Submission Number: PET11-11-00128

State owned firms: private debt, managerial commitment and welfare

Ridwan D. Rusli
University of Luxembourg

Abstract

A model of regulated monopoly with adverse selection and shadow cost of public funds is used to analyze how private debt financing affects managerial commitment and financing decisions in a state owned firm. Debt increases managerial commitment through the threat of default and privatization. Under symmetric information debt is welfare enhancing only when creditor funding cost and risk premium are low, the firm not too profitable and the fixed cost and debt levels moderate. Under adverse selection and high shadow cost debt is always welfare enhancing and further increases management commitment. This study contributes to the discussion about regulated monopolies (Laffont and Tirole, 1993, Auriol and Picard, 2009), privatization (Megginson and Netter, 2001, Schmidt, 1996, Laffont, 2005, Martimort and Straub, 2007), and the commitment value of debt (Spiegel and Spulber, 1994, Dewatripont and Tirole, 1994, Myers, 2001, Faure-Grimaud, 2000).

Submitted: February 28, 2011.

State Owned Firms: Private Debt, Managerial Commitment and Welfare*

Ridwan D. Rusli†‡

February 28, 2011

Abstract

A model of regulated monopoly with adverse selection and shadow cost of public funds is used to analyze how private debt financing affects managerial commitment and financing decisions in a state owned firm. Debt increases managerial commitment through the threat of default and privatization. Under symmetric information debt is welfare enhancing only when creditor funding cost and risk premium are low, the firm not too profitable and the fixed cost and debt levels moderate. Under adverse selection debt is always welfare enhancing and further increases management commitment.

1 Introduction

We study the interaction between private debt financing, adverse selection and shadow cost of public funds for a state owned firm in a country with tight government budget constraints. We examine two key research questions: How would debt financing affect a state owned firm manager's commitment to reveal cost truthfully? What is the welfare impact of introducing debt into a state owned firm's financing mix?

The privatization of state owned firms is expected to improve efficiency and managerial incentives through increased commercial focus, reduced political opportunism and more complete managerial contracts (Shleifer, 1998). This is in line with the notion of higher degree of moral hazard and less direct accountability of management agents associated with state ownership (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 to the state owned firms. This so-called soft-budget constraint arises because it is often difficult

*JEL classification: L33, G32.

†Center for Research in Economic Analysis (CREA), University of Luxembourg.

‡I thank Pierre M. Picard and Quentin David for valuable comments. All errors are mine.

for governments to discriminate between good and bad projects and managers.[1] Ex post governments are likely to transfer too many resources to firms. Privatization can help harden the budget constraint

However, economists also agree that a legal monopoly should be regulated to prevent wasteful duplication of investments while avoiding welfare loss from monopoly pricing. Governments also perceive the need to intervene in the case of externalities and in the provision of public goods (Megginson and Netter, 2001). Chang (07) argues that state owned firms are necessary in the cases of natural monopolies and positive externalities, failure of capital markets in providing long term finance in developing countries, and for projects with trade-off between profitability and social equity.

Auriol and Picard (2009) find that, when governments face tight budget constraints, maintaining profitable firms as regulated monopolies under state ownership can be welfare enhancing. Firstly, the government is able to take advantage of the positive cash flows and dividends from profitable state owned firms. Secondly, giving up direct control of the firms' operations may result in the loss of consumer surplus due to monopolistic pricing.[2] This has led bduget constrained governments in developing countries to control markets and production in strategic industries through state ownership, and to assume responsibility for such state owned firms' profits and losses.

Our model shows that when private creditors enter into debt contracts with a profitable state owned firm, cost discipline is strengthened and the budget constraint hardened through the threat of default and privatization. This helps mitigate the soft budget constraint and the information asymmetry and contracting problems of state owned companies, while preserving the government's control of the firm's positive cash flows as well as consumer surplus.

We consider a utilitarian government that offers a menu of incentive compatible contracts to the state owned firm. We model the state owned firm as a regulated monopoly. The government faces tight budget constraints and high shadow cost of public funds, as well as an adverse selection problem given the firm manager's private knowledge of the firm's marginal cost.[3] We

[1] See Kornai, 1993 and 2000, Frydman et. al., 1999, on the issue of soft budget constraints.

[2] Empirical evidence shows that output prices of natural monopolies generally increase following privatizations (Birdsall and Nellis, 2002, Estache et. al., 2002). While this can be mitigated through post privatization regulation, there is a tradeoff in terms of lower upfront privatization proceeds and increased asymmetric information between the regulator and the firm. Martimort and Straub (2007) develop a theoretical model on the possible loss of consumer surplus resulting from increased prices due to collusion between a regulator and a private firm.

[3] As in Laffont and Tirole (1993) and Auriol and Picard (2009) our model assumes that the shadow cost

assume that the business is valuable to the government given its profitability, and whenever the shadow cost of public funds is high profitable firms should not be privatized so that the government can enjoy the positive cash flows and shadow profits.[4]

We introduce debt financing from private domestic or foreign creditors. The optimal debt contract is derived endogenously from the government's welfare objective function, the firm's and the creditors' participation constraints. Whenever marginal cost exceeds a certain default threshold level, the firm is privatized. Post default privatization is modeled as the government relinquishing ownership to the creditors, following which the creditor could either appoint a new manager or sell the firm to another private owner. Upon privatization the government allows *laissez faire* monopoly pricing, while creditors and future private owners gain access to firm information.

The expected default and privatization threatens the firm manager and increases her commitment to report costs truthfully. The default threshold decreases and welfare increases when creditors are foreign and the government shadow costs high.

First best (FB) and second best (SB) welfare are compared to the all government transfer financed state owned firm. Under FB symmetric information debt enhances welfare only if creditor funding cost and risk premium are low. If the latter are high, the firm extremely profitable, or the fixed cost and debt levels too low or too high, it is welfare optimal not to raise debt. The government should fund the firm's fixed cost with transfers. Under SB adverse selection debt always improves welfare and further increases managerial commitment. The budget constrained government avoids costly transfers and gains from better informed creditors or owners post privatization.[5]

This paper comprises 5 sections. We summarize the related literature in section 2. The general set-up and model are presented in section 3, followed by an analysis of the various scenarios and comparative statics in section 4. Section 5 discusses policy implications, identifies areas for further research and concludes.

of public funds λ summarizes the tightness of the government budget constraint, whereby larger shadow costs indicate tighter budget constraints and increased opportunity cost of public funds.

[4] We define shadow profit as the government's opportunity gain, calculated as the product between the shadow cost of public funds and the firm's profit.

[5] We focus on adverse selection, while in a moral hazard setting the managerial commitment could be expanded to include cost reducing effort.

2 Literature

Our study contributes to the discussion about regulated monopolies, privatization and the commitment value of debt. In line with the regulation literature of Laffont and Tirole (1993) and Auriol and Picard (2009) we model regulated monopolies with adverse selection and shadow cost of public funds. Auriol and Picard (2009) observe that, despite the benefits of hardened budget constraints and reduced information asymmetry following privatization, maintaining profitable firms as regulated monopolies under state ownership is more welfare enhancing if shadow cost of public funds are high. *We expand their model by introducing private creditors and an endogenously derived debt contract, resulting in various commitment and welfare benefits and tradeoffs.*

The literature on privatization is extensive. Megginson and Netter (2001), Laffont and Tirole (1993), Schmidt (1996), Laffont (2005) and Chang (07) analyze the benefits and costs of state- and private ownership, and the impact of privatization. *We study the case in which state ownership of a profitable monopoly is preferred to private ownership when the government's shadow cost is high. Private debt financing mitigates the soft budget constraint and asymmetric information problems by inducing a higher degree of managerial commitment through the threat of default and privatization. Welfare increases since costly transfers are reduced and average profit increased.*

This study also complements three strands of the debt financing literature. First, studies that interact regulation with a firm's outside investors and capital providers. For example, Spiegel and Spulber (1994) examine the equilibrium price, investment and capital structure of a firm using a sequential model of regulation involving a firm, a regulator and capital market investors. They show that introducing debt financing reduces regulatory opportunism and increases regulated prices, albeit at a finite risk of bankruptcy. *We analyze debt financing of a state owned monopolist, regulated by a government with tight budget constraints and adverse selection problems.*

Secondly, Dewatripont and Tirole (1994), Tirole (2005) and Myers (2001) show that the introduction of short term debt can help commit managers to making investment and other 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 the firm in low profit states and seize control in states

where the manager might otherwise pursue low profit projects. Long term debt on the other hand creates a Myers-like 'debt overhang' that protects the manager from excessive shareholder involvement. *In our model increased commitment is the result of a government-facilitated debt contract, which imposes the threat of default and privatization on the state owned firm manager beyond a threshold marginal cost.*

The third relevant strand of debt literature 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. Faure-Grimaud observes an optimal debt contract comprising a standard fixed repayment structure with limited liability plus a probability of rewards to the firm in an adverse selection setting.[6] Povel and Raith (2004) ensure a close link between debt and investments by introducing variable production costs as the source of asymmetric information. Earnings and output are unobservable to the investor, while the investor can threaten liquidation. Similar to Faure-Grimaud they find that leveraged firms produce lower output than financially unconstrained ones. *We look at how a government makes output decisions to regulate a state owned monopolist that is partially debt financed, in the presence of adverse selection. The optimal regulated output is invariant in the level of debt, and output only decreases under monopoly pricing post default and privatization.*

In summary, none of the previous studies have looked at the interaction between debt financing, adverse selection, monopoly regulation and the government shadow cost of public funds. Our approach allows us to simultaneously address the questions of state owned firm capital structure and debt financing, managerial commitment and the welfare consequences of state- versus private ownership.

