of introducing debt into a state-owned firm's financing mix.

The economic literature presents privatization as a major mechanism to restore appropriate incentives to state-owned firms and to avoid socially inefficient transfers to them. Privatization is expected to improve efficiency and managerial incentives through increased commercial focus, reduced moral hazard and political opportunism, higher accountability and more complete managerial contracts (Shleifer, 1998, Laffont and Tirole, 1993). In industries associated with costly investments, volatile or low profitability, state ownership creates the problem of inefficient transfer of government funds. In many cases, information asymmetries between state-owned firms and their governments, as well as the high cost of public funds, motivate the privatization decision even if privatized firms may set too high price (Auriol and Picard 2009a, 2009b).

In this paper, we discuss another mechanism to improve managerial discipline and reduce transfers to state-owned firms. By asking state-owned firms to borrow, governments impose a debt contract between state-owned firms and private creditors, which include the possibility of not bailing out the firms when they report too high costs. Default provisions of typical loan agreements and bond prospectuses often exclude government guarantee clauses; they thus convey an implicit

[1] See Megginson and Netter (2001) and Borisova et al. (2012). According to Megginson and Netter (2001) state-owned firms' mean debt-to-asset ratio ranged from 29% to 66% in the period between 1994 and 1999. Borisova et al. (2012) describe no less than a thousand bonds issued by 215 listed state-owned firms across 43 countries in the last decade.

no-bailout commitment.

A number of state-owned firms have been defaulted in the past and are still undergoing default procedures nowadays. Creditors acquired (at least temporary) control of defaulting firms during the Asian banking crisis in the late 1990s. The Belgian state-owned firm, Sabena, was defaulted after air traffic demand dropped in 2001, which made it unable to pay the cost of the debt held on its fleet. Credit Lyonnais, the French national bank, was floated on the stock market in 1999 following two major government rescues and heavy losses due to large amounts of non-performing loans. Following privatization, two thirds of the company was owned by commercial banks and institutional investors. Thousands of Chinese central and regional state-owned companies are going bankrupt each year since 2002. The Portuguese state-owned airline Tap Air is currently being sold as part of the EU/IMF bailout in order to repay the company's outstanding debt. Additionally, the UK government is paving the way for the privatization of Royal Mail, which requires that part of its debt be written off.

Such cases of liquidation of state-owned firms necessitate governments' commitment to stop subsidizing the firm and face the risk of operational disruption and citizens' discontent. These examples take place under crisis conditions and in complex, multi-year processes, often involving interim subsidies. They nevertheless highlight the fact that debt contracts can be used as instruments to trigger governments' disinvestment in non-performing state-owned firms. Yet, in many instances, bankruptcy is not a necessary step for privatization. Numerous money-losing state-owned enterprises have put themselves under pressure from their creditors and, as a result, have been privatized and sold by their governments to consortia of investors that often included the former creditors. Hence, the broader question that we explore in this paper is whether the debt policy and its subsequent creditor's pressure can be used by governments as instruments to discipline state-owned firms.

To highlight this mechanism, we consider a utilitarian government that monitors a state-owned monopoly that must make an investment. Such state-owned firms usually operate in the market for transport, water, energy, waste, health, etc. The government faces an information asymmetry as the firm's manager has private knowledge about the firm's marginal cost. The government faces a budget constraint that affects its cost of public funding.[2] We introduce debt financing from private domestic or foreign creditors. The government maximizes a welfare objective that mixes the cost of public transfers to the firm with the surplus to consumer, producer and (local)

[2] As in Laffont and Tirole (1993) and Auriol and Picard (2009a, 2009b) our model assumes that the shadow cost of public funds summarizes the tightness of the government budget constraint, whereby larger shadow costs indicate tighter budget constraints and increased opportunity cost of public funds.

creditors. The government is constrained to give incentives to the state-owned firm's managers to reveal their private information and to leave some rents to the latter and the creditors to make them participate in the firms' operations. When the state-owned firm reports a too high cost and asks to be refunded, the government can either subsidize the firms' operation or let the firm default, relinquishing its ownership to the creditors.

We first study the benchmark case of full information where the government possesses the same information as the state-owned firm. In this case, we show that higher debt levels allow the government to diminish the subsidies to the state-owned firms with too high realized costs by defaulting them. In addition, debt allows governments to initially save on public funds needed to fund the investment. However, before the cost realizes, the benefits of debt and defaulting never exceed the social cost of paying principal and interest. In essence, this is because the interest paid back to the creditors must ultimately be reimbursed by tax payers and has a social cost. On the one hand, this result confirms the public economic principle that, under symmetric information, the government can always replicate private firms' decisions and can improve on them. On the other hand, it refutes the internal-external financing principle by which governments should adopt exclusive financing strategies: either internal funding from government budget and taxes when the cost of public funds is lower than the cost of borrowing in the credit market, or external borrowing in the credit market in the opposite case. Under symmetric information, we show that the use of external borrowing is never socially optimal. Such an argument is however qualified when the government is not fully informed.

We then study the situation in which the government is not informed about the firm's cost. Under asymmetric information, the government designs incentive contracts that entice the state-owned firm to report its true cost but leave an information rent to the firm. Ex-ante, the information cost increases with the range of costs under which the state-owned firm is asked to operate. The government has an incentive to reduce this range by defaulting the firms that report high costs more often. As a consequence, debt can be used to diminish the extent of information rents. However, the information asymmetry also diminishes the attractiveness of defaulting. Indeed, when it defaults the state-owned firm, the government does not know the firm's true cost and must let the creditors set a price that allows them to operate. This is likely to harm consumers, as creditors prefer and will set too high prices.

In this paper we show that the cost realization above which the government decides to default depends on the balance between information rents and allocative inefficiency after liquidation. The internal-external financing principle partly applies. In particular, when all creditors are domestic, the government never uses debt if its shadow cost of public funds is lower than borrowing cost in the interbank market. The optimal debt is also set to zero for low enough shadow costs of public funding. In this case, the information rent consists of a redistribution mechanism from tax payers to the state-owned firms, which has no social cost but makes debt an uninteresting instrument. In contrast, debt is used in many other situations. The debt level becomes positive and increases when the shadow cost of public funds increases above some threshold. This is because the social cost of information rents increases and entices the government to use higher debt level to discipline state-owned firms.

This paper comprises 6 sections. We summarize the related literature in section 2. The model is presented in section 3 and followed by the analysis of the symmetric information in section 4. Section 5 discusses the case of asymmetric information. Section 6 discusses further issues while Section 7 concludes and identifies areas for further research.

2 Literature

Our paper contributes to the abundant literature on regulation, privatization and debt contracting. Laffont and Tirole (1993), Schmidt (1996), Laffont (2005), Megginson and Netter (2001) and Chang (2007) analyze the benefits and costs of state and private ownership. As in Auriol and Picard (2009a), the present paper analyzes the cost and benefits of state ownership in the presence of asymmetric information and cost of public funding. Welfare increases because socially costly transfers are reduced and information revelation is improved when the less performing firms can be defaulted and privatized. Private debt financing relaxes the problems of soft budget constraint and information asymmetry.

The paper also complements a series of important research contribution about debt financing. A first contribution relates to the interaction between regulation and capital providers. Spiegel and Spulber (1994) examine the equilibrium price, investment and capital structure of a regulated firm in the presence of capital market investors. Debt is shown to reduce regulatory opportunism and increase regulated prices, albeit at a risk of bankruptcy. A second contribution concerns our discussion of borrowers' budget constraint. Holmstrom and Tirole (1997) explicitly model an entrepreneur's capital constraints and private benefits, resulting in a maximum pledgeable expected income from any investment. In contrast to those contributions, this paper does not consider regulatory opportunism. It discusses how a government may use debt financing to reduce transfers to a state-owned monopolist and mitigate the firm's information advantage.

Other contributions relate to the commitment created by debt contracts and the information transfer occurring at the liquidation stage. Dewatripont and Tirole (1994), Tirole (2005) and Myers (2001) show that the introduction of short term debt helps commit managers to making decisions that are better aligned with the objectives of firm owners, creditors and investors. Leite (2001) observes that short term debt investors and outside equity holders with unconditional control rights allow investors to liquidate or seize control of the firm in low profit states or to discipline managers. Long term debt on the other hand creates a Myers-like debt overhang that protects the manager from excessive shareholder involvement. Gale and Hellwig (1985) describe bankruptcy as an information transfer event, whereby creditors learn about the true state of the firm. Our analysis however differs from the costly bankruptcy model, where a firm's 'scrap' value might turn out lower than its going concern value. In this paper, the debt is used as an instrument to reduce the likelihood of subsidies to unprofitable state-owned firms. In this sense, debt can be seen as government's commitment device that hardens the firm's budget constraint. Also, this paper discusses different processes of information transmission at the liquidation stage. Ownership and control rights provide creditors with direct access to firm information. Information transmission is however assumed to be efficient because we focus on the welfare trade-off between information advantages before and after default.[3]

Lastly, our paper studies the interaction between debt financing and product market behavior. Faure-Grimaud (2000) and Povel and Raith (2004) derive debt as an optimal contract and investigate the implications of endogenous debt contracts on firms' product output decisions under asymmetric information. Among other results, they observe that leveraged firms produce lower output. We here look at how a government regulates a state-owned monopolist that is also debt financed. The optimal output is invariant in the level of debt in the state-owned firm but may fall after default and privatization.

In summary, none of the previous studies have looked at the interaction between state and private ownership of monopolies and private debt financing under adverse selection.

3 The model

We consider a state-owned firm with a natural monopoly position and an increasing return to scale technology. To produce the firm incurs an up-front fixed investment cost K and a marginal cost β. The firm sells its output Q to consumers who enjoy a surplus $S(Q)$, $S' > 0 > S''$, and whose inverse demand function is given by $P(Q) = S'(Q)$, $P' < 0$. To guarantee concavity conditions, we

[3] We provide a discussion how our model can be extended to explicitly account for bankruptcy cost, as well as creditor risk aversion. While they lower the maximum feasible debt level, our overall results remain unchanged.

assume that the demand function is not too convex: $P''Q + P' < 0$. We study three parties: the government as utilitarian planner and industry regulator, the manager of the state-owned firm, and a group of private creditors. The model includes two stages depicted in Figure 1.

INSERT FIGURE 1 HERE

In the first stage, all parties know the value of the fixed investment cost K, whereas the specific value of the marginal cost β is unknown. The parties nevertheless have the same common prior about the marginal cost support $[\underline{\beta}, \overline{\beta}]$ and its probability distribution density function $g(\beta)$. We assume that $P(0) > \overline{\beta}$ so that there always exists a positive production surplus after the investment is made. The government hires the state-owned firm manager, determines a debt level D that the firm raises from creditors, makes an equity transfer E to the firm and subsequently asks the firm to make the investment K.

In the first stage parties have the following utilities. The firm raises debt D and equity E and makes the investment K. The utility of its manager is then equal to $U_1 = D + E - K$, where the subscript 1 refers to the first stage. The creditors raise the debt amount D in the interbank, deposit or capital markets at an exogenous rate ρ and lend it to the firm at the interest r. They receive the debt repayment $R \equiv (1 + r)\, D$. In the first stage, the creditors lend to the state-owned firm the money they borrow in the interbank market so that their utility is given by $C_1 = D - D = 0$. The creditor group includes domestic and foreign debt investors with proportions $\alpha \in [0, 1]$ and $(1 - \alpha)$, respectively. They are assumed to be risk neutral.

The government incurs a social loss in making public transfers to the firms. The government therefore takes into account the social cost of its equity transfer as well as the utilities of the firm manager and domestic creditors. The welfare function is given by $W_1 = U_1 + \alpha C_1 - (1 + \lambda)E$ where $\lambda > 0$ is the shadow cost of public funds. The latter represents the deadweight cost of raising one dollar from tax payers. It reflects the administrative cost of taxation and/or the economic inefficiencies in taxing labor and consumption. It also reflects the government's shadow value of raising public funds; the tougher its budget constraint, the higher λ. It is estimated to lie in a range about $\lambda = 0.3$ in developed economies and in a range higher than $\lambda = 0.9$ in least developed countries. Given the above definition, the first stage welfare is equal to

$$W_1 = D - \lambda E - K. \tag{1}$$

In the second stage, the marginal cost β is realized. The government decides whether the firm is viable for production under state ownership or whether it should be defaulted and left to creditors. It also decides how much output $Q(\beta)$ and transfer $T(\beta)$ are optimal. Let $\varphi(\beta) \in \{0,1\}$ denote the default decision when the government defaults and relinquishes the firm to the private creditors. In the latter case, the firms is privatized. For the sake of conciseness, we drop the reference to β whenever no ambiguity arises.

The utilities of the parties are as follows. If the state-owned firm does not default ($\varphi = 0$), the firm manager collects the revenues from consumers, pays the cost of production, repays the debt and interest and collects the transfer.[4] If the state-owned firm defaults ($\varphi = 1$), the creditors take over the firm and fire the manager who gets a zero utility. The state-owned firm manager's utility writes as:

$$U_2 = [(P(Q) - \beta) Q - R + T] (1 - \varphi).$$

where the subscript 2 refers to the second stage. The creditors collect the repayment of debt plus interest, R, if the firm does not default. Otherwise, they take over the firm and get rights to the liquidation profits of the privatized firm. They repay the funds raised in the interbank, deposit or capital markets at the rate ρ. Their utility is given by

$$C_2 = R(1 - \varphi) + \left[P(Q^l) - \beta\right] Q^l \varphi - D(1 + \rho).$$

In this expression we assume that the creditors are allowed to set their output levels Q^l after default by government, following which they take over the firm.[5][6] Finally, the government takes into account the consumer net surplus $S(Q) - P(Q)Q$ under state ownership and post-default privatization. Together with firm utility and the domestic portion of creditor utility, the welfare function reads as:

$$W_2 = [S(Q) - P(Q)Q](1 - \varphi) + \left[S(Q^l) - P(Q^l)Q^l\right] \varphi - (1 + \lambda)T + U_2 + \alpha C_2.$$

We now study the debt and privatization decisions under symmetric and asymmetric information.

[4] When the firm does not default and repays the debt and interest, it can pay taxes, i.e., recieves negative transfers.

[5] In case of a default and takeover, the creditors may decide to sell the firm to a private investor. Assuming an efficient sale, they receive the same value. Our analysis remains unchanged.

[6] Under symmetric information the government ensures efficient output post liquidation. Under adverse selection, however, the government is forced to allow leave rents to creditors. For instance, defaulted national airline companies are usually allowed to set their prices freely after the default and privatization stage.

4 Symmetric information

Under symmetric information all parties including the government, the firm manager and creditors observe the firm's marginal cost. The government decides firstly on the debt contract and the equity level and then, after cost realization, it selects its default option, output and transfer levels. We show that when the marginal cost level is high the government defaults the firm and benefits from the reduction of transfers in the second stage. This benefit however does not compensate for the social cost of paying interests to creditors. So, issuing debt brings no welfare improvement.

In the first stage the government selects the debt, equity and repayment (D, E, R) that maximizes the ex-ante welfare $E\left[W_1 + W_2^*\right]$ subject to the firm manager's participation constraint $U_1 \geq 0$ and the creditors' participation constraint $E\left[C_1 + C_2\right] \geq 0$, where $E\left[f\right] = \int_{\underline{\beta}}^{\overline{\beta}} f(\beta)g(\beta)\mathrm{d}\beta$ denotes the expectation operator and W_2^* is the optimal welfare in the second stage. In the second stage the government maximizes the welfare function W_2 subject to the participation constraint of the firm manager, $U_2 \geq 0$. This yields the optimal variables φ^*, Q^* and T^* as well as the above optimal welfare W_2^*. This subgame perfect equilibrium is solved backwards. We first discuss the second stage decisions and then determine the decisions taken in the first stage.

