

# Government's Credit-Rating Concerns and the Privatization of Public Projects\*

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## Abstract

We study how considerations regarding the credit rating of the government's debt affect privatization policy. "Credit-market discipline" presses the government to put more weight on the monetary aspect of public projects, relative to their social benefits, as the anticipated income increases its creditors' confidence in its ability to repay debt. Yet, several informational problems undermine this discipline, leading to a costly downgrading of the credit rating. Dynamic inconsistency occurs when the monetary to social-benefit tradeoff is made only after the credit market has priced government's debt (such as in the decision of the toll on a road): projects are operated with an excessive emphasis on social benefits. Adverse selection occurs when the government has private information regarding a prospective project's characteristics (such as anticipated traffic). Project selection is tilted towards those with high social benefits and low monetary benefits. We study the possible roles for privatization to alleviate these informational problems, and evaluate the regimes with and without the option for privatization.

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# 1 Introduction

Large privatization programs have occurred in recent decades in developed countries, transition economies and developing countries. Mature state-owned entities, such as airlines and network utilities, were sold to private hands. Governments have also passed to the private sector an increasing share of the investment in new public projects, such as the development of transportation infrastructure and other services.

One function of privatization is to enable governments to capitalize the future monetary income of public enterprises. In the case of a new project, the private operator shares the setup cost in exchange for future revenue. For an existing enterprise, privatization raises an immediate revenue that can be used for other purposes. From this perspective, privatization of a project is a form of borrowing, and is an alternative to keeping ownership and raising the same amount by issuing additional government debt. Indeed, for assets that generate only monetary income, the two alternatives are equivalent: Privatization simply lowers both sides of the government's future balance sheet by the same amount (lower debt and lower revenue).

Our focus, however, is on public projects which, apart from monetary revenue, generate also social benefits that cannot be appropriated. For example, a toll road generates revenue, and also social benefits in drivers' surplus and in reduced congestion in other roads; a power plant generates marketable electric power plus pollution. We argue that for such projects, privatization and issuing debt are not equivalent. Whether the government raises funds by privatizing a public project or turns to the credit market and retains ownership, can have a differential effect on its credit rating. Therefore, credit-rating considerations affect privatization policy.

A government's credit rating reflects the credit market's confidence in its ability to repay debt. The implied interest rate depends on the perceived probability of default, and can vary considerably between governments. For example, the yield spread between Italian 10 years euro-denominated bonds (rated A+ by S&P) and their German counter-

part (rated AAA) has peaked to more than half a percentage point recently.<sup>1</sup> For some emerging economies, spreads are even higher. Sub-national and local governments also differ considerably in their credit worthiness. 5-years general obligation bonds of Trenton, NJ (rated Baa2 by Moody's) yielded 1.5% annually more than those of Durham, NC (rated AAA).<sup>2</sup> These differences in borrowing cost are substantial. For example, with Italy's above 100% debt to GDP ratio, the lower credit rating is responsible for an additional annual borrowing cost of about 0.5% of GDP. The size of debt and expected revenues from assets are two major determinants on the credit rating. Therefore, decisions regarding public projects, which affect both, must take into account their impact on the credit rating.

The driving force for our results is the different weights that the government and the credit market put on the social benefits of projects. While the government is concerned with both monetary and social outcomes, its credit rating is mostly affected by the monetary aspect, as this directly enhances the government's ability to repay its debt. A government that takes its credit rating into account is pressed to put more weight on the monetary side of projects relative to their social benefits. However, informational problems tend to hamper its "credit market discipline" and lead to inferior outcomes. This affects both the way in which projects are implemented, and the decision which projects to undertake. We argue that privatization can sometimes be used to alleviate these problems, but aggravates them in other cases.

Consider first the implementation issue, i.e., the government's decision on the mixture of monetary revenue and social benefits the project will generate. In the case of a toll road, for example, the main tradeoff between future operating profits and social benefits is determined by the toll level: by increasing the toll, revenue increases at the expense of reduced drivers' surplus and increased congestion in alternative roads. At the buildup stage, the government would like to assure the credit market of an eventual stream of

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<sup>1</sup>On March 7 2008 the spread reached 57 basis points. Sources: <http://www.bundesbank.de>, <http://www.bancaditalia.it>.

<sup>2</sup>Source: Yahoo! Finance.

toll revenue. But once the road is operational, the government, now free of credit-rating considerations, has no reason to undermine the social benefits and picks a low toll. The credit market foresees this at the buildup stage and downgrades the credit rating accordingly. The government thus faces a commitment problem, taking the form of a dynamically-inconsistent toll policy.

Privatization delegates away some of the government's discretion over the implementation decision. The virtue of delegation is that it eliminates the dynamic inconsistency problem. With suitable contracting with the private operator, the government can obtain its ex ante optimal outcome. This implies a higher toll on the road. While the high toll agreed with the private operator may seem suboptimal when viewed from an ex post perspective, criticism of the toll on an existing road often fail to account for these ex ante considerations.

In practice, contracting for the desired commitment outcome is often impossible. For example, the lack of adequate performance measures may limit the effectiveness of contracting with airport-security companies. In many such cases, a significant discretion over the mode of implementation is left to the private operator. Caring only about the monetary aspect of the project, it shifts the implementation to the other extreme, overly neglecting the social benefits. Thus the government's decision whether to privatize an asset involves a comparison between two regimes – private and government control – under which respective modes of implementation are shifted away from the desired outcome in opposite directions. This comparison between the regimes is, in general, ambiguous.

Note that if the public project's implementation were the same under privatization and government ownership, then, as in the case of a purely monetary project, we would have neutrality: Whether the government privatizes the project or retains ownership and issues more debt, its credit rating will be the same. The differential effect on the credit rating is due only to the difference in the modes of operations under the two regimes.

On top of the implementation issue, credit-rating considerations also have implications when the government has private information regarding the project's characteris-

tics. For example, when the government builds a new nuclear power plant, the credit market might not be able to tell its economic necessity and the effect on the government's credit worthiness. The mere observation that the government found the project worthy is insufficient, since the initiative can be in part motivated by a hidden desire to promote a military agenda. Similarly, the credit market may be in the dark regarding the intensity of other government motivations such as generating employment, subsidizing R&D, redistributing income etc.

Such private information gives rise to adverse selection in the government's decision whether to undertake a project or not. Relative to the complete information benchmark, the government's project selection is tilted towards undesirable projects with high social benefits and forgoes desirable income-intensive ones. Moreover, it undertakes projects with negative net value, taking advantage of the market's inability to distinguish them from those with high monetary revenue. But, as the credit market anticipates these effects, the revenue from projects taken in equilibrium is evaluated correctly on average, and the overall effect on the government's utility, *ex ante*, is negative.

In this context, privatization can alleviate the information asymmetry. A private entity that takes the equity of the project, has incentives to invest in verifying its revenue prospects. In that it differs from the holders of government (undedicated) debt, or even credit agencies, who do not have sufficient incentives for a costly investigation of a specific project. Thus, when a project is privatized, the government obtains the actual monetary revenue, rather than that of an average project in the pool of government-operated projects. Moreover, since the pool is now changed, the value of an average project that the government takes by itself changes with privatization.

For projects that allow full contracting over implementation, the government finds private operation at least as desirable as its own. In this case, the verification provided by privatization fully resolves the adverse selection problem. An unravelling argument shows that the government withdraws from taking projects altogether, delegating their provision exclusively to the private sector. In the absence of full contracting, government implementation is superior in projects whose social-benefit aspect is dominant. In this

case, there is a mixed provision of projects, where revenue-rich projects are provided by the private sector, and those more heavily endowed with social benefits remain in government's hands.

To sum, the option to privatize projects has two advantages: First, from the implementation perspective, for some projects, the government may prefer the private operator's emphasis on monetary aspects to its own, dynamically inconsistent, emphasis on social benefits. Second, from a pure project selection perspective (ignoring the implementation issue), since the projects that are more attractive to the credit market tend to be privatized, there is less scope for the government to undertake negative present value projects, hiding them in one pool with the attractive ones. Does this imply that the government can only gain from having the option for privatization? The answer is negative. Projects for which private implementation is inferior may still be privatized, to gain the full credit-market response to their better-than-average monetary output. But *ex ante*, the gain from taking them out of the pool of government projects is zero. Whenever this effect is dominant, the government would prefer, at the *ex ante* stage, a regime (or constitution) that forbids privatization altogether.

