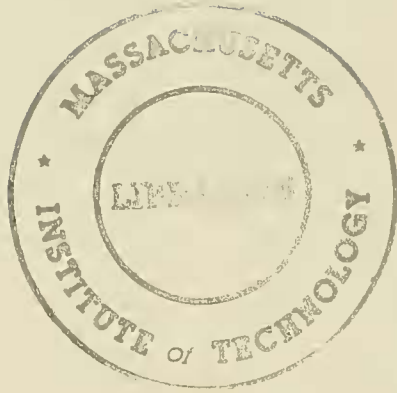
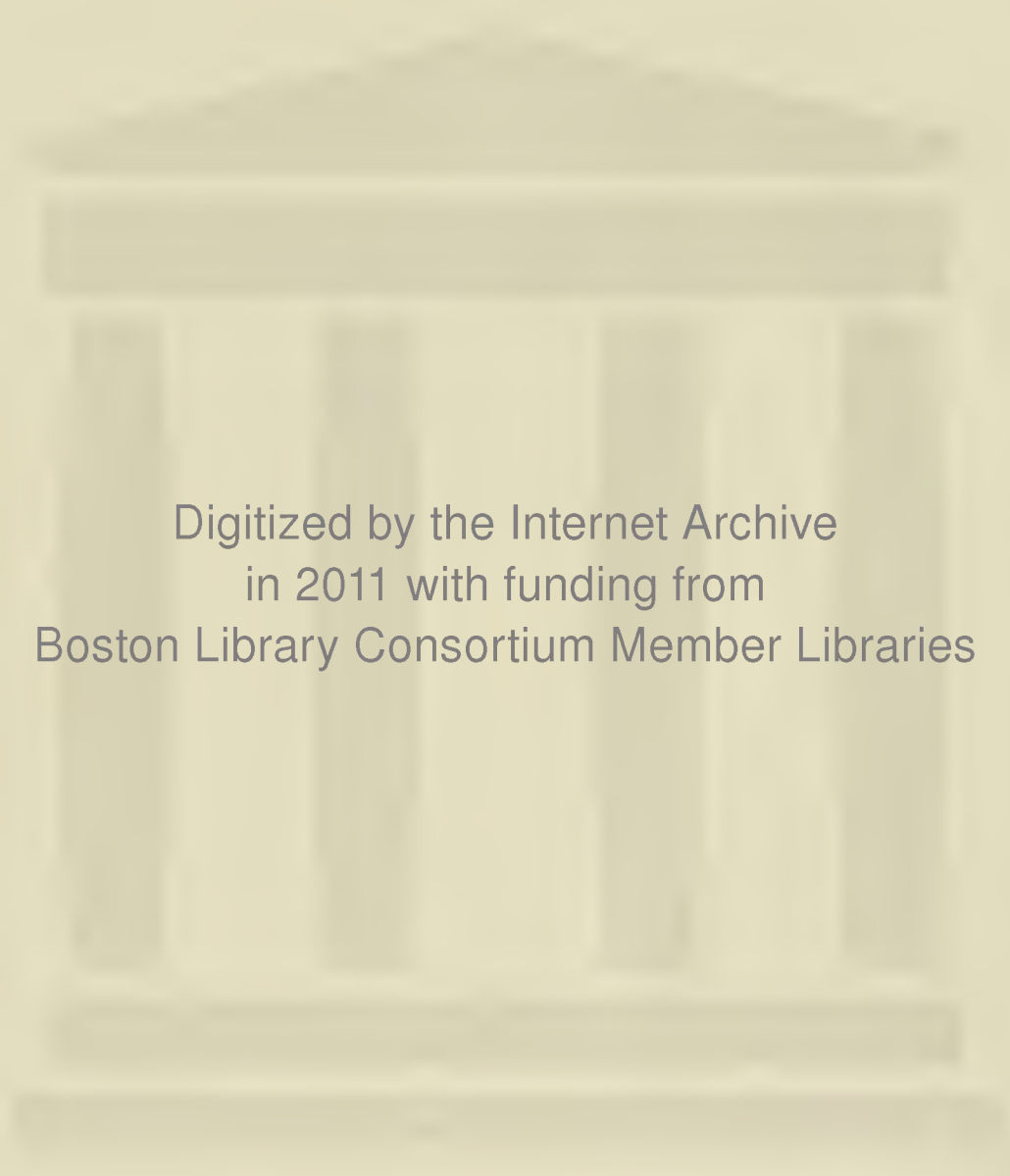


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PRIVATIZATION AND INCENTIVES

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Number 572

June 1990

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PRIVATIZATION AND INCENTIVES*

by

Jean-Jacques Laffont** and Jean Tirole***

June 1990

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1 - INTRODUCTION.

Is public or private ownership more likely to promote social welfare? This ancient and central question in economics has generated a fair amount of conventional wisdom on the benefits and costs of public production of goods and services. However the arguments underlying this conventional wisdom are often delicate. The first goal of this exploratory paper is to recast some of these arguments in the framework of modern agency theory ¹⁾. This paper will remain almost as superficial as the conventional wisdom it criticizes and will only try to suggest that recent research in agency theory may start offering clues for a more satisfactory analysis of comparative ownership structures.

The second goal of this paper is to analyse a specific trade-off between a public enterprise and a private regulated firm. In order not to exogenously presume the superiority of one ownership structure, we trace differences in efficiency not to intrinsic taste differences of managers and supervisors of public and private enterprises, but rather to different institutional arrangements and incentives. In our model, the cost of public ownership is a suboptimal investment by the firm's managers in those assets that can be redeployed to serve social goals pursued by the public owners. While such a reallocation of investment away from profit enhancing uses may be ex post socially optimal, it constitutes an expropriation of the firm's investment. This expropriation is less likely to take place under private ownership because the shareholders, like the managers, derive their monetary rewards from high profits. The cost of private ownership in our model is that the firm's managers must respond to two masters, the regulators and the shareholders. Conflicts between the regulators and the shareholders' goals have been perceived as a source of inefficiency in regulated industries. In our model, we focus on the conflict over managerial incentive schemes. The multi-principal situation dilutes incentives, and yields low-powered managerial incentive schemes and low managerial rents. This conclusion fits with very anecdotal evidence that US regulators complain about low managerial incentives in public utilities.²⁾ [Technically, the multi-principal distortion is very similar to the classic double marginalization on two complementary goods sold by non-cooperative monopolists.]