4.1 Output, transfers and default decisions

Suppose firstly that the firm is not defaulted ($\varphi = 0$). Because of the social cost associated with public funding, transfers are costly to the government. Under symmetric information, the government finds it optimal to diminish the transfer T so that the participation constraint of the firm manager binds: $U_2 = 0 \ \forall \beta$. So, $T^* = R - (P(Q) - \beta)\, Q$ and the welfare function becomes

$$W_2^0 \left(\beta, Q, R, D\right) = S(Q) + \lambda P(Q)Q - (1+\lambda)\beta Q - (1+\lambda)\, R + \alpha \left[R - (1+\rho)\, D\right]. \qquad (2)$$

While welfare increases with the consumer surplus, it increases with cash inflows to and decreases with cash outflows from the government, which are valued together with the shadow cost of public funds. Hence, welfare rises with the tax revenues $P(Q)Q$ but falls with production costs βQ and with debt repayment R. Finally, welfare increases with creditors' profit $R - (1+\rho)\, D$ provided that they are domestic.

The optimal output Q^* is the unique solution to the following FOC of (2) with respect to Q:

$$\frac{\mathrm{d}W_2^0}{\mathrm{d}Q} = P(Q) + \lambda \left[P'(Q)Q + P(Q)\right] - \beta(1+\lambda) = 0. \qquad (3)$$

Under our assumption on product demand, this condition is necessary and sufficient. As in Auriol and Picard (2009a), it can be checked that Q^* decreases with larger β and λ. It is independent of the debt level. The optimal output decreases with marginal cost as well as the shadow cost of public funds. Higher marginal costs require higher prices and lower output. Higher costs of public funds inflate the social cost of transfers to the firm and lead to a reduction of output. In the limit where $\lambda \to \infty$, the government cares only about the profits it can tap from the state-owned firm and setsthe firms' output $Q^*(\beta)$ to the laissez-faire monopoly level $Q^m(\beta)$.

Secondly supposethat the firm is defaulted ($\varphi = 1$). Then, the manager is fired, $U_2 = 0$, and no transfer occurs, $T = 0$. However, under symmetric information, the government knows the cost parameter β and maximizes the objective

$$W_2^1(\beta, D) = \left[S(Q^l) - P(Q^l)Q^l\right] + \alpha\left(\left[P(Q^l) - \beta\right]Q^l - D(1+\rho)\right)$$

subject to the constraint that the creditors should not make any operational loss: $\left[P(Q^l) - \beta\right]Q^l \geq 0$. Otherwise, they better shut the firm's operation. Obviously, when all creditors are domestic ($\alpha = 1$), the government maximizes the economic surplus $S(Q^l) - \beta Q^l$ and sets the efficient output $Q^l = Q^e$ that solves $P(Q^e) = \beta$ and gives no profits to creditors. This efficient output decreases with higher marginal cost β and is higher than the regulated output Q^* unless $\lambda = 0$. When fewer creditors are domestic ($\alpha < 1$), the government puts less weight on creditors' profit and would set the price $P(Q^l) = \beta + P'Q^l(1-\alpha)/\alpha$ that is lower than the marginal cost β. But, as this would lead to production shut down, the government must maintain its price to the efficient one, which yields no profit. To sum up, for any α, the government stipulates efficient output post liquidation and creditors get no profit from operation. Creditors nevertheless incur a loss equal to the debt plus interest, $D(1+\rho)$. So, the welfare reads as

$$W_2^1(\beta, D) = S(Q^e) - \beta Q^e - \alpha(1+\rho)D.$$

This welfare function falls with the creditors' interbank funding cost ρ to the extent that creditors are domestic.

As a result, the total welfare in the second stage can be written as

$$W_2 = (1-\varphi)W_2^0(\beta, Q^*, R, D) + \varphi W_2^1(\beta, D).$$

The optimal decision to default φ^* maximizes this expression. Let us express the welfare difference between state owned and privatized firm as

$$\begin{aligned} \Delta W_2(\beta, R) &\equiv W_2^0(\beta, Q^*, R, D) - W_2^1(\beta, D) \\ &= \left[S(Q^*) + \lambda P(Q^*)Q^* - (1+\lambda)\beta Q^*\right] - \left[S(Q^e) - \beta Q^e\right] - (1+\lambda-\alpha)R. \end{aligned} \tag{4}$$

One can then check that the optimal default decision is $\varphi^* = 0$ if $\Delta W_2(\beta, R) > 0$, $\varphi^* = 1$ if $\Delta W_2(\beta, R) < 0$ and $\varphi^* \in [0,1]$ if $\Delta W_2(\beta, R) = 0$. Note that $\Delta W_2(\beta, R)$ is a decreasing function of R and β because

$$\frac{\mathrm{d}\Delta W_2}{\mathrm{d}\beta} = -(1+\lambda)Q^* + Q^e \leq 0. \tag{5}$$

since it can be shown that $(1+\lambda)Q^*$ is a function that increases from Q^e to infinity as λ rises above zero (see proof of Lemma 1). A rise in marginal cost raises the cost of each production unit by a factor $1+\lambda$ because of transfers from the government. In the liquidated firm, it raises the cost of each production unit by 1. Given this property, the optimal default threshold β^* is given by the root of $\Delta W_2(\beta, R) = 0$. For costs below β^*, we get $\Delta W_2(\beta, R) > 0$ and the opposite for costs above β^*. We therefore get the following lemma:

Lemma 1 *There exists an optimal default threshold $\beta^*(R)$ such that the government defaults and privatizes the state-owned firm at higher marginal cost levels. More formally,*

$$\varphi^* = \begin{cases} 0 & \textit{if} \quad \beta \leq \beta^*(R) \\ 1 & \textit{if} \quad \beta > \beta^*(R) \end{cases}.$$

Furthermore, β^* is a decreasing function of R. It increases with α and λ.

Proof. See Appendix 1. ■

Figure 2 helps visualize how the second stage welfare functions behave. It plots the function $W_2^0(\beta, Q^*, R, D)$ and $W_2^1(\beta, D)$ (solid blue and red curves) and displays the default threshold $\beta^*(R)$ where $\Delta W_2(\beta, R) = 0$. Figure 2 is obtained for a linear inverse demand function $P = 1 - Q$, a uniform marginal cost distribution $g(\beta)$, $\beta \in [0, 1/2]$, and the parameters $\lambda = 0.8$, $\alpha = 1$ and $R = 0.1$. We observe an interior solution for β^*. When condition (5) holds, the function ΔW_2 accepts a unique root that we define as the optimal default threshold.

INSERT "NEW" FIGURE 2 HERE

The above Lemma also states that the optimal default threshold falls with repayment, R, and increases with the share of domestic creditors, α, and the shadow cost of public funds, λ. Higher repayments increases the likelihood that profits are too low to repay creditors and the government lets the state-owned firm default. Debt can therefore be used as a commitment to reduce the transfers to the state-owned firm. In contrast, a higher share of domestic creditors reduces the domestic welfare because domestic creditors lose money when the firm is defaulted. This makes the government more reluctant to liquidate the state-owned firm. Finally a larger cost of public funds entices government to tap the profit from the state-owned firm. It is therefore enticed to keep the state-owned firm and avoid liquidation.

Observe that the optimal default threshold β^* belongs to the marginal cost support $[\underline{\beta}, \overline{\beta}]$ when the repayment R belongs to the range $[\underline{R}, \overline{R}]$. The lower bound $\underline{R}$ corresponds to the situation of a high default threshold $\beta^* = \overline{\beta}$ so that $\Delta W_2(\overline{\beta}, \underline{R}) = 0$. Similarly, the higher bound $\overline{R}$ is obtained for the situation of a low default threshold $\beta^* = \underline{\beta}$ so that $\Delta W_2(\underline{\beta}, \overline{R}) = 0$. As a result, we get three possible cases. First, no firms are defaulted ($\varphi^* = 0$) when the repayment R level lies below $\underline{R}$ (i.e. $\beta^* > \overline{\beta}$). In this case the second stage welfare is equal to $W_2^0(\beta, Q^*, R, D)$ for any β. Second, all firms are defaulted ($\varphi^* = 1$) when R lies above $\overline{R}$ (i.e. $\beta^* < \underline{\beta}$). The welfare becomes $W_2^1(\beta, D)$ for any β. Finally, only the firms with cost in the range $(\beta^*, \overline{\beta}]$ are defaulted when the debt level lies between $\underline{R}$ and $\overline{R}$. The welfare is given by $W_2^0(\beta, Q^*, R, D)$ for $\beta \leq \beta^*$ and W_2^1 otherwise.

We can now discuss the debt and equity transfer decision that the government makes in the first stage.

4.2 Debt and equity decisions

In the first stage, no party has knowledge about the marginal cost β. The government chooses $\{E, D, R\}$ that maximizes the expected welfare $E[W_1 + W_2^*]$ subject to the firm manager's and creditors' participation constraints: $U_1 \geq 0$ and $E[C_1 + C_2^*] \geq 0$. Because the uncertainty applies only to the second stage outcomes, the expected welfare and constraint are equal to $\mathcal{W}(R, D) \equiv W_1 + E[W_2^*]$ and $C_1 + E[C_2^*] \geq 0$. Given the above analysis, we can write the second stage expected welfare and creditors' utility as:

$$E[W_2^*] = \begin{cases} \int_{\underline{\beta}}^{\overline{\beta}} W_2^0(\beta, Q^*, R, D)\ g(\beta)\mathrm{d}\beta & \text{if} \quad R < \underline{R} \\ \int_{\underline{\beta}}^{\beta^*} W_2^0(\beta, Q^*, R, D)\ g(\beta)\mathrm{d}\beta + \int_{\beta^*}^{\overline{\beta}} W_2^1(\beta, D)\ g(\beta)\mathrm{d}\beta & \text{if} \quad \underline{R} \leq R \leq \overline{R} \\ \int_{\underline{\beta}}^{\overline{\beta}} W_2^1(\beta, D)\ g(\beta)\mathrm{d}\beta & \text{if} \quad R > \overline{R} \end{cases} \tag{6}$$

and

$$E[C_2^*] = \begin{cases} \int_{\underline{\beta}}^{\overline{\beta}} [R - (1+\rho)\, D]\, g(\beta)\mathrm{d}\beta & \text{if} \quad R < \underline{R} \\ \int_{\underline{\beta}}^{\beta^*} [R - (1+\rho)\, D]\, g(\beta)\mathrm{d}\beta - D(1+\rho)\int_{\beta^*}^{\overline{\beta}} g(\beta)\mathrm{d}\beta & \text{if} \quad \underline{R} \leq R \leq \overline{R} \\ -D(1+\rho)\int_{\underline{\beta}}^{\overline{\beta}} g(\beta)\mathrm{d}\beta & \text{if} \quad R > \overline{R}. \end{cases} \tag{7}$$

In the first stage, the government sets the equity transfer so that the firm manager's constraint binds: $U_1 = D + E - K = 0$. The creditors indeed lend the funds they collect in the interbank market so that make no profit and have zero utility: $C_1 = D - D = 0$. The welfare becomes $W_1 = -(1+\lambda)(K - D)$. There are three cases to discuss.

Consider first the case of a low repayment level $R < \underline{R}$. Using $\int_{\underline{\beta}}^{\overline{\beta}} g(\beta)\mathrm{d}\beta = 1$, we get $C_1 + E[C_2^*] = R - (1+\rho)D = 0$, so that the government sets the repayment level $R = (1+\rho)D$. Using (1) and (2) the expected welfare reads and simplifies as

$$\mathcal{W}(R,D) = \int_{\underline{\beta}}^{\overline{\beta}} [S(Q^*) + \lambda P(Q^*)Q^* - (1+\lambda)\beta Q^*] \; g(\beta)\mathrm{d}\beta - (1+\lambda)[K + \rho D].$$

The expected welfare includes the value of welfare when debt is nil (first integral term) minus the cost of investment and debt repayment (second term), with all revenues and costs evaluated at the shadow cost of public funds. Yet, at low repayment levels $R < \underline{R}$, welfare falls with higher debt so that the optimal debt level is zero in this interval. Indeed, since the debt is always paid back, the interest payment exactly compensates the creditors' funding cost but has a social cost of $(1+\lambda)\rho D$.

Second, consider high repayment levels $R > \overline{R}$. The creditors' participation constraint reads as $C_1 + E[C_2^*] = -D(1+\rho) \geq 0$. Since debt is non-negative, this only holds when $D = 0$. When the state-owned firm is always defaulted and the creditors earn no profit after liquidation, the creditors do not lend.

Consider finally the case of intermediate repayment levels $R \in [\underline{R}, \overline{R}]$. The government also sets the repayment R such that the creditors lend to the firm: $C_1 + E[C_2^*] \geq 0$. Using the second line of expression (7), creditors supply capital if

$$D \leq \widehat{D}(R) \equiv \frac{1}{1+\rho} RG[\beta^*(R)] \tag{8}$$

where $\widehat{D}(R)$ is called the creditors' acceptable debt level. As illustrated in the left panel of Figure 3, $\widehat{D}(R)$ has a bell-shaped curve. For $R < \underline{R}$, it proportionally increases with R for $R < \underline{R}$. Because β^* falls with R, $\widehat{D}(R)$ then rises from and above $\underline{R}$ as R increases from $\underline{R}$ and then it falls back to zero as R reaches $\overline{R}$.

INSERT FIGURE 3 HERE

Rearranging the integral terms in the second line of (6), the government objective becomes

$$\mathcal{W}(R,D) = -(1+\lambda)(K-D) + \int_{\underline{\beta}}^{\beta^*(R)} \Delta W_2(\beta, R) \; g(\beta)\mathrm{d}\beta + \int_{\underline{\beta}}^{\overline{\beta}} W_2^1(\beta, D) \; g(\beta)\mathrm{d}\beta$$

Using the linearity of $W_2^1(\beta, D)$ in D, we get

$$\mathcal{W}(R,D) = -(1+\lambda)K + [(1+\lambda) - \alpha(1+\rho)]D + \int_{\underline{\beta}}^{\beta^*(R)} \Delta W_2(\beta, R)\ g(\beta)\mathrm{d}\beta + \int_{\underline{\beta}}^{\overline{\beta}} W_2^1(\beta, 0)\ g(\beta)\mathrm{d}\beta$$

where only the second term depends on D. On the one hand, note that if $(1+\lambda) - \alpha(1+\rho) < 0$ the debt has a negative contribution to the government's objective at any repayment level. Debt is thus avoided by the government. On the other hand, if $(1+\lambda) - \alpha(1+\rho) > 0$, the debt yields a positive contribution. Since the government has no incentives to leave excess rent to the creditors, it sets the debt up to the creditors' acceptable level; that is, so that constraint (8) binds. Differentiating the above expression and using the envelop theorem, we get

$$\frac{\mathrm{d}}{\mathrm{d}R}\mathcal{W}\left[R, \widehat{D}(R)\right] = [(1+\lambda) - \alpha(1+\rho)]\frac{\mathrm{d}\widehat{D}}{\mathrm{d}R} + \int_{\underline{\beta}}^{\beta^*(R)} \frac{\partial}{\partial R}\Delta W_2(\beta, R)\ g(\beta)\mathrm{d}\beta$$

The government balances the benefit of additional debt in the first stage with the cost of higher repayments in the second stage. The latter cost turns out to be always larger. Indeed, after some line of algebraic manipulations, we get

$$\frac{\mathrm{d}}{\mathrm{d}R}\mathcal{W}\left[R, \widehat{D}(R)\right] = -\frac{\rho}{1+\rho}(1+\lambda)G(\beta^*) + \frac{1}{1+\rho}[(1+\lambda) - \alpha(1+\rho)]Rg(\beta^*)\beta^{*\prime}$$

which is always negative when $(1+\lambda) - \alpha(1+\rho) > 0$ because the optimal default threshold falls with repayment ($\beta^{*\prime} = \mathrm{d}\beta^*/\mathrm{d}R < 0$). The government therefore always has an incentive to reduce any repayment R and there is no equilibrium repayment in the interval $[\underline{R}, \overline{R}]$. Combining the three cases, we can infer that the optimal debt level is zero.

This result is illustrated in Figure 3. The right panel displays the ex-ante welfare objective when there is no debt (bold curve) and when the acceptable debt is introduced (thin curve). It shows that ex-ante welfare always falls and that the government optimally requires no debt.