### **Literature on privatization**

There is a vast body of literature on privatization and its effects.<sup>3</sup> A main theme in this literature is that privatization changes the incentives of insiders within privatized firms and the incentives of the government when dealing with the firm (see for example the papers by Schmidt (1996) and Laffont and Tirole (1991) on some of the possible effects)<sup>4</sup>. As these papers demonstrate, the change in incentives can lead to substantial

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<sup>3</sup>Vickers and Yarrow (1988) discuss some of the main theoretical perspectives, and the experience of privatization programs in various countries. Megginson and Netter (2001) survey the empirical studies on privatization.

<sup>4</sup>Schmidt (1996) focuses on how privatization changes the preciseness of the information on the firm's cost available to the government. Laffont and Tirole (1991) looks at contracting externalities that may arise due to privatization (between regulators and owners) and the effect on effort elicitation from firm's managers.

differences in the level of cost-reducing investment and in the cost-efficiency of the service provision.

Another strand of the literature, which is more directly related to our model, demonstrates that privatization can also affect the quality of the services provided. Hart, Shleifer and Vishny (1997) argue that, under private control, managerial effort for both cost reduction and service improvements are higher than the levels exerted by state employees under public control. However, incentives for cost-reduction under privatization can be excessive, as cost reduction has an adverse effect on the quality of service provided. This tendency of private operators to focus on the monetary aspects of the service (in this case cost reduction), and ignore the benefits for the recipients, is similar to what is postulated in our model. Quality reduction can also arise through other channels. Ellman (2006) argues that the higher cost of service adaptation for a privatized public service demotivates the government from investigating public demands for service change, and discourage the public from pressuring for such changes, leading to a reduced quality of service under privatization.

A relatively recent trend is the increased use of private-public partnerships (PPP) for the delivery of various public services. The literature on such partnerships (see for example Hart (2003), Bentz, Grout and Halonen (2002), Bennett and Iossa (2006), Martimort and Pouyet (2008)) focuses on the benefits and costs of contracting the building of public services and their operation to a single contractor. de Bettignies and Ross (2007) point out that a hallmark of PPPs is the delegation of the financing responsibility to the private firm who will build and operate the project. They suggest that private provision can dominate public ownership because it induces more efficient termination decisions for undesirable projects. Similarly to our model, but for very different reasons, the delegation of decision rights on the project, which goes along with the private operator providing setup financing, can be beneficial because of the government's failing to act *ex post* in a manner which would be efficient *ex ante*.

The implications of privatization on government finances have not been studied extensively. Vickers and Yarrow (1991) argue that revenue-raising is unlikely to be a

important rationale for privatizations in developed countries. Selling bonds is likely a less costly way to raise revenue than selling equities, because of the direct costs of sale (prospectus, advertising, underwriting), and because of the more accurate pricing of bonds. They argue, however, that a revenue motive may be relevant in less developed countries provided that the commitment not to expropriate equityholders is more credible than the commitment not to expropriate bondholders. It may also be attractive to governments committed publicly to constraint their borrowing levels. The arguments presented here show that a revenue motive may be important even in the presence of a developed market for the country's debt.

The remainder of the paper is organized as follows. In section 2 we develop a minimalistic model that captures the effect of a government's balance sheet on its credit rating. We study how the level of government debt and the composition of assets it owns affect the probability of default and the interest it pays on its debt. This leads to a valuation formula for public projects that takes into account their mixture of monetary and social benefits. In section 3 we study the implementation of projects, and demonstrate the government's dynamic inconsistency in the choice of implementation. We study the possible role of delegation to the private sector in alleviating this problem. In section 4 we turn to the question of project choice under asymmetric information. We demonstrate the adverse selection problem that skews the government choice in favor of projects richer in social benefits. We then study the effects of allowing the privatization of some projects. Section 5 concludes.

## **2 Government's credit rating and the valuation of investment projects**

In this section we develop a minimalistic model that captures the effect of a government's balance sheet on its credit rating. The model highlights the differential effect of the monetary and social benefits aspects of government's assets on the probability of default. This leads to a valuation formula for public projects that is the foundation for our



subsequent analysis.

The basic premise of the model is that the government discounts the future more than the credit markets, and therefore wishes to borrow. (The force that limits borrowing in our model is costs associated with the risk of default, which increase with the size of debt). The model allows for two different interpretations: (1) A small, open economy in which the government mirrors a representative agent with a higher intertemporal substitution rate than that of the "world". Here, the government borrows from the international credit markets. (2) A closed-economy in which the government has a preference for supplying government goods over private consumption of citizens.<sup>5</sup> The government is myopic and borrows from its citizens. The government's myopia could stem, for example, from the uncertainty over whether it will remain in power in the second period (as in Bulow and Rogoff (1989a)).

## 2.1 Basic model

There are two periods,  $T = 1, 2$ . One should think of the time between the two periods as a few years.<sup>6</sup> The interest rate on secure debt is normalized to 0. The government discounts the future relative to the credit market; its utility function is:

$$U = u_1 + \delta u_2.$$

where the per-period utilities,  $u_1$  and  $u_2$ , are linear.

In period 1 the government issues debt with face value  $d$  which it promises to pay bond holders in period 2. The period-1 revenue from issuing that debt (which depends on credit market's assessment of the risk of default) is  $R$ . Period-1 utility is normalized

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<sup>5</sup>Such a preference can be due to many reasons, such as a positive effect on the probability of being re-elected, direct rents extracted from running a large government (empire-building), etc.

<sup>6</sup>Period 1 is the time in which investment in a new project is made or the time of sale of an existing asset. Period 2 is a reduced form for the asset's productive period. Both the time from investment to operation and the length of the operation period tend to be of the order of several years.

to 0 apart from debt-revenue  $R$  and investment expenses  $I$ :

$$u_1 = R - I.$$

The outcome from investments occurs in period 2 and consists of a monetary part,  $X$ , and social benefits  $Y$ . Period-2 utility is the sum of  $X$ ,  $Y$ , plus a random income from other sources  $s \geq 0$  (with cdf  $F$  and a continuous pdf  $f$ ), minus the amount  $e$  of debt that the government decides to repay. In case of default on (part or all of) the debt, there is also a utility loss of  $L > 1$  for every dollar of default  $d - e$ .<sup>7</sup> Thus,

$$u_2 = X + Y + s - e - L \cdot (d - e).$$

After it observes  $s$ , the government decides  $e$ , subject to a monetary feasibility constraint:

$$\max_e u_2 \quad s.t. \quad X + s - e \geq 0.$$

Thus, while  $X$  and  $Y$  are equivalent in terms of consumption value,  $X$  can also be used for debt repayment. For example, the government can use the revenue from an oil field ( $X$ ) to supply goods or to pay debt. In contrast, a natural preserve generates utility to citizens that cannot be monetized to pay debt in case of financial distress.

## 2.2 Debt-repayment decision

Because  $L > 1$ , the solution to the period-2 problem is simply:

$$e^*(d, X, s) = \min \{d, X + s\}. \quad (1)$$

In words, government repays as much of its debt as it can, and defaults (partially) only when it doesn't have enough cash to repay it all. For convenience, we also denote  $L^*(d, X, s) = L \cdot (d - e^*(d, X, s))$ .

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<sup>7</sup>In the small-economy interpretation, the loss  $L$  can represent the costs of direct sanctions in trade or of costly seizure of assets (see Bulow and Rogoff (1989a) for an in-depth discussion).  $L$  can also include the costs of lower reputation that diminishes the ability for future borrowing. In the closed-economy interpretation,  $L$  can represent the costs to the government from debt-holders' unrest, which can impact their future voting or even result in physical damage to government property.