In the remainder of the introduction we develop a taxonomy of ownership structures, we recall and criticize the conventional wisdom and we recast the debate in a framework of residual rights of control. Section 2 sets up a model which is analyzed in sections 3, 4 and 5. Final remarks are gathered in section 6.

i) Public enterprise, private regulated firm and unregulated firm.

Government intervention in production gives rise to a continuum of governance structures. For expositional convenience, we distinguish between two scopes of control to obtain three stylized ownership patterns. The government can exercise external and internal controls of the firm, or one of the two, or none.

External control is the control of all variables that link the firm with outsiders : consumers (regulation of prices, quality, product selection,...), competitors (regulation of entry, access pricing, ...), taxpayers (cost auditing, ...).

Internal control is the control of the firm's inputs and cost minimization process : influence on managerial inputs through managerial incentive schemes, intervention in the decisions concerning employment, level, location and type of investments, borrowing, etc...

We define a public enterprise as a firm whose assets are in majority owned by the government who therefore performs both internal and external control. In a private regulated firm, ownership belongs to the private sector who has residual rights over the firm's management. So the government contents itself with external control and the shareholders exercise internal control. A private unregulated firm is subject to neither external nor internal control by the government.

Clearly there are other governance structures. For instance, in a franchised firm (e.g. the naval dockyards in the U.K.), the government owns the assets and delegates operational tasks to the private sector. Furthermore each of the above governance structures admits several variants. There exist public enterprises (e.g. Renault in France) whose market is relatively unregulated and in which internal control may be as important as external control. In the regulated sector, the division of residual rights between agencies and the shareholders fluctuates across industries and over time ; for instance the US supreme court has moved toward allowing more agency discretion. Last, one may argue that there is no such thing as a "private unregulated firm". Most private firms are subject to antitrust laws, and are affected by tariffs, subsidies and other government decisions. A "private unregulated firm" must thus be thought off as a firm not subject to "personalized regulation", but only to general rules.

Another difficulty with such a simplistic taxonomy relates to the legal nature of ownership. After all the government can change the law and affect the distribution of control. For instance it is common during wars for governments to intervene in the business of private firms. Because governments may change the distribution of control, the relevant governance structure does not depend only on the formal allocation of residual rights of control, but also on the socio-political conditions that determine the government's cost of breaching contracts, altering ownership structures and interfering with private property. For instance, in a country in which the cost for the government of taking private property is small, public ownership is likely to be the only efficient or viable structure. From now on, we will ignore this issue and assume that, because of strong legal institutions and a high political cost of altering ownership structures, the government is able to abide by its contracts and to respect the ownership structures once these have been determined.

ii) Conventional wisdom about privatizations

While we will occasionally mention private unregulated firms, the interesting comparison for many instances of privatization in capitalist economies is that between public enterprises and private regulated firms, henceforth called "regulated firms".

The conventional wisdom (CW) has noted some analogies between a private firm and a public enterprise. Both face agency problems associated with the separation of ownership and control. Both have some sort of board of directors meant to represent dispersed ownership. Boards of directors are known to exert insufficient control over the firm either because they receive too little relevant information from the firm or because they collude with its managers (see Stigler (1971) for a discussion of a regulatory capture which although cast in a regulatory framework is relevant for a public enterprise and Mace (1971) for similar complaints about the control of private firms by their board of directors). Last, in both cases, takeovers (in the private sector, elections or administrative upheaval in the public sector) are known to be imperfect mechanisms for controlling the firm and its board of directors.

The conventional wisdom has identified the following costs of public ownership (a "minus" indexes a cost, a "plus" a benefit).

CW1⁻ (absence of capital market monitoring). "The managers of a public enterprise may mismanage its assets. First they invest too little as they are not given

the stocks and stocks options that would encourage them to take a long-term perspective. Stock market prices contain information about the firm's future prospects and thus about the managers's long-term decisions. By retiring the firm's stock, a public enterprise deprives itself of a measure of managerial performance and reduces managerial incentives. Second, a public enterprise is not subject to takeovers and its managers are therefore less concerned about losing their jobs."

The first argument in CW1⁻ is not as straightforward as it seems. First the government may, and sometimes does, retire only a fraction of the firm's stocks when nationalizing. A further argument is needed to explain why the stock price in a mixed firm (in which the government would hold 51 % of the shares, say) would be less informative about managerial performance at that of the same, private firm. Second, economists have never demonstrated that the stock market is the only instrument, or even the most efficient instrument to obtain outside information about a firm's health.

The absence-of-financial-takeovers argument is clearer, but isn't conclusive either. First, managers of public enterprises are fired and political takeovers occur. Second, this argument has little relevance in countries or in periods in which, for legal or other reasons, takeovers have played a minor role.

CW2⁻ (soft budget constraint) "A public enterprise is not subject to the discipline of the bankruptcy process because the government always bails it out in case of difficulty. This reduces managerial incentives".

One difficulty with CW2⁻ is that public enterprises may be shut down (although one would expect that this would occur less frequently than if the firm were private.) Another difficulty is that regulators do bail out private regulated firms in difficulty, by raising allowed prices for instance. Thus CW2⁻ does not distinguish clearly between a public enterprise and a regulated firm.

CW3⁻ (expropriation of investments) "Managers of public enterprises refrain from investing because once investments are sunk the government may use these investments for purposes they were not intended to serve. Hence managerial investments may be expropriated."

The argument in CW3⁻ is appealing in situations in which managerial incentive contracts are incomplete so that the government's residual rights of control over the firm may help it to ex post expropriate the managers's investments. However,

as it stands, it fails to distinguish between public and private ownership. Why wouldn't the shareholders of a private firm expropriate managerial investments in similar situation ?

CW4⁻ (lack of precise objectives): The multiplicity, fuzziness and changing character of government objectives exacerbates the problem of managerial control in public enterprises."

CW4⁻ also fails to distinguish among ownership structures. Governments' goals that are complex and vary over time will also affect the behavior of regulated firms.

CW5⁻ (lobbying): "Governments are subject to the pressure of interest groups to direct the behavior of public enterprises to enhance the welfare of these groups."