Proposition 2 *Under symmetric information, debt always reduces welfare so that the state-owned firm is never asked to borrow.*

Debt is useless for the governments when they share the same information as the state-owned firms. Although debt allows governments to initially save on public funds needed to fund the investment, this saving is recouped by the repayment of principal and interests to creditors when the state-owned firm performs well. When the firm performs badly and reports a too high cost, the government benefits from defaulting the firm because it cuts socially costly subsidies that are actually used to repay creditors. Defaulting even raises consumer surplus. However, before knowing the cost realization, the social cost of paying the interest rates required by creditors exceeds the benefit of defaulting. As will be shown in the next section, this conclusion is strongly qualified in the presence of information asymmetry.

5 Asymmetric information

Under asymmetric information, the government does not observe the realized marginal cost of the state-owned firm in the second stage. The state-owned firm manager may not report her marginal cost truthfully as she has an incentive to mimic a less efficient one. The government must therefore design contracts such that she truthfully reveals its cost information. While those contracts mitigate possible cost over-reporting or cost padding, they create information rents and make the state-owned firm less attractive for the government.[7] The government is incentivized to opt for liquidation in bad times.

Yet, liquidation has its drawbacks. It shifts the private information to the creditors who receive the control rights of the defaulted firm. This information asymmetry stems from the fact that creditors usually comprise a small group of informed banks with adequate monitoring technology and incentives.[8] To discuss this idea, we make the assumption that creditors are able to observe marginal cost directly, which gives them an informational advantage over the government. This is in line with Gale and Hellwig's (1985) view of bankruptcy being an informational event that allows creditors to learn the true state of the firm. As a consequence, when the government relinquishes its control rights on the firm and the production decision is transferred to the creditors, the government's information deficit makes it unable to regulate a well-defined price on the defaulting firm. To avoid the discussion of renegotiation of inadequate regulated prices, we assume that the defaulting firm gets no price and output restriction so that creditors are free to set laissez-faire prices post default and privatization. Compared to the symmetric information case, this set-up implies too high prices and profits after liquidation.

As before, the government chooses the debt, equity and repayment levels that satisfy creditors' constraint in the first stage. It then chooses the output and the transfer to the state-owned firm and decides whether to liquidate the latter if needed. This subgame perfect equilibrium is solved

[7] See Laffont, 2005, Auriol, 2006, Auriol and Blanc, 2009.

[8] James and Smith (2000), Altunbaş et. al. (2009) analyze the monitoring role and information advantage of banks. Nevertheless, various authors also document information asymmetry between lenders, investors and firms. See for example Dell'Ariccia, 2001, Bahattacharya and Thakor, 1993 and Van Damme, 94. We make the assumption that experienced lenders are better informed than the government.

backwards. We first discuss the second stage optimal output, transfer and default decisions and then determine the optimal debt level chosen in the first stage. In the sequel all variables are the same as under perfect information and are indexed by a double star ** only if we need to avoid confusion.

5.1 Output, transfers and default decisions

In the second stage the government chooses the output, transfer and default option that maximize its expected welfare subject to the firm manager' participation constraint and incentive compatibility constraint. That is, the government has the following program:

$$\max_{Q(\cdot),T(\cdot),\varphi(\cdot)} EW_2 = \int_{\underline{\beta}}^{\overline{\beta}} \{[S(Q) - P(Q)Q]\,(1-\varphi) + [S(Q^m) - P(Q^m)Q^m]\,\varphi \tag{9}$$

$$- (1+\lambda)T + U_2 + \alpha C_2\} g(\beta)\mathrm{d}\beta$$

subject to the incentive compatibility and participation constraints

$$\frac{\mathrm{d}U_2}{\mathrm{d}\beta} = -Q\,(\beta) \tag{10}$$

$$U_2(\beta) = [(P(Q) - \beta)\,Q - R + T]\,(1-\varphi) \geq 0 \tag{11}$$

and where the creditor's utility is given by

$$C_2 = R\,(1-\varphi) + (P(Q^m) - \beta)\,Q^m\varphi - D(1+\rho), \tag{12}$$

where Q^m and $\Pi(Q^m) \equiv (P(Q^m) - \beta)\,Q^m$ reflect the creditors' post privatization monopoly output and profit. The incentive compatibility constraint (10) is necessary and sufficient if $Q(\beta)$ is monotone decreasing, which is true under the assumption of increasing monotone hazard rate $G(\beta)/g(\beta)$. To avoid corner solutions we assume a demand function that ensures sufficient profitability such as to avoid a production shut-down once the fixed cost has been sunk, $P(0) \geq \max[2\overline{\beta}, \overline{\beta} + G(\overline{\beta})/g(\overline{\beta})]$.

The optimal output, transfer and default decisions are similar to the decisions obtained under symmetric information, except for the presence of information and liquidation costs. For the sake of simplicity we restrict our attention to the same default structure as under symmetric information. That is, we focus on the case where there exists a cost threshold β^{**} such that the state-owned firm is defaulted for cost reports larger than β^{**} (see Appendix 2 for a detailed analysis).

When the state-owned firm is not defaulted ($\varphi(\beta) = 0$, $\beta \in [\underline{\beta}, \beta^{**}]$), the optimal output Q^{**} is given by

$$\frac{\mathrm{d}W_2^0}{\mathrm{d}Q} = P(Q) + \lambda\,[P'(Q)Q + P(Q)] - \vartheta(\beta)(1+\lambda) = 0 \tag{13}$$

where

$$\vartheta(\beta) \equiv \beta + \frac{\lambda}{1+\lambda}\frac{G(\beta)}{g(\beta)} > \beta$$

is called the virtual cost. Comparing this expression with (3), we have that the optimal output of the state-owned firm, $Q^{**}(\beta)$, is equal to $Q^*[\vartheta(\beta)]$. At the lowest cost level, there is no output distorsion as $Q^{**}\left[\vartheta(\underline{\beta})\right] = Q^*(\underline{\beta})$. For any higher cost, the presence of information asymmetry obliges the government to distort output downward. Indeed, because $\vartheta(\beta)$ is larger than β and increases faster than β, we get $Q^{**}(\beta) < Q^*(\beta)$ and $Q^{**\prime}(\beta) < Q^{*\prime}(\beta) < 0$ for all $\beta > \underline{\beta}$. Such distortions are made to reduce the manager's incentive to mimic lower productivity firms and therefore to reduce her information rent.

As a result, the total welfare in the second stage can be re-written as

$$EW_2 = \int_{\underline{\beta}}^{\overline{\beta}} \left\{(1-\varphi)\, W_2^0\left(\beta, Q^{**}, R, D\right) + \varphi W_2^1\left(\beta, D\right)\right\} g(\beta)\mathrm{d}\beta$$

where the welfare in the state-owned firm and the defaulted firm are given by

$$W_2^0\left(\beta, Q, R, D\right) \equiv S(Q) + \lambda P(Q)Q - (1+\lambda)\vartheta(\beta)Q - (1+\lambda-\alpha)\, R - \alpha D\,(1+\rho) \tag{14}$$

and

$$W_2^1\left(\beta, D\right) \equiv S(Q^m) - (1-\alpha)\, P(Q^m)Q^m - \alpha\beta Q^m - \alpha D\,(1+\rho)\,. \tag{15}$$

These expressions are the same as under symmetric information except that β is replaced by the virtual cost $\vartheta(\beta)$ for the welfare of the state-owned firm and that the liquidation welfare is given by the laissez-faire output decision Q^m. The optimal decision to default φ^* maximizes EW_2 pointwise.

The levels of second stage welfare under asymmetric information are depicted as a function of β in Figure 2 (dashed blue and red curves) for the same parameter setting. Comparing those curves to the symmetric information ones (solid blue and red curves), we observe that both welfare under state and private ownership decrease under asymmetric information. On the one hand, under state ownership the lower welfare is due to the information rent, reflected in the virtual cost. This reduces the optimal second stage default threshold. On the other hand, post privatization monopoly results in the deadweight loss, which turn decreases the incentives to default the state-owned firm. Under this linear demand example, the optimal default threshold under adverse selection is lower than under symmetric information. However the change in the default threshold is a priori ambiguous and depends on the shape of the demand function, the parameters and the level of repayment.

As for the case of symmetric information, we can define the welfare differential between the state-owned and defaulted firm as

$$\Delta W_2(\beta, R) \equiv W_2^0\left(\beta, Q^*, R, D\right) - W_2^1\left(\beta, D\right) \tag{16}$$

Then, the government defaults the state-owned firm if and only if $\Delta W_2(\beta, R) < 0$. If this expression falls with β, the govenment liquidates only firms with high cost reports. This occurs if we impose the following sufficient condition:

$$\frac{\mathrm{d}\Delta W_2}{\mathrm{d}\beta} = -(1+\lambda)\vartheta'(\beta)Q + \alpha Q^m + P'(Q^m)Q^m Q^{m\prime} < 0. \tag{17}$$

This condition reflects the balance in the welfare losses in the state-owned and privatized firms. On the one hand, a higher marginal cost β in the state-owned firm is responsible for a welfare loss that increases faster in the presence of higher information cost (first negative term). This is because the virtual cost $\vartheta(\beta)$ increases faster than the true cost. This effect augments for higher shadow costs of public funds. On the other hand, a higher marginal cost also generates welfare losses when the firm is defaulted. It reduces the domestic creditor's profit (second positive term) and diminishes consumer surplus (third positive term). The sign of expression (17) is ambiguous for general demand functions and cost distributions. Nevertheless, the condition is satisfied for linear demand and cost distribution functions and, by continuity, it is fulfilled for neither too convex nor too concave demand functions. In addition there exist many classes of demand functions and cost distributions that do not satisfy this sufficient condition but that still satisfy the property that the govenment liquidates only firms with high cost reports.

Under condition (17), the cost interval $[\underline{\beta}, \overline{\beta}]$ can be partitioned in two sets where $\Delta W_2(\beta, R)$ is either smaller or larger than zero. Then, there exists a unique optimal default threshold β^{**} that solves

$$\Delta W_2(\beta^{**}, R) = 0.$$

This yields the following lemma.

Lemma 3 *Suppose that condition (17) is satisfied. Then, there exists a unique optimal default threshold $\beta^{**}(R)$ such that the government defaults if and only if $\beta \geq \beta^{**}(R)$. The threshold β^{**} is a decreasing function in R and it is an increasing function of α if and only if $R \geq P(Q^m)Q^m - \beta Q^m$ where β is evaluated at β^{**}.*

Proof. See Appendix 2. ■

Importantly, Lemma 3 states that the default threshold β^{**} decreases with repayment levels R. Under symmetric information, the government was able to use the debt and repayment levels to increase its commitment to default firms with bad cost reports. The welfare effect of this strategy was shown to be negative. However, under asymmetric information, this stronger commitment is also the source of a reduction of information rents. By being tougher on higher cost firms, the government is able to reduce the incentives of lower cost firms to mimic the higher cost ones. The detailed discussion of this issue is reported in Section 6.

Finally, because the default structure is the same as under symmetric information, the structure of repayment regimes is also the same. In particular, there exists two repayment levels $\underline{R}$ and $\overline{R}$ such that no firms are defaulted when $R < \underline{R}$, all firms are defaulted when $R > \overline{R}$ and only the firms with cost in the range $(\beta^{**}, \overline{\beta}]$ are defaulted when $R \in [\underline{R}, \overline{R}]$. Those two repayment levels are such that $\beta^{**} = \overline{\beta}$ and $\beta^{**} = \underline{\beta}$ respectively (or equivalently $\Delta W_2(\overline{\beta}, \underline{R}) = 0$ and $\Delta W_2(\underline{\beta}, \overline{R}) = 0$).

We now discuss the debt and equity transfer decision that the government makes in the first stage.

5.2 Debt and equity decisions

In the first stage no party has information about the marginal cost. The government maximizes its expected welfare $E[W_1 + W_2^{**}]$ subject to the firm manager's and creditors' participation constraints: $U_1 \geq 0$ and $E[C_1 + C_2^{**}] \geq 0$ and subject to the output, transfer and default decisions made in the second stage. The discussion follows the similar steps as under symmetric information. We first discuss the creditors' constraint and government's objective under asymmetric information. We then characterize the debt levels acceptable to creditors and the (local) ex-ante welfare optima. We finally discuss the impact of shadow cost of public funds and interbank interest cost.

5.2.1 Government's objective

The government has an incentive to reduce the equity transfer down to the point where the firm manager's first stage participation constraint binds: $U_1 = D + E - K = 0$. This sets the equity level to $E = K - D$ and welfare in the first stage to $W_1 = -(1+\lambda)(K - D)$. The expected welfare in the second stage is given by

$$E[W_2^{**}] = \begin{cases} \int_{\underline{\beta}}^{\overline{\beta}} W_2^0(\beta, Q^{**}, R, D) \;\; g(\beta)\mathrm{d}\beta & \text{if} \quad R < \underline{R} \\ \int_{\underline{\beta}}^{\beta^{**}(R)} W_2^0(\beta, Q^{**}, R, D) \;\; g(\beta)\mathrm{d}\beta + \int_{\beta^{**}(R)}^{\overline{\beta}} W_2^1(\beta, D) \;\; g(\beta)\mathrm{d}\beta & \text{if} \quad \underline{R} \leq R \leq \overline{R} \\ \int_{\underline{\beta}}^{\overline{\beta}} W_2^1(\beta, D) \;\; g(\beta)\mathrm{d}\beta & \text{if} \quad R > \overline{R} \end{cases}$$

Using the definition of ΔW_2 and the linearity of W_2^0 and W_2^1 in D, the ex-ante welfare objective $\mathcal{W}(R,D) \equiv W_1 + E\left[W_2^{**}\right]$ is therefore equal to

$$\mathcal{W}(R,D) = -(1+\lambda)K + [(1+\lambda) - \alpha(1+\rho)]D$$
$$+\begin{cases} \int_{\underline{\beta}}^{\overline{\beta}} W_2^0(\beta, Q^{**}, R, 0)\; g(\beta)\mathrm{d}\beta & \text{if} \quad R < \underline{R} \\ \int_{\underline{\beta}}^{\beta^{**}(R)} \Delta W_2(\beta, Q^{**}, R)\; g(\beta)\mathrm{d}\beta + \int_{\underline{\beta}}^{\overline{\beta}} W_2^1(\beta, 0)\; g(\beta)\mathrm{d}\beta & \text{if} \quad \underline{R} \leq R \leq \overline{R} \\ \int_{\underline{\beta}}^{\overline{\beta}} W_2^1(\beta, 0)\; g(\beta)\mathrm{d}\beta & \text{if} \quad R > \overline{R} \end{cases}$$

It is readily checked that the ex-ante welfare objective $\mathcal{W}$ is a continuous and weakly decreasing function of R. Indeed, β^{**} is a decreasing function of R, W_2^0 and ΔW_2 are linear and decreasing functions of R while $\Delta W_2 > 0$ on the interval $[\underline{\beta}, \beta^{**}]$. Then, $\mathcal{W}(R,D)$ linearly falls for $R < \underline{R}$, non-linearly falls for $\underline{R} \leq R \leq \overline{R}$ and becomes independent of R for $R > \overline{R}$. Intuitively, at any given debt level, higher repayment can only harm the government as it increases costly public transfers to creditors. By contrast, the debt level D raises or reduces the ex-ante welfare objective $\mathcal{W}$ according to whether $(1+\lambda) > \alpha(1+\rho)$ or not. If $(1+\lambda) > \alpha(1+\rho)$, the government benefits from imposing a debt to the state-owned firm. It will do so if this benefit outweighs the cost of higher repayment. However, if $(1+\lambda) < \alpha(1+\rho)$, the government loses from any positive debt and repayment level: it will then never borrow.

Proposition 4 *The government never asks the state-owned company to borrow if* $(1+\lambda) \leq \alpha(1+\rho)$.