3 The model

We consider a profitable state-owned firm in an increasing return to scale and regulated monopoly setting. Government complements its transfers to the firm with debt from domestic or foreign private creditors. We study three parties: the utilitarian government as planner and industry

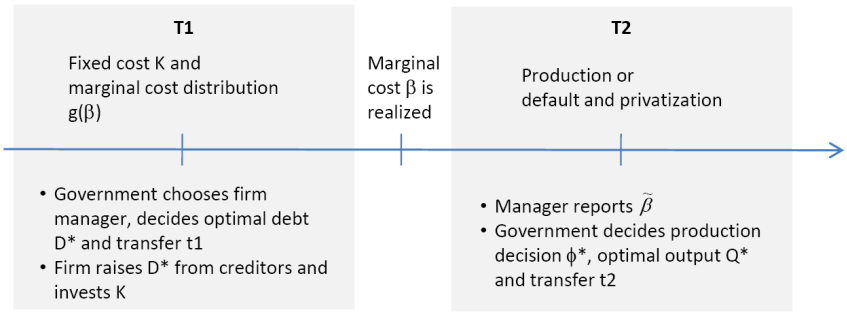
[6] These rewards could encompass additional funding including roll-over of existing debt à la Bolton and Scharfstein (1990), monetary incentives and or the expected release of security collateral upon debt repayment. In the latter case bad states of nature or bad performance would result in the seizing of collaterals, which can be interpreted as bankruptcy or liquidation cost.

regulator, the state owned firm and its manager, and the group of creditors.

3.1 Timing and setup

The basic two-period model setup and timing of decisions are depicted in figure 1.

Figure 1: Timing



First period T1: The government chooses the state owned firm manager. Fixed cost K, the marginal cost distribution $g(\beta)$ and support $\beta \in [\underline{\beta}, \overline{\beta}]$ are known to all parties. The government and the creditors determine the optimal debt level $D^*(\bullet)$ based on expectations of second period T2 marginal cost β and optimal output $Q^*(\beta)$. The firm enters into the debt contract with the creditors, receives the necessary government equity transfer t_1 and invests the fixed cost K. The creditor group could include domestic and foreign debt investors with proportions $\alpha \in [0, 1]$ and $(1 - \alpha)$, respectively.

Second period T2: We assume no time discounting between periods T1 and T2. Following the fixed capital cost investment and production start-up, marginal cost β is realized. The firm manager reports $\widetilde{\beta}$ to the government and the creditors. The government decides whether the firm is viable for production under state ownership and how much additional transfer $t_2(\widetilde{\beta})$ is appropriate. Alternatively, it may consider it optimal to default and privatize the firm. The government production decision $\phi(\widetilde{\beta})$ is a function of reported marginal cost:

$$\phi(\widetilde{\beta}) = \begin{array}{ll} 1 \text{ if } \underline{\beta} \leq \widetilde{\beta} \leq \widehat{\beta} & \text{Production regime} \\ 0 \text{ if } \widehat{\beta} < \widetilde{\beta} \leq \overline{\beta} & \text{Privatization regime} \end{array} . \tag{1}$$

The government determines an optimal default threshold marginal cost $\widehat{\beta}^*$ as the upper limit of the production regime below which state ownership dominates. In the privatization regime, on the other hand, the firm is defaulted and privatized. The creditor hires a new manager or

opts to sell the firm to a private entrepreneur. Post privatization the government allows *laissez faire* monopoly pricing.

3.2 General model

First period T1:

Firm (manager) utility is defined as the firm's profit plus the government transfer, $U_1 = D + t_1 - K$.[7] We assume that the creditors comprise a small group of informed banks, with adequate monitoring technology and incentives. The creditors raise the debt amount D in the interbank, deposit or capital markets, and repay their investors with interest in period T2, $D(1+\mu)$. Creditors lend D to the firm and break even in periof T1, $C_1 = D - D = 0$.

Period T1 welfare comprises firm utility, the utility of domestic creditors and the cost of government transfers including the shadow cost of public funds.[8] We use the fact that transfers are costly to the government. Therefore firm utility is assumed to be zero, $U_1 = 0$, the firm manager's assumed outside option.

As a result, T1 transfer is limited to the portion of fixed cost not funded with debt, $t_1 = K - D$. It includes the opportunity cost to the government of providing positive transfers to the firm i.e. the shadow cost of public funds λ. Thus we multiply t_1 by the factor $(1+\lambda)$. Welfare is thus expressed as $W_1 = U_1 + \alpha C_1 - t_1(1+\lambda) = -(K-D)(1+\lambda)$. Upon rearranging the expression for period T1 welfare obtains:

$$W_1 = D(1+\lambda) - K(1+\lambda). \tag{2}$$

Second period T2:

We distinguish two main cases. The symmetric information case assumes that the government, creditors and the firm observe the realized β in period T2. Thus $\widetilde{\beta} = \beta$. In the adverse selection case only the firm manager observes β, who may report untruthfully, $\widetilde{\beta} \geq \beta$.[9] The government must design the firm's contract such that the regulated firm reveals its private information about β truthfully. By virtue of the revelation principle, this requires that the gov-

[7] The subscripts denote the time periods T1 respectively T2.

[8] Only the utility of domestic creditors is considered in the government's welfare objective function.

[9] The manager of an efficient firm may wish to mimic a less efficient one.

ernment offer information rents to all but the least efficient firms.[10] The government decisions in period T2 include the level of optimal regulated output $Q^*(\beta)$, the decision whether to maintain production under state ownership or to privatize $\phi^*(\beta)$, and how much additional transfer $t_2(\beta)$ to provide.

We initially setup the basic model framework under symmetric information. We model firm production and utility, consumer surplus and the creditor utility function, and in turn total welfare. All parties observe the marginal cost in period T2 and objective functions and constraints will be functions of this realized β. However when government and creditor decisions on debt amount and interest must be made in period T1 i.e. before the marginal cost is realized, the corresponding objective functions and constraints are defined as expectations over the T2 probability distribution of $g(\beta)$.

Firm utility in period T2 comprises the firm's profit plus (minus) any additional positive (negative) government transfers, minus the debt repayment and interest cost. It represents the utility of the firm manager and captures the production regime under state ownership. The firm manager enjoys zero utility once creditors take over and or sell the firm. The production decision function is as defined in (1). Period T2 firm utility is equal to total firm utility since period T1 firm utility was set to zero:

$$U_2(\beta) = \left[\left(P(Q) - \beta\right) Q(\beta) - D(1+r) + t_2(\beta)\right] \phi(\beta). \tag{3}$$

Firm profits are used to repay the debt principal D and interest r. Creditor utility is determined by the period T1 debt raised and their expectations of period T2 debt repayment under state owned production and profit post default and privatization. The creditors' expected utility viewed from period T1 is represented as $EC = C_1 + EC_2$:

$$\begin{aligned} EC \quad = \quad & \int_{\underline{\beta}}^{\overline{\beta}} D(1+r) g(\beta) \phi(\beta) d\beta \\ & + \int_{\underline{\beta}}^{\overline{\beta}} \left(P(Q^p) - \beta\right) Q^p(\beta) g(\beta) \left(1 - \phi(\beta)\right) d\beta \\ & - D(1+\mu) - \pi(D). \end{aligned} \tag{4}$$

[10] This information rent is necessary to induce truthful revelation, which could help mitigate possible cost padding, funds misallocation in state owned and other companies around the world (see Laffont, 2005, Auriol, 2005, Auriol and Blanc, 2009).

The first line represents the production regime. After the creditors have raised and lent the same debt amount in T1, the firm subsequently repays the debt and interest while producing under state ownership in T2. Firm output and prices are regulated to maximize the government's welfare objective function.

The second line describes the privatization regime. It represents the profit gained by the creditors upon taking over the firm. Following default creditors may opt to hire a new manager or sell the firm to a private entrepreneur. In the latter case the full realization of the post privatization profit requires that the sale is efficient. This means that the sale or privatization process is transparent and value maximizing.

The realization by the creditors of this value post privatization hinges on the assumption that there is symmetric information between the creditors or the future private owner with the future firm manager. Lenders such as banks with sophisticated monitoring technology and industry expertise are generally better informed than the government. Coupled with the monitoring role and information advantage of banks, in our model creditors only gain access to the firm's cost information *post privatization*.[11] The superscript p denotes the regulatory regime that the government may subject the privatized firm to following privatization, whereby $p \in \{monopoly, competition, regulation)$. We assume that the government chooses to allow monopolist behaviour post privatization.

The term $-D(1+\mu)$ arises out of the creditors' need to raise the amount to be lent. It is the cost of repaying the amount which the creditors raised in the interbank, deposit or capital markets prior to lending to the firm. Mathematically it is also equivalent to an outside option for the creditors, in which case μ could be defined as the rate of return that creditors can earn from other investments of comparable risk.

The last term $\pi(D)$ represents the risk premium required by risk averse creditors to satisfy their participation constraints, $EC \geq 0$. Menezes and Hanson (1970) define the risk premium as the amount by which the expected value of the risk to the creditors, in this case the expected debt repayment and profit post privatization, must exceed their cash equivalent i.e. the initial loan investment and cost of funding. The risk premium increases at higher levels of debt and

[11] We assume that the creditors comprise a small group of informed banks, with adequate monitoring technology and incentives. 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.

with increased volatility of marginal costs, because of the increased risk of default. Thus a simplified expression for the risk premium can be formulated:

$$\pi(D) = kD\sigma_{\beta}^2. \tag{5}$$

where k is a constant and σ_{β}^2 is the variance of $\beta \in [\underline{\beta}, \overline{\beta}]$ with distribution $g(\beta)$.[12] We assume a creditor utility function with a risk aversion coefficient increasing in the amount of debt lent to the firm, thus $\frac{\partial \pi}{\partial D} = k\sigma_{\beta}^2 > 0$.[13] [14]

Net consumer surplus is defined as the gross consumer surplus minus the price consumers pay, all of which are functions of output and therefore marginal cost. Depending on the government production decision it encompasses both the production and privatization regimes. Without loss in generality we assume concave consumer surplus and demand throughout this paper.[15] The consumer surplus is realized only in the second period T2, and comprises both the state owned production- and privatization regimes:

$$V_2(\beta) = \left[S(Q) - P(Q)Q(\beta)\right]\phi(\beta) + \left[S(Q^p) - P(Q^p)Q^p(\beta)\right](1 - \phi(\beta)). \tag{6}$$

The period T2 government welfare combines firm utility, consumer surplus, the domestic fraction of creditor utility, as well as the T2 cost of government transfers including shadow cost:

$$W_2(\beta) = U_2(\beta) + V_2(\beta) + \alpha EC_2 - t_2(\beta)(1 + \lambda).^{16}$$

Only the domestic proportion α of creditor utility is accounted for by the government. This expression can be expanded using (3), (4), (5) and (6), by expressing the transfers through rearranging (3) and adding period T1 welfare (2) to yield total welfare from the perspective of period T1, $EW = W_1 + EW_2 = \int_{\underline{\beta}}^{\overline{\beta}} \left[U(\beta) + V(\beta) - t_2(\beta)(1 + \lambda)\right] g(\beta) d\beta + \alpha EC$:

[12] The variance σ_{β}^2 is calculated as $\frac{1}{(\overline{\beta} - \underline{\beta})} \int_{\underline{\beta}}^{\overline{\beta}} (\beta - E(\beta))^2 g(\beta) d\beta$ where $E(\beta) = \frac{1}{(\overline{\beta} - \underline{\beta})} \int_{\underline{\beta}}^{\overline{\beta}} \beta g(\beta) d\beta$.