An obvious objection to CW5⁻ is that interest groups successfully lobby governments to control regulated firms to their benefit, as well.

The main argument concerning the benefits of public ownership is :

CW1⁺ (social welfare): "Nationalizations give governments the means to achieve social goals that include, but are not confined to profit maximization."

While this argument is well-taken, it does not explain why the government could not achieve the same social goals in a regulatory framework.

CW2⁺ (centralized control): "By letting the government be responsible for both internal and external control, a nationalization prevents conflicts of objectives of the firm's regulators and owners."

While CW2⁺ suggests a potential inefficiency associated with the multi-masters feature of private regulated firms, it remains vague about the nature of the inefficiency.

iii) Residual rights considerations.

The previous section has discussed some difficulties with the conventional wisdom. This section hardly scratches the superficialities of the ownership puzzle but tries to point at ways to look at the issues. As emphasized by Williamson (1985) and Grossman and Hart (1986), the ownership structure does not matter if complete contracts can be written; therefore, if we are to distinguish between public enterprises and regulated firms, we must point at some contract incompleteness. Our goal is to examine where in the logic of the arguments incompleteness arises.

We argue that the ownership structure matters in two basic respects, which in turn imply further distinctions. First, (even partial) public ownership reduces the acquisition of (non contractable) information about the firm's managers's activity by outsiders, namely stock market participants. Second, public and private ownerships imply owners with different objectives and therefore different behaviors in case of contract incompleteness.

a) Acquisition of information about managerial activity.

The separation of ownership and control creates a problem of managerial discipline. One of the crucial roles of a stock market is to give managers incentives beyond those provided by reward schemes based on accounting data.

First, stock market participants, including investment bankers, lured by the prospect of speculative gains, analyze the firm's health and, to the extent that their knowledge is at least partly reflected in the stock price, convey information about the level and quality of managerial investments. Stocks and stock options accordingly induce managers to invest. The information conveyed by the stock price about the value of the firm disappears when the stock is retired, as in the case of public firm. In this respect, pure public firms have a hard time disciplining their managers. However, we mentioned above that the government could take control only of a majority of shares and have an active stock market for the remaining shares. The information value of 20 % of the shares, say, is a priori the same as that of 100 % of the shares. This might suggest that managerial incentives are unaffected when the government takes control, but does not retire the entire stock. Holmstrom and Tirole (1989a) however argue that the ownership structure matters because market liquidity is affected. Stock market participants have low incentives to acquire information in the illiquid market

created by high government stakes. The stock price is then a very garbled measure of managerial performance.

A limitation of the Holmstrom-Tirole analysis is that it takes for granted that a stock market is an (approximately) optimal institution to induce outsiders to acquire information about the firm's prospects. No such proposition has ever been proved, although the pervasiveness of the institution suggests that alternatives are hard to come by. Because the information held by outsiders is often not contractable (verifiable in the language of information economics), it is likely that incentives given to outsiders must be (positively or negatively) correlated with the firm's future performance, as an incentive compatible way for outsiders to "prove" that they have acquired relevant (favorable or unfavorable) information about the firm. This is exactly what speculation in the stock market does. However, one could think about disconnecting shareholding and property rights. For instance, absent legal constraints, a pure public enterprise could issue shares with non-voting rights. The speculator could still supply useful information about the firm by buying and selling such shares while leaving ownership to the government. Therefore the puzzle seems to find an explanation for the cost of depriving shares of their voting rights. We have little to offer on this issue beyond some superficial remarks. The government may be tempted to expropriate shareholders with non-voting shares (as well as minority shareholders with voting rights). Expropriation, which may take the form of sales of the firm's assets or products at artificially low prices to firms or interest groups favored by the government, may entail deadweight losses (e.g., result in suboptimal use of the assets or excessive consumption of the products). Second, it reduces the value of the shares and thus the incentives for speculators to search for information (think of the extreme case in which everything is expropriated); in this respect it has consequences similar to those of a reduction in market liquidity.

Second, stock market participants may intervene in management through a proxy fight or a takeover. Such interventions disappear under (pure or partial) public ownership. To be certain, there are also political takeovers. Ministry personnel changes, or, more drastically, the entire administration may change. Political takeovers however have two drawbacks. First, they tend to be "global" in that the change of ministry officers or of an entire administration is triggered by a whole set of regulatory issues, and not by the regulation of a particular public enterprise; in contrast, a financial takeover focuses on a specific, mismanaged firm. Second, civil servants may not always have enough incentives to invest in acquiring information

about mismanagement or potential synergies while corporate raiders have financial incentives.

b) Owner's objectives.

A government naturally has other objectives than profit maximization : prevent monopoly pricing ; control quality ; reduce negative externalities ; encourage sectoral policies, national independence, investment and employment in recessions, etc... The problem with many government objectives is that, unlike profit, they are hard to contract upon. It may be costly for instance to describe the state contingent shadow price of employment in a contract with the firm. Also, because the weights among objectives may change between successive administrations legal limitations on the power to commit must be introduced (this concern does not arise in a private firm, whose objective-value maximization-stays the same over time). This may explain why it is often felt that regulators have fuzzy and time-varying objectives (CW3⁻).

This observation per se does not shed light on the privatization issue, as it pertains to both public ownership and regulation. Where ownership makes a difference is when contingencies occur that are not covered by the contract between the government and the firm. Residual rights of control determine who can dispose of the assets in such contingencies. One should thus not expect the same response under public and private ownership.

First, a benefit from public ownership (CW1⁺) is that the government can impose socially desirable adjustments to the firm in unforeseen contingencies while it must bargain with a private firm.³⁾

Second, public ownership may lead to an expropriation of managerial investments (see the model in Section 2). Suppose that the manager invests today in non verifiable capital that permits cost reduction and profit enhancement tomorrow. Tomorrow, the government may reallocate this investment to an alternative use for which the manager is not rewarded. Even if such a reallocation is ex post socially optimal, it reduces the managers' incentive to invest and leads to a situation in which private ownership (in which managers are induced by incentive schemes and in which shareholders have no reason to ex post intervene to reduce profit) is superior even though it makes the socially wrong use of assets ex post (this is CW3⁻).

