Government Outsourcing:

Public Contracting with Private Monopoly

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Abstract: The paper studies the impact of government budget constraint in a pure adverse selection problem of monopoly regulation. The government maximizes total surplus but incurs some cost of public funds à la Laffont and Tirole (1993). An alternative to regulation is proposed in which firms are free to enter the market and to choose their price and output levels. However the government can contract ex-post with the private firms. This ex-post contracting set-up allows more flexibility than traditional regulation where governments commits to both investment and operation cash-flows. This is especially relevant in case of high technological uncertainties.

Keywords: Privatization, soft-budget constraint, adverse selection, regulation, natural monopoly.

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1 Introduction

Governments have dramatically reduced their scope over the last 20 years. In Europe national authorities have abandoned traditional macro-economic instruments such as monetary policy or import/export control through custom tariffs to achieve economic integration. They also have accepted to open their utilities to EU competitors which generally implied both deregulating and privatizing several national monopolies. The liberalization and privatization movement has not been limited to the EU construction nor to the transition process. It also occurred in other OECD countries and in many developing countries, generally as part of structural adjustment programs. Economists have put out a substantial amount of work to analyze the cost and benefit of the reforms. The paper aims to contribute to this collective effort by focusing on the government's monitoring of natural monopoly in pure adverse selection problem. It shows that ex-post contracting with a private firm is often a better policy than traditional regulation, even under the ideal assumption that a benevolent government is able to propose complete contracts and to fully commit.

Economists traditionally argue that it is suboptimal to leave the full control of a natural monopoly to private interests because it generates allocative inefficiencies. Governments are advised to set up regulation regimes in which prices and investments are monitored so that the firms break even or earn no supra-normal profit. In the wake of Baron and Myerson (1982) and Laffont and Tirole (1986) the regulation literature provides many insights about how to design contracts with public firms. Under the literature assumptions of government benevolence, full commitment ability, complete contracting and ex-post profitability of firms, the firms' ownership, which is related to the party committing the sunk cost investment, is irrelevant.[4] Auriol and Picard (2002) show that this result is upset if the last assumption is relaxed; that is, if profitability has to be satisfied ex-ante but not ex-post. If the private firm is residual claimant for its ex-post profit and

[4]In presence of information asymmetry, the debate about ownership structure is simply a matter of rents' redistribution, either to public managers/workers or to private owners (see Laffont and Tirole, 1993).

loss, privatization with *laissez-faire* monopoly pricing can be welfare improving because it reduces the need to subsidize money-loosing public firms. Auriol and Picard (2002) show that this argument is relevant only for relatively financially constrained goverments to which subsidies are relatively socially costly. Yet, goverments can do better than implementing *laissez-faire* monopolies: they can ask those monopolies to increase production toward the socially efficient level by offering ex-post contracts or subsidies. We refer to this situation as "government outsourcing" to distinguish it from traditional regulation. Outsourcing implies the set up of independent private firms and the possibility of ex-post contract after investments are made. Such a policy instrument involves far less commitment from the government and the firm than regulation does. The government is free to offer ex-post contracts or not; the private firm is free to accept them or not. As shown in this paper, government outsourcing not only increases the benefits of privatization over *laissez-faire* but, quite interestingly, it also makes privatization more attractive to financially *un*constrained governments to which subsidies are not socially costly.

The present paper compares the ex-ante welfare of natural monopoly in two situations. In the *regulation* regime, which is based on Baron and Myerson's (1982) model, the government decides to set up a regulated firm run by a manager who benefits from private information about productivity. Without loss of generality this regime is assimilated to public ownership. The government makes the investment and designs incentive contracts to entice the efficient level of production at some informational cost. In the *outsourcing* regime private investors are free to enter markets, to make investments and to choose their price and output levels. Since *laissez-faire* is not necessarily optimal, governments can improve welfare by offering ex-post contracts to the private firm (i.e., once sunk costs have been made and technological uncertainties have been solved). To accept such ex-post contracts, private firms must at least obtain their *laissez-faire* profits. Technically this implies that the individual rationality constraint of the firm is type dependent.

The paper contribution is twofold. First of all, it derives the optimal contracts between the government and the private firm in the outsourcing case. It shows that governments offer more selective contracts under outsourcing than under regulation: high cost firms receive no ex-post contracts. The intuition for this result is the following. At the contracting stage the technological uncertainties have been solved. The firm knows its cost parameter, the government does not. If the government chooses to contract with all type of firms, as it does in the regulation regime, incentive considerations impose to increase transfers to low cost firms and to reduce the output levels of high cost ones. That is, the output levels of inefficient firms have to be reduced to lower the incentive of efficient types to inflate their cost's report. The output levels of low productivity firms and the associated consumers' surplus end up to be smaller than under *laissez-faire*. Moreover, since the fallback position of the firm is its monopoly profit, the government has to compensate it for the lost production. The utilitarian government is simply better off without contracting with high cost firms. The production level under outsourcing, which is the maximum of the regulation and the *laissez-faire* outcomes, is higher than under regulation.

Second the paper derives necessary and sufficient condition under which outsourcing is preferred to regulation. The benefit of outsourcing can be decomposed into two effects. First governments collect franchise fees from the private sector and stop subsidizing money loosing projects. Private investors are now handling the business risk. This is the *fiscal* effect puts forward in Auriol-Picard (2002). Second production is higher under outsourcing. This is a new *consumers' surplus* effect that emerged from the optimal outsourcing contracts' analysis. When the sum of the two effects is large enough outsourcing is optimal. To assess the practical relevance of this result, the paper studies particular cases under which outsourcing is preferred to regulation. First, when the cost of public funds is small, outsourcing is optimal as soon as it exists a state of nature (i.e., a draw of the technological parameter) where the firm makes a loss. This is very likely to occur in industries involving large technological uncertainties. Second, outsourcing is optimal for any value of the cost of public funds if the government is able to obtain enough revenues with ex-ante franchise fees. For instance outsourcing is always better than regulation if the franchise fee is the result of an efficient bargaining process between the government and the private investors. Example with linear demand functions and uniform cost distributions shows that the set of economic parameters supporting outsourcing is not negligible. Moreover it shows that outsourcing is more likely to dominate regulation when the ex-ante technological uncertainty rises. The paper conclude by a brief discussion of the policy implications of the model. The pharmaceutical industry seems to be a good candidate for this type of ex-post contractual arrangement.