The above decision rule implies that the government defaults whenever the income shock  $s$  is below  $d - X$ . This has probability  $F(d - X)$ .<sup>8</sup>

### 2.3 Determination of the debt level

We assume that credit markets are risk neutral. Since the interest rate on secure debt is normalized to 0, the period-1 revenue  $R$  from issuing debt with face value  $d$  is the expected payout:

$$R(d, X) = E_s[e^*(d, X, s)]. \quad (2)$$

Given  $I$ ,  $X$  and  $Y$ , the government's debt-determination problem in period-1 is:

$$U(X, Y, I) = \max_d R(d, X) - I + \delta (X + Y + E_s[s - e^*(d, X, s) - L^*(d, X, s)]). \quad (3)$$

Substituting for  $R(d, X)$ , and taking the derivative with respect to  $d$ , we obtain the first-order condition:<sup>9</sup>

$$(1 - \delta) \frac{\partial E_s[e^*]}{\partial d} = \delta \frac{\partial E_s[L^*]}{\partial d}.$$

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<sup>8</sup>There is a vast literature on sovereign debt, the risk of default, and the mechanisms that enforce debt repayment by sovereign borrowers. One strand of the literature, beginning with the seminal paper by Eaton and Gersovitz (1981) considers the reputational effects of default on the creditor's future ability to borrow, as deterring from repudiation of the debt. The validity of this explanation has been questioned by Bulow and Rogoff (1989b). Another strand of the literature (see for example Bulow and Rogoff (1989a)) considers direct sanctions that lenders can impose on creditor countries within their own borders (for example trade sanctions, seizure of assets) or through international bodies.

A main premise in this entire literature is that it is the country's willingness to pay its debt, rather than its ability to pay, that determines the decision to default. Our aim here is to develop a simple model of credit rating, rather than the default decision by itself. We thus choose a simplified framework in which the default on the debt is solely the outcome of monetary constraints. While the model is a simplistic description of the sovereign's default decision, it yields a very tractable formulation to work with. The main intuitions developed in the rest of the paper, regarding the effects of the credit rating on the valuation of public projects, should follow also from more elaborate models of default and credit rating.

<sup>9</sup>Observe from the derivations below that the second-order condition is clearly satisfied.

(Increasing the nominal debt by one dollar implies a transfer of  $\partial E_s [e^*] / \partial d$  from period 2 to period 1. The net gain from this trade with the credit market equals the discounted additional loss in period 2.)

Note that the marginal dollar of debt augments  $e^*(X, s, d)$  by 1 if eventually there is no default – an event with probability  $1 - F(d - X)$ , and augments  $L^*(X, s, d)$  by  $L$  in case of default – probability  $F(d - X)$ . Thus:

$$\frac{\partial E_s [e^*(X, s, d)]}{\partial d} = 1 - F(d - X) \quad (4)$$

and

$$\frac{\partial E_s [L^*(X, s, d)]}{\partial d} = L \cdot F(d - X). \quad (5)$$

Substituting these into the first-order condition, we have:

$$(1 - \delta)(1 - F(d - X)) = \delta L \cdot F(d - X). \quad (6)$$

This first-order condition should be interpreted as follows: the government issues debt until the probability  $F$  of default is high enough, so that the gains from trade that result from increasing the debt by one more dollar equals the discounted period-2 marginal loss. In other words, as the government borrows more, its credit rating deteriorates, and the value of the marginal bond,  $\partial R / \partial d = 1 - F$ , decreases. As its discounting of period 2 can be significant ( $\delta \ll 1$ ), the government borrows a significant debt, until  $\partial R / \partial d$  is quite small.

What is the relationship between the model's variables and the numbers observed in the data? Note that, since we normalized the interest rate on secure debt to zero,  $\frac{1}{\partial R / \partial d}$  is the premium over secure debt paid on the marginal dollar of debt. Importantly, its order of magnitude can be much higher than that of the interest-rate spreads observed in the data (such as Italy's 1/2% spread over Germany's debt and Trenton's 1.5% over Durham's). This is so for two reasons. First, these spreads reflect the average premium over the entire debt; the spread on the marginal dollar is much higher than the average spread. Second, these spreads are in annual term, while borrowing costs in our model, from period 1 to period 2, reflect interest over several years.

## 2.4 Valuating social vs. monetary benefits

Assume that prior to the determination of debt  $d$ , the government can increase  $X$  or  $Y$  by a small marginal unit. How much would it be willing to pay for either in period 1?

By (3), and since  $Y$  does not affect the optimal debt-level decision nor the payout  $e^*$ , we simply have:  $\partial U(X, Y, I) / \partial Y = \delta$ .

The value of  $X$  is higher than that of  $Y$ . This has two reasons. First, in case of default,  $X$  is used to repay debt, in which case its period-2 marginal utility is  $L$  rather than 1. Thus, on top of its direct consumption value,  $X$  also has an *option value* to reduce default costs. Second, the revenue from the debt,  $R(d, X)$ , is higher, since the credit expects that  $X$  will sometimes be used to repay the debt. This is the *credit-market value* of  $X$ .<sup>10</sup> We now compute the two components.

We start with the credit-market value. An extra dollar in  $X$  will be used to repay debt if and only if government is in default – an event with probability  $F(d - X)$ . Since the density of the default probability,  $f(d - X)$ , is continuous, the change in the probability of default itself is of second order importance. Thus, the credit market value of  $X$  is simply  $F(d - X)$ .<sup>11</sup>

The internal value of  $X$  (which comprises of the consumption value plus the option value) is a weighted average of 1 (the value in case the income shock  $s$  is above  $d - X$  so there is no default and the added  $X$  is used for consumption) and  $L$  (the value in case  $s$  is below  $d - X$  so government uses the additional  $X$  to reduce the amount of default). The respective probabilities of the two events are  $1 - F(d - X)$  and  $F(d - X)$ . (Again, because  $f$  is continuous we can ignore the change in the probability of default). Discounted to period-1 utility, the internal value of  $X$  is thus  $\delta [(1 - F(d - X)) \cdot 1 + F(d - X) \cdot L]$ .

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<sup>10</sup>A third element in the value of  $X$  is the change in utility due to the fact that the government can re-optimize the level of debt  $d$  in response to the change in  $X$ . However, for small changes in  $X$  this element is negligible by the envelope theorem.

<sup>11</sup>More formally,  $\frac{\partial R(d, X)}{\partial X} = \frac{\partial E_s[e^*(d, X, s)]}{\partial X} = \frac{\partial [\int_{s=\underline{s}}^{d-X} (X+s)f(s) + \int_{s=d-X}^{\bar{s}} d \cdot f(s)]}{\partial X}$ . Because  $f$  is continuous, the derivatives with respect to the integrals' endpoints  $d - X$  cancel each other. Thus:  $\frac{\partial R(d, X)}{\partial X} = \int_{s=\underline{s}}^{d-X} f(s) = F(d - X)$ .

By the first-order condition for the debt (6), this is simply  $1 - F(d - X)$ .

The sum of the two effects is 1. This could also be deduced directly: If the government accompanies the increase in  $X$  by an identical increase in the debt  $d$ , then by (1) the payout  $e^*$  will increase by 1 independently of the income shock  $s$ . This leaves period-2 consumption unchanged, and increases the period-1 revenue  $R(d, X)$  by 1.<sup>12</sup>

## 2.5 Valuating public projects

We conclude this section with a simple valuation formula for government projects, which will be the building block of our subsequent analysis. This formula captures the differential weights put on the projects' monetary and social benefits.

Consider a small project that yields a monetary benefit  $x$  and social benefit  $y$ . In the case where  $x$  is commonly known, the first-order approximation of the net present value to government from the project is, by Section 2.4,

$$V(x, y) = x + \delta y \tag{7}$$

As we observed, the weight of 1 on  $x$  is the sum of its internal value ( $1 - F$ ) and its credit market value ( $F$ ). If the credit market's belief  $x^e$  is different from the true  $x$ , the internal value applies to the true  $x$ , while the credit-market value applies to the belief  $x^e$ . The first-order approximation of the project's value is then:

$$V(x, y; x^e) = (1 - F) \cdot x + F \cdot x^e + \delta y. \tag{8}$$

(Where  $F$  is the probability of default given the (optimal) stock of  $d$  and  $X$ ).