When all creditors are domestic ($\alpha = 1$), Proposition 4 simply states that the government prefers to use public funds when its shadow cost is lower than interbank interest rates ($\lambda < \rho$). This is a very intuitive principle of internal-versus-external funding. However, this case for public funding is probably not the most relevant one because shadow costs of public funds often lie above the opportunity costs of capital in interbank markets. For instance, in developed economies, λ is assessed about 0.3, which is lower than a cost of public borrowing of about $\rho = 0.05$. The same is true for less developed countries. In addition, the case for public funding is further weakened in the presence of foreign creditors for which the government gives no social valuation. When all creditors are foreigners ($\alpha = 0$), Proposition 4 does not apply and futher analysis is required. The sequel of the analysis therefore focuses on the case where $(1+\lambda) > \alpha(1+\rho)$.

5.2.2 Creditors' constraint

Repayments are linked to the creditors' participation constraint. In the first stage, the creditors' utility is nil because they lend to the state-owned firm what they borrow from the interbank market: $C_1 = D - D = 0$. Their ex-ante constraint becomes $C_1 + E\left[C_2^{**}\right] = E\left[C_2^{**}\right] \geq 0$ where

$$E\left[C_2^{**}\right] = \begin{cases} \int_{\underline{\beta}}^{\overline{\beta}} \left[R - (1+\rho)\, D\right] g(\beta)\mathrm{d}\beta & \text{if} \quad R < \underline{R} \\ \int_{\underline{\beta}}^{\beta^{**}(R)} \left[R - (1+\rho)\, D\right] g(\beta)\mathrm{d}\beta & \\ \quad + \int_{\beta^{**}(R)}^{\overline{\beta}} \left[\left(P(Q^m) - \beta\right) Q^m - (1+\rho) D\right]\; g(\beta)\mathrm{d}\beta & \text{if} \quad \underline{R} \leq R \leq \overline{R} \\ \int_{\underline{\beta}}^{\overline{\beta}} \left[\left(P(Q^m) - \beta\right) Q^m - (1+\rho) D\right]\; g(\beta)\mathrm{d}\beta & \text{if} \quad R > \overline{R}. \end{cases}$$

This constraint determines the creditors' acceptable debt level $\widehat{D}(R)$ as it follows:

$$\widehat{D}(R) = \frac{1}{(1+\rho)} \begin{cases} R & \text{if} \quad R < \underline{R} \\ RG\left[\beta^{**}(R)\right] + \int_{\beta^{**}(R)}^{\overline{\beta}} \left[\left(P(Q^m) - \beta\right) Q^m\right]\; g(\beta)\mathrm{d}\beta & \text{if} \quad \underline{R} \leq R \leq \overline{R} \\ \int_{\underline{\beta}}^{\overline{\beta}} \left[\left(P(Q^m) - \beta\right) Q^m\right]\; g(\beta)\mathrm{d}\beta & \text{if} \quad R > \overline{R}. \end{cases}$$

The acceptable debt level $\widehat{D}(R)$ is an increasing function for small $R < \underline{R}$ and is independent of R for large $R > \overline{R}$. For $\underline{R} \leq R \leq \overline{R}$, $\widehat{D}(R)$ is monotonically increasing or bell-shaped. Because β^{**} falls with R, the first term of second line of the above expression, $RG\left[\beta^{**}(R)\right]$, is a bell-shaped function of R. It indeed rises from and above $\underline{R}$ as R increases from $\underline{R}$ and then falls to zero as R reaches $\overline{R}$. The second term is a decreasing function of β^{**} and therefore an increasing function of R. The sum of the two terms yields a function that increases for low R and that may increase or decrease for high R. The left panel of Figure 4 depicts four typical possibilities of acceptable debt functions. On the interval $[0, \overline{R}]$, the acceptable debt curve (a) is bell-shaped but lower than curve (b); curve (c) and (d) are monotonically increasing.

INSERT FIGURE 4 HERE

5.2.3 Local welfare maxima

The optimal repayment level maximizes the welfare function $\mathcal{W}\left[R, \widehat{D}(R)\right]$. Because of the linearity of $\mathcal{W}$ with respect to D, the welfare can be broken down as the sum of the welfare at zero debt, $\mathcal{W}\left[R, 0\right]$, and the social value of the acceptable debt $\left[1 + \lambda - \alpha\,(1+\rho)\right]\, \widehat{D}(R)$. This decomposition allows us to discuss the optimal repayment level within each regimes of repayments.

For $R < \underline{R}$, debt is repaid for any cost realization. Then, $\mathcal{W}\left[R, 0\right] = \int_{\underline{\beta}}^{\overline{\beta}} W_2^0\left(\beta, Q^{**}, R, 0\right)\; g(\beta)\mathrm{d}\beta$ is linear in R so that

$$\mathcal{W}\left[R, \widehat{D}(R)\right] = -\left(1+\lambda\right) K - \left(1+\lambda\right) R \frac{\rho}{1+\rho} + \int_{\underline{\beta}}^{\overline{\beta}} W_2^0\left(\beta, Q^{**}, 0, 0\right)\; g(\beta)\mathrm{d}\beta$$

which always strictly falls in R if $\rho > 0$. As a result, provided that $\underline{R} > 0$, a zero repayment and debt levels are always a local welfare maximum if $\rho > 0$. When $\rho = 0$, the repayment is just equal to the reimbursement of debt and creates no social cost so that the debt level is irrelevant to welfare.

For $R > \overline{R}$,

$$\mathcal{W}\left[R, \widehat{D}(R)\right] = -(1+\lambda)K + \frac{(1+\lambda) - \alpha(1+\rho)}{1+\rho} \int_{\underline{\beta}}^{\overline{\beta}} \left[(P(Q^m) - \beta) Q^m\right] g(\beta)\mathrm{d}\beta + \int_{\underline{\beta}}^{\overline{\beta}} W_2^1(\beta, 0) \ g(\beta)\mathrm{d}\beta$$

which is constant. Finally, for $\underline{R} \leq R \leq \overline{R}$, the ex-ante welfare is given by

$$\mathcal{W}\left[R, \widehat{D}(R)\right] = -(1+\lambda)K + \left[(1+\lambda) - \alpha(1+\rho)\right]\widehat{D}(R) + \int_{\underline{\beta}}^{\beta^{**}(R)} \Delta W_2(\beta, R) \ g(\beta)\mathrm{d}\beta + \int_{\underline{\beta}}^{\overline{\beta}} W_2^1(\beta, 0) \ g(\beta)\mathrm{d}\beta \tag{18}$$

The latter expression includes a term in the acceptable debt level $\widehat{D}(R)$, which is increasing or bell-shaped. It also includes the ex-ante welfare value without debt (the other terms), which is a decreasing function of R. Indeed, using the envelop theorem, we get

$$\frac{\mathrm{d}}{\mathrm{d}R}\mathcal{W}[R, 0] = \int_{\underline{\beta}}^{\beta^{**}(R)} \frac{\partial}{\partial R}\Delta W_2(\beta, R) \ g(\beta)\mathrm{d}\beta = -(1+\lambda-\alpha)G(\beta^{**}) < 0 \tag{19}$$

The right panel of Figure 4 displays four possibilities of ex-ante welfare values. The bold curve displays the ex-ante welfare value at zero debt; as state-above, it is a monotonically decreasing function. The curves (a), (b), (c) and (d) represent the ex-ante welfare functions with the different possibilities of acceptable debt. Typically, the ex-ante welfare value falls on the interval $[0, \underline{R}]$, is increasing or bell-shaped on $[\underline{R}, \overline{R}]$ and then constant for $R > \overline{R}$. In example (a), the ex-ante welfare has global maximum at zero repayment R and a local maximum within $[\underline{R}, \overline{R}]$. In this case, the optimal debt D is zero. In examples (b) and (c), the ex-ante welfare has local maximum at zero repayment R but a global maximum at R^{**} within $[\underline{R}, \overline{R}]$ (see in the figure R_b^{**} and R_c^{**}). The optimal debt D is $\widehat{D}(R^{**})$. In example (d), the ex-ante welfare has local maximum at zero repayment R but a global maximum at any $R \geq \overline{R}$. In this case the optimal debt is set at $\widehat{D}(\overline{R})$ such that the state-owned firm always default. This amounts to the government privatizing the state-owned firm ex-ante.

The following Proposition clarifies when the above possibilities can be local equilibria. Let us define

$$\Delta V(\beta) \equiv \left[S(Q) + \lambda P(Q)Q - (1+\lambda)\vartheta(\beta)Q\right] - \left[S(Q^m) + \lambda P(Q^m)Q^m - (1+\lambda)\beta Q^m\right] \tag{20}$$

which expresses the ex-post welfare difference between the state-owned firm at the incentive compatible output and the laissez-faire output. This measure isolates the welfare difference between information and allocative inefficiency. This satisfies $\Delta V(\underline{\beta}) > 0$. Using this, we can write the marginal ex-ante welfare (18) as

$$\frac{\mathrm{d}\mathcal{W}}{\mathrm{d}R} = -\frac{(1+\lambda)\,\rho}{1+\rho}G - \frac{(1+\lambda)-\alpha\,(1+\rho)}{1+\rho}\frac{\Delta V(\beta)}{\Psi(\beta)}g \tag{21}$$

which is evaluated at $\beta = \beta^{**}(R)$ and where

$$\Psi(\beta) \equiv -\left[-(1+\lambda)\vartheta'(\beta)Q^{**} + \alpha Q^m + P'(Q^m)Q^m Q^{m\prime}\right] > 0.$$

The ex-ante welfare increases with repayment at $R = \underline{R}$ if and only if

$$\frac{\Delta V(\overline{\beta})}{\Psi(\overline{\beta})}\frac{g\left(\overline{\beta}\right)}{G\left(\overline{\beta}\right)} < -\frac{(1+\lambda)\,\rho}{(1+\lambda)-\alpha\,(1+\rho)}. \tag{22}$$

Under this condition, ex-ante welfare increases in the interval $(\underline{R}, \overline{R})$. To have a local maximum in this interval, it remains to prove that ex-ante welfare decreases for high enough R. This is shown in the proof of the following proposition.

Proposition 5 *Consider that $(1+\lambda) > \alpha\,(1+\rho)$. Then, (i) a zero repayment and debt level is always a local ex-ante welfare optimum provided that $\rho > 0$ and $\underline{R} \geq 0$. (ii) There exists a local optimal repayment and debt level $(R^{**}, \widehat{D}(R^{**}))$ under condition (22). (iii) There exists no optimal repayment level such that $R \geq \overline{R}$. In other words, the government never uses debt to trigger a privatization ex-ante.*

Proof. See Appendix 3. ■

Proposition 5 gives conditions under which a zero debt and a positive debt are locally optimal. It does not determine which one is the global maximum. The latter is found by comparing the ex-ante welfare without debt and with the optimal repayment and debt $(R^{**}, \widehat{D}(R^{**}))$ where R^{**} is the root of expression (21). In general this task can be performed using specific functional forms of demand and cost distribution and/or numerical simulations.

Note that the optimal repayment R^{**} and its associated ex-ante welfare fall with higher interbank cost ρ. Indeed, one can check that the welfare gradient (21) falls with higher ρ so that a local maximum (when it exists) must occur for lower R^{**} as ρ rises. Also, it can also be checked that the optimal repayment is on the increasing section of the acceptable debt $\widehat{D}(R)$ (see Figure 4). As a result, the optimal debt $\widehat{D}(R^{**})$ falls with higher ρ. So does $\mathcal{W}$. This is intuitive: higher interbank costs make funding more expensive and reduce the attractiveness of debt to government.

Several interesting cases can be highlighted. We discuss the optimal debt level for low interbank borrowing cost and for very high and low of shadow costs of public funds.

5.3 Small interbank lending costs

The interbank cost lending ρ is a key factor in the government's decision to make the state-owned firm borrow. When the state-owned firm is never defaulted, the interbank cost must ultimately be fully financed by tax payers at the social cost λ. It is nevertheless interesting to shut down this channel because it isolates the interactions between the state-owned firm's rent and the surpluses of consumers and creditors. It also considerably simplifies the government's tradeoff and equilibrium analysis while it may be seen as a reasonable simplification as interbank market rates are (historically) negligible compared to costs of public funding in many countries.

When the interbank cost is nil ($\rho = 0$), the ex-ante welfare is constant on the interval $[0, \underline{R}]$ so that a zero repayment and debt can be a global optimum only if ex-ante welfare falls in the interval $[\underline{R}, \overline{R}]$. In the latter, the marginal ex-ante welfare, $\mathrm{d}\mathcal{W}/\mathrm{d}R$, takes the opposite sign of $\Delta V(\beta)$ when $\rho = 0$. If we assume that this function is smooth and changes at most once its sign from positive to negative value, it is apparent that $\mathrm{d}\mathcal{W}/\mathrm{d}R$ is negative for small costs β (because $\Delta V(\underline{\beta}) > 0$) and therefore large repayment levels R and that $\mathrm{d}\mathcal{W}/\mathrm{d}R$ becomes positive for large cost β and small repayment levels R if and only $\Delta V(\beta)$ changes its sign. In this case, R^{**} is the global maximum. If $\Delta V(\beta)$ does not change it sign on the interval $[\underline{\beta}, \overline{\beta}]$ and remains positive, then the ex-ante welfare falls on the interval $[\underline{R}, \overline{R}]$ and the global maximum is $R = 0$. By continuity this conclusion holds for small enough ρ. We summarize and extend this argument in the following proposition.

Proposition 6 *Suppose that there is no interbank cost $\rho = 0$ and that there exists a cost value $\widehat{\beta}$ ($\widehat{\beta} > \underline{\beta}$) such that $\beta \leq \widehat{\beta} \iff \Delta V(\beta) \geq 0$. Then, the state-owned firm takes no debt if $\widehat{\beta} \geq \overline{\beta}$ while, otherwise, it takes a non-zero debt $\widehat{D}(R^{**})$ where R^{**} solves $\beta^{**}(R^{**}) = \widehat{\beta}$. Furthermore, production falls after default. The optimal default threshold $\widehat{\beta}$ falls with higher λ while the optimal repayment R^{**} and debt $\widehat{D}(R^{**})$ increases with λ. The optimal default threshold $\widehat{\beta}$, repayment R^{**} and debt $\widehat{D}(R^{**})$ are independend of α.*

Proof. See Appendix 4. ■

In this setting, the government's trade-off in the borrowing decision is simple. Indeed, it only depends on the value of $\Delta V(\beta)$, which expresses the ex-post welfare difference between operating the state-owned firm at the incentive compatible output and at the laissez-faire output (see (20)). This measure isolates the welfare difference between the information revelation cost and the allocative inefficiency costs resulting from laissez-faire pricing. The government therefore sets the optimal debt level that triggers the default of the firms that create more information inefficiency than allocative inefficiency when defaulted. When $\widehat{\beta} \geq \overline{\beta}$ so that $\Delta V(\beta) \geq 0$ for all β, no state-owned firm creates more information inefficiency than it would generate allocative inefficiency if its price was not controlled for. So, borrowing is more costly for the government and debt is not used for information revelation purpose. By contrast, when $\widehat{\beta} < \overline{\beta}$, the government asks the state-owned firm to take some debt in order to induce liquidation of the higher cost firms for which the information asymmetry creates the strongest distortion.

The impact of shadow costs of public funds on borrowing is easily explained. A higher λ raises government's incentives to reduce subsidies. To diminish transfers and their information rent content, the government makes the state-owned firm default at lower cost realizations. This strategy can be implemented by setting higher repayment and debt levels.