The paper relates to the existing literature in several ways. First of all, it belongs to the traditional regulation literature initiated by Baron and Myerson's (1982) and Laffont and Tirole's (1986) models of natural monopoly. However, contrary to these earlier contributions, it does not postulate that regulation is optimal. Indeed over the last 20 years many contributions have pointed out the drawbacks of public management. First the literature on deregulation and optimal industry design under incomplete information insists that choosing an industry structure in increasing returns to scale industries is not a trivial issue (see Auriol-Laffont, 1993, Dana and Spier, 1994, McGuire and Riordan, 1995). The "natural monopoly" assumption turns out to be suboptimal in many contexts. Second, the paper is related to the literature on privatization. This literature considers that public firms are less efficient because governments lack economic orientation[5] and/or because they do not provide appropriate incentives to firm managers. In particular, because governments lack the commitment not to bail out money-losing firms, public firms' managers tend to undertake money loosing projects. By hardening the firm's budget constraint, privatization helps restoring appropriate investment incentives (see Dewatripont and Maskin 1995, Schmidt 1996a and 1996b, Segal 1998, Maskin 1999). This theory has provided support to the possibility of productivity improvements through privatization reforms in transition economies and in the banking sector. Recent empirical evidence has suggested that privatization indeed improves the internal efficiency of firms.[6] Yet this literature has not addressed the important issue of allocative inefficiencies (price distor-

[5]For instance in Kornai and Weibull (1983), or in Boycko, Shleifer and Vishny (1996), governments have 'parternalistic' or political behavior as they seek to protect or increase employment; in Shapiro and Willig (1990), governments are malevolent.

[6]Megginson and Netter (2001) in their literature review covering 65 empirical studies (some at the national level and some across countries) at the firm level conclude that private firms are more productive and more profitable than their public counterparts.

tion) induced by privatization reforms in increasing returns to scale industries, which is the scope of the present paper.[7] Finally the paper is related to the literature on mechanism design under type-dependent utility (see Lewis and Sappington 1989, Jullien 2000, and Laffont and Martimort 2002, Chap. 3). Indeed the possibility of ex-post contracting involves type-dependent individually rationality constraint.

The paper is structured as follows. Section 2 describes the model. Section 3 and 4 derive the optimal contracts under regulation and under outsourcing respectively. Section 5 analyzes the conditions under which outsourcing yields a higher welfare than regulation. Section 6 concludes.

2 The Model

The government has to decide whether a natural monopoly should be operated under public or private management. In line with Laffont and Tirole (1993), we call *regulation regime* the regime in which the government has control and cash-flow rights over a *regulated firm*. As it is standard in the regulation literature the government's control rights are associated with accountability on profits and losses. That is, it subsidizes the regulated firm in case of losses whereas it taxes it in case of profits. Concretely one can think of public ownership.[8] In contrast, we call *outsourcing* the regime in which a private unregulated firm produce the commodity. Under outsourcing, control and cash-flow rights belong to a private entrepreneur or, namely, a *private firm*. The government takes no responsibility for the firm's profits and losses. It can nevertheless asks the potential producer to pay a franchise fee for the right to operate as a monopoly. Moreover the

[7] The present paper differs from "soft budget constraint" models as it does not rely on governments' lack of commitment and on moral hazard issues. Instead, this paper is based adverse selection, individual rationality and cost of public funding. It nevertheless shares the implication of cutting the subsidies to unproductive firms.

[8] However this is also true with private firms that are under government control. For instance privately-owned regulated public utilities are rarely allowed to go bankrupt. They receive public subsidies, increases in tariff or preferential loans in case of losses (see Kornai *et al.* 2000).

government can contract ex-post with the firm to increase the supply of the commodity. We refer to this situation as *ex-post contracting*. When the government offers no ex-post contracts, the firm chooses the *laissez-faire* production level.

The paper focuses on natural monopoly. That is, the firm needs to make an investment $K > 0$ before being able to produce. The investment K is sunk. For instance if one focuses on public health care the investment K corresponds to R&D costs which are necessary to bring a new medicine or a new vaccine to the market. To keep the analysis simple we assume that the investment K has a fixed size and is verifiable (e.g., in the pharmaceutical example the R&D costs represent 17% of the industry sales revenues).[9] The uncertainty lies on the impact of the investment on the technology. That is, after the investment stage, the firm incurs an idiosyncratic marginal cost β to produce the output in quantity Q. We assume that the marginal cost β is independently drawn from the support $[\underline{\beta}, \bar{\beta}]$ according to the density and cumulative distribution functions $g(\cdot)$ and $G(\cdot)$. The expectation operator is denoted E so that $E\left[h(\beta)\right] = \int_{\underline{\beta}}^{\bar{\beta}} h(\beta)dG(\beta)$. For example, β captures the uncertainty inherent to a R&D project. A larger variance corresponds to a more risky project. In the sequel, the terms 'ex-post' and 'ex-ante' correspond to the period before and after the realization of β.

To summarize, the firm cost function is as in Baron and Myerson (1982)

$$C(\beta, Q) = K + \beta Q$$

where K (e.g., the budget allocated to R&D) is known in advance while β is random.

Consumers have a decreasing inverse demand function, denoted $P(Q)$. The gross surplus associated with the consumption of Q units of the commodity is defined as $S(Q) = \int_0^Q P(x)dx$. We focus on commodity that generates a large enough surplus so that shutting down production is never optimal. Technically the willingness to pay for the first unit of the produced good must be sufficiently large (i.e., above the highest possible virtual cost). This is formally stated in the following assumption:

[9]This assumption simplifies the analysis by ruling out moral hazard issue about the optimal size of investment. For an analysis of the moral hazard issue see for instance Dewattripont and Maskin (1995).

A1 $P(0) > \overline{\beta} + \frac{G(\overline{\beta})}{g(\overline{\beta})}$

Under assumption **A1**, public and private firms are always able to make a positive margin. Since fixed costs are sunk, firms never shut down production. The firm's profit in the absence of public transfer is equal to

$$\pi(\beta, Q) = P(Q)Q - \beta Q - K \tag{1}$$

The firm's profit with public transfer is equal to

$$\Pi(\beta, Q, t, F) = \pi(\beta, Q) + t - F \tag{2}$$

where t is the ex-post transfer that the firm gets from the government and where F is a possible ex-ante franchise fee paid to the government. The transfer to the firm can either be positive (i.e., a subsidy), or negative (a tax).

As in Laffont and Tirole (1993), the government is benevolent and utilitarian. It maximizes the sum of consumer's and producer's surpluses minus the social cost of transferring public funds to the firm. The government's objective function is

$$W(\beta, Q, t, F, \lambda) = S(Q) - \beta Q - K - \lambda t + \lambda F \tag{3}$$

where λ is the shadow cost of public funds.

The shadow cost of public funds, λ, drives the results of the paper. This shadow cost, which can be interpreted as the Lagrange multiplier of the government budget constraint, measures the social cost of the government's economic intervention. For λ close to 0, the government maximizes the net consumers' surplus; for larger λ, the government puts more weight on the social cost of transfers. The shadow cost of public funds is positive because transfers to regulated firms imply either a decrease in the production of public goods, such as schooling and health care, or an increase in distortionary taxation. Each dollar that is transferred to the regulated firm costs $1 + \lambda$ dollars to society. In developed economies, λ is mainly equal to the deadweight loss accrued to imperfect income taxation. It is assessed to be around 0.3 (Snower and Warren 1996). In developing countries, low income levels and difficulties in implementing effective taxation programs are strong constraints on the government's budget, which leads to higher values of λ. In particular, the value is very high in countries close to financial bankruptcy. As a benchmark case the World Bank (1998) suggests a shadow cost of 0.9.

We next compare regulation and outsourcing in the benchmark case of symmetric information between the firms and the government.