Recall that the internal value of  $x$ ,  $1 - F$ , is already larger than the value of  $y$ , which is  $\delta$ , as it includes the option value of using it to repay debt. Thus, even when the credit market does not observe  $x$ , the government values  $x$  more than it values  $y$ . When the credit market observes  $x$ , the government puts an additional weight of  $F$  on  $x$ . We refer

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<sup>12</sup>In this case there is no need to employ the envelope theorem to argue that the effect of debt-reoptimization is negligible, since increasing the debt by 1 is in fact optimal in this case (see the first-order condition (6)).

to this additional weight as the effect of "credit market discipline" on the government's valuation of public projects.

### 3 Project implementation and government's commitment problem

As the road example discussed in the introduction illustrate, the government faces a decision on the mixture of monetary revenue to social benefits. This applies both to new projects it undertakes and to mature assets it already owns (if the mixture can be changed over time). By delegating the operation of an asset to the private sector,<sup>13</sup> the government limits its own control over the mixture of monetary revenue and social benefits. In light of the credit-market considerations discussed in the previous section, the government may benefit from tying its hands in that manner.

We assume therefore that the government is deliberating whether to privatize a small project. The project is characterized by a commonly known convex set  $A$  of monetary-social benefits pairs  $(x, y)$ , with a smooth, concave efficient frontier  $y = h(x)$ . The set  $A$  and the function  $h$  are illustrated in the Figure 1.

Whoever operates it (government or private operator) chooses an implementation  $(x, h(x))$ . For simplicity, we ignore at this stage the option of not performing the project.

We categorize projects according to timing at which the decision on the implementation point  $(x, y)$  is taken:

- T1 – Early-characterization project.

Here the project's characteristics  $(x, y)$  are chosen when the project is initiated, in period 1, and cannot be altered later. The credit market observes this choice before the

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<sup>13</sup>Such delegation is most often termed "Build-Operate" (BO) or "Public-Private-Partnership" (PPP) in the case of a new project, while "privatization" more often applies to the sale of a mature asset. In the first case period 1 represents the buildup stage, while in the latter it is the time of sale. Period 2 is, in both cases, the time when fruits of the project are realized.

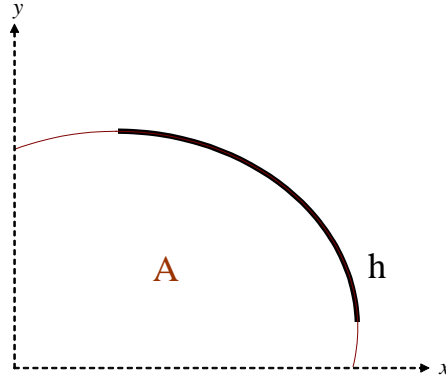


Figure 1: Efficient frontier of a possible implementations

government issues its debt and thus takes  $(x, y)$  into consideration in pricing the debt. An example of a T1-project is a power plant that can be coal- or gas-operated. This decision must be taken (and will be observed) at the early design stages.

- T2 – Late characterization project.

In this case the project's characteristics are determined only in period 2, before  $s$  is realized. An example is the decision on the toll level of a road.<sup>14</sup> Here,  $(x, y)$  is not known to the credit market when it prices the debt, so that the pricing is done given its rational expectations. We include in this category also projects for which the implementation is determined in period 1 but is unobservable to the credit market. As no additional information will be gained between periods 1 and 2, they are equivalent for our purpose.

### 3.1 Benchmark: Optimal decisions with commitment

The government undertakes the project (T1 or T2) and commits to the implementation scheme  $(x_c, y_c = h(x_c))$  before the credit market prices the debt. By (7), the govern-

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<sup>14</sup>In this and many other examples, the operation phase can be quite long. In this case, the income shock  $s$  is slowly revealed over time, and the implementation can change continuously over the operation period. The T2 case can be viewed as a lower bound on the timing of the implementation decision. In the concluding section we discuss the upper bound – an implementation decision taken after  $s$  is revealed.



ment's maximization problem is:

$$\max_x V(x, h(x)) = \max_x x + \delta h(x)$$

Taking the first order condition for  $x$  yields:

$$h'(x_c) = -\frac{1}{\delta}. \quad (9)$$

The solution is the point on the efficient frontier where the slope equals the prices ratio  $1/\delta$ . The value of the project to the government is:

$$V(x_c, h(x_c)) = x_c + \delta h(x_c). \quad (10)$$

### 3.2 Government implementation absent commitment

We now study the outcome when the government makes the implementation decisions without commitment. We consider the two categories of projects: T1 (early-characterization) and T2 (late characterization).

#### T1: Early-characterization project

Clearly, the outcome in this case is the same as in the commitment case analyzed above. Denoting the implementation  $(x_{T1}, y_{T1})$ , we simply have  $(x_{T1}, y_{T1}) = (x_c, y_c)$ . The government's utility reaches that of full commitment.

#### T2: Late-characterization project

In this case the choice of implementation scheme is made only after government issues its debt  $d$ . Since the credit market does not observe  $x$ , it prices the debt according to its expectation  $x^e$ . The government thus takes the credit market value of  $x$ , namely  $F \cdot x^e$ , as sunk and maximizes the present values of  $x$  and  $y$ . By (8), this is simply

$$\max_x V(x, h(x); x^e) = \max_x F \cdot x^e + (1 - F) \cdot x + \delta h(x). \quad (11)$$

Denoting the optimal solution by  $x_{T2}$ , the first-order condition is:

$$-h'(x_{T2}) = \frac{1 - F}{\delta}. \quad (12)$$

Thus, instead of choosing the point  $(x_c, y_c)$  on the efficient frontier where its slope  $h'(x_c)$  is  $\frac{1}{\delta}$ , the government now has no "credit-market discipline": it ignores the credit-market value of  $x$  and chooses the point where the slope is  $\frac{1-F}{\delta}$ .

By rational expectations of the credit market,  $x^e = x_{T2}$ . We thus have:

$$V(x_{T2}, h(x_{T2}); x_{T2}) = V(x_{T2}, h(x_{T2})) = x_{T2} + \delta h(x_{T2})$$

by revealed preference, this is less than the full commitment outcome  $V(x_c, h(x_c)) = \max_x V(x, h(x))$ .

To recap the intuition, the government ignores the externality on its debt holders when it chooses the implementation, and thus puts too much weight on the social benefit aspect  $y$ . But as its debt holders foresee that, they price the debt accordingly, and in a rational expectations equilibrium the government pays exactly for the negative externality. The government thus faces a *dynamic inconsistency* problem: it would like to promise its creditors that it will shift the implementation towards the monetary aspect  $x$ , but such promise would not be credible.

### 3.3 Operation by the private sector

We now turn to check the scope for delegation to the private sector, so as to alleviate the government dynamic inconsistency problem. We sidestep any differences that may exist in the efficiency of the private operator relative to the government. The only difference may be in the choice of the implementation point on the efficient frontier.

We assume that there is a competitive supply of private operators so that their bids for the project would equal their expected net operational revenues. This may be positive or negative, implying that the government need to offer the private operator a subsidy. Denoting the eventual implementation of the project by the private operator (to be computed later) by  $(x_{po}, y_{po})$  the government is paid  $x_{po}$  for the project. In period 2 the government no longer has monetary income from the project and just enjoys the social benefit  $y_{po}$ . Thus, the period-1 value to the government from privatizing the project is  $x_{po} + \delta y_{po}$ . Note that this is exactly  $V(x_{po}, y_{po})$ . This means that for a government

that has access to credit markets, the value of a project *fixing the implementation* is the same whether it is financed by the private sector or by the government. The two will differ only when privatization changes the implementation. We now turn to analyzing this issue.

We first note that delegation of the implementation decision to a private operator has no use in the case of early-characterization projects (T1), as for those projects the government already achieves the commitment outcome. Thus, we focus on T2 projects. For those projects we can distinguish between two cases: one in which the private operator gains full discretion over the implementation decision and another in which the implementation is decided in a contract between the government and the operator.<sup>15</sup>

### 3.3.1 Private Operator with full discretion

If the project is delegated to a private operator (PO) who is put in charge of choosing the implementation scheme, it chooses the point that maximizes  $x$ , ignoring  $y$ . Denoting  $x_m = \max \{x : (x, y) \in A\}$ , we have:

$$(x_{po}, y_{po}) = (x_m, h(x_m)).$$

Clearly the value of the project to the government in this case,  $V(x_{po}, h(x_{po}))$ , is below the full commitment outcome  $V(x_c, h(x_c))$ . The comparison of  $V(x_{po}, h(x_{po}))$  to the value in case of operation by the government itself,  $V(x_{T2}, h(x_{T2}))$ , is in general ambiguous. These two modes of implementation are shifted away from the commitment outcome in opposite directions. This is illustrated in Figure 2.