The case against public enterprise may be even stronger when the government does not maximize social welfare. As is well-known, government decision-

making may be captured by interest groups. The increase in a non-benevolent government's power associated with a nationalization may thus reduce welfare (CW4). An example is the frequent pressure of governments on public enterprises in the military sector not to compete with private firms on civilian markets, even if the public enterprises have idle capacity and the machinery and expertise to produce the civilian goods.

Last, the divergence of objectives between government and shareholders may explain why the US public utilities' shareholders have the right of control over their managers' incentive schemes. A possible explanation is that it is difficult for the government and the shareholders to agree contractually on the details of managerial incentive schemes and that a government which has residual rights of control over managerial incentive schemes might not induce managers to properly maintain the shareholders' assets and to make the profit maximizing investment decisions (this is yet another variant on the theme that expropriation might occur if private shareholders leave residual rights of control to the government). We have little more to offer than this conjecture, and much more work will be required to explain the fact.

2 - THE MODEL

A government wants to realize an indivisible project with social value S . A single firm can realize this project at cost :

$$(2.1) \quad C = \beta - e$$

where $\beta \in [\underline{\beta}, \bar{\beta}]$ parameterizes the firm's efficiency, and e is managerial effort. β is known to the firm's managers only. Other parties have prior cumulative distribution $F(\cdot)$ over β with a strictly positive density. We make the usual monotone hazard rate assumption $\left(\frac{d}{d\beta} \frac{F(\beta)}{f(\beta)} > 0 \right)$ to avoid bunching in optimal incentive schemes. Managerial effort creates a disutility $\Psi(e)$ in monetary units with $\Psi' > 0$, $\Psi'' > 0$, $\Psi''' > 0$.

Moreover, managers can commit some non monetary investment, $\tilde{I} \in (0,1)$. I is a non monetary cost for managers (which is to be added to $\Psi(e)$). Not investing ($\tilde{I} = 0$) yields no benefit. If the investment is made ($\tilde{I} = 1$), it has one of two alternative uses. Its "internal use" yields private (non monetary) benefit $D > I$ to the

firm's insiders (the managers) and 0 to outsiders. Its "external use" yields private benefit $D' > D$ to outsiders and 0 to insiders. Investment and accrual of benefit take place during the single period of the model. The benefit, like the investment, is not contractable (not verifiable) and therefore cannot be sold. Let $\Delta = D - I$.

Last, the firm's outsiders bring a level of cost reductions or synergies equal to a . (For notational simplicity, we do not include a in the cost function.) We will say more on this shortly.

Two ownership structures will be considered :

Public ownership : The government owns the firm and gives to the firm's managers an incentive scheme based on the realization of cost, $t(C)$. Making the accounting convention that costs are paid by the government the managers' utility level is

$$U = t - \Psi(e).$$

Because the investment and its benefit are not contractable, the government cannot commit not to expropriate managers in order to maximize ex post public use of the investment⁴). Anticipating this behavior, the managers do not invest. Let us give simple examples of such behavior. The managers of a government-owned firm will be reluctant to invest in facilities (e.g., cafeteria, theater or holiday resort) or machines if they know that access to those will be later granted to the general population by the government. More importantly, the government may reduce the return on a new plant by forcing to keep excess labor in bad states of demand or to buy domestically produced inputs. In all these examples, the government's action may be ex post optimal but represents an expropriation of the firm's investment. We let B_p denote the social value of the cost reductions or synergies coming from the firm's outsiders (ministry, board of directors, intervenors....). B_p is the value $(1 + \lambda)a^*$ of the cost reduction, where λ is the shadow cost of public funds, minus the agency cost (also evaluated at $(1 + \lambda)$ per dollar spent) of inducing cost reduction a^* from the bureaucratic system. [B_p is of course taken at the value a^* that maximizes this difference]. For our purpose, it is useful to preserve generality by not specifying the process of monitoring of public enterprises by outsiders.

Accordingly, the objective function of an utilitarian government is

$$(2.2) \quad W = S - (1 + \lambda)(t + C) + B_p + U,$$

where $(t + C)$ is total regulatory cost.

Regulated private firm: Suppose now that the government privatizes and regulates the firm⁵⁾. We assume the following timing. First, the government sells the firm at price p to the public. Second, the government regulates the firm for the relevant project, and the shareholders offer an incentive scheme to the managers. The tax rate τ can be determined in either stage; for concreteness, we assume it is chosen on the first stage. The assumption that the government does not commit to a regulatory scheme when privatizing reflects the idea that privatizations are long-term decisions whose effects cover several periods. If the government could commit to a regulatory scheme at the privatization stage, it could sell the social surplus associated with the owners' decisions to them and multi-principal conflicts would not arise. Privatization would always be optimal.

In a regulated firm, private shareholders select managerial incentive schemes. Shareholders are taxed at rate τ which is endogenous to the model. Let w denote the managers' reward (including perks) provided by the stockholders. The firm realizes the project and receives its income from the government.

Let $B_r(\tau)$ denote the social value of cost reductions or synergies brought about by the firm's outsiders (board of directors, stock market). We assume that $B_r(\cdot)$ is strictly decreasing; that is, higher taxes reduce incentives to collect information that benefits the firm. (Example: suppose a single shareholder incurs disutility of effort $g(a)$ to reduce the firm's cost by a . He will choose $a = a^*(\tau)$ so as to maximize $(1 - \tau)a - g(a)$. In this example, $B_r(\tau) = (1 - \tau)a^*(\tau) - g(a^*(\tau)) + (1 + \lambda)\tau a^*(\tau)$ is always strictly decreasing in the neighborhood of $\tau = 1$, and is strictly decreasing elsewhere for α sufficiently small).

We will use the decomposition of $B_r(\tau)$ into the stockholders' private gain $B_r^1(\tau)$ and the social value of additional taxes obtained from this cost reducing activity $B_r^2(\tau)$. (In the above example, $B_r^1(\tau) = (1 - \tau)a^*(\tau) - g(a^*(\tau))$ and $B_r^2(\tau) = (1 + \lambda)\tau a^*(\tau)$.)