3 Symmetric Information

The timing under regulation is as follows. The government firstly decides whether or not to invest K ; if K is sunk, nature chooses the marginal cost β according to the distribution function $G(\cdot)$; the regulated firm's manager and the government learn β; the government proposes a production and transfer scheme $(Q^r(\cdot), t^r(\cdot))$. The government being the residual claimant of firm's profit, there is no need to consider franchise fees. Under symmetric information the government maximizes the utilitarian welfare function:

$$\max_{\{Q(\cdot),t(\cdot)\}} EW = E\left[S(Q(\beta)) - \beta Q(\beta) - K - \lambda t(\beta)\right]$$

subject to the public manager's participation constraint: $\Pi\left[\beta, Q(\beta), t(\beta), 0\right] = 0$. Pointwise maximization yields the following first order condition for $Q^r(\beta)$:

$$P(Q) + \frac{\lambda}{1+\lambda} P'(Q)Q = \beta \tag{4}$$

The transfer is equal to $t^r(\beta) = -P(Q^r)Q^r + \beta Q^r + K$. The government subsidizes firms ($t^r > 0$) when they happen to make losses and it taxes them ($t^r < 0$) in case of profits. Ex-ante welfare writes as $EW^r = E[S(Q^r) + \lambda P(Q^r)Q^r - (1+\lambda)\beta Q^r - (1+\lambda)K]$.

Under outsourcing, the timing is as follows. First, a private investor chooses to enter the market by paying the franchise fee F and by investing K. If the private firm enters, then nature chooses the marginal cost β according to the distribution $G(\cdot)$. Under symmetric information the private firm's manager and the government learn β. The government then proposes a set of contracts $\{t^o(\beta), Q^o(\beta)\}$. The firm either chooses to pick a contract and to implement its terms, or it chooses not to contract with the government in which case it sets its production at the *laissez-faire* monopoly level. Production, exchange and transfer occur as agreed upon.

Once entered, the firm's fallback position is the *laissez-faire* equilibrium. After the realization of β, the private monopoly maximizes its profit $\pi(\beta, Q)$. The first order condition is $\pi_Q(\beta, Q) = 0$. It yields the *laissez-faire* monopoly levels of production $Q^m(\beta)$ solution to

$$P(Q) + P'(Q)Q - \beta = 0. \tag{5}$$

We denote $\Pi^m(\beta) \equiv P(Q^m)Q^m - \beta Q^m - K$ the associate profit. Since it is not optimal to let private monopoly operate at the *laissez-faire* level, the government can offer ex-post transfers to correct the monopoly's price.

After the firm's entry, the government proposes an ex-post contract that maximizes $EW = E\left[S(Q(\beta)) - \beta Q(\beta) - K - \lambda t(\beta)\right]$ subject to the private owner's participation constraint: $P(Q^r)Q^r - \beta Q^r + t \geq P(Q^m)Q^m - \beta Q^m$; that is, the private owner should not earn less than its monopoly profit by accepting the ex-post contract. The private firm's reservation profit is equal to its *laissez-faire* profit. Substracting K on both sides, the participation constraint writes more compactly as $\Pi(\beta, Q(\beta), t(\beta), 0) \geq \Pi^m(\beta)$. This participation constraint is is type dependent and decreases with larger marginal costs β. The government's program differs from the previous one only by the term $\Pi^m(\beta)$. Since it is independent on the output chosen by the government, the optimal output is the same as the output under regulation, $Q^o(\beta) = Q^r(\beta)$. The difference between regulation and outsourcing lies in the values of transfers. Under outsourcing, *all* firms receive a *positive transfer*. Indeed, the transfer t is equal to $\Pi^m(\beta) - P(Q^r)Q^r + \beta Q^r + K$ which is equal to $P(Q^m)Q^m - \beta Q^m - [P(Q^r)Q^r - \beta Q^r]$. It is positive because Q^m is the maximizer of private profits. At the equilibrium all firms get their reservation profits $\Pi^m(\beta)$.

Before entry, the firm pay the franchise fee F so that its ex-ante profit $E\Pi^m - F$ is positive. Ex-ante welfare under outsourcing is then equal to $EW^o = E[S(Q^r) + \lambda P(Q^r)Q^r - (1+\lambda)\beta Q^r - (1+\lambda)K - \lambda \Pi^m + \lambda F]$. Outsourcing yields a larger ex-ante welfare than regulation if and only if $EW^o \geq EW^r$. That is, if $\lambda(F - E\Pi^m) \geq 0$. Therefore, outsourcing is at best equilivalent to regulation either if the shadow cost of public funds λ

is zero or if the government is able to tap the whole ex-ante surplus profit through the franchise fee.

Proposition 1 *Under symmetric information, outsourcing does not yield a higher welfare than traditional regulation.*

It is known in the regulation theory that a regulated firm managed by a benevolent, fully informed government cannot perform worse than the market since the regulated firm is always able to replicate the market outcome. The above proposition goes behind this statement: the regulated firm does not perform worse than the market even though the government has instruments that allow it to correct price distortions ex-post.

We study next what happens to this result under the more realistic assumption of asymmetric information.

4 Asymmetric Information

Under asymmetric information, the government is not able to acquire for free the information about firms' cost conditions. The timing of regulation and outsourcing is the same as in Section 3 except that cost realization β is now firms' private information. The government proposes a contract $(Q(\widehat{\beta}), t(\widehat{\beta}))$ which entices firms to reveal their private information $\widehat{\beta}$. We sequentially discuss the case of regulation and outsourcing, which we will also denote by the same superscripts r and o without risk of confusion. The analysis of regulation replicates the standard mechanism design literature as it is presented in Baron and Myerson (1982) and Laffont and Tirole (1993). The analysis of outsourcing is somewhat more interesting as it involves the design of incentive contracts under type-varying participation constraint (Jullien 2000). A consequence of this peculiarity is that some firms are not offered contracts by the government.

4.1 Regulation

Under asymmetric information, the government proposes a production and transfer scheme $(Q^r(\widehat{\beta}), t^r(\widehat{\beta}))$ that entices the regulated firm to reveal its private information $\widehat{\beta}$. Production and transfer take place according to the contract $(Q^r(\widehat{\beta}), t^r(\widehat{\beta}))$. There is no franchise fee: $F^r = 0$. By the revelation principle, the analysis can be restricted to direct truthful revelation mechanism $(\widehat{\beta} = \beta)$. To avoid the technicalities of 'bunching', we make the classical monotone hazard rate assumption (see Guesnerie and Laffont 1984, Jullien 2000):

A2 $\quad G(\beta)/g(\beta)$ and $(G(\beta) - 1)/g(\beta)$ are non decreasing.