**Remark** Up to this point we have assumed that the private operator extracts the entire monetary benefit  $x$  of the project. More realistically, the government often retains part of the monetary benefits even under privatization. For example, part of the surplus to the users of a toll road also generates additional tax revenues due to the increased

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<sup>15</sup>Casual observation suggests that full discretion is more often the case in privatization of mature assets, while the operation of BO and PPP projects is typically subject to a contract.

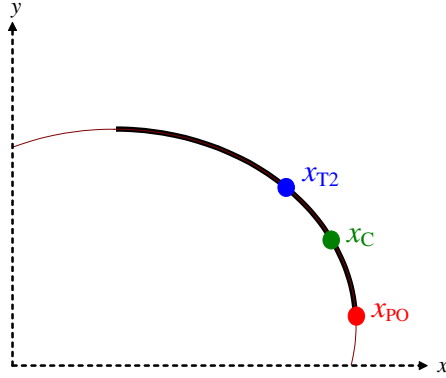


Figure 2: Government vs. PO implementations

profitability of commercial users. This case can easily be analyzed in our framework by increasing  $\delta$  so to capture that part of  $y$  is still discounted while other part of it is not, since it is treated like  $x$ . The crux of our results remains; one difference is that the PO's implementation is not optimal even when the future is extremely discounted ( $\delta \rightarrow 0$ ). This is because the PO maximizes the direct revenue from the project (the toll), rather than the true  $x$ .

### 3.3.2 Contracting with the Private Operator

Assume now that the government and the PO can write a binding contract  $(x, h(x) = y)$  on the implementation scheme for the project. Clearly, the contract will mimic the full commitment outcome, and the value to the government will be  $V(x_c, h(x_c)) = \max_x V(x, h(x))$ . In this sense, one can view the delegation to the PO as a commitment device.

An important insight is that the optimal ex ante contract will seem suboptimal when viewed from an ex post perspective. For example, the toll on an existing toll road (as contracted with the PO) might seem excessive when compared to the one that generates the ex post optimum  $(x_{T2}, y_{T2})$ . Arguments that criticize the "excessive" toll often fail to account for the ex ante considerations that put more weight on  $x$  due to credit-market

discipline.

In summary, whenever full contracting with the private operator is feasible, all projects should be undertaken by the private sector, thereby restoring the commitment outcome. However, in practice, such contracting for the desired commitment outcome is often impossible.

Consider, for instance, the problem of devising an optimal toll on a road. The optimal contract may require a toll that depends on the momentary demand curve for the road (as this influences the slope of  $h$ ). But since demand is usually non-verifiable, the contract can only impose a fixed maximum price. Another desired clause in the optimal contract would specify a reduced toll whenever the alternative road is compromised due to construction work, since then the social value of relieving congestion there is higher. However, such a contract can be easily manipulated later by government, sending a construction worker to establish presence and improve her tan.

Whenever the best implementation scheme depends on such non-verifiable or fungible variables, only partial contracting is possible. We refrain from developing a full-fledged model for limited contracting. We note that the value of to the government of privatizing the project is between  $V(x_c, y_c)$  and  $V(x_{po}, y_{po})$ .

## 4 Project choice and adverse selection

We now shift our attention to a second informational asymmetry: aspects of the project that are privately known to the government, but not to the credit market. For example, when the government builds a new power plant, parameters such as future demand for electricity and operation costs may not be fully observed by the credit market when it estimates the government's credit worthiness. The government may also have an informational advantage regarding the potential social benefits of the project: generating employment, guaranteeing a reliable electricity supply to consumers etc.

The government's informational advantage over the credit market can lead to an adverse selection problem. Whenever the government undertakes a project, the credit

market will price its debt as if it was an average project. Since the credit-market value of all projects is now the same, the government's valuation of projects is distorted: projects rich in monetary income are undervalued whereas projects poor in monetary income are overvalued. This creates a bias in the government's project selection towards those poorer in monetary benefits and richer in social benefits.

If instead a private entity engages in the project, it will invest resources in learning the parameters of the project.<sup>16</sup> Thus, the option to privatize will (on top of changing the implementation as in section 3) enable the government to credibly disclose the project's characteristics to the market. The option to privatize not only changes the value that government extracts from a project that it chooses to privatize; also projects that it still undertakes by itself will now have different values. The reason is that the credit market will update its beliefs given the fact that the government didn't exercise the option to privatize.

To capture the idea that projects can have different intensities of potential monetary and social benefits, while maintaining the implementation decision non-trivial, we expand the model of section 3 as follows: Consider a parametric class of projects which are all scalings of a basic function  $y = h(x)$ . For any two positive scalars  $\alpha_x, \alpha_y$  the project

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<sup>16</sup>The incentive to invest in studying the specifics of the project is what distinguishes the private operator from other parties. Clearly, small debt holders do not have sufficient incentive to carry out, on their own, an expensive investigation of the parameters of the project. Neither are there adequate incentives for credit-rating agencies, who rate the entire debt, to perform an in-depth analysis of each project. While they do perform crude estimations of the asset side of the government's balance sheet, and thus take into account the investment in new projects, they do not gain enough from fine tuning their estimations of the specifics of each project. For instance, a credit-rating agency might count the number of miles of roads, but refrain from performing large scale surveys to anticipate the demand in different conditions. The option that the government hire an external auditor to appraise the specific project is also unlikely to help. The auditor would also not have strong incentives to invest resources and maintain his reputation. The reason in this case is that the monetary income from the specific project is not likely to be easily observed by the public: as the project is owned by the government, it will be hard to sift its income from the soup of the government's finances.

$\alpha = (\alpha_x, \alpha_y)$  is defined by the efficient frontier

$$y = \alpha_y h\left(\frac{x}{\alpha_x}\right).$$

Note that  $\alpha_x$  "stretches" the function  $h$  in the  $x$  direction, while  $\alpha_y$  stretches it in the  $y$  direction. If  $\alpha_x = \alpha_y$ , the  $(\alpha_x, \alpha_y)$ -project's efficient frontier is simply stretched out proportionally. These transformations are illustrated in Figure 2.

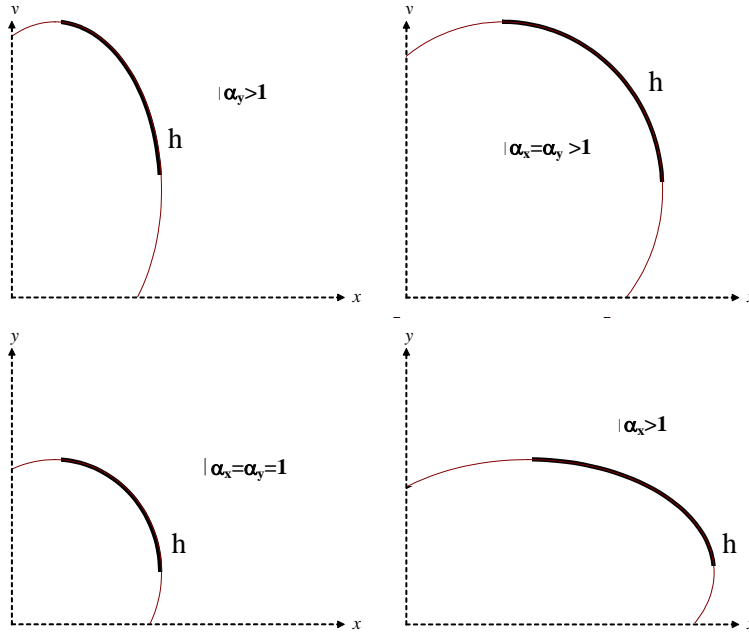


Figure 2: Scaling of a basic function  $h$

The prior distribution of  $\alpha$  is  $G(\alpha)$  (with a continuous p.d.f.  $g$ ) with support  $[0, M] \times [0, M]$  for some large  $M$ . All projects have a cost 1. Recall that we think of project as small relative to government's stock of debt (for any project in the distribution) so that the linear approximations of projects' valuations (section 2.5) can be applied.