We assume that the government observes only cost C , but not w . This assumption makes particular sense in a multiproduct firm in which the government observes only the cost of the product line it is interested in and is unable to measure various components (including perks) of managerial compensation that enter the firm's global accounting. The government makes a transfer to the firm $z(C)$ and its objective function is again the sum of surpluses in society.

$$(2.3) \quad W - S - (1 + \lambda) (z + C - \tau(z - w)) + B_r(\tau) \cdot U + (1 - \tau) (z - w) + \lambda p$$

where $U = w - \Psi(e) + \Delta$.⁶⁾

Note that, now the shareholders have no incentive to reallocate the benefits of the investment to outsiders and, knowing this the managers invest and reap net private benefits Δ .^{7) 8)}

We assume that the government and the shareholders make simultaneous contract offers. The government offers $z(C)$ to the firm and the shareholders offer $w(C)$ to the managers. The managers produce only if they accept both offers.

Clearly, the advantage of private ownership is to make credible the commitment of non expropriation of managerial investments. The cost will come from the multiprincipal structure of regulation and the inability of the government to fully tax stockholders's profits.

Before studying optimal regulation under the different ownership structures let us determine the optimal allocation of resources under complete information : the investment should be made and allocated ex post to outsiders. The marginal disutility of effort should equate its marginal utility, i.e. $\Psi'(e^*) = 1$ and the transfer to managers should saturate their IR constraint. If S is large enough the project should always be realized.

3 - OPTIMAL REGULATION WITH PUBLIC OWNERSHIP

Under public ownership the managers do not invest. The manager's utility level is :

$$(3.1) \quad \bar{U} = t - \Psi(e) = t - \Psi(\beta - C).$$

Incentive compatibility requires :

$$(3.2) \quad \bar{U}(\beta) = - \Psi'(e(\beta)) \quad \forall \beta \in [\underline{\beta}, \beta_r^*]$$

where β_r^* is the largest value of β for which the project is undertaken, and

$$(3.3) \quad \dot{C}(\beta) > 0 \quad \forall \beta \in [\underline{\beta}, \beta_r^*]$$

Using (3.2), the IR constraint, $(U(\beta) > 0 \quad \forall \beta \in [\underline{\beta}, \beta_r^*])$ can be rewritten.

$$(3.4) \quad U(\beta_r^*) > 0.$$

An utilitarian government maximizes, under the IC and IR constraints (3.2) (3.3) (3.4), expected social welfare, i.e.:

$$(3.5) \quad \int_{\underline{\beta}}^{\beta_r^*} \left[S + B_r - (1 + \lambda) \left(\beta - e(\beta) + \Psi(e(\beta)) \right) - \lambda U(\beta) \right] dF(\beta).$$

Proposition 1 : (Laffont-Tirole (1986)) : The optimal regulatory outcome under public ownership is given by :

$$(3.6) \quad \Psi'(e_p(\beta)) = 1 - \frac{\lambda}{1 + \lambda} \frac{F(\beta)}{f(\beta)} \Psi''(e_p(\beta))$$

$$(3.7) \quad U(\beta) = \int_{\underline{\beta}}^{\beta_r^*} \Psi'(e_p(\beta)) d\beta$$

$$(3.8) \quad \text{either} \quad S + B_r - (1 + \lambda) \left[(\beta_r^* - e_p(\beta_r^*)) + \Psi(e_p(\beta_r^*)) \right] - \lambda \frac{F(\beta_r^*)}{f(\beta_r^*)} \Psi'(e_p(\beta_r^*)) = 0$$

$$\text{or} \quad \beta_r^* = \underline{\beta}.$$

(3.7) defines the rent of asymmetric information captured by a firm with efficiency β . (3.6) describes the optimal distortion from efficiency to mitigate the rent of asymmetric information. (3.8) defines the cut-off point β_r^* .

From Laffont-Tirole (1986), we know that the optimal mechanism can be implemented by a menu of linear contracts defined by :

$$u(C, C^a) = a(C^a) + b(C^a) (C^a - C)$$

where C^a is the announced cost and C the realized cost. $b(C^a)$ defines the sharing of overruns and is equal to $\Psi'(e_p(\underline{\beta}))$. For $\beta = \underline{\beta}$, $F(\underline{\beta}) = 0$ and $\Psi'(e_p(\underline{\beta})) = 1$; type $\underline{\beta}$ selects a fixed price contract and has the right incentive to minimize cost. Less efficient types have part of their cost, $1 - \Psi'(e_p(\beta))$, reimbursed by the regulator

and consequently exert a socially suboptimal effort. This distortion in allocative efficiency enables the regulator to decrease the costly rent of asymmetric information.

4 - OPTIMAL REGULATION OF A PRIVATE FIRM

We assume that the government and the shareholders of the private firm simultaneously offer incentive schemes $z(C)$ and $r(C)$ to managers. The scheme $z(\cdot)$ is a monetary reward to managers offered by the government and $r(\cdot)$ is a rental contract required by shareholders. Alternatively one can think of $z(\cdot)$ as being offered to the shareholders who offer $w(\cdot) = z(\cdot) - r(\cdot)$ to managers. We look for a differentiable Nash equilibrium in these contracts.⁹⁾

Taking $z(\cdot)$ as given, the shareholders maximize their expected profit subject to the managers' incentive compatibility and individual rationality constraints. We allow the shareholders to offer incentive schemes such that some high β types do not want to produce. Let β_r^* denote the "cut-off type", i.e., the type who is indifferent between producing and not producing.

Managers receive $w(C)$ as well as the benefit of their investment, Δ , and incur a disutility $\Psi(e)$. Their utility level is:

$$(4.1) \quad U(\beta) = w(C(\beta)) + \Delta - \Psi(e(\beta)).$$

From the point of view of the managers $w(\cdot)$ plays the same role as $u(\cdot)$ in Section 3 and therefore, incentive compatibility and individual rationality constraints are as in Section 3. Accordingly, the shareholders' optimization program is (using $w(C(\beta)) = U(\beta) - \Delta + \Psi(e(\beta))$):

$$(4.2) \quad \text{Max} (1 - \tau) \int_{\beta_r^*}^{\beta_r^*} [z(\beta - e(\beta)) - U(\beta) + \Delta - \Psi(e(\beta))] dF(\beta) + B_r^i(\tau)$$

$$\{e(\cdot), \beta_r^*\}$$

s.t

$$(4.3) \quad U(\beta) = - \Psi(e(\beta))$$

$$(4.4) \quad U(\beta_r^*) = 0.$$

The first order conditions of this program are (see appendix 1) :