Moreover in order to rule out corner solution in the sequel of the paper we focus on not too convex demand function. That is,

A3 $\quad P''(Q)Q + P'(Q) < 0$

Under asymmetric information the government maximizes the utilitarian welfare function:

$$\max_{\{Q(\cdot),t(\cdot)\}} EW = E\left[S(Q(\beta)) - \beta Q(\beta) - K - \lambda t(\beta)\right]$$

subject to

$$\begin{aligned}
(d/d\beta)\Pi(\beta, Q(\beta), t(\beta), 0) &= -Q(\beta) && (6)\\
(d/d\beta)Q(\beta) &\leq 0 && (7)\\
\Pi(\beta, Q(\beta), t(\beta), 0) &\geq 0 && (8)
\end{aligned}$$

Conditions (6) and (7) are the first and second order incentive compatibility constraints and condition (8) is the public manager's participation constraint.[10] This problem is a standard adverse selection problem of regulation under asymmetric information. Under assumption A3 it admits an interior solution. The optimal output, denoted $Q^r(\beta)$, solves

$$P(Q) + \frac{\lambda}{1+\lambda}P'(Q)Q = \beta + \frac{\lambda}{1+\lambda}\frac{G(\beta)}{g(\beta)} \tag{9}$$

Under assumption A2 the output $Q^r(\beta)$ is non increasing in β so that condition (7) is satisfied. Comparing equation (9) with equation (4), one can check that the output level

[10] The public manager's earnings are normalized to zero. Allowing a positive earning would reduce further the attractiveness of regulation compared to outsourcing.

under perfect information is obtained by setting $G(\beta)/g(\beta)$ to zero. Because the LHS of (9) decreases in Q, we deduce that the output level under asymmetric information is lower than under perfect information. In order to reduce the firm's incentive to inflate its cost report, the government orders high cost firms to produce less than it would ask under perfect information. The distortion increases with λ.

We next turn to the computation of the regulated firm's transfer. Integrating equation (6) while using equation (8) the firm's information rent is equal to

$$\Pi^r(\beta) = \int_{\beta}^{\overline{\beta}} Q^r(\beta)\, d\beta \tag{10}$$

The firm with the lowest productivity (i.e., the highest cost $\overline{\beta}$) gets zero information rent: $\Pi^r\left(\overline{\beta}\right) = 0$. More efficient firm gets an informational rent. Substituting (10) into (2) yields the regulated firm's transfer

$$t^r(\beta) = \int_{\beta}^{\overline{\beta}} Q^r(\beta)\, d\beta + \beta Q^r(\beta) + K - P(Q^r(\beta))Q^r(\beta) \tag{11}$$

Larger fixed costs raise the transfers to the regulated firm. The ex-ante welfare writes as

$$EW^r = \int_{\underline{\beta}}^{\overline{\beta}} \left[S(Q^r(\beta)) - \beta Q^r(\beta) - K - \lambda t^r(\beta)\right] dG(\beta) \tag{12}$$

The paper aims to study contracting arrangement that permits to deliver the commodity to consumers in the most efficient way. In what follow we study outsourcing as an alternative to regulation.

4.2 Government Outsourcing

Under outsourcing the firm is managed by private investors or entrepreneurs. The timing is the same as in the full information case, except that β is now private information. This means that, the private firm firstly chooses to enter the market by paying the franchise fee F and by investing K. If it enters, then nature chooses the marginal cost β according to the distribution $G(\cdot)$. The private firm's manager learns β while the government does not. The government proposes a set of contracts $\{t^o(\beta), Q^o(\beta)\}$. The firm either chooses to commit with the government by picking a contract and by implementing its terms, or it chooses not to contract with the government by setting its production at the *laissez-faire* monopoly level. Production, exchange and transfer occur as agreed upon.

Under outsourcing, the firm's fallback position is given by its *laissez-faire* monopoly profit, $\Pi^m(\beta)$, which has been derived in Section 3. It is not necessarily optimal to let private monopoly operate at the *laissez-faire* level. If the investment is worthwhile the government may contract ex-post with the firm in order to avoid the welfare loss associated to monopoly pricing. In this case it subsidies the firm to produce more than its monopoly quantity. We firstly show that only a fraction of firms signs a contract with the government and secondly that the number of firms signing a contract decreases with the shadow cost of public funds.

4.2.1 Selective ex-post contracts

Let $Q^o(\beta)$ and $\Pi^o(\beta)$ denote the output and the profit of the private monopoly under ex-post contracting. After entry, the franchise fee is sunk. Since it plays no role in the quantity/price decision, we temporarily set F to zero. The government solves

$$\max_{\{Q(\cdot),t(\cdot)\}} EW = E\left[S(Q(\beta)) - \beta Q(\beta) - K - \lambda t(\beta)\right]$$

subject to

$$\begin{aligned}
(d/d\beta)\Pi(\beta, Q(\beta), t(\beta), 0) &= -Q(\beta) && (13)\\
(d/d\beta)Q(\beta) &\leq 0 && (14)\\
P(Q(\beta))Q(\beta) - \beta Q(\beta) + t(\beta) &\geq P(Q^m(\beta))Q^m(\beta) - \beta Q^m(\beta) && (15)
\end{aligned}$$

Incentive compatibility constraints (13) and (14) are equivalent to (6) and (7). However, the private firm's participation constraint (15) differs from the participation constraint under regulation (8). Under ex-post contracting, the minimum profit acceptable to the firm is the operating profit level it would get under *laissez-faire* and after sinking the fixed cost K. Substracting K on both sides of inequality (15), we can write the participation constraint more simply as

$$\Pi(\beta, Q(\beta), t(\beta), 0) \geq \pi(\beta, Q^m(\beta)) \tag{16}$$

Contrary to regulation, the firm's participation constraint now depends on its type β.

The government is obliged to leave a large rent to low cost firms if it wants to contract with them. However it is not committed to compensate for the losses of high cost firms. As firms are private and unregulated, they endorse the responsibility of their investments. When costs are too high, the government may decide not to contract with the private firm. This result is formally stated in the following lemma.

Lemma 2 *Under Assumptions A1 to A3 there exists a unique* $\beta_0 \in [\underline{\beta}, \overline{\beta}]$ *such that* $\beta_0 = \min\{\beta_0', \overline{\beta}\}$ *where* β_0' *solves*

$$P(Q^m(\beta_0')) = \beta_0' + \lambda \frac{G(\beta_0')}{g(\beta_0')} \tag{17}$$

Output and profit of the firm under ex-post contracting are equal to

$$Q^o(\beta) = \begin{cases} Q^r(\beta) > Q^m(\beta) & \textit{if} \quad \beta < \beta_0 \\ Q^m(\beta) & \textit{if} \quad \beta \geq \beta_0 \end{cases} \tag{18}$$

$$\Pi^o(\beta) = \begin{cases} \Pi^m(\beta_0) + \int_\beta^{\beta_0} Q^r(\beta)\, d\beta > \Pi^m(\beta) & \textit{if} \quad \beta < \beta_0 \\ \Pi^m(\beta) & \textit{if} \quad \beta \geq \beta_0 \end{cases} \tag{19}$$

Proof. See Appendix 1. ■

Figure 1 illustrates output and profit functions under regulation (thin curves), laissez-faire (dashed curves) and ex-post contracting (bold curves). Under regulation and ex-post contracting, low cost firms are enticed to claim larger subsidies by reporting higher cost levels. Because the high cost firms' profits are more sensitive to output than low cost firms, the government alleviates the mis-reporting effect by imposing smaller output levels in firms that report high costs. However, under regulation, the output distortion can be so strong that the high cost firms may produce less than under *laissez-faire*: $Q^r(\beta) \leq Q^m(\beta)$ for all $\beta \geq \beta_0$. This does not occur under ex-post contracting because the fall back position of the government is the *laissez-faire* equilibrium. To understand this result consider the firm with $\beta = \beta_0$ so that $Q^o(\beta_0) = Q^r(\beta_0) = Q^m(\beta_0)$. There is no point to offer an ex-post contract to this firm: its output level is the government's preferred output level. Ex-post contracting and *laissez-faire* yield the same consumer and producer surpluses. Consider now a firm with $\beta > \beta_0$. If the government proposes an ex-post contract to this firm it is unable to get a surplus larger than under laissez-faire because incentive compatibility obliges to distort output down to $Q^r(\beta) < Q^m(\beta)$. Moreover any transfer to this firm also increase the subsidies to all firms having smaller costs. Both effects harms the government.