To understand the impact of domestic creditors we must first shed light on the value of repayment levels and on the relationship between state-owned firm's subsidies and default policy. When $\rho = 0$, the repayment level is shown to be equal to the highest profit that creditors can expect after liquidation:

$$R^{**} = \left[P(Q^m(\widehat{\beta})) - \widehat{\beta}\right] Q^m(\widehat{\beta}). \tag{23}$$

Stated differently, creditors always earn more when the state-owned firm is not defaulted. This implies that the government liquidates the state-owned firm to shut the subsidies to this firm. Indeed, the transfer to the marginal state-owned firm $\widehat{\beta}$ is equal to $T(\widehat{\beta}) = R^{**} - \left[P(Q(\widehat{\beta})) - \widehat{\beta}\right] Q(\widehat{\beta}) + U_2(\widehat{\beta})$ where $U_2(\widehat{\beta}) = 0$. That is, $T(\widehat{\beta}) = \left[P(Q^m(\widehat{\beta})) - \widehat{\beta}\right] Q^m(\widehat{\beta}) - \left[P(Q(\widehat{\beta})) - \widehat{\beta}\right] Q(\widehat{\beta})$, which is positive since production falls after defaulting ($Q(\widehat{\beta}) \geq Q^m(\widehat{\beta})$). It is readily checked that transfers are even larger to firms with lower cost realizations. So, although the state-owned firm makes positive operational profits, it requires subsidies to repay the creditors. The government cuts those subsidies by defaulting and privatizing the state-owned firm.

Finally, repayment levels are independent of the share of domestic creditors α. This is consistent with the last statement in Lemma 3 and condition (23). The creditors exactly recoup their foregone repayment when they get the control and cash-flow rights of the marginal state-owned firm with cost β^{**}. However, the government's default decision depends on the social valuation of the domestic creditors' profits at that cost β^{**} (ΔW_2 is a function of α $[R - (P(Q^m) - \beta)\, Q^m]$). Since this profit is nil under condition (23), the default decision does not change with the share of domestic creditors.

5.4 Shadow costs of public funds

The welfare optimal debt level can be characterized in the case of sufficiently low and sufficently high shadow costs of public funds. Those cases allow us to discuss the optimal debt decision when the government faces weak or tough financial constraints ($\lambda \to 0$ and $\lambda \to \infty$). As explained below, the government then puts no weigh either on the social cost of state-owned managers' rents or on the surplus of consumers and creditors.

First, consider small enough shadow cost of public funds, $\lambda \to 0$, while maintaining the condition $(1+\lambda) > \alpha(1+\rho)$. We then get $\vartheta(\beta) = \beta$. Information rents are simple transfers that are not socially costly. So, the firm output becomes $Q(\beta) = Q^e(\beta) > Q^m(\beta)$ and importantly $\Delta V(\beta) = [S(Q^e) - \beta Q^e] - [S(Q^m) - \beta Q^m] > 0$ for all β. So, expression (21) is negative and the optimal repayment level cannot lie in the inverval $[\underline{R}, \overline{R}]$. Since welfare increases with lower R in the range $[0, \underline{R})$, the global optimal repayment is nil. Intuitively, for very low λ, the information rents are not socially costly but the liquidation option creates a welfare loss because it raises consumer prices. So, the government avoids to impose a debt that cause liquidation with a positive probability. Then, since the state-owned firm is never liquidated, it always repays its debt plus the interbank cost, which has a social cost of $\lambda\rho D$ and entices the government not to use the credit market.

Second, consider a very high shadow cost of public funds, $\lambda \to \infty$. In this case, the government maximizes the transfers it can extract from the state-owned firms. The problem is equivalent to the one of the shareholder's delegation, where an uninformed shareholder seeks to extract the maximum dividend from the informed manager of a private firm. Then, we show below that the zero repayment level is never the global ex-ante welfare optimum if

$$1 + \rho < \frac{\int_{\underline{\beta}}^{\overline{\beta}} [(P(Q^m) - \beta)\, Q^m] \;\; g(\beta)\mathrm{d}\beta}{\int_{\underline{\beta}}^{\overline{\beta}} [P(Q^m_\infty)Q^m_\infty - \vartheta_\infty(\beta)Q^m_\infty] \;\; g(\beta)\mathrm{d}\beta} \tag{24}$$

where $\vartheta_\infty(\beta) = \lim_{\lambda\to\infty} \vartheta(\beta) = G(\beta)/g(\beta) > \beta$ and $Q^m_\infty = Q^m[\vartheta_\infty(\beta)] < Q^m(\beta)$. The denominator and numerator of the RHS are respectively equal to the laissez-faire profits with and without information asymmetry in the firms setting monopoly laissez-faire prices. Therefore, the RHS is larger than one and is a measure of the information cost in this firm. As a consequence, condition (24) states that this information cost for a profit maximizing government is more important than the interbank lending cost. In this case, government chooses non-zero debt. The intuition goes as it follows. Since the government seeks to tap money from the state-owned fir, it would like to set the monopoly laissez-faire output and price. Under asymmetric information, it is obliged to distort output and leave information rents, which decreases its transfers (or dividend). When the social cost of such information leakages are lower than the social cost of interbank credit, the government does not borrow. Otherwise, to reduce information costs, it chooses to take a debt level that will trigger the liquidation of high cost firms.

We summarize these results in the following proposition:

Proposition 7 *(i) The state-owned firm never takes debt for small enough shadow cost of public funds. (ii) For high enough shadow cost of public funds, it takes a positive level of debt if (24) holds; that is, if the information cost is more important than interbank lending cost.*

Proof. See Appendix 5. ■

5.5 Linear demand and cost distribution

A formal discussion of the factors underlying the state-owned firm's debt decision is unfortunately difficult when our model is kept to its general specification. We can however get more information about the optimal debt level for the class of a linear demand and uniform cost distributions. For this class, we can restrict attention to $P(Q) = 1 - Q$ and $g(\beta) : [\underline{\beta}, \overline{\beta}] \to \mathbb{R}^+$, $g(\beta) = 1/\left(\overline{\beta} - \underline{\beta}\right)$, with $\overline{\beta} < 1/2$. We study the effects of shadow cost of public funds, creditors' funding cost, share of foreign creditors, firm profitability and cost uncertainty. Throughout this analysis, the acceptable debt level increases with the shadow cost of public funds. This stems from condition (21) and from the fact that the equilibrium repayment is on the increasing section of the acceptable debt curve $\widehat{D}(R)$ (see Figure 4).

Figure 5 depicts the optimal debt level as a function of shadow cost of public funds for various interbank costs and shares of domestic creditors. The left hand panel plots the optimal debt level for interbank funding costs $\rho \in \{0, 0.5, 1\}$ and $\alpha = 1$ and $\beta \in [0, 0.5]$. It shows that the debt level increases at lower interbank funding costs. This is intuitive since cheaper funding cost makes it easier to satisfy the creditors' participation constraint. The right hand panel plots the optimal debt level for share of domestic creditors, $\alpha \in \{0, 0.5, 1\}$ and for $\rho = 0.1$, $\underline{\beta} = 0$ and $\overline{\beta} = 0.5$. It shows that the debt level decreases with higher various shares of domestic creditors. A higher share of local creditors indeed reduces the marginal welfare benefit from larger repayment levels and entices the government to reduce debt repayments. Since the equilibrium repayment is on the increasing section of the acceptable debt curve $\widehat{D}(R)$ (see Figure 4), the optimal debt level falls with a higher share of local creditors.

INSERT FIGURE 5 HERE

Figure 6 presents the relationship between optimal debt and shadow costs for various changes in cost distributions. In the left hand panel, we vary the expected value of marginal cost while keeping its variance constant. In this exercise, marginal costs successively belong to intervals: $[0.1, 0.3]$, $[0.2, 0.4]$ and $[0.3, 0.5]$. Interestingly we observe that optimal debt levels increase with expected costs. Firms with higher expected costs and lower expected profits are thus offered higher optimal debt levels. This can be understood using equation (21), which represents the trade-off between the social cost of raising debt and thus paying debt interest (first term), and the net social benefit of hardening the government's budget constraint (second term).[9] Under uniform cost distributions, an upward shift of the cost interval reduces the cumulative probability $G(\beta)$ and virtual cost $\vartheta(\beta)$ at any β while it keeps the probability density $g(\beta)$ and the derivative $\vartheta'(\beta)$ constant. Therefore the first term of (21) becomes less negative and its second term more positive as it reduces $\Delta V(\beta)$ to further negative values. So, an upward shift of the cost interval decreases the social cost of paying debt interest and increases the net social benefit of hardening the government's budget constraint. As a result, the government raises the optimal repayment and therefore debt level when the state owned firm is expected to have higher costs and lower profits. This summarizes the main point of the paper: Under asymmetric information, the government inflates the debt level of firms that are expected to become inefficient because it helps them to default those firms when they report too high costs and ask for subsidies.

INSERT FIGURE 6 HERE

In the right hand panel of Figure 6, we successively change the marginal cost variance while we maintain a constant average cost at $\beta = 0.25$. In particular, we perform numerical exercises for $\beta \in [0.2, 0.3]$, $[0.1, 0.4]$ and $[0, 0.5]$. For sufficiently high shadow costs, we observe that the optimal debt falls with a higher variance. This can again be rationalized using (21). Under uniform cost distributions, a mean preserving spread of the cost distribution reduces the probability density $g(\beta)$ but does not affect much the cumulative probability $G(\beta)$ on the condition that β is close enough to its mean. Therefore, it leaves the first negative term of (21) unchanged and makes its second term less positive on the condition that $\Delta V(\beta)$ is not too much changed. Under those two conditions, the social cost of paying debt interests roughly remains the same while the net social benefit of hardening the government's budget constraint diminishes. The government then reduces the repayment level and therefore the debt level. When those two conditions are not met, this trade-off is altered and the optimal debt may increases with a higher cost variance. This is the

[9] For any given repayment level R expression (26) is associated with a fixed second period optimal default threshold marginal cost $\beta^{**}(R)$. Here marginal cost mean and variance only affect $G(\beta)$ and $g(\beta)$.

case for low enough shadow costs of public funds. So, the relationship between optimal debt and cost variance is ambiguous.

6 Discussions

It is interesting to outline the role of information asymmetry and shadow cost of public funds on the default decision of the state-owned firm. We then discuss the relationship between debt and investment cost as well as the impact of corporate taxation. We finally brief out some policy recommendations.

6.1 Role of information asymmetry on default decision

What is the effect of asymmetric information on the optimal default threshold? In this model, the information rent is given by

$$\int_{\underline{\beta}}^{\beta^{**}} U_2 g(\beta)\mathrm{d}\beta = -\int_{\underline{\beta}}^{\beta^{**}} \frac{\mathrm{d}U_2}{\mathrm{d}\beta} G(\beta)\mathrm{d}\beta + [U_2 G]_{\underline{\beta}}^{\beta^{**}} = \int_{\underline{\beta}}^{\beta^{**}} Q(\beta) \frac{G(\beta)}{g(\beta)} g(\beta)\mathrm{d}\beta$$

because $U_2(\beta^{**}) = 0$ and $G(\underline{\beta}) = 0$. It increases with larger default thresholds β^{**}. So, the government has an incentive to reduce β^{**} to minimize the social cost of this rent. So, since the default threshold falls with repayments, the government is enticed to raise repayments and thus the level of the associated debt. However, as mentioned above, information costs within the state-owned firm must be balanced with the cost of losing control over prices at the liquidation stage.

We can compare the default thresholds under symmetric and asymmetric information as follows. To make notation more precise, we temporarily denote the welfare differential under symmetric and asymmetric information with a single and double star as $\Delta W_2^* (\beta, R)$ and $\Delta W_2^{**} (\beta, R)$ (see respectively expressions (4) and (16)). Since the welfare differential under asymmetric information $\Delta W_2^{**} (\beta, R)$ falls in β and is zero at $\beta = \beta^{**}$, it must be that $\beta^* > \beta^{**}$ if and only if $\Delta W_2^{**} (\beta^*, R) < 0$. Because $\Delta W_2^*(\beta^*, R) = 0$, we get that $\beta^* > \beta^{**}$ if and only if $\Delta W_2^{**} (\beta^*, R) - \Delta W_2^* (\beta^*, R) < 0$. That is, if

$$\begin{aligned}
&[S(Q^*) + \lambda P(Q^*)Q^* - (1+\lambda)\beta Q^*] - [S(Q^{**}) + \lambda P(Q^{**})Q^{**} - (1+\lambda)\vartheta(\beta)Q^{**}] \\
&\qquad\qquad > \\
&[S(Q^e) - \beta Q^e] - [S(Q^m) - \beta Q^m] + (1-\alpha)[P(Q^m)Q^m - \beta Q^m]
\end{aligned} \tag{25}$$

which is evaluated at $\beta = \beta^*$. The LHS of this inequality is positive and expresses the welfare loss caused by the presence of asymmetric information in the state-owned firm. Asymmetric information distorts output ($Q^{**} < Q^*$) so that the gross surplus falls. It also implies a rent to the state-owned firm (see $\vartheta(\beta)$). The RHS is also positive and reflects the liquidation costs, which encompasses the difference in gross surplus between the efficient and laissez-faire product allocations (two first terms) and the profit leakages to foreign investors (last term). As a result, information asymmetry entices the government to set a lower default threshold β^{**} and therefore to liquidate the state-owned firm more often if the information cost in the state-owned firm outweighs the liquidation cost. If the government had been informed about the exact cost of the liquidated state-owned firm, it could set the price equal to this cost and the output to Q^e so that the RHS would vanish. In this case, the government would set a tougher default threshold that disciplines the cost revelation in the state-owned firm. In general, defaulting is more likely under asymmetric information for larger cost uncertainty (because it increases the virtual cost $\vartheta(\beta)$) and larger share of domestic creditors (higher α), especiallly at high repayment R.

6.2 Role of cost of public funds on default decision

What is the effect of shadow cost of public funds on the optimal default threshold? We first investigate the relationship between information asymmetry and cost of public funds. On the one hand, note that the inequality (25) is never fulfilled at $\lambda = 0$. Indeed, the LHS is nil since $Q^* = Q^{**}$ and $\vartheta(\beta) = \beta$ at $\lambda = 0$. In this case, we get that $\beta^* < \beta^{**}$ so that liquidation is *less* likely in the presence of asymmetric information. Intuitively, for very small shadow costs, the social cost of information asymmetry is so weak that it is dominated by the liquidation costs associated with too high prices and profit leakage to foreign creditors. This gives an incentive to the government to avoid defaulting the state-owned firm. On the other hand, observe also that the inequality (25) is always satisfied for $\lambda \to \infty$ as the LHS tends to positive infinity because $P(Q^*)Q^* - \beta Q^* > P(Q^{**})Q^{**} - \vartheta(\beta)Q^{**}$ as $\lim_{\lambda\to\infty} \vartheta(\beta) > \beta$. In that case, we get that $\beta^* > \beta^{**}$ so that liquidation is *more* likely under asymmetric information. Here, the government is concerned only by its financial position and minimizes the subsidies to the state-owned firm. Because information rents increase such subsidies that partly serve to repay creditors, the government has strong incentives to liquidate the state-owned firm. It is shown in the proof below that the LHS of condition (25) is a monotonically increasing function of λ. This implies that the former and latter situations occur for costs of public funds below and above some threshold $\widetilde{\lambda}$.

We can also discuss how the default decision depends on the cost of public funds. Because λ has no impact on the output of the defaulted firm, the liquidation costs have no direct effect on how β^{**} varies with λ. The government then balances the repayment capabilities against the information rents of the state-owned firm. On the one hand, a higher λ increases the weight of profits in the government's objective so that the latter entices the state-owned firm to set higher prices and collect larger profits. This raises the state-owned firm's repayment capability and increases the cost levels above which default becomes imminent. In this case, β^{**} rises with λ. This effect does not depend on the presence of information asymmetries and corresponds to the result in Lemma 1. On the other hand, a higher λ increases the social cost of information asymmetry and entices the government to reduce information rents by defaulting at smaller production costs. In this case, β^{**} falls with λ. The following proposition formalizes this argument and shows that the former effect dominates for large costs of public funds and the latter for small ones.