$$(4.5) \quad \Psi'(e_r(\beta)) = -z'(\beta - e_r(\beta)) - \frac{F(\beta)}{f(\beta)} \Psi''(e_r(\beta))$$

$$(4.6) \quad \text{either } \left[z(\beta_r^* - e_r(\beta_r^*)) + \Delta - \Psi(e_r(\beta_r^*)) \right] + \frac{B_r^1(\tau)}{1-\tau} f(\beta_r^*) - F(\beta_r^*) \Psi'(e_r(\beta_r^*)) = 0$$

or $\beta_r^* = \bar{\beta}$

Note that (4.5) differs from the formula (3.6) obtained in the case of public ownership in two ways. First, a unit reduction in cost is valued (-z') by shareholders (which is what the firm receives from the government) instead of 1. Second the ratio of the cost of transfers to the cost of real expenditures is equal to 1 for the profit maximizing shareholders instead of $\frac{\lambda}{1+\lambda}$ for the welfare maximizing government.

The government chooses $z(\cdot)$ to maximize expected social welfare subject to the managers' incentive compatibility and individual rationality constraints, taking $r(\cdot)$ as given. Ex post social welfare is :

$$(4.7) \quad S - (1+\lambda) \left(\beta - e(\beta) + z(\beta - e(\beta)) - \tau r(\beta - e(\beta)) \right) + U(\beta) + (1-\tau) r(\beta - e(\beta)) + B_r(\tau) + \lambda p$$

$$- S - (1+\lambda) \left(\beta - e(\beta) + \Psi(e(\beta)) - \Delta \right) - \lambda U(\beta) - \lambda(1-\tau) r(\beta - e(\beta)) + B_r(\tau) + \lambda p$$

Hence, we have the following government's optimization program :

$$(4.8) \quad \text{Max}_{\beta} \int \left\{ S - (1+\lambda) \left(\beta - e \cdot \Psi(e(\beta)) - \Delta \right) - \lambda U(\beta) - \lambda(1-\tau) r(\beta - e(\beta)) \beta - e(\beta) \right. \\ \left. + B_r(\tau) + \lambda p \right\} dF(\beta)$$

$$\{ e(\cdot), \beta_r^{**} \}$$

s.t.

$$(4.9) \quad U(\beta) = -\Psi'(e(\beta))$$

$$(4.10) \quad U(\beta_r^{**}) = 0$$

The first order conditions of this program are (see appendix 1):

$$(4.11) \quad \Psi'(e_r(\beta)) = 1 + \frac{\lambda}{1+\lambda} (1-\tau) r'(\beta - e_r(\beta)) - \frac{\lambda}{1+\lambda} \frac{F(\beta)}{f(\beta)} \Psi''(e_r(\beta)).$$

$$(4.12) \text{ either } \left\{ \begin{aligned} S - (1+\lambda)(\beta_r^{**} - e_r(\beta_r^{**})) - \Delta \cdot \Psi(e_r(\beta_r^{**})) \\ - \lambda(1-\tau)r(\beta_r^{**} - e_r(\beta_r^{**})) \cdot B_r(\tau) \cdot \lambda p \} f(\beta_r^{**}) \\ - \lambda F(\beta_r^{**}) \Psi'(e_r(\beta_r^{**})) = 0 \end{aligned} \right.$$

$$\text{or } \beta_r^{**} = \bar{\beta}.$$

From the managers' first order incentive compatibility condition we have:

$$(4.13) \quad -z'(\beta - e(\beta)) + r'(\beta - e(\beta)) = \Psi'(e(\beta)).$$

Multiplying (4.5) by $\frac{\lambda}{1+\lambda} (1-\tau)$, adding to (4.11) and using (4.13) yields:

$$(4.14) \quad \Psi'(e_r(\beta)) = 1 - \frac{\lambda}{1+\lambda} (2-\tau) \frac{F(\beta)}{f(\beta)} \Psi''(e_r(\beta)).$$

In equilibrium $\beta_r^* = \beta_r^{**}$. From (4.13) and (4.4)

$$(4.15) \quad r(\beta - e_r(\beta)) - z(\beta - e_r(\beta)) = \int_{\bar{\beta}}^{\beta_r^*} \Psi'(e_r(\bar{\beta})) (1 - e_r(\bar{\beta})) d\bar{\beta} + \Delta \cdot \Psi(e_r(\beta_r^*)).$$

An interesting observation is that the shareholders make a positive profit at the cut-off type β_r^* . (The managers have no rent at the cut-off type, just like in the case of a public enterprise). The reason is obvious: the shareholders would lose nothing from shutting off a type who brings them no problem, and would reduce the rent of better types by doing so.¹⁰⁾

From (4.11) we obtain:

$$(4.16) \quad r(\beta - e_r(\beta)) - \frac{(1-\lambda)}{\lambda(1-\tau)} \int_{\beta}^{\beta_r^*} \left[1 - \Psi'(e_r(\beta)) - \frac{\lambda}{1-\lambda} \frac{F(\beta)}{f(\beta)} \Psi''(e_r(\beta)) \right] (1 - e_r(\beta)) d\beta + r(\beta_r^* - e_r(\beta_r^*)).$$

From (4.5) and (4.12) we obtain the constants $r(\beta_r^* - e_r(\beta_r^*))$ and $z(\beta_r^* - e_r(\beta_r^*))$ and using (4.4) we determine β_r^* .

From (4.6) we obtain :

$$(4.17) \quad z(\beta - e_r(\beta)) - \int_{\beta}^{\beta_r^*} \left[\Psi'(e_r(\beta)) + \frac{F(\beta)}{f(\beta)} \Psi''(e_r(\beta)) \right] (1 - e_r(\beta)) d\beta + z(\beta_r^* - e_r(\beta_r^*)).$$

Next we must ask whether the second-order conditions for the agent and the two principals are sufficient. The second-order condition for the agent is $\dot{e} - 1 - \dot{e} > 0$. But (4.14) implies that effort is decreasing with type under our assumptions :

$$\dot{e} = \frac{-\lambda}{1+\lambda} (2-\tau) \Psi'' \frac{d}{d\beta} \frac{F}{f} \left[\Psi'' + \frac{\lambda}{1+\lambda} (2-\tau) \frac{F}{f} \Psi''' \right] < 0.$$

Hence the agent's global second-order condition is satisfied.