INSERT FIGURE 1 HERE

We have restricted our analysis to the case of not too convex demand function (i.e., to $P'' + P'Q < 0$). Suppose instead that the demand is very convex. For low marginal costs β *laissez-faire* profits increase very fast as β drops. Hence, the ex-post contracts to the firms with low costs would involve very large rents and would attract firms with higher marginal costs. Incentive compatibility constraint would then be difficult to maintain. Therefore, firms with very low marginal cost would also be excluded from contracting. With type dependent participation constraints, exclusion can thus affect both very high and very low types simultaneously (see Jullien 2000, Proposition 2). For the sake of simplicity we rule out this case by making assumption A3.

If we assume that output and profit are continuous variables, ex-post contracting and regulation yield the same output level at β_0. That is $Q^m(\beta_0) = Q^r(\beta_0)$ and $\Pi^o(\beta_0) = \Pi^m(\beta_0)$. Moreover if $\lambda \to \infty$, we have $\beta_0 \to \underline{\beta}$ so that with very large shadow costs of public funds ex-post contracting is never optimal. Finally define λ_0 as the shadow cost which gives $\beta_0 = \overline{\beta}$:

$$\lambda_0 = g(\overline{\beta}) \left[P(Q^m(\overline{\beta})) - \overline{\beta} \right]. \tag{20}$$

We deduce easily the following result.

Proposition 3 *Let β_0 and λ_0 be defined equation (17) and (20).*
(i) If $\lambda \leq \lambda_0$ all firms receive an ex-post contract under outsourcing ($\beta_0 = \overline{\beta}$).
(ii) If $\lambda > \lambda_0$ a fraction $G(\beta_0) > 0$ of firms receive an ex-post contract under outsourcing ($\beta_0 < \overline{\beta}$). This fraction decreases with λ and tends to zero when $\lambda \to \infty$.

Since the opportunity cost of public funds tends to decrease with a country's wealth, Proposition 3 suggests that ex-post contracting is more likely to occur in advanced economies. In developing countries outsourcing is more likely to take the extreme form of *laissez-faire*.

4.2.2 Transfers

We now study transfers under ex-post contracting. By the envelop theorem, we have $(d/d\beta)\,\Pi^m(\beta) = \pi_\beta(\beta, Q^m(\beta)) = -Q^m(\beta)$. We deduce that

$$\Pi^m(\beta) = \int_\beta^{\beta_0} Q^m(\beta)\,d\beta + \Pi^m(\beta_0) = \int_\beta^{\overline{\beta}} Q^m(\beta)\,d\beta + \Pi^m\left(\overline{\beta}\right) \tag{21}$$

Combining (21) with (19) into (2) we easily get

$$t^o(\beta) = \begin{cases} \int_\beta^{\beta_0} \left[Q^r(\beta) - Q^m(\beta)\right] d\beta \\ \quad + \pi(\beta, Q^m(\beta)) - \pi(\beta, Q^r(\beta)) & \text{if} \quad \beta < \beta_0 \\ 0 & \text{if} \quad \beta \geq \beta_0 \end{cases}$$

High cost firms with $\beta \geq \beta_0$ receive no transfer. The difference between the transfer under ex-post contracting and regulation is simply equal to $t^o(\beta) - t^r(\beta) = -t^r(\beta)$. This difference is positive if the government taxes the firm under regulation; it is negative if the government subsidizes it. Low cost firms with $\beta < \beta_0$ receive a transfer that consists of two positive terms: an information rent and a subsidy to compensate for the revenue fall associated with the higher output levels specified in the contracts. Since $t^o(\beta)$ involves a difference between profits under regulation and under *laissez-faire*, term K cancels out. In contrast to regulation, the government does not compensate for the fixed cost investment. Note also that, by construction, the transfer $t^o(\beta)$ is non negative. After collecting the franchise fee (i.e., a lump sum tax), the government has no right to grab the firm's positive profits, nor to oblige it to produce more without a monetary compensation. The next lemma compares $t^o(\beta)$ with the transfer for regulated firms, $t^r(\beta)$ for low cost firms.

Lemma 4 *Let $\Delta t(\beta) \equiv t^o(\beta) - t^r(\beta)$. Then, for all $\beta < \beta_0$, $\Delta t(\beta)$ is independent of the type β and equal to*

$$\Delta t = \Pi^m(\beta_0) - \Pi^r(\beta_0) = \int_{\beta_0}^{\overline{\beta}} [Q^m(\beta) - Q^r(\beta)]\, d\beta + \Pi^m(\overline{\beta}) \tag{22}$$

Proof. See Appendix 2. ■

Expression (22) is a constant which depends on β_0. It includes the profit of the private firm $\Pi^m(\beta_0)$, which decreases with fixed costs, and the rent of the public manager $\Pi^r(\beta_0)$, which is independent of fixed costs. Hence, larger fixed costs decrease the level of transfers under ex-post contracting compared to regulation. Since $Q^m(\beta) > Q^r(\beta)$ for all $\beta > \beta_0$ (see Figure 1), the constant Δt is positive if $\Pi^m(\overline{\beta}) > 0$. In this case the government pays larger transfers under ex-post contracting than it would under regulation. Some firms receive positive transfers whereas they would pay a tax under regulation (i.e., $t^o(\beta_0) = 0 > t^r(\beta_0)$). However, the result can be reversed if $\Pi^m(\overline{\beta})$ is sufficiently negative (i.e., Δt can be negative). The government then pays smaller transfers under ex-post contracting than under regulation. Some firms receive no transfers whereas they would be subsidized under regulation (i.e., $t^o(\beta_0) = 0 < t^r(\beta_0)$).