[13] See Menezes and Hanson (1970) and Pratt (1964) for discussions on various types of risk aversion and risk premia. Risk neutral creditors do not require this risk premium.

[14] We simplify and assume constant marginal cost variance. A more formal treatment would define the variance as a function of the default threshold, and in turn on the debt level.

[15] This drives the behaviour of optimal output. See Appendix 1.

[16] We simplify dependent-variable designations, e.g. we drop β, λ whenever no ambiguity results.

$$
\begin{aligned}
EW \;=\;& D(1+\lambda) - K(1+\lambda) \\
&+\int_{\underline{\beta}}^{\overline{\beta}} \left[S(Q) + \lambda P(Q)Q(\beta) - \beta Q(\beta)(1+\lambda)\right] g(\beta)\phi(\beta)d\beta \\
&-\int_{\underline{\beta}}^{\overline{\beta}} D(1+r)(1-\alpha+\lambda)g(\beta)\phi(\beta)d\beta - \int_{\underline{\beta}}^{\overline{\beta}} \lambda U_2(\beta)g(\beta)\phi(\beta)d\beta \\
&+\int_{\underline{\beta}}^{\overline{\beta}} \left[S(Q^p) - (1-\alpha)P(Q^p)Q^p(\beta) - \alpha\beta Q^p(\beta)\right] g(\beta)\left(1-\phi(\beta)\right) d\beta \\
&-\alpha D(1+\mu) - \alpha k D\sigma_\beta^2.
\end{aligned} \tag{7}
$$

A few observations are noteworthy. T1 welfare in represented by the first line. Debt raising produces a positive welfare effect through the government's opportunity gain of lower initial transfers. Nevertheless the fixed capital investment made by the state owned firm includes the shadow cost of public funds.

The second and third lines in (7) describe consumer surplus, firm and creditor utility under state ownership. Within the production regime part or all of the firm profits are used to repay the debt and interest. The third line comprises two parts. The debt repayment term $-D(1+r)(1-\alpha+\lambda)$ includes the government shadow cost. It is reduced by the fraction of domestic creditors whose utility is included in the government objective function. The negative term $-\lambda U_2(\beta)$ shows that leaving residual utility to the firm is costly to the government.

The fourth line represents consumer surplus and domestic creditor utility after the creditors take over or sell the company. Both depend on the government's choice of post privatization regulation p, which in our case is *laissez faire* monopoly. The creditor funding cost and risk premium term in the fifth line are adjusted for the fraction of domestic creditors.

In the following sections we derive the government welfare maximization decisions under various assumptions. Whenever practical we use the envelope theorem for the optimization problems and or the implicit function theorem to examine the marginal effect of changes in parameter and variable values.[17] Section 3.3 describes the symmetric information case, section 3.4 the asymmetric information with adverse selection. The corresponding propositions and comparative statics are presented.

[17] See the mathematical appendix of Mac-Collell, Whinston, Green (1995).

4 Scenario analysis

4.1 Symmetric information case

First Best (FB) welfare EW^* is defined using (7). Under symmetric information all parties including the government, the creditors and the firm observe the true β realized in period T2. The government's objective function for this FB case is:

$$\begin{aligned} \{Q_2^*(\beta), \phi_2^*(\beta), D_1^*(\bullet)\} &= argmax_{\{Q,\phi,D\}} EW^* \\ &\text{subject to} \\ U_2(\beta) &\geq 0 \\ EC &\geq 0. \end{aligned} \tag{8}$$

The government determines the optimal regulated output for the firm, the limits of the production regime and the post-default privatization regime, and the optimal debt level. The participation constraints of the firm, the consumers and the creditors must be fulfilled. Since government transfers are costly and the firm's outside option is normalized to zero the firm is given zero rent in both periods and $U_2(\beta) = 0$ and $U_1 = 0$. We assume that consumer surplus must be positive and that creditors will lend as long as their participation constraint is satisfied, $EC = 0$.

Optimal regulated output

The government optimizes period T2 output by applying the first order condition (FOC) on period T2 welfare with respect to output:

$$\frac{dW_2^*(\beta)}{dQ} = S'(Q^*) + \lambda \left[P'(Q^*)Q^*(\beta) + P(Q^*)\right] - \beta(1+\lambda) = 0. \tag{9}$$

The FOC holds at the optimal regulated output $Q^*(\beta, \lambda)$.[18] Since the government is not in control of the firm post default and privatization, Q^* is only determined over the production regime. Since the debt level is fixed in period T1, $\frac{dD}{dQ} = 0$ in period T2.[19] The optimal output maximizes total welfare and decreases with marginal cost as well as the shadow cost. This

[18] While $Q(\beta, \lambda)$ is a function of both marginal- and shadow costs, we simplify and use $Q(\beta)$ or Q whenever appropriate and unambiguous.

[19] The same invariance of output with regard to debt is obtained using the implicit function theorem. See Appendix 1.

is intuitive. Higher marginal cost levels need to be compensated by lower output to ensure sufficient profitability of the firm. This becomes more important when shadow costs are high, when the state owned firm's profit becomes more valuable and government transfers more costly compared to consumer surplus (see Appendix 1).[20]

Production versus default and privatization decision

The government makes the production and ownership decision by applying the FOC with respect to $\phi(\beta)$ on period T2 welfare:

$$\begin{aligned}\frac{dW_2^*(\beta)}{d\phi} &= [S(Q^*) + \lambda P(Q^*)Q^*(\beta) - \beta Q^*(\beta)(1+\lambda) - D(1+r)(1-\alpha+\lambda)] \\ &\quad - [S(Q^p) - (1-\alpha)P(Q^p)Q^p(\beta) - \alpha\beta Q^p(\beta)] = 0. \end{aligned} \tag{10}$$

We find that the FOC holds at a unique marginal cost level. We define this level as the FB default threshold marginal cost $\widehat{\beta}^*(D, r, \alpha, \lambda)$. The default threshold determines the level of marginal cost that drives the optimal production decision function. At $\widehat{\beta}^*$ respectively $\phi(\widehat{\beta}^*)$ period T2 welfare under state ownership is equal to welfare following default and privatization.

The default threshold divides the marginal cost range into the two regimes defined in (1): the lower marginal cost production regime spanning $\underline{\beta} \leq \beta \leq \widehat{\beta}^*$ within which production under state ownership achieves higher welfare, and the higher cost privatization regime covering $\widehat{\beta}^* < \beta \leq \overline{\beta}$ where default and privatization are more welfare enhancing. The government uses the default threshold to decide whether to produce under state ownership, or to default and privatize the firm. This avoids costly transfers whenever the marginal cost realized in period T2 is higher than the default threshold.

It should be noted that when the firm is highly profitable the default threshold may exceed the upper bound marginal cost level, $\widehat{\beta}^* \geq \overline{\beta}$. In this case the debt level must exceed a certain minimum level, D^{mm}, before the default threshold starts separating the production from the privatization regimes. In other words, if the firm is highly profitable raising too little debt is not beneficial to the government. The firm will never be defaulted and managerial commitment remains unchanged.[21]

[20] Auriol and Picard (2009) use a linear demand function $P = a - bQ$ and find that the optimal regulated output under symmetric information, $Q^* = \frac{(a-\beta)}{b}\frac{1+\lambda}{1+2\lambda}$, decreases with β and λ.

[21] We show later that welfare actually decreases at low fixed cost and debt levels as creditors must be compensated to lend to the firm.

We show in Appendix 2 that the default threshold decreases with increasing levels of debt:[22]

$$\frac{d\widehat{\beta}^*}{dD} = -\frac{(1+r)(1-\alpha+\lambda)}{[Q^*(\beta)(1+\lambda)-\alpha Q^p(\beta)]} < 0. \tag{11}$$

Since the default threshold decreases with debt, the feasible debt level must have an upper bound since the default threshold can not fall below the lower bound marginal cost. There exists a maximum debt level D^{max} such that $\widehat{\beta}^*(D^{max*}) = \underline{\beta}$. Beyond D^{max*} the balance of the firm's fixed cost should be financed with government transfers.

At any given debt level the default threshold increases when more creditors are domestic, but decreases at higher shadow costs. The intuition is as follows. Since the utility of domestic creditors enters the welfare objective function, the government maintains state ownership up to a higher default threshold. Accepting lower firm profits under state ownership is compensated by incremental benefits in creditor utility as default is delayed to higher thresholds. In the case of higher shadow costs, on the other hand, maintaining state ownership is costlier and it is welfare optimal to default and privatize the firm at a lower threshold marginal cost.

From a modelling standpoint, we are now able to substitute $\phi(\widehat{\beta})$ by its value into the integration border $\widehat{\beta}$. For example, the creditor utility function (4) can now be rewritten as:

$$EC = -D(1+\mu) - kD\sigma_\beta^2 + \int_{\underline{\beta}}^{\widehat{\beta}^*} D(1+r)g(\beta)d\beta + E\Pi^{p*}(D) \geq 0, \tag{12}$$

where we have introduced the definition of the expected profit of creditors post privatization, $E\Pi^{p*}(D) = \int_{\widehat{\beta}^*}^{\overline{\beta}} \left(P(Q^p) - \beta\right) Q^p(\beta) g(\beta) d\beta$.[23] The firm repays the debt and interest at low levels of marginal cost, but is defaulted and privatized at marginal cost levels beyond the default threshold.