Before turning to the principals' second-order conditions, we derive results of independent interest concerning the curvature of reward functions. Differentiating (4.5), (4.13) and (4.14) yields :

$$(4.18) \quad r'' = \frac{\Psi''}{\frac{\lambda}{1+\lambda} (2-\tau)} \frac{\dot{e}}{1-\dot{e}} < 0$$

$$(4.19) \quad z'' = \left[1 - \frac{\lambda}{1+\lambda} (2-\tau) \right] r''$$

and

$$(4.20) \quad w'' = z'' - r'' = -\frac{\lambda}{1-\lambda} (2-\tau) r'' > 0.$$

That is, the net reward of the agent, $w(\cdot)$, is convex in cost as in Laffont-Tirole [1986]. In the single-principal (i.e., public ownership) case, the transfer from the government, $t(\cdot)$, is equal to $w(\cdot)$ and is therefore convex in cost; the regulator can therefore replace his reward scheme by a menu of linear contracts. In contrast, $z(\cdot)$ is concave in cost if $\lambda < 1/(1-\tau)$, and the regulator cannot use a menu of linear contracts, and the shareholders' reward function, $-r(\cdot)$, is convex in cost. However, this does not imply that they can replace their reward scheme, $-r(\cdot)$, by a menu of linear contracts. The regulator might want to change his own scheme to take advantage of the shareholders' linear sharing of cost by inducing large cost padding by the managers.

We can turn to the principals' second-order conditions. First, if $\lambda < 1/(1-\tau)$, the Hamiltonian in program (4.2) is concave in effort. Second, it can be shown that there exists $\lambda_0 > 0$ such that $\lambda < \lambda_0$ implies that the Hamiltonian in program (4.8) is concave in effort. The second-order conditions are then satisfied.

Last we determine the optimal tax rate τ . Using $p = E_{\beta} \left[(1-\tau)r(\beta-e(\beta)) \right]$

ex ante social welfare is

$$E_{\beta} \left[S - (1-\lambda)(\beta - e + \Psi(e) - \Delta) - \lambda U \right] + B_{\tau}(\tau),$$

where e depends on τ as shown in equations (4.14) and (4.12). For our purpose, it suffices to note that the tax rate that maximizes ex ante social welfare is strictly lower than 1. The derivative of the first term in ex ante social welfare with respect to τ is equal to 0 at $\tau=1$ by the envelope theorem (from (4.12) and (4.14), the ex post loss to shareholders $\lambda(1-\tau)r$ and the distortion of effort due to multiple principals vanish when $\tau=1$).

We now summarize our main conclusions.

Proposition 2:

The necessary conditions for the optimal regulatory outcome under private ownership is given by equations (4.12), (4.14), (4.16) and (4.17). These conditions are sufficient if $\lambda < \min \{ \lambda_0, 1/(1-\tau) \}$. The managers' net reward function is convex in cost. The government's net transfer to the firm is concave in cost.

Non differentiable equilibria. We have focused on the equilibrium in which z and r are differentiable functions of C . There also exist non differentiable equilibria. Consider the following schemes :

$$(4.21) \quad z(C) = \begin{cases} \bar{z} & \text{if } C \leq \bar{C} \\ -\infty & \text{otherwise} \end{cases}$$

$$r(C) = \begin{cases} \bar{r} & \text{if } C \leq \bar{C} \\ -\infty & \text{otherwise} \end{cases}$$

The agent accepts those schemes iff $\bar{z} - \bar{r} > \Psi(\beta - \bar{C})$. Can a principal do better than this simple cost target scheme ? For this not to be the case, \bar{r} and \bar{z} must satisfy :

$$(4.22) \quad \bar{r} = \arg \max_r \left\{ F(\bar{C} + \Psi^{-1}(\bar{z} - r)) r \right\}$$

and

$$(4.23) \quad \bar{z} = \arg \max_z \left\{ \begin{aligned} & \bar{C} \cdot \Psi^{-1}(z - \bar{r}) \\ & \int_{\bar{z}}^z \left[S - (1-\lambda) (\bar{C} + \Psi(\beta - \bar{C}) - \Delta) - \lambda [z - \bar{r} - \Psi(\beta - \bar{C})] \right. \\ & \left. + \lambda(1-\tau)\bar{r} + B_r(\tau) + \lambda_p \right] f(\beta) d\beta \end{aligned} \right\}$$

From (4.23), since transfers to the firm are socially costly (the cost for society of these transfers is $\lambda(z - \tau r)$ with $\tau < 1$ and $z > r$ from the agent's individual rationality) z is bounded above, say by z^* . Therefore, r is also bounded above by z^* .

The existence of the pooling equilibrium is guaranteed if $F(\cdot)$ is concave and $f(\cdot)$ bounded below by a positive number. The function defined in (4.22) is strictly concave in r and maps \mathbb{E} from $[\Psi(\underline{\beta}-\bar{c}), z^*]$ into $[0, z^*]$.

The function defined in (4.23) is strictly concave in z and maps r from $[0, z^*]$ into $[\Psi(\underline{\beta}-\bar{c}), z^*]$. We can apply Brouwer's theorem in the compact space $[0, z^*] \times [\Psi(\underline{\beta}-\bar{c}), z^*]$ to obtain the existence of a solution.

5 - COMPARISON OF OWNERSHIP STRUCTURES

The main result is that effort is lower in the regulated private firm than in the public firm, as one can check by differentiating (4.14) with respect to e and τ .

Proposition 3 : $e_r(\beta) < e_p(\beta)$ for any $\beta \in (\underline{\beta}, \beta^*)$.

The intuition for the result is straightforward. As program (4.8) shows, the existence of shareholders and the fact that the tax rate is less than 100 % (to preserve incentives for information acquisition), create an additional ex post rent. It is therefore more costly to elicit the same effort level as in the public firm and the regulator settles for a lower level of effort.

For S large enough, $\beta_r^* = \beta_r^* = \beta$; furthermore, $v(\beta - e_r(\beta)) = \Psi(e_r(\beta)) - \Delta$ from (4.1) but the decomposition of $v(\beta - e_r(\beta))$ between $z(\beta - e_r(\beta))$ and (minus) $r(\beta - e_r(\beta))$ is arbitrary at the Nash equilibrium as long as the left-hand sides in (4.6) and (4.12) are non-negative.