4.2.3 Welfare

By Lemma 2, expected welfare under ex-post contracting writes as

$$\begin{aligned} EW^o(\lambda) &= \int_{\underline{\beta}}^{\beta_0} W(\beta, Q^r(\beta), t^o(\beta), F, \lambda)\, dG(\beta) \\ &\quad + \int_{\beta_0}^{\overline{\beta}} W(\beta, Q^m(\beta), 0, F, \lambda) dG(\beta) \end{aligned} \tag{23}$$

Using expression (22), the linearity of the welfare function $W(\cdot)$ in $t(\beta)$ and F, and Lemma 4 , we rewrite the expected welfare function as

$$\begin{aligned} EW^o(\lambda) &= \int_{\beta_0}^{\overline{\beta}} W(\beta, Q^m(\beta), 0, 0, \lambda) dG(\beta) \\ &+ \int_{\underline{\beta}}^{\beta_0} W(\beta, Q^r(\beta), t^r(\beta), 0, \lambda) dG(\beta) - \lambda \Delta t G(\beta_0) + \lambda F \end{aligned} \tag{24}$$

The ex-ante welfare consists of four elements: the welfare accrued to private firms with high cost β receiving no ex-post contract, the welfare accrued to private firms with low cost β that contract with the government to produce the regulated level output, the social cost of leaving the additional rent Δt to the fraction $G(\beta_0)$ of firms under ex-post contract, and finally the social value of the franchise fee.

The next section discusses the optimal choice between regulation and outsourcing.[11]

5 Regulation Versus Outsourcing

Under asymmetric information, outsourcing is preferred to regulation if and only if $EW^o(\lambda) > EW^r(\lambda)$. To facilitate the welfare comparison we change the integration boundaries in (24). We obtain

$$\begin{aligned} EW^o(\lambda) &= EW^r(\lambda) - \lambda \Delta t G(\beta_0) + \lambda F \\ &- \int_{\beta_0}^{\overline{\beta}} \left[W(\beta, Q^r(\beta), t^r(\beta), 0, \lambda) - W(\beta, Q^m(\beta), 0, 0, \lambda) \right] dG(\beta) \end{aligned} \tag{25}$$

Using the welfare function linearity w.r.t. transfer $t^r(\beta)$, we obtain that outsourcing is preferred to regulation if and only if

$$\left. \begin{array}{l} \int_{\beta_0}^{\overline{\beta}} \left[W(\beta, Q^m(\beta), 0, 0, \lambda) - W(\beta, Q^r(\beta), 0, 0, \lambda) \right] dG(\beta) \\ + \lambda \left[F + \int_{\beta_0}^{\overline{\beta}} t^r(\beta) dG(\beta) - \Delta t G(\beta_0) \right] \end{array} \right\} > 0 \tag{26}$$

The difference in welfare between outsourcing and regulation is decomposed into two effects: the *consumers' surplus effect*, which corresponds to the first term (the first integral), and the *fiscal effect*, which corresponds to the second term (the parenthesis). The

[11] There is no need to compare *laissez-faire* with regulation. Ex-post contracting always dominates it.

consumer's surplus effect is a new effect. Under outsourcing, low cost firms produce the same quantity than regulated firms but high cost firms' produce more (i.e., they produce the laissez-faire output). This increases the consumers' surplus. The fiscal effect is decomposed into three terms: the social value of the franchise fee F, the social value of the reduction in subsidies to regulated firm (the integral) and the social cost of additional rents to private firms under outsourcing Δt. The sum of these three terms is weighted by λ, the opportunity cost of the public funds, because it represents the net saving/spending in public funds generated by outsourcing compared to regulation.

In what follows we show that the range of parameters for which outsourcing dominates regulation is not empty. We focus on two situations: small shadow costs of public funds and high franchise fees.

5.1 Small shadow costs of public funds

According to Proposition 3, the government offers an ex-post contract to all firms when $\lambda \leq \lambda_0$. By equation (20), this is equivalent to set $\beta_0 = \overline{\beta}$. Since $\Pi^r\left(\overline{\beta}\right) = 0$ and $G(\overline{\beta}) = 1$, we deduce that $\Delta t G(\beta_0) = \Pi^m\left(\overline{\beta}\right) - \Pi^r\left(\overline{\beta}\right) = \Pi^m\left(\overline{\beta}\right)$. The transfers under outsourcing are larger by an amount equal to the *laissez-faire* profit in the worst cost realization. When this value of profit is positive, firms receive larger rents under outsourcing than under regulation.[12] The reverse is true when firms make losses as the government avoids the social cost of subsidizing them in the worst cost realization. Moreover, by virtue of Lemma 2, the quantities produced under regulation and under outsourcing are the same when $\beta_0 = \overline{\beta}$. The consumers' surplus effect vanishes (i.e., the second integral in expression (25) cancels out when $\beta_0 = \overline{\beta}$). The choice between the two structures then

[12]To accept the ex-post contracts, private firms need at least to get the *laissez-faire* profit. In contrast the public manager receive nothing in case of the worst cost realization.

depends on the fiscal effect.[13] That is, the ex-ante welfare becomes

$$EW^{o}(\lambda) = EW^{r}(\lambda) - \lambda\Pi^{m}\left(\overline{\beta}\right) + \lambda F$$

We deduce the following result.

Proposition 5 *For $\lambda \leq \lambda_0$ outsourcing is preferred to regulation if and only if $F > \Pi^{m}\left(\overline{\beta}\right)$.*

Proposition 5 offers a sharp characterization of the optimal industrial policy. For low values of shadow cost of public funds, which is more likely to occur in advanced economies,[14] the government should outsource as soon as it recoups the *worst* profit realization of the *laissez-faire* monopoly through a franchise fee. Since $E\Pi^{m} > \Pi^{m}\left(\overline{\beta}\right)$, it should always do so when it is able to sell the firm at its expected market price, $F = E\Pi^{m}$. More interestingly, even if the government is not able/allowed to raise a franchise fee, it should outsource as long as the firm make a loss with positive probability (i.e., $\Pi^{m}\left(\overline{\beta}\right) < 0$). Natural monopolies in rich economies subjected to large uncertainty, such as the pharmaceutical industry, seem good targets for such ex-post contractual arrangement.

5.2 High franchise fees

We now show that outsourcing dominates regulation if the government is able to tap a sufficiently large share of the firm's expected profit through the ex-ante franchise fee, independently of the value of λ. We first study exogeneous franchise fee. Since they are bounded by private firms' gains, we also study the fees that entrepreneurs are likely to pay when they bargain with the government. We show that the government always prefers outsourcing to regulation when franchise fees are determined in a efficient bargaining process. Finally we briefly discuss the robustness of the results.

[13] The attractiveness of the outsourcing regime lies on the government ability to recoup enough of the expected monopoly profits through the franchise fee to balance the social cost of additional transfers to the private firm.

[14] For instance, shadow costs of public funds are assessed to about 0.3 in OECD countries while the threshold λ_0 is equal to 0.5 in the linear demand and uniform distribution example (see section 5.3).