Optimal debt level

In period T1 the government chooses the debt level by taking into account periods T1 and T2 welfare, $\frac{dEW^*}{dD} = \frac{dW_1}{dD} + \frac{dEW_2}{dD}$. We utilize the envelope theorem and examine $\frac{dEW_2}{dD} = \frac{\partial EW_2}{\partial D}$

[22] It is noteworthy that under low creditor funding cost and risk aversion the endogenous interest rate could turn negative at higher debt levels. The reason is that creditors enjoy high monopoly profits post privatization. However we assume positive interest throughout because creditors always have outside investment i.e. lending options that offer positive returns.

[23] References to creditors include future private owners in case of a post privatization sale by creditors.

at the optimal $Q^*(\beta, \lambda)$ and $\widehat{\beta}^*$. Differentiating with respect to debt we obtain:

$$\begin{aligned} \frac{dEW^*}{dD} &= (1+\lambda) - \int_{\underline{\beta}}^{\widehat{\beta}^*} (1+r)(1-\alpha+\lambda)g(\beta)d\beta - \alpha(1+\mu+k\sigma_\beta^2) \qquad (13) \\ &= (1-\alpha+\lambda)[1 - \int_{\underline{\beta}}^{\widehat{\beta}^*} (1+r)g(\beta)d\beta] - \alpha(\mu+k\sigma_\beta^2). \end{aligned}$$

In a competitive and liquid lending market one could assume that the debt interest r is exogenously given. Applying the FOC on (13) and assuming an exogenous interest rate r^{exo} indicates a minima in the convex welfare function at $G(\widehat{\beta}^*(D^{\min,exo})) = \frac{(1-\alpha+\lambda)-\alpha(\mu+k\sigma_\beta^2)}{(1-\alpha+\lambda)(1+r^{exo})}$.[24] More pertinent, however, is the question about the slope and the shape of the welfare function if interest rates are determined endogenously.

It is often the case that state owned firms in developing countries only have a few potential domestic or foreign creditors to raise debt from. These firms could be attractive potential borrowers, but the country's credit rating only feasible to a few large domestic and selected international lenders. In such cases the state owned firm, on its own or with government assistance, negotiates the debt contract with the creditors.

The debt contract and the interest r are therefore endogenously determined using the creditors' participation constraint. The latter is defined by setting (12) equal to zero, the creditors' assumed outside option:

$$EC = -D(1+\mu) - kD\sigma_\beta^2 + D\int_{\underline{\beta}}^{\widehat{\beta}^*} (1+r)g(\beta)d\beta + E\Pi^{p*}(D) = 0, \qquad (14)$$

and by substituting into (13) we obtain

$$\frac{dEW^*}{dD} = (1-\alpha+\lambda)\frac{E\Pi^{p*}(D)}{D} - (1+\lambda)(\mu+k\sigma_\beta^2). \qquad (15)$$

We observe that the slope of the welfare function is negative at low levels of debt due to the creditor funding cost and risk premium. The welfare function is convex and reaches a minima at $D^{\min}$.[25] This minima shifts to higher debt levels the more profitable the firm is. Two possible cases exist at debt levels below the minima $D^{\min}$. The first case is a consequence of the fact that at high profitability the default threshold could remain above the upper bound marginal cost at low debt levels. Within this range of low debt $D \leq D^{mm}$ and correspondingly high default threshold $\widehat{\beta}^* \geq \overline{\beta}$ creditor profits $E\Pi^{p*}(D) = 0$ are zero because the firm will never be privatized.

[24] Since $\frac{d\widehat{\beta}^*}{dD} < 0$ the second derivative $\frac{d^2EW^*}{dD^2} = -(1-\alpha+\lambda)(1+r^{exo})g(\widehat{\beta}^*)\frac{d\widehat{\beta}^*}{dD} > 0$ is positive at constant r (See Appendix 3).

[25] We show in Appendix 3 that the welfare function is convex with regard to debt.

The second case is when the welfare slope starts increasing as post privatization profit becomes positive, $E\Pi^{p*}(D) > 0$, but is still negative because $D^{mm} < D < D^{\min}$. It should be noted that, at high creditor funding cost and risk premium the welfare slope could remain negative throughout and debt financing could reduce welfare at all debt levels.

Beyond $D^{\min}$ the welfare slope turns positive. However it is not until a breakeven debt level $\widetilde{D}^*$ that welfare with debt financing becomes equal and starts surpassing the zero debt welfare benchmark. Thus debt becomes welfare enhancing at $D > \widetilde{D}^*$.

The required fixed cost investment, which is to be funded partially or entirely with debt, could lie within the range of debt levels from zero; through the minimum debt level where the default threshold falls below the upper bound marginal cost D^{mm} such that $\widehat{\beta}^*(D^{mm}) = \overline{\beta}$; the welfare minima $D^{\min}$; a breakeven debt level $\widetilde{D}^*$ such that welfare with debt financing starts exceeding the zero debt welfare level i.e. where $EW^*(\widetilde{D}^*) = EW^*(0)$; up to the maximum debt $D^{\max *}$; or beyond this target range:[26]

$$K \in [0 \leq D^{mm} < D^{\min} < \widetilde{D}^* \leq D^{\max *}].$$

The range of welfare enhancing optimal debt levels is therefore bounded in accordance with $D^* \in [\widetilde{D}^*, D^{\max *}]$. Whenever the fixed cost level K is moderate and lies within this range, it is welfare enhancing to fund the entire fixed cost with debt. If $K \geq D^{\max *}$, only a portion of the fixed cost up to $D^{\max *}$ can be funded with debt. The rest needs to be funded with transfers.[27] On the other hand if K is too low at $K < \widetilde{D}^*$, the government should not raise debt. The firm's fixed cost should be funded with transfers.

Applying the implicit function theorem on (14) we find that the endogenous interest rate r increases with debt (see Appendix 3). The interest rate r satisfies the creditor participation constraint:

$$(1 + r^*(D)) = \frac{1}{G(\widehat{\beta}^*(D))}\left[1 + \mu + k\sigma_\beta^2 - \frac{E\Pi^{p*}(D)}{D}\right]. \tag{16}$$

To the extent that the firm is defaulted creditors require compensation. This is provided

[26] The conditions for the welfare minima and break even debt levels $D^{\min}$ and $\widetilde{D}^*$ are $(1 - \alpha + \lambda)\frac{E\Pi^{p*}(D)}{D} = (1 + \lambda)(\mu + k\sigma_\beta^2)$, and respectively $(1 - \alpha + \lambda)\int_0^{\widetilde{D}^*} \frac{E\Pi^{p*}(D)}{D} dD = (1 + \lambda)(\mu\widetilde{D}^* + k\widetilde{D}^*\sigma_\beta^2)$.

[27] This is a theoretical result. It is intuitive that the closer the default threshold is to the lower bound marginal cost, the more difficult it is for the state owned manager to operate within such a narrow range of low marginal cost. Thus in practice the maximum debt amount must be markedly lower than the maximum debt.

through the endogenous interest rate, which increases with the creditor funding cost and risk premium, but decreases with post privatization profits.

It is noteworthy that under low creditor funding cost and risk aversion the endogenous interest rate could turn negative at higher debt levels. The reason is that creditors enjoy high monopoly profits post privatization. Nevertheless, we assume positive interest throughout because experienced, large banks do have outside investment and lending options that offer positive returns.

For the government and the firm the lowering of the default threshold below the upper bound marginal cost has a positive effect on managerial commitment. It improves managerial incentive to truthfully reveal marginal costs since beyond the default threshold the firm is threatened by the risk of privatization, and the firm manager is assumed to prefer state ownership.[28]

Total welfare increases faster with debt when the proportion of foreign creditors increases and the shadow cost increases. At the limit of only foreign creditors, $\alpha = 0$, welfare is highest because the government is willing to default and privatize the firm at a lower default threshold. No costly transfers are needed in period T2. While the creditors receive their remaining repayment from monopoly profits post privatization, consumer surplus is positive. With higher shadow cost the opportunity benefit of raising debt to reduce period T1 transfers and the benefit of privatizing the firm at a lower default threshold increases.

The other border solution when all creditors are domestic, $\alpha = 1$, and in the theoretical case of zero shadow costs, $\lambda = 0$, can be analyzed from (15). Here $\frac{dEW^*}{dD}$ is negative at all debt levels and the introduction of debt is never welfare enhancing. Intuitively, if all creditors are domestic the government is least inclined to default the firm. Concurrently at zero shadow cost there is no benefit of avoiding transfers because transfers are not costly.

Total FB welfare is the sum of welfare with zero debt and the change in welfare as a consequence of debt raising. Zero debt welfare is equal to the all equity welfare with government shadow cost, which from (7) is $EW^*(0) = \int_{\underline{\beta}}^{\overline{\beta}} \left[S(Q) + \lambda P(Q)Q(\beta) - \beta Q(\beta)(1+\lambda)\right] g(\beta)d\beta - (1+\lambda)K$.[29] The debt induced welfare component is calculated by integrating (15) over the debt amount raised.

[28] This could be due to the satisfaction of managing a state owned firm or to avoid being audited by more well informed creditors or owners post privatization.

[29] At zero debt $\phi(\beta) = 1$ throughout.

The resulting expression for welfare under symmetric information obtains:

$$\begin{aligned} EW^*(D^*) &= EW^*(0) + \int_0^{D^*} \left[(1-\alpha+\lambda)\frac{E\Pi^{p*}(D)}{D} - (1+\lambda)(\mu + k\sigma_\beta^2) \right] dD \qquad (17) \\ &= \int_{\underline{\beta}}^{\overline{\beta}} \left[S(Q) + \lambda P(Q)Q(\beta) - \beta Q(\beta)(1+\lambda) \right] g(\beta) d\beta - (1+\lambda)K \\ &\quad + (1-\alpha+\lambda)\int_0^{D^*} \frac{\int_{\widehat{\beta}^*}^{\overline{\beta}} \left(P(Q^p) - \beta \right) Q^p(\beta) g(\beta) d\beta}{D} dD \\ &\quad - (1+\lambda)(\mu D^* + k D^* \sigma_\beta^2). \end{aligned}$$

The FB optimal debt level D^* is therefore:

$$\begin{aligned} D^* &= \min[K, D^{\max *}] \text{ if } K \geq \widetilde{D}^*, \text{ or} \\ D^* &= 0 \qquad\qquad\qquad \text{if } K < \widetilde{D}^*. \end{aligned}$$

We summarize:

Proposition 1 *Under low creditor funding cost and risk aversion, moderate debt levels improve welfare. Managerial commitment is increased due to threat of default and privatization. Optimal debt level equals fixed cost.*

Corollary 2 *If fixed cost is very high optimal debt is capped and the firm should be funded with debt and transfers. If creditor funding cost and risk premium are high, the government should fund fixed cost solely with transfers.*

Proofs: See Appendices 1-3.