For lower levels of S , β_r^* differs from β and is (uniquely) defined by :

$$(5.1) \quad S - (1+\lambda) \left(\beta_r^* - e_r(\beta_r^*) + \Psi(e_r(\beta_r^*)) \right) + (1+\lambda)\Delta + \lambda p + B_r(\tau) \\ = \lambda \left[(2-\tau) \frac{F(\beta_r^*)}{f(\beta_r^*)} \Psi'(e_r(\beta_r^*)) - B_r'(\tau) \right]$$

In this case, $z(\beta_r^* - e_r(\beta_r^*))$ and $r(\beta_r^* - e_r(\beta_r^*))$ are uniquely defined by (4.6) and (4.12). That the principals' transfers are either determinate or defined up to a constant should not surprise the reader familiar with the theory of

public goods. In the case of a corner solution ($\beta_r^* = \beta$), both principals are responsible for making sure that type β produces, and reducing the transfer to the agent by one principal and increasing the one by the other principal by an equal amount preserves equilibrium as long as the second principal strictly prefers type β to produce. There is therefore a range of possible transfers to type β (and therefore to more efficient types) for each principal. The transfer received by the agent however is determinate. In the case of an interior solution ($\beta_r^* < \beta$), an increase in the transfer that a principal must pay for β_r^* to produce would lead him to reduce his cut-off point β_r^* , and would induce the other principal to raise his cut-off point, thereby destroying equilibrium.

The costs and benefits of regulation in this model can be summarized as follows:

1. Incentives to reduce cost are lower in a regulated firm
2. A regulated firm's managers invest more because they are more likely to derive private benefits from investment
3. Last, public and private ownerships differ in their incentives for outsiders to collect information about cost reduction or synergies. We left the values of information B_p and $B_r(\tau^*)$ general. Opening the black boxes of public and private monitoring of firms is an important item on the research agenda, but is outside the scope of this paper.

APPENDIX 1

Proof of (4.6)

The Hamiltonian of program (4.2) is, up to a constant :

$$H(\beta) = (1-\tau) \left[z(\beta - e(\beta)) - U(\beta) + \Delta - \Psi(e(\beta)) \right] \Gamma(\beta) - \mu(\beta) \Psi'(e(\beta))$$

From the Pontryagin principle we have :

$$\dot{\mu}(\beta) = (1-\tau) \Gamma(\beta)$$

Using the transversality condition $\mu(\beta) = 0$, we get $\mu(\beta) = (1-\tau) F(\beta)$. Maximization of the Hamiltonian with respect to $e(\cdot)$ gives

$$(1-\tau) \left[- \left(z'(\beta - e(\beta)) \right) - \Psi'(e(\beta)) \right] \Gamma(\beta) - (1-\tau) F(\beta) \Psi''(e(\beta)) = 0$$

that is to say, (4.4).

Proof of (4.11)

The Hamiltonian of program (4.8) is, up to a constant :

$$H = \left\{ S - (1+\lambda)(\beta - e(\beta)) + \Psi(e(\beta)) - \Delta - \lambda U(\beta) - \lambda(1-\tau)r(\beta - e(\beta)) \right\} \Gamma(\beta) - \mu(\beta) \Psi'(e(\beta))$$

$$\dot{\mu}(\beta) = - \frac{\partial H}{\partial U} = \lambda \Gamma(\beta)$$

$$\mu(\beta) = 0 \Rightarrow \mu(\beta) = \lambda F(\beta)$$

$$\frac{\partial H}{\partial e} = 0 \Leftrightarrow \left\{ -(1+\lambda) \left(\Psi'(e(\beta)) - 1 \right) + \lambda(1-\tau)r'(\beta - e(\beta)) \right\} \Gamma(\beta) - \lambda F(\beta) \Psi'(e(\beta)) = 0$$

$$\text{or } \Psi'(e(\beta)) = 1 + \frac{\lambda}{1+\lambda} (1-\tau) r'(\beta - e(\beta)) - \frac{\lambda}{1+\lambda} \frac{F(\beta)}{\Gamma(\beta)} \Psi''(e(\beta))$$

-FOOTNOTES-

- 1) See Sappington-Stiglitz (1987), Riordan (1988), Vickers and Yarrow (1985) for interesting discussions of the theoretical issues related to privatization.
- 2) In a recent case in point, regulators in Syracuse tried to force a utility to raise managerial incentives.-
- 3) In particular if bargaining takes place under asymmetric information, inefficiencies will typically result, as pointed out in Milgrom-Roberts (1987) and Holmstrom-Tirole (1989b).
- 4) Here the investment yields higher benefits if controlled by the government than if controlled by shareholders, because it is expropriated by the government under public ownership. One can think of cases in which the incentives to invest are higher under government ownership than under private ownership. This would occur for instance if socially conscious managers were to make investment that would be redirected by the shareholders away from their original purpose to enhance profits. The case we consider seems however more realistic in many situations.
- 5) One could consider the converse experiment in which the firm is initially private and is nationalized by the government. The analysis is unchanged.
- 6) Note that in equilibrium $p = \frac{E(1-\tau)(z-w)}{\beta}$. However it is important to treat it as a sunk revenue for the government. That is, by changing its regulatory process today, the government does not affect the price that the public paid for the shares.
- 7) Under our assumption, the stockholders are actually indifferent between ordering the managers to reallocate or not. It seems reasonable to assume that they favor their managers, which they would strictly prefer if the internal use of the investment had any direct or indirect monetary value to the firm.
- 8) By assuming Δ to be exogenous and not monetary we completely separate the costs and the benefits of privatization. As this section clearly shows the same model would obtain if we made the assumption that the government cannot commit not to expropriate managers whereas stockholders can. Therefore a political theory of differences in commitment abilities could be substituted to the incomplete contract theory we relied upon here.

9) In independent work, Stole (1990) offers a general analysis of mechanism design under common agency, and shows how the lack of coordination between principals aggravates or alleviates allocative inefficiencies depending on whether the principals' screening variables are complements (as is the case here) or substitutes in the agent's utility function.

10) This is the same argument as that showing that a monopolist charges a price above his marginal cost.

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