5.2.1 Exogeneous franchise fees

Let us first consider exogenous franchise fees. We compute the value of the maximal franchise fee, i.e., the monopoly's expected profit when no franchise fee is asked. Using (19) and (21), we know that the profit under outsourcing is equal to the profit under *laissez-faire* plus a positive information rent that is equal to $\int_{\beta}^{\beta_0}[Q^r(z) - Q^m(z)]dz$ for each firm with $\beta < \beta_0$. Using (10) and (11), this information rent can be written as $\Pi^r(\beta) - \Pi^r(\beta_0) - [\Pi^m(\beta) - \Pi^m(\beta_0)]$, which by (22) is equal to $\Pi^r(\beta) - \Pi^m(\beta) + \Delta t$. Hence, the ex-ante profit with zero franchise fee is equal to

$$\begin{aligned} E\Pi_0^o &= E\Pi^m + \int_{\underline{\beta}}^{\beta_0} \int_{\beta}^{\beta_0} [Q^r(z) - Q^m(z)]dzdG(\beta) \\ &= E\Pi^m + G(\beta_0)\Delta t + \int_{\underline{\beta}}^{\beta_0} [\Pi^r(\beta) - \Pi^m(\beta)]dG(\beta) \end{aligned} \tag{27}$$

We add $\lambda E\Pi_0^o$ on both sides of condition (26). After some substitutions and simplifications (see Appendix 3), the necessary and sufficient condition (26) becomes

$$\lambda [E\Pi_0^o - F] < \left\{ \begin{array}{l} \lambda \int_{\underline{\beta}}^{\overline{\beta}} \Pi^r(\beta)\, dG(\beta) \\ +\lambda \int_{\beta_0}^{\overline{\beta}} [\Pi^m(\beta) - \pi(\beta, Q^r(\beta))] dG(\beta) \\ + \int_{\beta_0}^{\overline{\beta}} [W(\beta, Q^m(\beta), 0, 0, \lambda) - W(\beta, Q^r(\beta), 0, 0, \lambda)] dG(\beta). \end{array} \right. \tag{28}$$

The RHS of this condition includes three terms: the expected value of the public manager's information rent, the additional profit and the additional (gross) surplus that high cost firms generate under outsourcing. It is straightforward to check that each term is positive. Indeed we have that $E\Pi^r(\beta) \geq 0$ and that $\Pi^m(\beta) = \max_Q \pi(\beta, Q) \geq \pi(\beta, Q^r(\beta))$. The consumers' surplus effect is always positive because $Q^m(\beta) \geq Q^r(\beta)$ for $\beta > \beta_0$ and because welfare is a decreasing function of output for this range of the parameters (indeed, both $Q^m(\beta)$ and $Q^r(\beta)$ are smaller than the output under regulation with symmetric information as shown in equation (4)). We deduce the following result.

Proposition 6 *If the franchise fee F is sufficiently close to $E\Pi_0^o$, outsourcing is preferred to regulation for any shadow cost of public funds $\lambda > 0$.*

Proof. See Appendix 3 ■

This proposition sharply contrasts with our conclusion in the full information context where regulation is always the best policy. Here outsourcing is *strictly* preferred to regulation for any shadow cost of public funds if the government is able to tap the whole ex-ante profit through the franchise fee. This is likely to occur when the number of investors is large, when they do not collude and when there exist no information asymmetry at the ex-ante stage. These conditions corresponds to perfectly competitive financial markets. Moreover the possibility to successfully auction public projects to private investors and entrepreneurs strongly depends on the government's ability to commit not to expropriate them once the investments are sunk. This ultimately depends on the credibility and on the stability of the political and judicial institutions. Efficient financial markets, strong legal system and credible governments are found in advanced economies. Such institutions are lacking in developing countries where attracting private investors is difficult. In such countries, governments might be unable to tap a large amount of private firms' ex-ante profits. They might thus prefer regulation.[15]

Finally the LHS of (28) decreases with the fixed cost (through the term $E\Pi^m$ in $E\Pi_0^o$) while the RHS is independent of it. Higher fixed costs diminish the franchise fee that makes the government indifferent between regulation and outsourcing. Hence, when the ex-ante industry profit is sufficiently small, the franchise fee needs not be positive. The government may indeed pay the entrepreneur to take the business risk.

5.2.2 Endogenous franchise fees

In the above discussion, we have considered exogenous franchise fees. Yet Proposition 6 offers an important implication when franchise fees are endogenously negotiated between the government and a risk-neutral private entrepreneur: there is always room for negotiation as there always exists a franchise fee that is accepted by the private entrepreneur and that makes the government prefer outsourcing. The negotiation should nevertheless

[15] In contrast, strong moral hazard issues, time inconsitency and lack of governments' economic focus can be rationales for privatization in least developed countries (see Kornai *et al.* 2002).

be efficient in the sense that no economic opportunities are lost during the bargaining process. This is formally stated in the following corollary.

Corollary 7 *Outsourcing is always preferred to regulation when the franchise fee F is endogenously determined by an efficient bargaining process.*

To clarify this statement, let us assume that the franchise fee is the Nash bargaining solution. The entrepreneur's payoff is equal to $E\Pi_0^o - F$ and its fallback position is equal to zero. The government's welfare can be decomposed into the social benefit of the franchise fee λF and $EW_0^o(\lambda) \equiv EW^o(\lambda) - \lambda F$. Its fallback position is regulation which yields a welfare level equal to $EW^r(\lambda)$. The Nash bargaining allocation solves

$$\max_F \left[EW_0^o(\lambda) + \lambda F - EW^r(\lambda)\right]^\phi \left(E\Pi_0^o - F\right)^{1-\phi}$$

where $\phi \in [0,1]$ is the government's bargaining power. Since the payoff function is linear in F, the Nash bargaining solution is

$$F^\phi = \phi E\Pi_0^o - (1-\phi)\left[EW_0^o(\lambda) - EW^r(\lambda)\right]/\lambda$$

The franchise fee can be positive or negative. It will be negative when the government has weak bargaining power (i.e., ϕ is close to zero) and/or when expected profits are negative. When the market is not profitable the government is willing to help a firm to enter. It subsidizes the sunk cost and proposes ex-post contracts. The franchise fee will also be negative when the welfare level under regulation is sufficiently small compared to the welfare level under outsourcing without franchise fee. In this situation the firm is able to extract an ex-ante rent from the government because it knows that the option of regulation is not very attractive.

5.2.3 Robustness

The results of the paper rest on two key assumptions: first, risk neutral entrepreneurs have access to efficient financial markets and second, government does not auction the right to run the regulated firm to potential public managers. This last assumption is usually justified by the fact that information rents take the form of in-kind benefits that are difficult to trade. But, for the sake of the argument, suppose that the government is able to perfectly auction the right to operate a private-regulated firm to some risk neutral manager. The government is then able to recoup the manager's expected rents,

$$\int_{\underline{\beta}}^{\overline{\beta}} \Pi^r(\beta)\, dG(\beta).$$

The ex-ante welfare associated with regulation is increased by this amount. This is equivalent to cancel the first term in (28). Proposition 6 is still valid. Outsourcing is preferred to regulation for any franchise fee F that is sufficiently close to $E\Pi_0^o$. The crucial assumption of the paper is thus the existence of efficient financial markets. Here again policy implications are more likely to fit advanced economies.

5.3 Numerical example and policy implications

We have shown in Section 5.1 that outsourcing is better than regulation when the opportunity cost of public funds is "low" and the firm makes a loss with a positive probability. The practical relevance of this result depends on the threshold value λ_0 below which the result holds. Moreover the result suggests that outsourcing is more valuable when ex-ante riskiness is large. We compute an example to check this intuition and the level of λ_0. It allows us to explore the benefits of outsourcing for larger shadow costs of public funds and for smaller franchise fees.