Whenever a marginal cost level higher than the default threshold is realized, the government privatizes the firm and relinquishes control of the firm's profits to the creditors. The impact of debt on total FB welfare is initially negative due to the creditor funding cost and risk premium, especially at low fixed cost and debt levels. However at moderate debt levels debt can be welfare enhancing due to the avoidance or reduction of costly transfers to fund fixed costs in period T1 and debt repayment in Period T2.

Privatization ensures the continued consumer surplus upon production by the creditors or new owner in period T2, albeit at a lower level under *laissez faire* monopoly. In the case of default creditors receive their repayment from the profit or sale proceeds post privatization.

The positive incremental welfare is higher when all creditors are foreign and the shadow cost high. The lower the magnitude of domestic creditor utility to protect and the higher the opportunity cost of government transfers, the more beneficial it is to raise debt.

When creditor funding cost and risk premium are high debt can be welfare reducing at all levels. The government should fund fixed cost with transfers.

Managerial commitment to reveal cost truthfully is increased due to the threat of privatization at a default threhold below the upper bound marginal cost. The range of marginal costs within which the manager is assured of state ownership is narrower and lower.

Lastly, the regulatory regime post privatization will affect creditor value post privatization. Creditor profits increase as the industry structure post privatization moves from competition, over status quo regulated output, to allowing *laissez faire* monopoly pricing. Although higher creditor monopoly profits entail lower consumer surplus, the latter is compensated by a relative increase in the corresponding default threshold and decrease in debt level.[30]

4.2 Adverse selection case

Under second best (SB) asymmetric information the β realized in period T2 is not observed by the government and the creditors. The firm manager may report untruthful marginal cost, $\widetilde{\beta} \geq \beta$. The government must design contracts such that the regulated firm reveals its privately observed marginal cost. Incentive compatibility constraints and the revelation mechanism are required to induce truthful revelation. We use the standard assumption of classical monotone hazard rate and define the virtual cost as $\vartheta(\beta, \lambda) = \beta + \frac{\lambda}{1+\lambda}\frac{G(\beta)}{g(\beta)}$, following Baron and Myerson (1982).[31]

Lemma 3 *Under adverse selection marginal cost is replaced by the virtual cost. The SB optimal regulated output, default threshold and maximum debt level are reduced compared to FB.*

Proofs: See below and Appendix 4.

[30] From (10) we infer that while higher profits post privatization benefits creditors or future owners, the default threshold adjusts upwards to account for the relative loss in consumer surplus. This adjusts the lower integration border of creditor profits in (15).

[31] The virtual cost increases with β if the standard monotone hazard assumption $\frac{G(\beta)}{g(\beta)} \geq 0$ is made. It increases with the shadow cost, taking a limit of $\vartheta(\beta, \infty) = \beta + \frac{G(\beta)}{g(\beta)}$ at very high λ.

We wish to substitute $\vartheta(\beta,\lambda)$ in lieu of β to determine $Q^{**}(\vartheta(\beta,\lambda))$, $\vartheta(\widehat{\beta}^{**},\lambda)$ and $D^{**}(\bullet)$ such as to maximize total welfare. We start with (18), which is similar to (7) if the marginal cost under state ownership was replaced by the virtual cost:[32] [33]

$$\begin{aligned} EW &= +D(1+\lambda)-K(1+\lambda) \\ &\quad +\int_{\underline{\beta}}^{\widehat{\beta}}\left[S(Q)+\lambda P(Q)Q(\vartheta)-\vartheta(\beta,\lambda)Q(\vartheta)(1+\lambda)\right]g(\beta)d\beta \\ &\quad -\int_{\underline{\beta}}^{\widehat{\beta}}D(1+r)(1-\alpha+\lambda)g(\beta)d\beta \\ &\quad +\int_{\widehat{\beta}}^{\overline{\beta}}\left[S(Q^p)-(1-\alpha)P(Q^p)Q^p(\beta)-\alpha\beta Q^p(\beta)\right]g(\beta)d\beta \\ &\quad -\alpha D(1+\mu)-\alpha k D\sigma_\beta^2. \end{aligned} \tag{18}$$

Optimal output

We apply the FOC with regard to output on the period T2 portion of (18) while setting the risk premium to zero:

$$\frac{dW_2^{**}}{dQ}=S'(Q)+\lambda\left[P'(Q)Q(\vartheta)+P(Q)\right]-\vartheta(\beta,\lambda)(1+\lambda)=0. \tag{19}$$

Since the virtual cost is higher than the marginal cost output decreases under asymmetric information. Adverse selection forces the government to offer lower output quantities and positive information rents to the firm manager.[34] For the same level of realized β, SB output is lower than FB i.e. $Q^{**}(\vartheta(\beta,\lambda))<Q^{*}(\beta,\lambda)$.

Production versus privatization decision and default threshold

Next, applying the FOCs on (18) with regard to the production decision variable we obtain the SB default threshold:

$$\begin{aligned} \frac{dW_2^{**}}{d\phi} &= \left[S(Q^{**})+\lambda P(Q^{**})Q^{**}(\vartheta)-\vartheta(\beta,\lambda)Q^{**}(\vartheta)(1+\lambda)-D(1+r)(1-\alpha+\lambda)\right] \\ &\quad -\left[S(Q^p)-(1-\alpha)P(Q^p)Q^p(\beta)-\alpha\beta Q^p(\beta)\right]=0. \end{aligned} \tag{20}$$

[32] We use ϑ in lieu of $\vartheta(\beta,\lambda)$ whenever practical.
[33] We obtain (18) upon simple rearrangement of (33) from Appendix 4.
[34] Consistent with (27) in Appendix 1 and (32) in Appendix 4. See also Auriol and Picard (2009).

The higher virtual cost under state ownership due to adverse selection results in a lower default threshold compared to FB, $\widehat{\beta}^{**} < \widehat{\beta}^{*}$. Managerial commitment further increases with adverse selection. The intuition is as follows. We assumed symmetric information post privatization because creditors or the future owner observe the true realized marginal cost once they control the firm and replace the manager. If informed creditors are rationale and honest, the government achieves the same post privatization output and consumer welfare as under FB. Since the SB output is lower than FB, and the virtual cost higher, the SB default threshold must be lower than FB to satisfy (20). In fact, we also obtain that SB default threshold is lower than FB at the zero debt level.

Optimal debt

Applying the FOC with respect to debt in analogy to (13), (15) and (16) we obtain:

$$\frac{dEW^{**}}{dD} = (1-\alpha+\lambda)[1-\int_{\underline{\beta}}^{\widehat{\beta}^{**}}(1+r)g(\beta)d\beta-\alpha(\mu+k\sigma_{\beta}^{2})], \tag{21}$$

$$\frac{dEW^{**}}{dD} = (1-\alpha+\lambda)\frac{E\Pi^{p**}(D)}{D}-(1+\lambda)(\mu+k\sigma_{\beta}^{2}), \tag{22}$$

and respectively

$$(1+r^{**}(D)) = \frac{1}{G(\widehat{\beta}^{**}(D))}\left[1+\mu+k\sigma_{\beta}^{2}-\frac{E\Pi^{p**}(D)}{D}\right]. \tag{23}$$

The total SB welfare expression is as follows:

$$\begin{aligned} EW^{**}(D^{**}) &= EW^{**}(0)+(1-\alpha+\lambda)\int_{0}^{D^{**}}\frac{E\Pi^{p**}(D)}{D}dD \qquad (24)\\ &= \int_{\underline{\beta}}^{\overline{\beta}}\left[S(Q)+\lambda P(Q)Q(\upsilon)-\beta Q(\upsilon)(1+\lambda)-\lambda Q(\upsilon)\frac{G(\beta)}{g(\beta)}\right]g(\beta)d\beta-(1+\lambda)K\\ &\quad +(1-\alpha+\lambda)\int_{0}^{D^{**}}\frac{\int_{\widehat{\beta}^{**}}^{\overline{\beta}}\left(P(Q^{p})-\beta\right)Q^{p}(\beta)g(\beta)d\beta}{D}dD\\ &\quad -(1+\lambda)(\mu D^{**}+kD^{**}\sigma_{\beta}^{2}). \end{aligned}$$

The zero debt SB welfare under adverse selection is lower than under the symmetric information FB case. The reason is the positive information rent provided to the profitable firm.

Equally importantly, under adverse selection we find that the welfare slope is positive throughout. This is the case even at high creditor funding costs and risk premium, and if the firm is highly profitable. The reason is that the information rent, which increases with

higher shadow costs, reduces the SB zero debt welfare significantly below FB. In fact, the default threshold falls below the FB level at all debt levels. This in turn reduces the zero debt SB default threshold below the upper bound marginal cost even when the firm is highly profitable. At the same time post privatization profit increases faster than debt.[35] The combined result is that, while starting from a lower base at zero debt, total SB welfare increases with debt monotonously, and more steeply, at all debt levels.

The critical assumption is that creditors are assumed to observe marginal costs and report truthfully post privatization.[36] Thus there is no loss in information rents post privatization in comparison to production under state ownership. The creditors' information advantage allows them to capture the information rent and enjoy firm profits post privatization.

From the government's point of view, total welfare and managerial commitment increase monotonously in debt. The government benefits from avoiding costly transfers.

The lower default threshold also results in a lower maximum debt level that renders the default threshold equal to the lower bound marginal cost. Thus we obtain that $D^{max**} < D^{max*}$. Since this maximum debt level could also fall below the fixed cost, the optimal debt might be the lower of the fixed cost and the maximum debt. Thus the optimum SB debt level D^{**} under adverse selection is:

$$D^{**} = \min[K, D^{\max **}].$$

Under adverse selection debt improves welfare under all debt levels. The moment creditors enter the picture, their information advantage incentivizes the government and the creditors to enter into the endogenous debt contract.