The timeline is as follows: At the onset of period 1, the government privately learns the attributes  $\alpha$  of a single project. It then chooses one of three options: dismissing the project; undertaking it by itself, or privatizing it.<sup>17</sup> The credit market observes this

<sup>17</sup>For concreteness we think of the project as new; In case of a privatization of an existing asset, if the

decision (but not  $\alpha$ ) and then prices the government's debt.<sup>18</sup> The period-2 timeline is unchanged.

In the case of a T1 project, the market observes the implementation point  $(x, y)$  before it prices the debt. This makes the asymmetric information regarding  $(\alpha_x, \alpha_y)$  inconsequential.<sup>19</sup> We thus focus in this section on T2 projects.

We analyze this game going backwards: Given project  $\alpha = (\alpha_x, \alpha_y)$ , we use the results from section 3 to find the implementation scheme  $(x, y)$  under government or private operation. We then revert to project-selection stage.

We now compute the implementation  $(x, y)$  as a function of the project attributes  $(\alpha_x, \alpha_y)$  in government's or PO's implementation. Denote  $\gamma = \frac{\alpha_y}{\alpha_x}$  and  $\eta(z) = h'^{-1}(z)$ .<sup>20</sup> In the case of implementation by the government, the first-order condition (12) yields  $1 - F + \delta\gamma h' \left( \frac{x}{\alpha_x} \right) = 0$ . Thus:

$$(x_{gov}(\alpha), y_{gov}(\alpha)) = \alpha_x \cdot \left( \eta \left( -\frac{(1-F)}{\delta\gamma} \right), \gamma h \left( \eta \left( -\frac{(1-F)}{\delta\gamma} \right) \right) \right). \quad (13)$$

In the case of PO's implementation, we have:

$$(x_{po}(\alpha), y_{po}(\alpha)) = \alpha_x \cdot (x_m, \gamma h(x_m)) \quad (14)$$

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option to shut down exists, the analysis is the same with the cost taken as zero. Without this option, the analysis to follow is similar, while the equilibrium characterization is slightly modified, as discussed at the end of the section.

<sup>18</sup>Since the project itself is assumed to be small relative to the stock of debt, we ignore the impact of debt level reoptimization when the government chooses to undertake the project. By the envelope theorem this has a second-order effect on its utility. We also ignore possible signaling of the project's characteristics using the debt level. This could be made formal by introducing some noise into the debt decision, by assuming a little private information on the discount factor  $\delta$  or in the market's observation of the debt  $d$ , but is beyond the scope of this paper.

<sup>19</sup>An alternative interpretation of T1 projects could make their analysis with asymmetric information non trivial. We could assume that the "implementation" that the market observes in period 1 is a function from project characteristics  $\alpha$  to monetary-social benefits pairs  $(x, y)$ . The analysis under this definition has some subtleties, and is discussed in the concluding remarks section.

<sup>20</sup>Note that since  $h$  is concave,  $\eta$  is decreasing.



(recall that  $x_m$  is the maximal  $x$  or the basic project  $h$ ).

## 4.1 Project selection without the private sector

We first consider the case in which the option to privatize does not exist. The government decides between undertaking the project and dismissing it.

Note that, since the transformation from  $\alpha = (\alpha_x, \alpha_y)$  to  $(x_{gov}(\alpha), y_{gov}(\alpha))$  is one-one, when analyzing government's decision whether to undertake the project or dismiss it, one may simply identify a project  $\alpha$  with the corresponding government implementation in the  $(x, y)$  space. Only when we compare the alternative forms of implementation (government's vs. PO's), we must work in the common representation – the  $(\alpha_x, \alpha_y)$  space.

### 4.1.1 Benchmark: complete information

We first consider the case where  $\alpha$  is common knowledge. Let  $(x, y) = (x_{gov}(\alpha), y_{gov}(\alpha))$  be the final outcome of the project if implemented by the government. The credit market observes  $\alpha$  and thus knows the outcome  $(x, y)$ . Government will undertake the project as long as its value exceeds its cost of 1:

$$V(x, y) = x + \delta y \geq 1.$$

Figure ?? illustrates the set of (outcomes of) projects that the government would take in the  $(x, y)$  space. The division line between that region (*GOV*) and that of projects that are dismissed (*NON*) has slope  $-1/\delta$ .

Denoting the induced probability distribution over  $(x, y)$  by  $G_{xy}$ , the government's ex ante utility is:

$$U_{CI} = \int_{x+\delta y-1 \geq 0} (x + \delta y - 1) dG_{xy}.$$

### 4.1.2 Asymmetric information

With asymmetric information, the credit market only knows the distribution  $G_{xy}$  of the random implementation point  $(x, y)$ , while the government knows the realization.

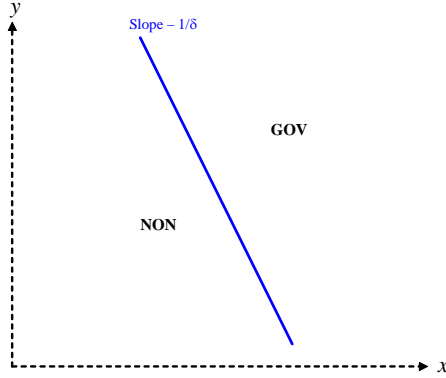


Figure 3: Project selection - complete information benchmark

Denote the set of possible projects that the government would take in equilibrium by  $GOV$ .

When the government undertakes the project, the (risk neutral) credit market – unaware of the true  $x$  – prices the debt as if the monetary outcome of the project was the average of monetary outcomes of all projects in the set  $GOV$ , i.e.,

$$x^e = E[x | (x, y) \in GOV].^{21}$$

By (8), the government will undertake the project if

$$V(x, y; x^e) = (1 - F) \cdot x + F \cdot x^e + \delta y \geq 1$$

or:

$$x + \delta y + F \cdot (x^e - x) \geq 1.$$

This decision rule can be compared to the complete information counterpart (where  $x^e = x$ ):

$$x + \delta y \geq 1.$$

Thus, relative to the benchmark, the government adds to the value of the project the amount  $F \cdot (x^e - x)$  which is positive for a project whose monetary benefit  $x$  is below the average  $x^e$  and negative otherwise.

The set  $GOV$  is thus defined by:

$$GOV = \{(x, y) : V(x, y; x^e) \geq 1\}$$

where  $x^e = E[x | (x, y) \in GOV]$

Figure 4 illustrates the set of (outcomes of) projects that government would take in the  $(x, y)$  space:

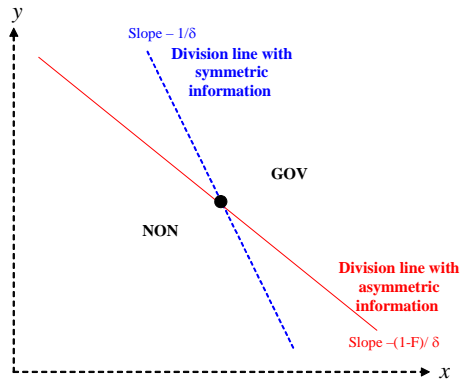


Figure 4: Project selection under asymmetric information

The division line is flatter than that pertaining to the complete information benchmark (slope  $(1 - F) / \delta$  vs.  $1 / \delta$ ). Moreover, since points on the division line tend to have a lower  $x$  than that of an average point in the set  $GOV$  (which lies to the right of the division line), then the difference between the decision rules of the two cases,  $F \cdot (x^e - x)$ , tends to be positive. In other words, the marginal project tends to be subsidized by the average project, making it more profitable. This effect pushes the division line further to the left.