Proposition 8 *(i) There exists a default threshold $\widetilde{\lambda}$ such that default is less likely under asymmetric information (i.e. $\beta^{*} \leq \beta^{**}$) if and only if $\lambda \leq \widetilde{\lambda}$. (ii) The default threshold β^{**} can be non-monotone in λ. For instance, when there are only domestic creditors ($\alpha = 1$), default becomes more likely with a rise in λ (i.e. $\mathrm{d}\beta^{**}/\mathrm{d}\lambda < 0$) for small enough λ and less likely (i.e. $\mathrm{d}\beta^{**}/\mathrm{d}\lambda > 0$) for large enough λ.*

Proof. See Appendix 6. ■

6.3 Relationship between debt and investment cost

In our analysis, the optimal debt level $\widehat{D}(R^{**})$ depends on the state-owned firm's ability to meet its repayment commitment R^{**}. This ability is influenced by product demand, cost distribution, interbank lending cost, presence of domestic creditors and shadow cost of public funds. It is however not related to the investment cost K. So, what can be the impact of this cost on our previous discussion?

If the optimal debt level is lower than the investment cost ($\widehat{D}(R^{**}) < K$), the state-owned firm is limited in its ability to raise funds and the government is obliged to contribute to the equity for an amount of $E = K - \widehat{D}(R^{**}) > 0$. In this case our analysis remains the same. By contrast, if the optimal debt level is higher than the investment cost ($\widehat{D}(R^{**}) > K$), the state-owned firm is able to raise more than its investment cost. This leads to two possibilities. On the one hand, the government may have a negative equity position, meaning that it collects $\widehat{D}(R^{**}) - K$ in the first stage and saves on public funding for the same amount. In that case our analysis is also unchanged. On the other hand, the investment cost K may consists of a cap on the borrowing possibilities.

This can be motivated by moral hazard issues that are not modeled here: the infrastructure is the only physical asset that the creditors can seize and that is pledgeable. In a such situation, the optimal debt is constrained to $\widehat{D}(R) = K$. When $\widehat{D}$ is monotonically increasing, this gives the maximum repayment $R = \widehat{D}^{-1}(K)$. The optimal debt and repayment are given by the maximum between $\mathcal{W}(0,0)$ and $\mathcal{W}\left[\widehat{D}^{-1}(K), K\right]$. The introduction of this moral hazard constraint shifts the debt level $\widehat{D}(R^{**})$ either to the positive level $\widehat{D}^{-1}(K)$ or zero. So, a light moral hazard constraint can have dramatic implication on the use of the debt by government.

6.4 Corporate taxes

In most countries, privatized firms are subject to corporate taxes. The introduction of such tax does not change drastically our analysis. Indeed, suppose that the defaulted and privatized firm pays a corporate tax τ. The creditors' benefit C_2 would be reduced by the transfer $T = \tau\left[P(Q) - \beta\right] Q\varphi$ while the welfare would be augmented by the same transfer evaluated at the shadow cost $1 + \lambda$. Under symmetric information, the creditors make no profit from the defaulted firm so the introduction of a corporate tax does not change our analysis. Under asymmetric information, ex-post welfare should be increased by the tax on the privatized firm, $\tau\left(P(Q^m) - \beta\right) Q^m$, evaluated at the shadow cost of public funds corrected for the domestic creditor's utility loss, $1 + \lambda - \alpha > 0$. This amount should be added to (9) and (15). This amount does not change the state-owned firm's optimal output and repayment capabilities. It however makes the decision to default more beneficial to government. So, quite intuitively, the liquidation of the state-owned firm is more likely under corporate taxation. As a result, the government has an additional incentive to increase the repayment levels. However, since the corporate tax reduces profits after default, it diminishes the debt level acceptable by creditors. In Figure 4, the acceptable debt (left panel) falls for $R > \underline{R}$ while the welfare at zero debt (right panel bottom curve) increases. The effect of corporate tax on welfare is therefore a priori ambiguous.

6.5 Policy implications

We have shown that under asymmetric information the government can discipline the state owned firm by imposing a debt contract, which threatens default and privatization when too high costs are reported. From a policy perspective this mechanism can be facilitated in several ways. Firstly, the government should target private creditors with lower interbank funding cost and better ability to acquire information at the liquidation stage. In general, this is helped by international diversification, experience and reputation. On the one hand, this increases the optimal repayment and the acceptable debt level. On the other hand, managerial discipline to reveal costs truthfully can be induced *ex post* after debt contracting. Secondly, it is critical that the government's commitment to default and privatize the firm at high costs be credible. Otherwise the government may decide to bail out the firm at high cost realization, although it may decrease welfare. This can for example be achieved by the debt contract including a prior approval for automatic privatization in case of default.

7 Summary and conclusion

We examine the role of private debt contracts in inducing truthful cost revelation and improving the welfare of state owned firms. In the first stage the government chooses the levels of equity, debt and debt repayment. In the second stage it decides how much output the state owned firm should produce and, in case of too high cost, whether the firm should be defaulted. In the case of liquidation, the government relinquishes ownership to the private creditors. We find that, when the government and the state owned firm share the same information over the firm, debt never improves welfare because the social cost of paying the interest rates required by creditors exceeds the benefit of defaulting. The government therefore never has recourse to external funding. This policy is however qualified when the state-owned firm has private information.

Indeed, debt may enhance welfare when the state owned firm has private information. The government then balances two additional costs: the information cost that must be paid to have the state owned firm truthfully report its costs and the liquidation cost that stems from government's loss of control over production and prices when it defaults and privatizes the state-owned firm. We show that the government sets a lower default threshold and liquidates more often compared to the symmetric information case when information costs exceeds liquidation costs. Also, debt improves welfare if the shadow cost of public funds exceeds the interbank funding rate. The debt contract allows the government to reduce firms' subsidies and information rents by defaulting the firm. We show that the optimal debt level increases when the cost of public funds rises, creditors are more foreign based. The government induces the firm to borrow when fixed cost is low, or combines equity transfers with the optimal debt amount when fixed cost is high.

Our study can be expanded in several ways. We could analyze different types of investors based on their information (dis)advantage post liquidation, their funding and monitoring cost. In case of dispersed groups of bondholders, additional collective action costs can be introduced as well. The latter relate to the more general question of inefficiencies in the bankruptcy process (Gale and Hellwig 1985), or in a subsequent privatization auction (Arozamena and Weinschelbaum (2006, 2009), Burguet and Perry (2007)). These reduce the liquidation profits that creditors can enjoy post privatization. Next, the regulated monopoly setup can be expanded to examine oligopolies, to include only state owned or a combination of state owned and private firms. Furthermore, the government could protect part of the post privatization consumer surplus by introducing appropriate price caps to regulate output and prices after creditors take over.

8 References

Altunbaş, Yener, Alper Kara and David Marqués-Ibáñez. 2009. "Large Debt Financing: Syndicated Loans versus Corporate Bonds", *European Central Bank, Working Paper Series*, 1028.

Arozamena, Leandro, and Federico Weinschelbaum. 2006. "A Note on the Suboptimality of Right-of-First-Refusal Clauses", *Economics Bulletin*, 4:24, pp. 1-5.

Arozamena, Leandro, and Federico Weinschelbaum. 2009. "The Effect of Corruption on Bidding Behaviour in First-Price Auctions", *European Economic Review*, 53, pp. 645-657.

Auriol, Emmanuelle, and Aymeric Blanc. 2009. "Capture and Corruption in Public Utilities: The Cases of Water and Electricity in Sub-Saharan Africa", *Utility Policy*, 17:2, pp. 203-216.

Auriol, Emmanuelle, and Pierre M. Picard. 2009a. "Infrastructure and Public Utilities Privatization in Developing Countries", *The World Bank Economic Review*, 23:1, pp. 77-100.

Auriol, Emmanuelle, and Pierre M. Picard. 2009b. "Government Outsourcing: Public Contracting with Private Monopoly", *The Economic Journal*, 119:540, pp. 1464-1493.

Baron, David P., and Roger B. Myerson. 1982. "Regulating a Monopolist with Unknown Costs", *Econometrica*, 50, pp. 911-930.

Bhattacharya, S., and A. Thakor. 1993. "Contemporary Banking Theory", *Journal of Financial Intermediation*, 3, pp. 2-50.

Birdsall, Nancy, and John Nellis. 2002. "Winners and Losers: Assessing the Distributional Impacts of Privatization", *Center for Global Development, Working Paper No. 6.*

Burguet, Roberto, and Martin K. Perry. 2007. "Bribery and Favouritism by Auctioneers in Sealed-Bid Auctions", *The B. E. Journal of Theoretical Economics*, 7:1, Article 23.

Chang, Ha-Joon. 2007. "State-owned Enterprise Reform", *National Development Strategies Policy Notes, United Nations Department for Economic and Social Affairs (UNDESA)*, New York.

Dell'Ariccia, Giovanni. 2001. "Asymmetric Information and the Structure of the Banking Industry", *European Economic Review*, 45, pp. 1957-1980.

Dewatripont, Mathias, and Jean Tirole. 1994. "A Theory of Debt and Equity: Diversity of Securities and Manager-Shareholder Congruence", *The Quarterly Journal of Economics*, 109:4, pp. 1027-1054.

Estache, Antonio, Vivien Foster, and Quentin Wodon. 2002. "Accounting for Poverty in Infrastructure Reform, Learning from Latin America's Experience", *World Bank Institute Development Studies.*

Faure-Grimaud, Antoine. 2000. "Product Market Competition and Optimal Debt Contracts: The Limited Liability Effect Revisited", *European Economic Review*, 44, pp. 1823-1840.

Frydman, Roman, Cheryl W. Gray, Marek Hessel, and Andrzej Rapaczynski. 1999. "When Does Privatization Work? The Impact of Private Ownership on Corporate Performance in Transition Economies", *The Quarterly Journal of Economics*, 114:4, pp. 1153-1191.

Gale, Douglas, and Martin Hellwig. 1985. "Incentive-Compatible Debt Contracts: The One-Period Problem", *Review of Economic Studies*, LII, pp. 647-663.

Holmstrom, Bengt, and Jean Tirole. 1997. "Financial Intermediation, Loanable Funds, and the Real Sector", *The Quarterly Journal of Economics*, 112:3, pp. 663-691.

James, Cristopher, and David C. Smith. 2000. "Are Banks still Special? New Evidence on their Role in the Corporate Capital-Raising Process", *Journal of Applied Corporate Finance*, 12:4, pp. 8-19.

Kornai, János. 1993. "The Evolution of Financial Discipline Under the Post-socialist System", *Kyklos*, 46:3, pp. 315-336.

Kornai, János. 2000. "Ten Years after 'The Road to a Free Economy': The Author's Self Evaluation", *Working Paper, Harvard University*, Cambridge, MA.

Laffont, Jean-Jacques. 2005. *Regulation and Development.* Cambridge, UK: Cambridge University Press.

Laffont, Jean-Jacques, and David Martimort. 2002. *The Theory of Incentives: The Principal-Agent Model.* Princeton, NJ: Princeton University Press.

Laffont, Jean-Jacques, and Jean Tirole. 1993. *A Theory of Incentives in Procurement and Regulation.* Cambridge, MA: MIT Press.

Leite, Tori. 2001. "Optimal Financial Structure: An Incomplete Contracting Model", *Scandinavian Journal of Economics*, 103:4, pp. 707-722.

Martimort, David, and Stéphane Straub. 2007. "Infrastructure Privatization and Changes in Corruption Patterns", *Working Paper, Toulouse School of Econonomics and University of Edinburgh.*

Megginson, William, and Jeffry Netter. 2001. "From State to Market: A Survey of Empirical Studies on Privatization", *Journal of Economic Literature*, 39, pp. 321-389.

Myers, Stewart C.. 2001. "Capital Structure", *Journal of Economic Perspectives*, 15:2, pp. 81-102.

Povel, Paul, and Michael Raith. 2004. "Financial Constraints and Product Market Competition: Ex ante vs. Ex post Incentives", *International Journal of Industrial Organization*, 22, pp. 917-949.

Sappington, David E. M., and Joseph E. Stiglitz. 1987. "Privatization, Information and Incentives", *Journal of Policy Analysis and Management*, 6:4, pp. 567-582.

Schmidt, Klaus M. 1996. "The Costs and Benefits of Privatization: An Incomplete Contracts Approach", *Journal of Law, Economics and Organization*, 12:1, pp. 1-24.

Shleifer, Andrei. 1998. "State Versus Private Ownership," *Journal of Economic Perspectives*, 12, pp. 133-150.

Spiegel, Yossef, and Daniel F. Spulber. 1994. "The Capital Structure of a Regulated Firm", *The Rand Journal of Economics*, 25:3, pp. 424-440.

Tirole, Jean. 2005. *The Theory of Corporate Finance.* Princeton, NJ: Princeton University Press.

Van Damme, E. 1994. "Banking: A Survey of Recent Microeconomic Theory", *Oxford Review of Economic Policy*, 10, pp. 14-33.

Appendices

Appendix 1: Proof of Lemma 1

First, we show that $\Delta W_2(\beta, R)$ is a decreasing function of β because $(1+\lambda)Q^*$ is an increasing function that takes value above Q^e. Indeed, at $\lambda = 0$, we get $Q^* = Q^e$ for all β. Then, we compute

$$\frac{\mathrm{d}}{\mathrm{d}\lambda}\left[(1+\lambda)Q^*\right] = \lambda Q^* \frac{P''(Q^*)Q^* + 2P'(Q^*)}{\lambda P''(Q^*)Q^* + (1+2\lambda)P'(Q^*)}$$

where both numerator and denominators are negative under the assumption that $P''Q + P' < 0$. So, $\mathrm{d}\Delta W_2/\mathrm{d}\beta < 0$.

Second we show that β^* is a decreasing function of R, while it is increasing in α and λ. First note that $\mathrm{d}\Delta W_2/\mathrm{d}R < 0$ and $\mathrm{d}\Delta W_2/\mathrm{d}\alpha > 0$. Then, $\mathrm{d}\beta^*/\mathrm{d}R = -\left(\mathrm{d}\Delta W_2/\mathrm{d}R\right)/\left(\mathrm{d}\Delta W_2/\mathrm{d}\beta\right) < 0$ and $\mathrm{d}\beta^*/\mathrm{d}\alpha = -\left(\mathrm{d}\Delta W_2/\mathrm{d}\alpha\right)/\left(\mathrm{d}\Delta W_2/\mathrm{d}\beta\right) > 0$. Second, using the envelop theorem, we compute $\mathrm{d}\Delta W_2/\mathrm{d}\lambda = P(Q^*)Q^* - \beta Q^* - R$ where β evaluated at β^*. This is positive at $\beta = \beta^*$ for any $R \geq 0$, since, from $\Delta W_2(\beta^*, R) = 0$, we get

$$P(Q^*)Q^* - \beta Q^* - R = \{[S(Q^e) - \beta Q^e] - [S(Q^*) - \beta Q^*] + (1-\alpha) R\}/\lambda$$

where the RHS is positive because $Q^e \geq Q^*$ and $S(Q) - \beta Q$ is an increasing function for any Q smaller than its maximizer Q^e. Hence, $\mathrm{d}\beta^*/\mathrm{d}\lambda = -\left(\mathrm{d}\Delta W_2/\mathrm{d}\lambda\right)/\left(\mathrm{d}\Delta W_2/\mathrm{d}\beta\right) > 0$.