The only limitation to raising debt to fund the entire fixed cost is if the latter is higher than the maximum debt level.[37] In this case the government would have to fund fixed cost with both debt and transfers.

We therefore summarize:

Proposition 4 *Under adverse selection welfare is initially lower by the information rent. Debt*

[35] Recall that under FB symmetric information, if the company is highly profitable, post privatization profit is zero and the welfare slope negative until the default threshold falls below the upper bound marginal cost.

[36] Reference to creditors include future owners in case of post privatization sale by the creditors.

[37] Similar to the above case, if the maximum debt D^{max**} is lower than the fixed cost K, the optimal SB debt D^{**} must be sufficiently lower than D^{max**} such as to ensure a feasible marginal cost range for the state owned manager.

always improves welfare when the government is budget constrained. Managerial commitment is further improved. Optimal debt equals fixed cost.

Corollary 5 *If fixed cost is very high the optimal debt is capped. Fixed cost is funded with debt and transfers.*

4.3 Comparative statics

The Propositions provide the basis to summarize the commitment and welfare impact of financing state owned firms with a combination of private debt and government transfers. The key driver of managerial commitment and welfare is the default threshold marginal cost. This default threshold is a function of the (i) level of debt, (ii) degree of information asymmetry and information rent, (iii) creditor funding cost and risk aversion, (iv) creditor domicile, (v) the level of shadow cost of public funds, and (vi) firm profitability. The main benchmarks used are the welfare levels of an all-transfer i.e. zero debt state owned firm, with or without adverse selection between the government and the firm (Auriol and Picard, 2009).

	Symmetric Information (FB)	**Adverse Selection (SB)**
$\widehat{\beta}(0)$	$\widehat{\beta}^*(0) \geq \overline{\beta}$ $\widehat{\beta}^*(D^{mm}) = \overline{\beta}$ $\widehat{\beta}^*(D) < \overline{\beta}$ if $D > D^{mm}$	$\widehat{\beta}^{**}(0) \leq \overline{\beta}$ $\widehat{\beta}^{**}(D) < \widehat{\beta}^*(D)$
$\frac{d\widehat{\beta}}{dX}$	$\frac{d\widehat{\beta}^*}{dD} < 0$; $\frac{d\widehat{\beta}^*}{d\alpha} > 0$; $\frac{d\widehat{\beta}^*}{d\lambda} < 0$; $\frac{d\widehat{\beta}^*}{d(1+r)} < 0$	$\frac{d\widehat{\beta}^{**}}{dD} < 0$; $\frac{d\widehat{\beta}^{**}}{d\alpha} > 0$; $\frac{d\widehat{\beta}^{**}}{d\lambda} < 0$; $\frac{d\widehat{\beta}^{**}}{d(1+r)} < 0$
$\frac{dEW(D)}{dD}$	$-(1+\lambda)(\mu + k\sigma_{\widehat{\beta}}^2) < 0 \ \forall \ \widehat{\beta}^*(D \leq D^{mm*}) \geq \overline{\beta}$ since $\frac{E\Pi^{m*}(D)}{D} = 0$ $(1-\alpha+\lambda)\frac{E\Pi^{m*}(D)}{D} - (1+\lambda)(\mu + k\sigma_{\widehat{\beta}}^2) > 0$ when $D > D^{\min *}$	$(1-\alpha+\lambda)\frac{E\Pi^{m**}(D)}{D} - (1+\lambda)(\mu + k\sigma_{\widehat{\beta}}^2) > 0$ $\forall \ D \geq 0$
$EW(D)$	$EW^*(0)$ $EW^*(D) \geq EW^*(0)$ if $D \geq \widetilde{D}^*$	$EW^{**}(0) < EW^*(0)$ $EW^{**}(D) > EW^{**}(0)$
$D^{Optimal}$	$D^* = K$ if $\widetilde{D}^* < K < D^{max**}$ $D^* < D^{max*}$ if $\widetilde{D}^* < D^{max**} < K$ $D^* = 0$ if $K < \widetilde{D}^* < D^{max**}$	$D^{**} = K$ if $K < D^{max**}$ $D^{**} < D^{max**}$ if $D^{max**} < K$

(25)

Default threshold, optimal debt and managerial commitment

The default threshold represents the marginal cost level that renders welfare under state owned production and post privatization creditor ownership equal. Below the default threshold

state ownership dominates. At marginal cost levels higher than the default threshold, welfare under private creditor ownership decreases less and thus dominates.

The default threshold decreases with increasing debt levels, increasing government shadow cost and the fraction of foreign creditors. It also decreases with higher creditor funding cost and risk premium, as well as due to the information rent and lower output under adverse selection.

When debt raising reduces the default threshold below the upper bound marginal cost, managerial commitment to reveal costs truthfully is increased. The higher the debt level, the lower the default threshold and the stronger the commitment of the firm manager.

Welfare and optimal debt

The optimal debt level is determined by two factors. On the one hand, the default threshold decreases at higher levels of debt. There exists a maximum level of debt that renders the default threshold equal to the lower bound marginal cost.

On the other hand, under FB the welfare slope decreases initially at low debt levels due to the creditor funding cost and risk premium. There exists a breakeven debt level below which debt is welfare reducing. The breakeven debt level increases rapidly when creditor funding cost and risk premium increase, and when the firm is very profitable. Thus debt may not be welfare enhancing at any debt level, and the government funds fixed costs with transfers.

In the case of SB adverse selection the slope of the welfare function with respect to debt is positive throughout. It is therefore optimal to maximize the amount of debt raised.

Whenever the fixed cost reaches or becomes higher than the maximum debt level, the optimal debt level must be sufficiently lower than the maximum debt. For practical purposes the government would choose an optimal debt level that is significantly lower than the maximum debt such as to render the range of possible marginal cost levels realistic and feasible to the state owned manager.

Total welfare increases with the proportion of foreign creditors and with higher shadow costs of public funds.The comparative welfare under FB and SB is affected by the relative magnitudes of the information rent and the decrease in the respective default thresholds.

5 Summary and conclusion

This study analyzes the impact of adverse selection and shadow costs of public funds on the financing decisions of a regulated state owned firm. The regulated monopoly model is utilized to derive conditions that maximize overall welfare and improve managerial commitment while satisfying the creditors participation constraints.

Adverse selection between government and the firm necessitates additional costs of information acquisition and information rents, which in turn reduce optimal output and debt levels. The default threshold marginal cost decreases with adverse selection even at zero debt. Beyond the default threshold the government avoids costly transfers by defaulting and privatizing the firm.

The impact of debt financing on welfare and managerial commitment depends on the information asymmetry and marginal cost distribution, the type of creditors, the creditor funding cost, the degree of creditor risk aversion as well as on the post privatization regulation. Debt financing for state owned firms results in several tradeoffs. The benefits of reduced government transfers and improved managerial commitment to reveal true costs have to be weighed against the cost of compensating for the creditor's funding cost and risk premium. However to the extent creditors and future owners are better informed than the government post privatization, under adverse selection debt always help the government improve welfare and managerial commitment.

Several implications for policy are obtained from this analysis. Firstly, on the financing of state owned firms with outside debt. It is critical that the government's commitment to default and privatize the firm at high cost levels must be credible and non-renegotiable. The government should target informed private creditors with lower funding cost, international diversification, experience and reputation. Given a government's tight budget constraint even partial debt financing reduces costly transfers. Managerial discipline and commitment to reveal costs truthfully is induced both *ex ante* during the creditor due diligence and negotiation stage, and *ex post* after debt contracting.

Secondly, emerging market governments should not utilize their state owned lenders to support industrial policy. The falacy of 'low state owned funding cost' is invalid since state owned lenders similarly affect the government budget constraint, shadow cost and costly transfers. Moreover state owned banks are often not better informed than the government and regulator, and any post default privatization and sale may be less efficient. Therefore state owned lenders

should be considered on their own merit, based on their standalone efficiency and profitability.

Our study can be expanded in several ways. Firstly, the assumption of full information post privatization could be relaxed. Depending on the type and characteristic of creditors, appropriate audit and monitoring technologies could be introduced. Additional rewards or punishment mechanisms in form of re- or new financing (Bolton and Scharfstein, 1990), partial liquidation and renegotiation (Faure-Grimaud, 2000) can be introduced to render truthful revelation incentive compatible

Secondly, the premise of efficient firm value post privatization can be addressed through appropriate auction mechanisms. Related to this, the question of corruption and capture is of particular interest particularly in developing countries with high shadow costs of public funds (Laffont, 2005, Auriol, 2005, Auriol and Blanc, 2009). Capture can originate from the firm manager, the government as regulator/planner, and or from collusion amongst creditors and the state owned manager.

Thirdly, the regulated monopoly setup can be expanded to examine oligopolies. The case of strategic industries in developing countries with dominant state owned firms are relevant examples of oligopolies or Stackelberg markets.

Fourthly, the adverse selection model can be combined with a moral hazard setting (Dewatripont and Tirole, 1994, Dewatripont, Legros and Matthews, 2003).

6 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.

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

Auriol, Emmanuelle, and Pierre M. Piccard. 2006. "Government Outsourcing: Public Contracting with Private Monopoly", *CESIfo Working Paper,* 1733.

Auriol, Emmanuelle. 2005. "Corruption in Procurement and Public Purchase", *Working Paper, University of Toulouse 1 & IDEI*, France.

Auriol, Emmanuelle, and Aymeric Blanc. 2009. "Capture and Corruption in Public Utilities: The Cases of Water and Electricity in Sub-Saharan Africa", *Utility Policy*, 19, pp. 203-216.

Baron, David P., and Roger B. Myerson. 1982. "Regulating a Monopolist with Unknown

Costs", *Econometrica*, 50, pp. 911-930.

Bell, Allison, Karen Schneider, Lindsay Fairhead, and Christopher Short. 2004. "The Asia Pacific LNG Market: issues and outlook", *Abare Research Report*, 04.1.

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.*

Bolton, Patrick, and David S. Scharfstein. 1990. "A Theory of Predation Based on Agency Problems in Financial Contracting", *The American Economic Review*, 80:1, pp. 93-106.