#### 4.1.3 The ex ante cost of asymmetric information

As we saw, the government exploits the fact that the credit market does not know the exact  $x$  of a given project, to undertake projects with low  $x$  and high  $y$  that with complete information would have negative value ( $V(x, y) < 0$ ). It also dismisses projects with high

$x$  and low  $y$  that would otherwise have positive value. While this is optimal given its knowledge of  $x$ , the credit market – which has rational expectations – cannot be fooled on average. Thus, government’s ex ante utility with asymmetric information is less than that of the complete information case, as we now show:

$$\begin{aligned} U_{AI} &= \int_{GOV} (V(x, y; x^e) - 1) dG_{xy} \\ &= \int_{GOV} (x + \delta y + (x^e - x)F - 1) dG_{xy} \\ &= \int_{GOV} (x + \delta y + (E[x | (x, y) \in GOV] - x)F - 1) dG_{xy} \end{aligned}$$

Since  $\int_{GOV} E[x | (x, y) \in GOV] dG_{xy} = \int_{GOV} x dG_{xy}$ , this equals.

$$\int_{GOV} (x + \delta y + (x - x)F - 1) dG_{xy} = \int_{GOV} (x + \delta y - 1) dG_{xy}$$

This is, of course, less than the government’s utility with symmetric information,  $U_{CI} = \int_{x+\delta y-1 \geq 0} (x + \delta y - 1) dG_{xy}$ , which takes the same integrand but sums it exactly over the set of points where it is positive.

## 4.2 Adding the option to privatize

We now introduce the possibility of delegating the project to a private operator. Projects can either be dismissed, privatized or undertaken by the government itself. We assume that prospective private contractors can verify the project’s characteristics  $\alpha = (\alpha_x, \alpha_y)$ . As in section 3.3, the competitive supply of potential bidders brings the privatized project’s value to the government to  $V(x_{po}(\alpha), y_{po}(\alpha)) - 1$ . The verification of  $\alpha$  by the private operator has the potential for alleviating the adverse selection problem. However, as we saw in section 3, the choice of implementation point is different in private vs. government ownership. We start our analysis with a benchmark case that focuses on the first effect by trivializing the implementation decision.

### 4.2.1 Benchmark: fixed implementation

Assume that there is only one possible implementation technology. That is, the basic project  $h$  yields an outcome  $(x_0, y_0)$ . Thus, project  $\alpha$  is associated with the outcome

$(\alpha_x x_0, \alpha_y y_0)$ . The option to privatize is in this case, solely a way for the government to reveal the project's true  $\alpha$ .

For the realizations of  $\alpha$  that are most attractive from the credit market's perspective (those with high  $\alpha_x$ ), the government prefers to privatize the project – otherwise, the credit markets would take the project as an average one. Understanding that, the credit market considers projects that are not privatized as belonging to a set of inferior projects. Consequently, the government is induced to privatize also the "better" projects in the new smaller set. Continuing with this unravelling argument shows that the government must withdraw completely from undertaking projects; every project will either be privatized or dismissed.

To see this formally, denote the set of projects undertaken by the government in this case by  $GOV$  and assume by contradiction that the set  $GOV$  has positive measure, and let  $x^e = E_{\alpha \in GOV} [\alpha_x] \cdot x_0$ . Let  $\hat{\alpha} = (\hat{\alpha}_x, \hat{\alpha}_y)$  be a point in the closure of  $GOV$  such that  $\hat{\alpha}_x \geq \alpha_x$  for all  $(\alpha_x, \alpha_y) \in GOV$ . Because  $GOV$  has positive measure, we must have  $\hat{\alpha}_x x_0 > x^e$ . Since  $\hat{\alpha}$  is in the closure of  $GOV$ , continuity of  $V$  implies that its value if government undertakes it must be at least as the value if it is privatized:  $V(\hat{\alpha}_x x_0, \hat{\alpha}_y y_0; x^e) \geq V(\hat{\alpha}_x x_0, \hat{\alpha}_y y_0)$ , or  $\hat{\alpha}_x x_0 + \delta \hat{\alpha}_y y_0 + F(x^e - \hat{\alpha}_x x_0) \geq \hat{\alpha}_x x_0 + \delta \hat{\alpha}_y y_0$ , a contradiction.<sup>22</sup>

**Remark** This result applies, a-fortiori, to the case of full contracting, since there private implementation dominates government's. (See section 3.3.2.)

#### 4.2.2 Different government vs. private implementation

We now return to the full-blown model where implementation changes when the project is privatized.

The calculation of the project's value to the government is very similar to that of

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<sup>22</sup>In fact, a stronger result holds: the set  $GOV$  is either empty or a singleton with  $\alpha_y = M$ . This is because for any point  $\hat{\alpha}$  in  $GOV$ , also the open triangle  $\{\alpha : \alpha_x < \hat{\alpha}_x, \alpha_y > \hat{\alpha}_y, (\alpha_y - \hat{\alpha}_y) y_0 < (1 - F)(\hat{\alpha}_x - \alpha_x) x_0\}$  to the northwest of  $\hat{\alpha}$  must also be in  $GOV$ . But if  $\hat{\alpha}_y < M$ , this triangle would have positive measure.

the case in which the option to privatize did not exist. The only difference is that the credit market's calculation of  $x^e$  now takes expectation over a smaller set of projects – that without those that are privatized. Formally define:

$$\begin{aligned} V_{gov}(\alpha) &= V(x_{gov}(\alpha), y_{gov}(\alpha); x^e) \\ V_{po}(\alpha) &= V(x_{po}(\alpha), y_{po}(\alpha)), \end{aligned}$$

where

$$\begin{aligned} x^e &= E_{\alpha \in GOV} [x_{gov}(\alpha)] \\ \text{and } GOV &= \{\alpha = (\alpha_x, \alpha_y) : V_{gov}(\alpha) \geq \max(V_{po}(\alpha), 1)\}. \end{aligned}$$

We also define

$$PO = \{\alpha = (\alpha_x, \alpha_y) : V_{po}(\alpha) \geq \max(V_{gov}(\alpha), 1)\},$$

as the set of projects that are delegated to a private operator.<sup>23</sup>

In order to describe the partition of the  $(\alpha_x, \alpha_y)$  space into the three region (projects taken by government, projects delegated to PO, and projects that are dismissed), we first characterize the division lines  $V_{gov}(\alpha) = 1$ ,  $V_{po}(\alpha) = 1$  and  $V_{gov}(\alpha) = V_{po}(\alpha)$ . To calculate their slopes we first need to find the derivatives with respect to  $\alpha_x$ ,  $\alpha_y$ . By (11), we have:

$$V_{gov}(\alpha) = x^e F + \max_x (1 - F) x + \delta \alpha_y h\left(\frac{x}{\alpha_x}\right)$$

By the envelope theorem:

$$\frac{\partial V_{gov}}{\partial \alpha_y} = \delta h\left(\frac{x_{gov}(\alpha)}{\alpha_x}\right)$$

and

$$\frac{\partial V_{gov}(\alpha)}{\partial \alpha_x} = \delta \alpha_y h'\left(\frac{x_{gov}(\alpha)}{\alpha_x}\right) \left(-\frac{x_{gov}(\alpha)}{(\alpha_x)^2}\right)$$

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<sup>23</sup>Note that as in many adverse selection model, the possibility of multiple equilibria arises also here. The characterization we offer below applies to any of these equilibria.

which, by the first-order condition (12) of the government's second-stage problem,  $(1 - F) + \delta\gamma h' \left( \frac{x_{gov}(\alpha)}{\alpha_x} \right) = 0$ , is:

$$\frac{\partial V_{gov}}{\partial \alpha_x} = (1 - F) \frac{x_{gov}(\alpha)}{\alpha_x}.$$

Since both derivatives are positive, there is a downward sloping line such that for any project above (below) the line  $V_{gov}(\alpha) > (<)1$ .<sup>24</sup>

As for the value under private operation:

$$\begin{aligned} V_{po}(\alpha) &= \alpha_x x_m + \delta \alpha_y h(x_m) \\ \frac{\partial V_{po}(\alpha)}{\partial \alpha_x} &= x_m \\ \frac{\partial V_{po}(\alpha)}{\partial \alpha_y} &= \delta h(x_m) \end{aligned}$$

there is a downward sloping (and linear) line such that for any project above (below) the line  $V_{po}(\alpha) > (<)1$ .