Appendix 2: Proof of Lemma 3

First, we solve the government's problem (9) under the constraints (10), (11) and (12). We can plug C_2 and the solution of T from the equality (11) to get the government's problem

$$\begin{aligned}\max_{Q(\cdot),\varphi(\cdot),U_2(\cdot)} EW_2 = \int_{\underline{\beta}}^{\overline{\beta}} &\{[S(Q) + \lambda P(Q)Q - (1+\lambda)\beta Q - (1-\alpha+\lambda)R - \lambda U_2](1-\varphi) \\ &+ [S(Q^m) - P(Q^m)Q^m + \alpha\left(\left(P(Q^m) - \beta\right)Q^m\right)]\varphi\}g(\beta)\mathrm{d}\beta \\ - \alpha D(1+\rho)&\end{aligned}$$

subject to (10) and $U_2(\beta) \geq 0$. Let us suppose the same structure of default decision as under symmetric information. That is, there exits a unique β^{**} such that $\varphi(\beta) = 0$ if $\beta \in [\underline{\beta}, \beta^{**}]$ and $\varphi(\beta) = 1$ if $\beta \in (\beta^{**}, \overline{\beta}]$. In this case, by (10), $U_2(\beta)$ falls with $\beta \in [\underline{\beta}, \beta^{**}]$. Since the objective falls in U_2, the government chooses to leave no rent to the high cost in this interval: $U_2(\beta^{**}) = 0$. The participation binds at the highest cost. In addition, the term $U_2(1-\varphi)g$ can be replaced by $Q\frac{G}{g}(1-\varphi)g$. Indeed, for any $\beta \in [\underline{\beta}, \beta^{**}]$, we successively get $\int_{\underline{\beta}}^{\beta^{**}} U_2(1-\varphi)g\mathrm{d}\beta = \int_{\underline{\beta}}^{\beta^{**}} \frac{\mathrm{d}U_2}{\mathrm{d}\beta}G\mathrm{d}\beta + [U_2 G]_{\underline{\beta}}^{\beta^{**}} = \int_{\underline{\beta}}^{\beta^{**}} Q\frac{G}{g}(1-\varphi)g\mathrm{d}\beta + U_2(\beta^{**})G(\beta^{**}) - U_2(\underline{\beta})G(\underline{\beta}) = \int_{\underline{\beta}}^{\beta^{**}} Q\frac{G}{g}(1-\varphi)g\mathrm{d}\beta$ where the last equality holds because $G(\underline{\beta}) = 0$ and $U_2(\beta^{**}) = 0$. So, the government's problem becomes

$$\begin{aligned}\max_{Q(\cdot),\varphi(\cdot)} EW_2 = \int_{\underline{\beta}}^{\overline{\beta}} &\{\left[S(Q) + \lambda P(Q)Q - (1+\lambda)\beta Q - (1-\alpha+\lambda)R - \lambda Q\frac{G}{g}\right](1-\varphi) \\ &+ [S(Q^m) - P(Q^m)Q^m + \alpha\left(\left(P(Q^m) - \beta\right)Q^m\right)]\varphi\}g(\beta)\mathrm{d}\beta \\ - \alpha D(1+\rho)&\end{aligned}$$

Maximizing with respect to $Q(\cdot)$ yields (13). This condition is sufficient given our assumptions on demand $P(Q)$ and cost distribution $G(\beta)$. Finally, we can re-write the problem as

$$EW_2 = \int_{\underline{\beta}}^{\overline{\beta}} \left\{(1-\varphi)W_2^0(\beta, Q^{**}, R, D) + \varphi W_2^1(\beta, D)\right\} g(\beta)\mathrm{d}\beta$$

where $W_2^0(\beta, Q^{**}, R, D)$ and $W_2^1(\beta, D)$ are defined in (14) and (15). The optimal decision to default φ^* maximizes EW_2 pointwise. Under condition (17), $W_2^0(\beta, Q^{**}, R, D) - W_2^1(\beta, D)$ falls in β and crosses zero at some β^{**}. So, the optimal default decision φ^* is 1 for $\beta < \beta^{**}$ and 0 for $\beta > \beta^{**}$, which confirms the structure we have supposed above.

Second, we show that β^* is a decreasing function of R, but increasing in α at high R. First note that $\mathrm{d}\Delta W_2/\mathrm{d}R < 0$ and $\mathrm{d}\Delta W_2/\mathrm{d}\alpha = R - [P(Q^m)Q^m - \beta Q^m]$. Then, by condition (17), $\mathrm{d}\beta^*/\mathrm{d}R = -(\mathrm{d}\Delta W_2/\mathrm{d}R) / (\mathrm{d}\Delta W_2/\mathrm{d}\beta) < 0$ and $\mathrm{d}\beta^*/\mathrm{d}\alpha = -(\mathrm{d}\Delta W_2/\mathrm{d}\alpha) / (\mathrm{d}\Delta W_2/\mathrm{d}\beta) > 0$ if $R > P(Q^m)Q^m - \beta Q^m$.

Appendix 3: Proof of Proposition 5

We here discuss the existence of each candidate of welfare local maximum: $R = 0$, $R^{**} \in [\underline{R}, \overline{R})$ and $R \geq \overline{R}$.

First note that $R = 0$ is always a local (corner) maximum if $\underline{R} > 0$ and $\rho > 0$.

Second, we characterize the local maxima where $R^{**} \in [\underline{R}, \infty)$. By (18), the ex-ante welfare writes as $\mathcal{W}\left[R, \widehat{D}(R)\right] = \mathcal{W}[R, 0] + [1 + \lambda - \alpha(1+\rho)]\,\widehat{D}(R)/(1+\rho)$ for any $R \in [\underline{R}, \overline{R})$. The gradient of this is the weighted sum of the derivative $\mathrm{d}\mathcal{W}[R, 0]/\mathrm{d}R$, given in expression (19), and the derivative $\mathrm{d}\widehat{D}/\mathrm{d}R = (1+\rho)^{-1}\{G(\beta^{**}) - [R - (P(Q^m) - \beta^{**})Q^m]\,g(\beta^{**})(-\beta^{**\prime})\}$. Noting the fact that $\Delta W_2(\beta^{**}, R) = \Delta V(\beta^{**}) - (1 + \lambda - \alpha)[R - (P(Q^m) - \beta^{**})Q^m] = 0$, we can substitute $[R - (P(Q^m) - \beta^{**})Q^m]$ for a term in $\Delta V(\beta^{**})$ and get expression (21). The root of expression (21) yields the local welfare optimum R^{**}.

On the one hand, note that expression (21) is decreasing at $\overline{R}$. Indeed, since $\beta^{**}(\overline{R}) = \underline{\beta}$, we readily get that

$$\left[\frac{\mathrm{d}\mathcal{W}}{\mathrm{d}R}\right]_{\overline{R}} = -\frac{(1+\lambda) - \alpha(1+\rho)}{1+\rho}\frac{\Delta V(\underline{\beta})}{\Psi(\underline{\beta})}g(\underline{\beta})$$

is negative because $\Delta V(\underline{\beta}) > 0$ and $(1+\lambda) - \alpha(1+\rho) > 0$. As a consequence, there exists no optimal repayment level such that $R \in [\overline{R}, \infty)$. Indeed, any repayment levels such that $R \geq \overline{R}$ yields the constant ex-ante welfare $\mathcal{W}\left[\overline{R}, \widehat{D}(\overline{R})\right]$, which, by the last argument, must be smaller than $\mathcal{W}\left[\overline{R} - \varepsilon, \widehat{D}(\overline{R} - \varepsilon)\right]$ where $\varepsilon > 0$ is small enough. It means that the example (d) in Figure 4 is never optimal. It also means that the government never uses the debt to trigger a privatization ex-ante.

On the other hand, there will exist an interior maximum R^{**} in the interval $[\underline{R}, \overline{R})$ if expression

(21) changes its sign from a positive to negative value on this interval. At $R = \underline{R}$, we get

$$\left[\frac{\mathrm{d}\mathcal{W}}{\mathrm{d}R}\right]_{\underline{R}} = -\frac{(1+\lambda)\,\rho}{1+\rho}G\left(\overline{\beta}\right) - \frac{(1+\lambda)-\alpha\,(1+\rho)}{1+\rho}\frac{\Delta V(\overline{\beta})}{\Psi(\overline{\beta})}g\left(\overline{\beta}\right)$$

This will be positive if and only if condition (22) holds. Under this sufficient condition, the ex-ante welfare function increases in R for any R lying close enough to the right of $\underline{R}$. Since it decreases at $\overline{R}$, there must be an interior maximum R^{**} in the interval $[\underline{R}, \overline{R})$. Condition (22) implies that $\Delta V(\overline{\beta})$ should be sufficiently negative. Since only the RHS depends on ρ, we can infer that it is more likely to be satisfied for small interbank costs.

Appendix 4: Proof of Proposition 6

We need to prove the second part of the proposition when $\rho = 0$. First, at $\beta = \widehat{\beta}$, we get $Q(\widehat{\beta}) \geq Q^m(\widehat{\beta})$. Indeed, using (20), $\Delta V(\beta) = 0$ implies $[S(Q) + \lambda P(Q)Q - (1+\lambda)\beta Q] - [S(Q^m) + \lambda P(Q^m)Q^m - (1+$ $= (1+\lambda)\,[\vartheta(\beta) - \beta]\,Q > 0$. Since $S(Q) + \lambda P(Q)Q - (1+\lambda)\beta Q$ is the concave objective function under symmetric information, it increases in Q on the interval $[0, Q^*]$. Since Q^{**} and Q^m are smaller than Q^*, each squared bracket term in the above expression increases in Q. This implies that $Q(\widehat{\beta}) > Q^m(\widehat{\beta})$. Finally, since $Q(\beta) > Q(\widehat{\beta})$ for $\beta < \widehat{\beta}$ and $Q^m(\beta) < Q^m(\widehat{\beta})$ for $\beta > \widehat{\beta}$, production falls after default.

Second, we compute $\mathrm{d}\Delta V/\mathrm{d}\alpha = 0$ and $\mathrm{d}\Delta V/\mathrm{d}\lambda = -\left(\beta + G/g\right)Q - [P(Q^m)Q^m - \beta Q^m] < 0$. Therefore, since $\widehat{\beta}$ solves $\Delta V = 0$, we get $\mathrm{d}\widehat{\beta}/\mathrm{d}\alpha = 0$ and $\mathrm{d}\widehat{\beta}/\mathrm{d}\lambda = -(\mathrm{d}\Delta V/\mathrm{d}\lambda)/(\mathrm{d}\Delta V/\mathrm{d}\beta) < 0$ since $\mathrm{d}\Delta V/\mathrm{d}\beta < 0$ at $\beta = \widehat{\beta}$. So, $\widehat{\beta}$ is independent of α and decreasing with λ. Third, noting the fact that $\widehat{\beta} = \beta^{**}$, $\Delta V(\beta^{**}) = 0$ and $\Delta W_2(\beta^{**}, R) = \Delta V(\beta^{**}) - (1+\lambda-\alpha)\left[R - \left(P(Q^m) - \beta^{**}\right)Q^m\right]$ $= 0$, we get the optimal repayment level $R^{**} = \left(P(Q^m) - \beta\right)Q^m$ where β is evaluated at $\widehat{\beta}$. This means that the repayment level is just equal to the highest profit that creditors can expect after liquidation. So, R^{**} falls with $\beta = \widehat{\beta}$ and therefore increase with λ. Finally, at the equilibrium, the debt level can successively be written as $\widehat{D} = R^{**}G(\widehat{\beta}) + \int_{\widehat{\beta}}^{\overline{\beta}} \left[\left(P(Q^m) - \beta\right)Q^m\right]\; g(\beta)\mathrm{d}\beta = \left\{\left[P\left(Q^m(\widehat{\beta})\right) - \widehat{\beta}\right]Q^m(\widehat{\beta})\right\}G(\widehat{\beta}) + \int_{\widehat{\beta}}^{\overline{\beta}} \left[\left(P(Q^m) - \beta\right)Q^m\right]\; g(\beta)\mathrm{d}\beta$ so that, using the envelop theorem, $\mathrm{d}\widehat{D}/\mathrm{d}\lambda = -\widehat{\beta}' Q^m(\widehat{\beta})G(\widehat{\beta}) + \{[P(Q^m(\widehat{\beta})) - \widehat{\beta}]\; Q^m(\widehat{\beta})\}\; g(\widehat{\beta})\widehat{\beta}' - \{[P(Q^m(\widehat{\beta})) - \widehat{\beta}]Q^m(\widehat{\beta})\}g(\widehat{\beta})\widehat{\beta}'$ $= -\widehat{\beta}' Q^m(\widehat{\beta})G(\widehat{\beta})$, which is positive.

Appendix 5: Proof of Proposition 7

Consider a very high shadow cost of public funds, $\lambda \to \infty$. Then, using $\Delta W_2(\overline{\beta}, \underline{R}) = 0$, the minimum repayment $\underline{R}$ can be computed as $P(Q^m)Q^m - \vartheta(\overline{\beta})Q^m$ where output is evaluated at $Q^m =$

$Q^m\left[v(\overline{\beta})\right]$ and which is positive under our cost assumption about minimum firms' profitability. The local ex-ante welfare maximum at $R=0$ tends to infinity with the slope

$$\begin{aligned}\lim_{\lambda\to\infty}\frac{\mathcal{W}(0,0)}{\lambda} &= -K+\int_{\underline{\beta}}^{\overline{\beta}}\lim_{\lambda\to\infty}W_2^0\left(\beta,Q^{**},0,0\right)\ g(\beta)\mathrm{d}\beta\\ &= -K+\int_{\underline{\beta}}^{\overline{\beta}}\left[P(Q_\infty^m)Q_\infty^m-\vartheta_\infty(\beta)Q_\infty^m\right]\ g(\beta)\mathrm{d}\beta \qquad (26)\end{aligned}$$

where output is evaluated at $Q_\infty^m = Q^m\left[\vartheta_\infty(\beta)\right]$ and $\vartheta_\infty(\beta)=\lim_{\lambda\to\infty}\vartheta(\beta)$. However, using $\Delta W_2(\underline{\beta},\overline{R})=0$, we can compute the maximum repayment $\overline{R}$ as $P(Q^m)Q^m-\underline{\beta}Q^m$ where Q^m is given by $Q^m(\underline{\beta})$ and which is larger than $\underline{R}$. The ex-ante welfare value at $R>\overline{R}$ also tends to infinity with a slope equal to

$$\lim_{\lambda\to\infty}\frac{\mathcal{W}\left[\overline{R},\widehat{D}(\overline{R})\right]}{\lambda} = -K+\frac{1}{1+\rho}\int_{\underline{\beta}}^{\overline{\beta}}\left[\left(P(Q^m)-\beta\right)Q^m\right]\ g(\beta)\mathrm{d}\beta \qquad (27)$$

where output is evaluated at $Q^m=Q^m\left(\beta\right)$. By Proposition 5, the ex-ante welfare value at $R>\overline{R}$ is smaller than the local ex-ante welfare maximum at $R^{**}\in[\underline{R},\overline{R}]$. Therefore, if expression (26) is smaller than (27), the zero repayment level is never the global ex-ante welfare optimum. This gives condition (24).

In the above argument, condition (24) is proved to be sufficient and not necessary. However, it can be shown that $\lim_{\lambda\to\infty}\mathrm{d}\mathcal{W}/\mathrm{d}R=0$ at $R=\overline{R}$. So, under the condition that $\mathrm{d}\mathcal{W}/\mathrm{d}R$ changes its sign only once from positive to negative values, we can infer that the local maximum R^{**} tends to $\overline{R}$ and that $\mathrm{d}\mathcal{W}/\mathrm{d}R>0$ for any $R\in[\underline{R},\overline{R}]$. In this case, the ex-ante welfare rises to $R^{**}=\overline{R}$ so that $\overline{R}$ is a global maximum at the limit where $\lambda\to\infty$.

Appendix 6: Proof of Proposition 8

First, we show that the LHS of (25) is an increasing function of λ. Indeed, using the envelop theorem for variations in Q^* and Q^{**}, the derivative of LHS w.r.t. λ is equal to $[P(Q^*)Q^*-\beta Q^*]-[P(Q^{**})Q^{**}-\beta Q^{**}]+[\vartheta(\beta)-\beta]\,Q^{**}+(1+\lambda)Q^{**}\mathrm{d}\vartheta(\beta)/\mathrm{d}\lambda$, where the difference between the first and second terms is positive and the third and last terms are positive.