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

Davis, Jeffrey, Rolando Ossowski, Thomas Richardson, and Steven Barnett. 2000. "Fiscal and Macroeconomic Impact of Privazization", *IMF Occasional Paper*, 194.

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

Dewatripont, Mathias, Patrick Legros, and Steven A. Matthews. 2003. "Moral Hazard and Capital Structure Dynamics", *Penn Institute for Economic Research, Working Paper No. 03-006.*

Dewatripont, Mathias, and Patrick Legros. 2005. "Public-Private Partnerships: Contract Design and Risk Transfer", *European Investment Bank Papers*, 10:1, pp. 120-145.

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.

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.

Jensen, Michael C., and William H. Meckling. 1976. "Theory of the Firm: Managerial Behavior, Agency Costs and Ownership Structure", *Journal of Financial Management*, 3:4, pp. 305-360.

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.

Lopez-de-Silanes, Florencio, Andrei Shleifer, and Robert W. Vishny. 1997. "Privatization in the United States", *The Rand Journal of Economics*, 28:3, pp. 447-71.

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

Mas-Colell, Andreu, Michael D. Whinston, and Jerry R. Green. 1995. *Microeconomic Theory*. New York, NY: Oxford University Press.

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.

Menezes, Carman F., and David L. Hanson. 1970. "On the Theory of Risk Aversion", *International Economic Review*, 11:3, pp. 481-487.

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.

Pratt, John W. 1964. "Risk Aversion in the Small and in the Large", *Econometrica*, 32:1-2, pp. 122-136.

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.

Shleifer, Andrei, and Robert W. Vishny. 1989. "Management Entrenchment: The Case of Manager-specific Investments", *Journal of Financial Economics*, 25, pp. 123-139.

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

Spiegel, Yossef, and Daniel F. Spulber. 1997. "Capital Structure with Countervailing Incentives", *The Rand Journal of Economics*, 28:1, pp. 1-24.

Stiglitz, Joseph E. 1998. "The Private Uses of Public Interests: Incentives and Institutions", *Journal of Economic Perspectives*, 12, pp. 3-22.

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.

7 Appendices

Appendix 1: Regulated optimal output

To proof that (9) is a maxima we apply the second order condition (SOC) and show that the second derivative (26) is negative at $Q^*(\beta, \lambda)$:

$$\frac{d^2EW_2^*}{dQ^2} = S''(Q^*) + \lambda \left[P''(Q^*)Q^*(\beta,\lambda) + 2P'(Q^*)\right] < 0. \tag{26}$$

Assuming concavity the second derivative of gross consumer surplus and revenue are negative, $S''(Q) < 0$ and $\frac{d}{dQ}[P'(Q)Q(\beta,\lambda) + P(Q)] < 0$. Price decreases with quantity, thus $P'(Q) < 0$.[38] Therefore (26) is negative and the SOC for a maxima at $Q^*(\beta,\lambda)$ obtains.

To verify that output decreases with marginal cost we make use of the implicit function theorem whereby $\frac{dQ^*}{d\beta} = -\frac{\partial}{\partial\beta}\left(\frac{dEW_2^*}{dQ}\right) / \frac{\partial}{\partial Q}\left(\frac{dEW_2^*}{dQ}\right)$. Partially differentiating (9) with respect to β yields the numerator $\frac{\partial}{\partial\beta}\left(\frac{dEW_2^*}{dQ}\right) = -(1+\lambda)$. On the other hand, the denominator is identical to (26). Upon substitution we obtain:

$$\frac{dQ^*}{d\beta} = \frac{(1+\lambda)}{S''(Q^*) + \lambda\left[P''(Q^*)Q^*(\beta,\lambda) + 2P'(Q^*)\right]} < 0. \tag{27}$$

Since we have just shown that the denominator of (27) is negative, and the shadow cost is positive, we proof that optimal output decreases with increasing marginal cost.

Differentiating with respect to λ we verify the sign for $\frac{dQ^*}{d\lambda} = -\frac{\partial}{\partial\lambda}\left(\frac{dEW_2^*}{dQ}\right) / \frac{\partial}{\partial Q}\left(\frac{dEW_2^*}{dQ}\right)$. The numerator becomes $\frac{\partial}{\partial\lambda}\left(\frac{dEW_2^*}{dQ}\right) = [P'(Q^*)Q^*(\beta,\lambda) + P(Q^*) - \beta]$, while the negative denominator remains the same as (26)**:**

$$\frac{dQ^*}{d\lambda} = -\frac{[P'(Q^*)Q^*(\beta,\lambda) + P(Q^*) - \beta]}{S''(Q^*) + \lambda\left[P''(Q^*)Q^*(\beta,\lambda) + 2P'(Q^*\right]} < 0. \tag{28}$$

Since $P(Q^{monopoly}) > P(Q^*) > \beta$ and $P'(Q^*)Q^*(\beta,\lambda) < 0$ the numerator of (28), which describes the change in profit with increasing output, must be negative. We find that the effect of the shadow cost of public funds on the optimal output is negative and thus the optimal output decreases with the shadow cost of public funds. Note that Auriol and Picard (2009) use a linear demand function $P = a - bQ$ and observe that the optimal regulated output under symmetric information, $Q^* = \frac{(a-\beta)}{b}\frac{1+\lambda}{1+2\lambda}$, decreases with β and λ.

To calculate the impact of the level of debt on the regulated output we use the implicit function theorem $\frac{dQ^*}{dD} = -\frac{\partial}{\partial D}\left(\frac{dEW_2^*}{dQ}\right) / \frac{\partial}{\partial Q}\left(\frac{dEW_2^*}{dQ}\right)$. The numerator is zero from (9), while the denominator again is negative. It follows that regulated quantity is independent of debt and $\frac{\partial Q^*}{\partial D} = 0$. This is straightforward since debt is determined in T1 and remains constant in T2.

[38] Since β is fixed in period T2, from the government's perspective the term $\frac{d\beta}{dQ}(1+\lambda) = 0$.

Appendix 2: Default threshold marginal cost

To verify that $\phi^*(\beta)$ and $\widehat{\beta}^*$ maximize T2 welfare and that default and privatization is more welfare enhancing than state ownership at higher marginal costs, we first rearrange (10):

$$\begin{aligned} & [S(Q^*(\beta)) + \lambda P(Q^*)Q^*(\beta) - \beta Q^*(\beta)(1+\lambda) - D(1+r)(1-\alpha+\lambda)] \\ = \; & [S(Q^p(\beta)) - (1-\alpha)P(Q^p)Q^p(\beta) - \alpha\beta Q^p(\beta)] \text{ at } \widehat{\beta}^*. \end{aligned} \tag{29}$$

The left hand side of (29) represents total welfare under state ownership in the production regime, whereas the right hand side describes total welfare in the privatization regime. At the default threshold $\widehat{\beta}^*$ total welfare is the same in both regimes. Both left and right hand side terms decrease at higher marginal costs. However we show that the left hand side decreases faster with increasing marginal costs compared to the right hand side, and thus $\frac{d}{d\beta}\left(\frac{dW_2^*}{d\phi}\right) < 0$ is negative at $\widehat{\beta}^*$. Differentiating (10) with respect to β we obtain:

$$\begin{aligned} \frac{d}{d\beta}\left(\frac{dW_2^*}{d\phi}\right) \;=\; & \begin{bmatrix} S'(Q^*) + \lambda\left[P'(Q^*)Q^*(\beta,\lambda) + P(Q^*)\right] \\ -\beta(1+\lambda) \end{bmatrix} \frac{dQ^*(\beta,\lambda)}{d\beta} \\ & - \left[S'(Q^p) - (1-\alpha)\left(P'(Q^p)Q^p(\beta) + P(Q^p)\right) - \alpha\beta\right] \frac{dQ^p(\beta)}{d\beta} \\ & - \left[Q^*(\beta)(1+\lambda) - \alpha Q^p(\beta)\right], \end{aligned} \tag{30}$$

where we have utilized the chain rule and the fact that the debt level $D(\bullet)$ is already fixed in period T2. Using the envelope theorem at the optimal outputs $Q^*(\beta,\lambda)$ and $Q^p(\beta)$, respectively, we obtain $\frac{d}{d\beta}\left(\frac{dW_2^*}{d\phi}\right) = -\left[Q^*(\beta)(1+\lambda) - \alpha Q^p(\beta)\right] < 0$ at $\widehat{\beta}^*$. This expression is negative considering that $[Q^*(\beta)(1+\lambda) - \alpha Q^p(\beta)] > 0$ because $0 \leq \alpha \leq 1$ and $\lambda > 0$. Thus we show that (10) optimizes total welfare at $\widehat{\beta}^*$ and that at higher marginal cost levels default and privatization become comparatively more welfare enhancing than production under state ownership.

To show that the default threshold $\widehat{\beta}^*$ decreases with the level of debt, we determine the sign of $\frac{d\widehat{\beta}^*}{dD} = -\frac{\partial}{\partial D}\left(\frac{dW_2^*}{d\phi}\right) / \frac{\partial}{\partial\beta}\left(\frac{dW_2^*}{d\phi}\right)$. The numerator is the partial derivative of (10) with respect to the debt level, $-(1+r)(1-\alpha+\lambda) < 0$, and thus negative. The denominator is the partial derivative with regard to marginal cost, $-\left[Q^*(\beta)(1+\lambda) - \alpha Q^p(\beta)\right] < 0$, and is also negative at $\widehat{\beta}^*$. Thus we verify that $\frac{d\widehat{\beta}^*}{dD} = -\frac{(1+r)(1-\alpha+\lambda)}{[Q^*(\beta)(1+\lambda)-\alpha Q^p(\beta)]} < 0$ is negative.

Additionally, to understand how the default threshold changes with increasing proportion of domestic creditors, we examine the sign of $\frac{d\widehat{\beta}^*}{d\alpha} = -\frac{\partial}{\partial\alpha}\left(\frac{dW_2^*}{d\phi}\right) / \frac{\partial}{\partial\beta}\left(\frac{dW_2^*}{d\phi}\right)$. The numerator,

$D(1+r) - [P(Q^p)Q^p(\beta) - \beta Q^p(\beta)] > 0$, is positive at $\widehat{\beta}^*$. Although we assumed profitability both under the state production and privatization, in neither regime are profits sufficient to repay all the debt plus interest. Since the denominator is again negative we obtain that $\frac{d\widehat{\beta}^*}{d\alpha} > 0$, the default threshold increases as more creditors are domestic. It is noteworthy that as the creditor funding cost and risk premium increase, the endogenous interest rate increases and the default threshold increases faster the higher the proportion of domestic creditors.