Finally, we look for the slope of the division line between *GOV* and *PO*, given by  $V_{gov}(\alpha) = V_{po}(\alpha)$ .

$$\begin{aligned} \frac{\partial}{\partial \alpha_x} (V_{gov}(\alpha) - V_{po}(\alpha)) &= (1 - F) \frac{x_{gov}(\alpha)}{\alpha_x} - x_m = \frac{1}{\alpha_x} [(1 - F) x_{gov}(\alpha) - x_{po}(\alpha)] < 0 \\ \frac{\partial}{\partial \alpha_y} (V_{gov}(\alpha) - V_{po}(\alpha)) &= \delta \left( h \left( \frac{x_{gov}(\alpha)}{\alpha_x} \right) - h(x_m) \right) = \delta \frac{1}{\alpha_y} [y_{gov}(\alpha) - y_{po}(\alpha)] > 0 \end{aligned}$$

Thus, there is an upward sloping line such that for any project above (below) the line  $V_{gov}(\alpha) > (<)V_{po}(\alpha)$ .

Summing these three results, we conclude that the partition of the  $(\alpha_x, \alpha_y)$  space into three regions is as illustrated in Figure 5.<sup>25</sup>

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<sup>24</sup>This result could also be established using a simpler revealed-preference argument: An increase in  $\alpha_x$  or in  $\alpha_y$  expands the project's efficient frontier. Since there is no effect on the value assigned to the project by the (uninformed) credit market, then either one of these changes increases  $V_{gov}(\alpha)$ .

<sup>25</sup>In the case of privatization of an existing asset, and if the option to shutdown does not exist, then, by definition, the *NON* region is empty. The project space has only two regions *GOV* and *PO*, divided by an upward-sloping line.

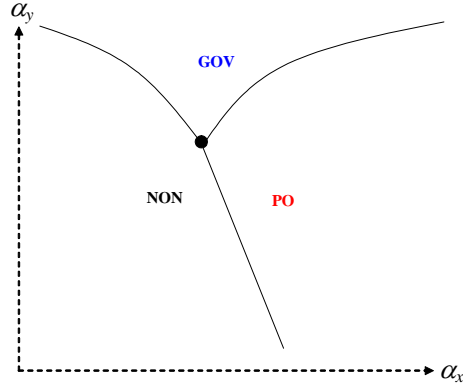


Figure 5: Projects' allocation with the option to privatize

**Remark** The division to two contiguous regions *PO* and *GOV* might break down with complete information on  $\alpha$ . The reason is that an increase in  $\alpha_y$ , which means a larger technological set, does not guarantee that the value of the project to the government is higher: the credit market may reduce the government's credit rating if it foresees that the increase in  $\alpha_y$  will cause the government to tilt the implementation point toward higher  $y$  and lower  $x$ . This never happens with incomplete information, as we saw, because the information on the project attributes is never revealed, implying that the government's implementation and project selection decisions are guided by the same criterion, that ignores the credit-market value.

Implementation changes abruptly when crossing the division line between the *GOV* and *PO* regions. Taking two very similar projects at the opposite sides of the line, the one implemented by the *PO* is heavily monetized while the implementation of the one on the *GOV* side emphasizes social benefits much more. In addition, from an ex ante (value-maximizing) perspective, projects in the neighborhood of the division line are implemented incorrectly: For points  $\alpha$  in this area satisfying  $x_{gov}(\alpha) > x^e$  government's implementation is strictly better as  $V_{po}(\alpha) < V(x_{gov}(\alpha), y_{gov}(\alpha))$ . Similarly for points satisfying  $x_{gov}(\alpha) < x^e$ , the converse is true: *PO* implementation is strictly preferred. If those projects could have changed hands without changing the credit market valuation of



the entire set of projects taken by the government, the government would have benefitted.

### 4.3 Evaluating the option to privatize

We saw that the introduction of privatization changes the set of projects taken by the government. When privatization does not have an effect on the project's implementation (our benchmark case), we observed that the ex ante effect on the government's utility is unambiguously positive. This conclusion holds also if privatization has a small effect on the implementation. We now show by example that this may no longer hold when implementation changes significantly with privatization.

For simplicity of exposition we look at a discrete example, in which there are only two possible projects in the distribution of  $\alpha$ 's; It is clear that the example can be modified to one with a continuous density.

**Example 1** *Let the basic project be defined by the positive ortant of the unit circle so that for a project  $\alpha = (\alpha_x, \alpha_y)$ , the efficient frontier is given by*

$$y = \alpha_y \sqrt{1 - \frac{x^2}{\alpha_x^2}}$$

*Let  $\delta = 1/3$  and pick the rest of the model's parameters so that the probability of default is  $F = 1/3$ . Consider first the implementation decision. Under government's control, the first order-condition, (12), is*

$$-\frac{\alpha_y}{\alpha_x^2} \frac{x}{\sqrt{\frac{\alpha_x^2 - x^2}{\alpha_x^2}}} = -\frac{2/3}{1/3} = -2,$$

*and therefore*

$$x_{gov}(\alpha_x, \alpha_y) = \frac{2\alpha_x^2}{\sqrt{4\alpha_x^2 + \alpha_y^2}}; \quad y_{gov}(\alpha_x, \alpha_y) = \frac{\alpha_y^2}{\sqrt{4\alpha_x^2 + \alpha_y^2}}.$$

*Under PO control*

$$x_{po}(\alpha_x, \alpha_y) = \alpha_x; \quad y_{po}(\alpha_x, \alpha_y) = 0.$$

*We now assume that the distribution of projects contains only two points: (1, 1) and (1.21, 1). Both projects are assigned equal probability by the uninformed credit market.*

The values of the two projects under complete information are:

$$V(x_{gov}(1, 1), y_{gov}(1, 1)) = 1.043$$

$$V(x_{po}(1, 1), y_{po}(1, 1)) = 1$$

and

$$V(x_{gov}(1.21, 1), y_{gov}(1.21, 1)) = 1.245$$

$$V(x_{po}(1.21, 1), y_{po}(1.21, 1)) = 1.21$$

Under complete information, both projects have positive values under either implementation and a higher value under the government's operation. When the option to privatize does not exist, both projects are undertaken by the government. If the option to privatize exists however this is no longer an equilibrium. Denote by  $x^e = [x_{gov}(1, 1) + x_{gov}(1.21, 1)] / 2$  the average over the set of projects under such candidate equilibrium. This implies

$$V(x_{gov}(1.21, 1), y_{gov}(1.21, 1); x^e) = 1.208$$

which is slightly less than  $V(x_{po}(1.21, 1), y_{po}(1.21, 1)) = 1.21$ . The government would thus prefer to move this project to the hand of a PO. The (unique) equilibrium is therefore for the project (1, 1) to be taken by the government and for project (1.21, 1) to be transferred to a PO. The ex ante value of to the government under such equilibrium is lower than that when privatization is not allowed.

To sum, in this example there is no change in the group of projects implemented whether the option to privatize is available or not – both projects are implemented under both regimes. If implementation was the same under privatization, the decoupling of the two projects under privatization would be neutral in terms of ex ante utility. But as the implementation under privatization is dominated, the overall effect on the value extracted by the government is negative.

So far we have discussed one case in which the option to privatize has a positive value (the full-contracting case) and another in which its value is negative (the above example). In the general case illustrated in Figure 5, the introduction of privatization has several

effects. First, some projects that would otherwise be undertaken by the government are now privatized. This effect can be negative or positive, depending on the type of project. The effect is necessarily negative for those projects just on the border of the *GOV* and *PO* regions, and with  $x_{gov}(\alpha) > x^e$ .

In addition, projects with high monetary value and low social benefits that would have been dismissed in the absence of the option to privatize, are now undertaken by a PO. This effect is unambiguously positive.

Finally, the introduction of the PO changes the set of projects taken by the government. The analysis in this case is subtle and depends on the effect on  $x^e$ . If the introduction of privatization leads to an increase in the value of the average project in the *GOV* region, the government would take on some additional projects (as the line  $V_{gov}(\alpha) = 0$  is shifted to the left). Some of these projects have positive ex ante net value, while others have negative net value. If the introduction of privatization leads to a decrease in the value of the average project in *GOV*, the government dismisses some projects that it would have taken otherwise. Again these projects can have either positive or negative ex ante net values.

## 5 Concluding Remarks

To be completed.

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