Second, we show that the default threshold β^{**} can be non monotone in λ. Because of condition (17), $\mathrm{d}\beta^{**}/\mathrm{d}\lambda=-\,(\mathrm{d}\Delta W_2/\mathrm{d}\lambda)\,/\,(\mathrm{d}\Delta W_2/\mathrm{d}\beta)$ has the same sign as $\mathrm{d}\Delta W_2/\mathrm{d}\lambda$. Using the envelop theorem, we compute

$$\frac{\mathrm{d}\Delta W_2}{\mathrm{d}\lambda}=\left[P(Q)Q-\beta Q-R\right]-\frac{G(\beta)}{g(\beta)}Q$$

where β and Q are evaluated at β^{**} and Q^{**}. The squared bracket term reflects the the reimbursement capacity of the firm. Solving $\Delta W_2(\beta^{**}, R) = 0$ for R and substituting this in the former expression, we get $\mathrm{d}\Delta W_2/\mathrm{d}\lambda \leq 0$ if and only if

$$[S(Q) - \beta Q] - [S(Q^m) - \beta Q^m] \geq (1-\alpha)\left\{[P(Q)Q - (\beta + G/g)\,Q] - [P(Q^m)Q^m - \beta Q^m]\right\}$$

where β and Q are again evaluated at β^{**} and Q^{**}. Note that $S(Q) - \beta Q$ is increasing for $Q < Q^e(\beta)$. So, the RHS is positive if and only if $Q^{**} > Q^m$. So, consider $\alpha = 1$. Then, we get that $\mathrm{d}\Delta W_2/\mathrm{d}\lambda < 0$ if $Q^{**}(\beta) > Q^m(\beta)$. Since $Q^{**}(\beta) = Q^e(\beta) > Q^m(\beta)$ at $\lambda = 0$ and since $Q^{**}(\beta) = Q^m\left[\lim_{\lambda\to\infty} \vartheta(\beta)\right] < Q^m(\beta)$ at $\lambda \to \infty$, $\mathrm{d}\Delta W_2/\mathrm{d}\lambda < 0$ for small λ and $\mathrm{d}\Delta W_2/\mathrm{d}\lambda > 0$ for large λ.

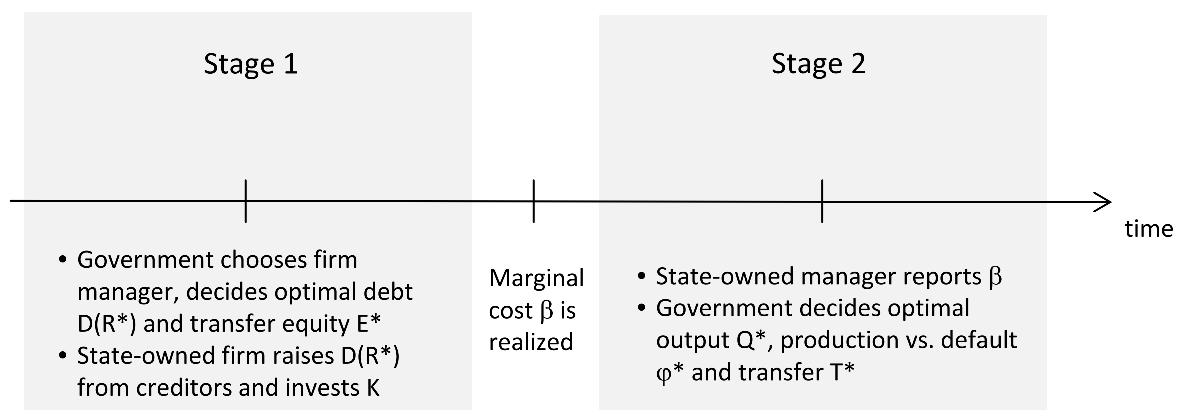

Figure 1: Timing

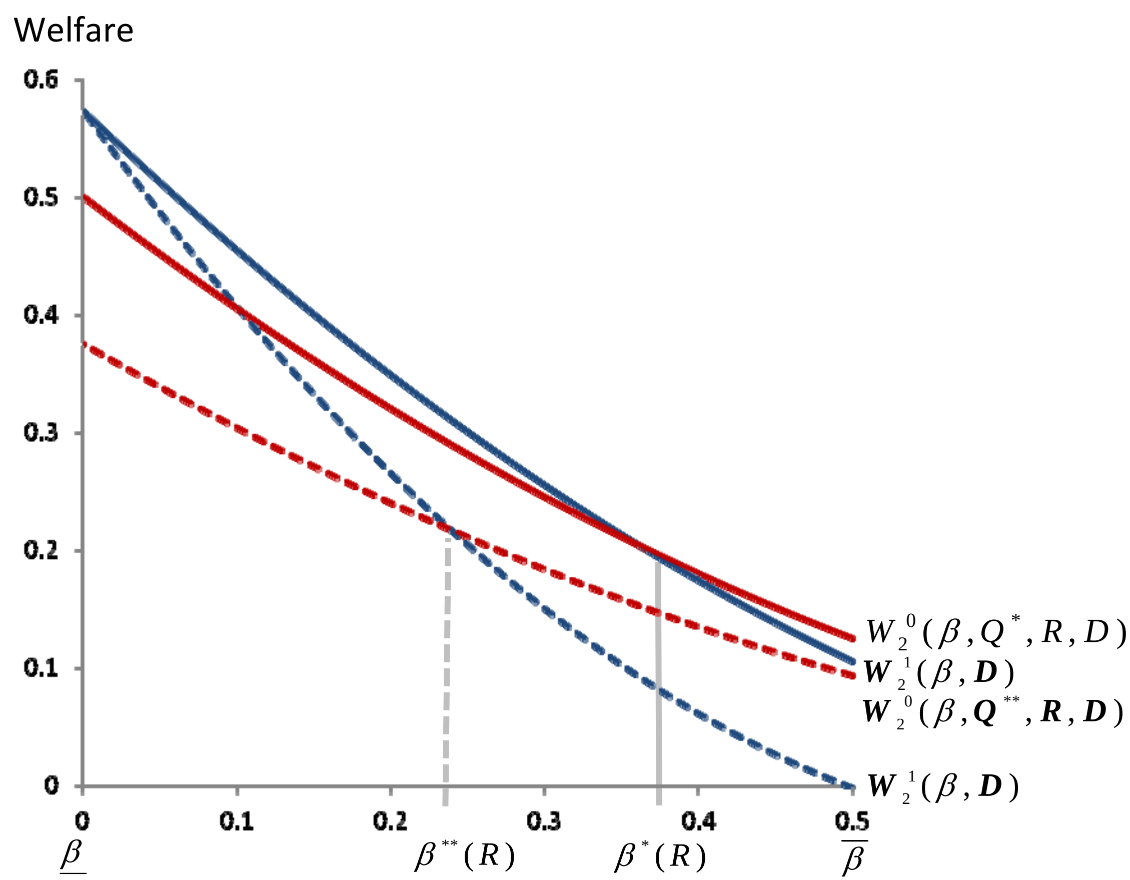

Figure 2: Second stage welfare vs. reported cost

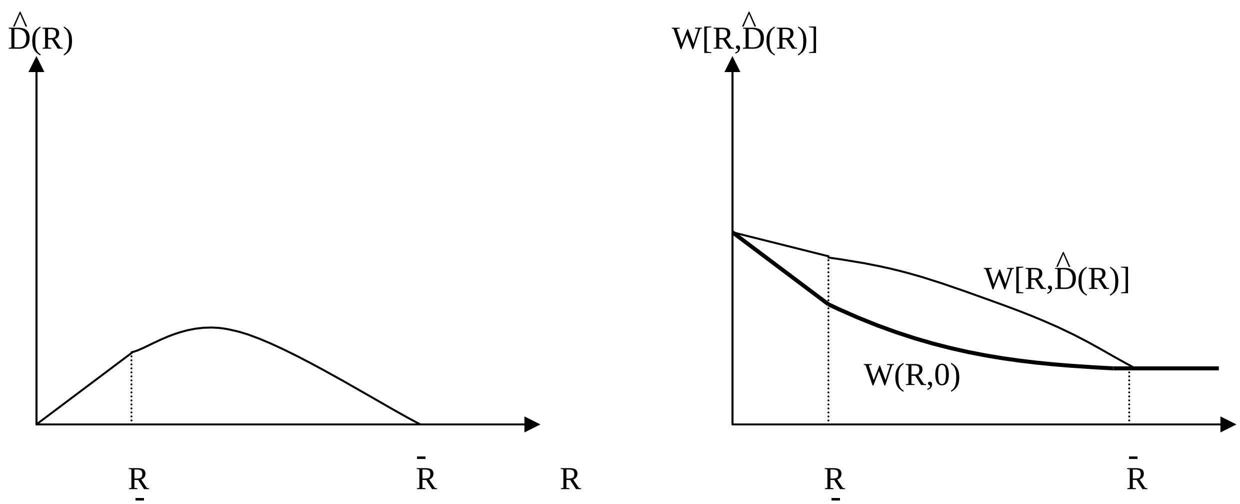

Figure 3: Acceptable debt and ex-ante welfare under symmetric information

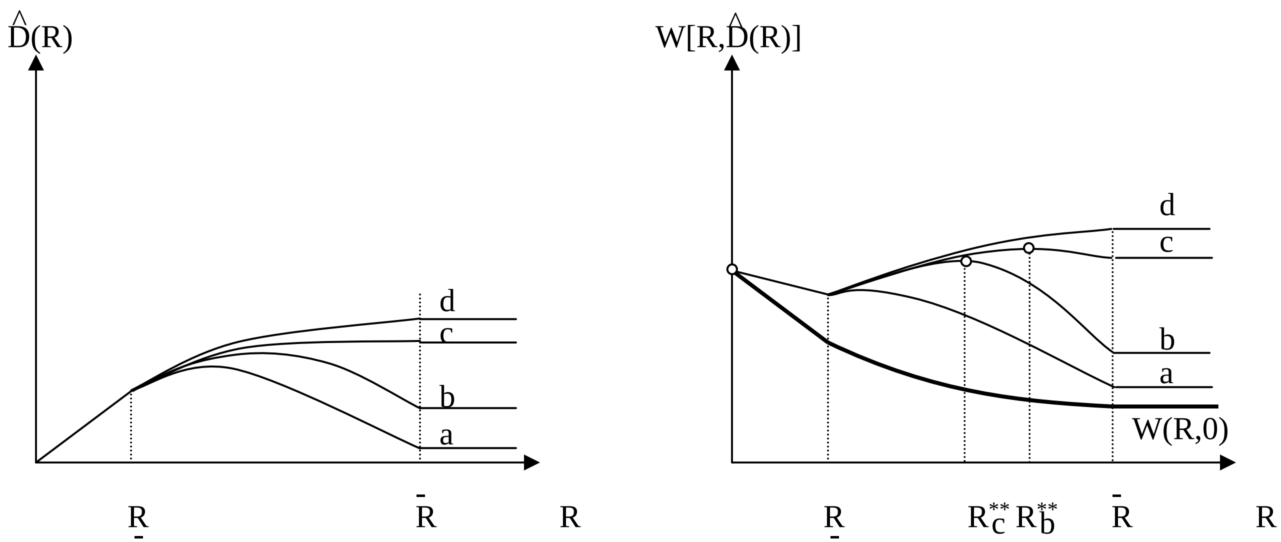

Figure 4: Acceptable debt and ex-ante welfare under asymmetric information

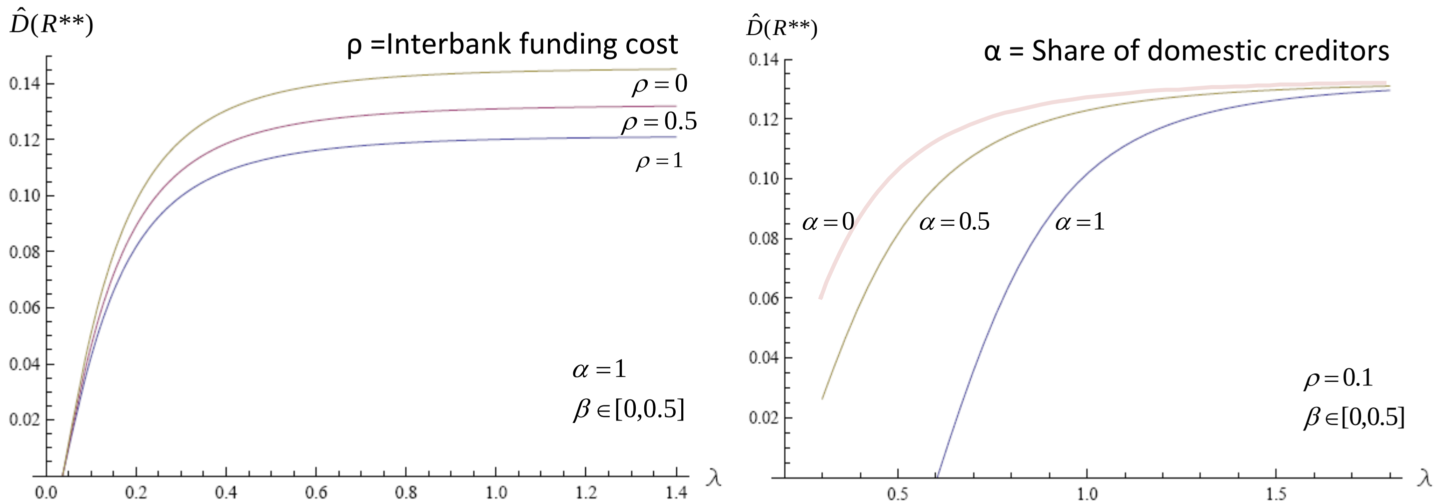

Figure 5: Optimal debt vs. shadow cost

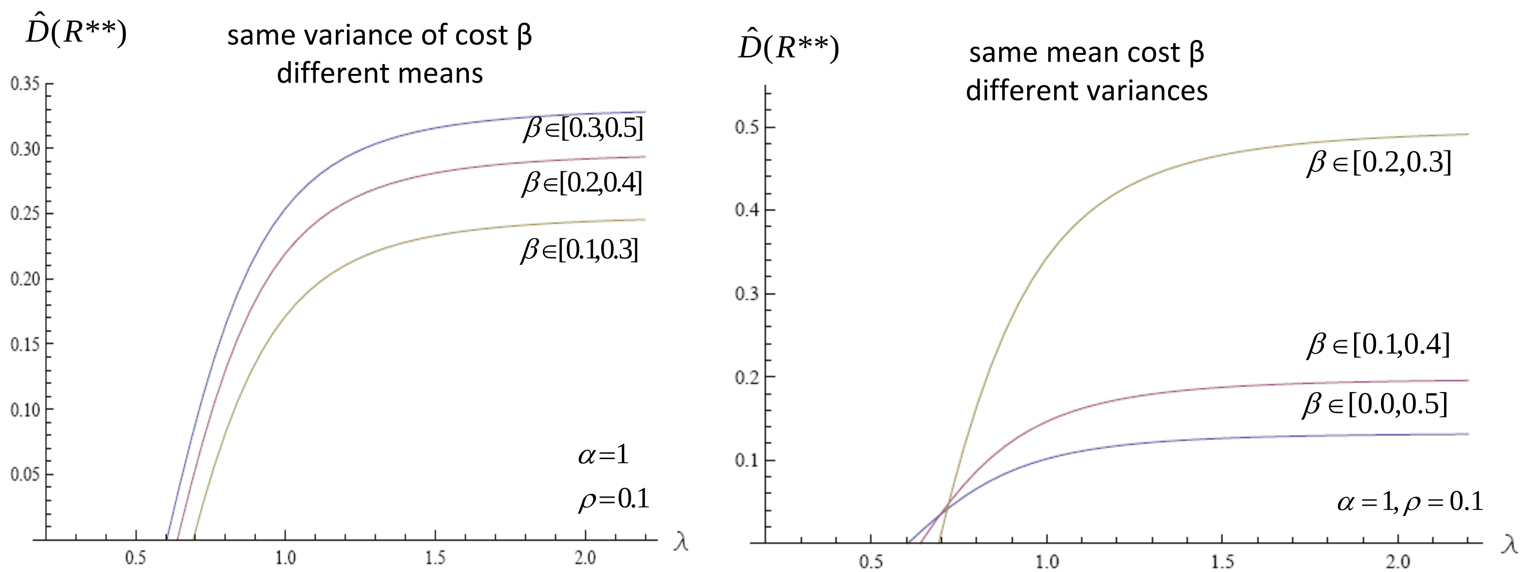

Figure 6: Optimal debt vs. shadow cost