Finally, using $\frac{d\widehat{\beta}^*}{d\lambda} = -\frac{\partial}{\partial\lambda}\left(\frac{dW_2^*}{d\phi}\right) / \frac{\partial}{\partial\beta}\left(\frac{dW_2^*}{d\phi}\right)$ we verify the relationship between the default threshold and the shadow cost. The numerator, $P(Q^*)Q^*(\beta) - \beta Q^*(\beta) - D(1+r) < 0$, is negative since at $\widehat{\beta}^*$ the firm is defaulted because profits under state ownership are insufficient to repay all the debt. Thus we find that $\frac{d\widehat{\beta}^*}{d\lambda} < 0$ and the default threshold decreases with higher shadow cost.

Appendix 3: Welfare as a function of debt and interest

We have shown in Appendix 3 that $\frac{d\widehat{\beta}^*}{dD} < 0$. Applying the SOC on (13) we find that $\frac{d^2EW^*}{dD^2} = -(1-\alpha+\lambda)(1+r^{exo})\frac{dG(\widehat{\beta}^*)}{dD} > 0$ at constant exogenous r^{exo}. Therefore welfare is convex under constant, exogenous debt interest levels.

More importantly is the case of endogenous interest rates. Differentiating (15) we obtain:

$$\frac{d^2EW^*}{dD^2} = \frac{(1-\alpha+\lambda)}{D^2}\left[-\left(P(Q^p) - \widehat{\beta}^*\right)Q^p(\widehat{\beta}^*)D\frac{dG(\widehat{\beta}^*)}{dD} - \int_{\widehat{\beta}^*}^{\overline{\beta}}\left(P(Q^p) - \beta\right)Q^p(\beta)g(\beta)d\beta\right]. \tag{31}$$

Since $\frac{dG(\widehat{\beta}^*)}{dD} < 0$ and the firm is assumed to be profitable post privatization, the first expression inside the square brackets is positive. The second expression is negative or zero at low debt levels because the default threshold approaches, or could be higher than, the upper bound marginal cost. At higher debt levels the positive first expression, which is $\propto \frac{1}{D}$, increases faster than the negative second expression, which is $\propto \frac{1}{D^2}$. Thus $\frac{d^2EW^*}{dD^2} > 0$ and the welfare function is convex in debt.

To examine the behaviour of endogenous interest rates we examine the sign of $\frac{d(1+r)}{dD} = -\frac{\partial}{\partial D}(EC) / \frac{\partial}{\partial(1+r)}(EC)$. From (14) the numerator,

$-\left[1+\mu+k\sigma_\beta^2 - (1+r)G(\widehat{\beta}^*)\right] + \left[D(1+r) - \left(P^p(Q^p) - \widehat{\beta}^*\right)Q^p(\widehat{\beta}^*)\right]\frac{dG(\widehat{\beta}^*)}{dD}$, is negative, while the denominator, $DG(\widehat{\beta}^*)$, is positive. Thus we obtain $\frac{d(1+r)}{dD} > 0$ and the interest rate increases in the amount of debt raised. This is intuitive.

Similarly, we can show that $\frac{d(1+r)}{d\widehat{\beta}^*} < 0$ because $\frac{\partial}{\partial\beta}(EC) = D(1+r)g(\beta) + \frac{\partial}{\partial\beta}\int_{\widehat{\beta}^*}^{\overline{\beta}} (P(Q^p) - \beta)\, Q^p(\beta) g(\beta) d\beta = [D(1+r) - (P(Q^p) - \beta)\, Q^p(\beta)]\, g(\beta) > 0$ at $\widehat{\beta}^*$. When the default threshold decreases interest rates must rise for any given level of debt. This is despite the partially compensating increase in creditor profits post privatization

Appendix 4: Revelation mechanism and virtual cost under asymmetric information

To determine the incentive compatible contracts to all firm types, the government ensures that the firm's incentive constraint is satisfied both at the true, realized marginal cost β and at the reported $\widetilde{\beta}$, and offers the necessary information rent to ensure truthful revelation:

$$\text{IC}(\beta) \quad : \quad U_2(\beta) = (P(Q(\beta)) - \beta)\, Q(\beta) - D(1+r) + t_2(\beta) \geq \left(P(Q(\widetilde{\beta})) - \beta\right) Q(\widetilde{\beta}) - D(1+r) + t_2(\widetilde{\beta})$$
$$\text{IC}(\widetilde{\beta}) \quad : \quad U_2(\widetilde{\beta}) = \left(P(Q(\widetilde{\beta})) - \widetilde{\beta}\right) Q(\widetilde{\beta}) - D(1+r) + t_2(\widetilde{\beta}) \geq \left(P(Q(\beta)) - \widetilde{\beta}\right) Q(\beta) - D(1+r) + t_2(\beta).$$

Taking the sum of IC(β) and IC($\widetilde{\beta}$) we obtain $(-\beta + \widetilde{\beta})Q(\beta) + (\beta - \widetilde{\beta})Q(\widetilde{\beta}) \geq 0$, thus $\frac{Q(\widetilde{\beta}) - Q(\beta)}{\widetilde{\beta} - \beta} \leq 0$, and $\frac{dQ}{d\beta}(\beta) \leq 0$.[39] The incentive compatibility contract stipulates that the government monotonously differentiates firms based on their disclosed marginal cost.[40] The higher the marginal cost, the lower the incentive compatible regulated output. The utility to the firm manager who realizes β but discloses $\widetilde{\beta}$ is $U_2(\widetilde{\beta}, \beta) = \left(P(Q(\widetilde{\beta})) - \beta\right) Q(\widetilde{\beta}) - D(1+r) + t_2(\widetilde{\beta})$, and the total differential is $\frac{dU_2(\widetilde{\beta},\beta)}{d\beta} = \frac{\partial U_2(\widetilde{\beta},\beta)}{\partial\beta} + \frac{\partial U_2(\widetilde{\beta},\beta)}{\partial\widetilde{\beta}} \frac{\partial\widetilde{\beta}}{\partial\beta}$. To ensure truthful revelation of $\widetilde{\beta} = \beta$ the firm manager must perceive no benefit of not truthfully disclosing the realized β. Thus at $\widetilde{\beta} = \beta$, $\frac{\partial U_2(\widetilde{\beta},\beta)}{\partial\widetilde{\beta}} = 0$. The firm manager does not benefit from disclosing $\widetilde{\beta} > \beta$ because she will be offered a lower output by the government. We obtain at $\widetilde{\beta} = \beta$ that

$$\frac{dU_2(\widetilde{\beta}, \beta)}{d\beta} = \frac{\partial U_2(\widetilde{\beta}, \beta)}{\partial\beta} = -Q(\widetilde{\beta}). \tag{32}$$

To find the expression for $U_2(\beta)$ in the welfare function (7), we integrate (32) over $[\beta, \overline{\beta}]$ and observe $\int_{\beta}^{\overline{\beta}} \frac{dU_2}{d\beta} d\beta = -\int_{\beta}^{\overline{\beta}} Q(\beta) d\beta = U_2(\overline{\beta}) - U_2(\beta)$. Now setting $U_2(\overline{\beta}) = 0$ because the least efficient type that discloses the upper bound marginal cost (or default threshold) receives zero information rent, we get $U_2(\beta) = \int_{\beta}^{\overline{\beta}} Q(\beta) d\beta$. Moreover, using the partial integration technique we obtain $\int_{\underline{\beta}}^{\overline{\beta}} U_2(\beta) g(\beta) d\beta = \int_{\underline{\beta}}^{\overline{\beta}} (\int_{\beta}^{\overline{\beta}} Q(x)dx) g(\beta) d\beta = \left[\int_{\beta}^{\overline{\beta}} Q(x)dx \cdot G(\beta)\right]_{\underline{\beta}}^{\overline{\beta}} - \int_{\underline{\beta}}^{\overline{\beta}} (-) Q(\beta) G(\beta) d\beta$

[39] This is consistent with (27).

[40] Well-behaved solutions are ensured by the monotone hazard assumption.

$= \int_{\underline{\beta}}^{\overline{\beta}} Q(\beta)G(\beta)d\beta$. Since the terms in square brackets is zero at either boundary, we use the last surviving term of this equation, multiply it by $-\lambda$, subsitute into the utility term $-\int_{\underline{\beta}}^{\overline{\beta}} \lambda U_2(\beta)g(\beta)\phi(\beta)d\beta$ in (7) and rearrange the integration boundaries:

$$\begin{aligned} EW &= \int_{\underline{\beta}}^{\widehat{\beta}^{**}} \left[S(Q(\upsilon)) + \lambda P(Q(\beta))Q(\upsilon) - \beta Q(\upsilon)(1+\lambda) - \lambda Q(\upsilon)\frac{G(\beta)}{g(\beta)} \right] g(\beta)d\beta \\ &\quad + D(1+\lambda) - \int_{\underline{\beta}}^{\widehat{\beta}^{**}} D(1+r)(1-\alpha+\lambda)g(\beta)d\beta - K(1+\lambda) \\ &\quad + \int_{\widehat{\beta}^{**}}^{\overline{\beta}} \left[S(Q^p(\beta)) - (1-\alpha)P(Q^p(\beta))Q^p(\beta) - \alpha\beta Q^p(\beta) \right] g(\beta)d\beta \\ &\quad - \alpha D(1+\mu) - \alpha k D\sigma_\beta^2. \end{aligned} \tag{33}$$

We find that (33) is the same expression as (7) if the marginal cost under state ownership is replaced by the virtual cost, namely $\vartheta(\beta,\lambda) = \beta + \frac{\lambda}{1+\lambda}\frac{G(\beta)}{g(\beta)}$. The virtual cost increases with β if the standard monotone hazard assumption $\frac{G(\beta)}{g(\beta)} \geq 0$ is made. It also increases with the shadow cost of public funds, taking a limit of $\vartheta(\beta,\infty) = \beta + \frac{G(\beta)}{g(\beta)}$ at very high shadow cost levels.