We consider a linear inverse demand function $P(Q) = a - bQ$, so that assumption A3 holds, and a uniform distribution of cost $\beta \in [0, \overline{\beta}]$ so that assumption A2 holds. That is, $G(\beta)/g(\beta) = \beta$.[16] Assumption A1 becomes $a \geq 2\overline{\beta}$. To meet this requirement we index the spread of the cost distribution by $\alpha \in [0,1]$ so that $\overline{\beta} = \alpha\, a/2$. A larger α corresponds to a higher business risk. Under these assumptions it is straightforward to check that equation (17) yields $\beta_0 = a/(1+2\lambda)$ and equation (20) yields $\lambda_0 = (2-\alpha)/(2\alpha)$

[16] Because what really matters is the net surplus from consumption by the first consumer (i.e., $a - \beta$), we can normalize $\underline{\beta} = 0$ without loss of generality.

so that $\lambda_0 \in [0.5, +\infty)$.[17] Since the value generally retained for the marginal cost of public funds in advanced economies is $\lambda \simeq 0.3$, it is plausible that outsourcing dominates regulation in risky business in OECD countries. Moreover let V be the ex-ante variable profit of a *laissez-faire* monopoly (i.e., $E\Pi^m = V - K - F$). One can check that $V = (12 - 6\alpha + \alpha^2)\, a^2/(48b)$. Appendix 4 shows that EW^r and EW^o are fully characterized by the parameters V, λ, α, F and K.

INSERT FIGURE 2 HERE

We normalize the fixed cost to its share in the *ex-ante* variable profit of the *laissez-faire* monopoly. That is, let $k \equiv K/V$. A *laissez-faire* firm makes zero ex-ante profit when $k = 1$ and it makes $E\Pi^m = (1-k)\,V$ when $0 < k < 1$. Figure 2 shows the normalized levels of fixed costs, k, above which outsourcing is preferred in the case of a zero franchise fee and in the case of a franchise fee equal to half the *ex-ante laissez-faire* profit: $F = E\Pi^m/2$. Each curve is drawn for a cost spread varying between $\alpha = 0.05$ and 0.5. It is not surprising that outsourcing is preferred when the government is able to tap a large franchise fee from the monopoly. However outsourcing is still a good policy when the government cannot extract franchise fee from investors. It is also readily observed that outsourcing is preferred for smaller opportunity costs of public funds (i.e., for richer countries).

Finally, Figure 2 shows that outsourcing is preferred for large cost spreads, i.e. for large business risk. By contrast, outsourcing is dominated for all values of fixed costs and of costs of public funds when the cost spread tends to zero ($\overline{\beta} \to 0 = \underline{\beta}$ or $\alpha \to 0$). This is precisely the outsourcing decision derived under symmetric information. Indeed, one can readily check the continuity of our model as a function of the business risk under the above uniform cost distribution. Because $g(\beta) = 1/\overline{\beta}$ tends to infinity when the cost

[17] Let consider a risky project so that $\alpha = 1$ and $\lambda_0 = 1/2$. If the government chooses outsourcing, all private firms receive an ex-post contract if $\lambda \leq 1/2$. If $\lambda > 1/2$, the fraction of private firms that contract ex-post with the government is equal to $G(\beta_0) = 2/(1+2\lambda)$. For instance at $\lambda = 0.9$, 71% of the firms get an ex-post contract and at $\lambda = 2$, they are 40%.

spread vanishes, we observe that λ_0 also tends to infinity and that all firms get subsidized. Hence, Proposition 5 applies and it becomes easy to check that $EW^o(\lambda) - EW^r(\lambda) \geq \lambda [F - \Pi^m(0)]$, which is the condition that justifies Proposition 1.

The present paper presents normative results about the management of natural monopolies under asymmetric information and costly public funds. To be useful we should derive some positive results about ownership structure and contractual arrangements in existing industries. We believe that the pharmaceutical industry offers a good instance of the type of ex-post contractual arrangement developed in the paper. It is a high-technology industry. The largest firms, which account for the majority of the patents, spend heavily on R&D (i.e., in 2002 about 17% of their sales revenues).[18] The R&D costs are sunk. They confer a natural monopoly structure to the industry embodied in the patent system. Since they are a major component of the health care system, drugs are subjected to official scrutiny and approval throughout their life cycle. Despite the sunk costs plus the safety and externality concerns, the pharmaceutical industry is for most of it owned and managed privately. A major difference between this industry and other increasing-return-to-scale industries, such as traditional public utilities, is uncertainty. Of 10000 pharmaceutical products patented, only 10 are marketed (OECD 2000).[19] With such a low rate of success, the present analysis suggests that governments are better of by contracting ex-post with the private sector rather than assuming the full responsibility of the investments through public ownership or traditional regulation. Consistently with the theoretical recommendation, firms, protected by the patent system, have much freedom in prices setting.[20] Consumers' access to the medicines then is subsidized. In average

[18]In 2002 pharmaceutical companies spent about $32 billion on R&D (the Pfizer Journal, 2003). They spent even more on marketing.

[19]Of these, only a few are commercially successful. That is, 75 percent of drug company profits come from just 10 percent of all marketed drugs.

[20]In some countries, such as Germany, Norway, Finland, United-States or Canada, prices are free. In the US pharmacies are unregulated and it is legal to purchase pharmaceutical via the internet. In other ones, such as Australia, Belgium, France or Italy, prices of prescribed drugs are negotiated (but not regulated) by government agencies because they are covered by public insurance.

OECD countries more than three-quarters of pharmaceutical expenditure is reimbursed in some way, usually by a mix of public and private insurance, except in North-America (Jacobzone 2000). On the other hand, the prices of over-the-counter medicines, which are not reimbursed, are free. The classification between reimbursed and non-reimbursed drugs is consistent with the optimal outsourcing scheme. Only the most efficient types lead to contractual agreement between the health insurances and the firms. These approved drugs are reimbursed so that consumption is higher than under *laissez-faire*. Less efficient drugs are left to the market.

6 Conclusion

The paper studies a model of natural monopoly under adverse selection. A benevolent government maximizes a utilitarian welfare function à la Baron and Myerson (1982). We compare two regimes. In the regulation regime, a public manager, who reports cost to the regulator, runs the firm's operation. Because of information rents, the government is not able to implement the first best solution. In the outsourcing regime, the government abandons the firm's operation to a private entrepreneur. The private firm chooses freely its price and its output levels. In the absence of government intervention this yields the monopoly *laissez-faire* solution. The government can however propose ex-post contracts to increase production and exchange. The ex-post contracts need to leave the private firm with at least its *laissez-faire* profit. We show that the government chooses to offer ex-post contracts to low cost firms only. They are subsidized to produce the regulation output. In contrast, high cost firms do not receive any ex-post contracts. They operate under *laissez-faire*, which yields higher output than regulation.

Ex-post contracting generates two types of benefits. First, it prevents the government from subsidizing money loosing firms. By the same token it forbids the government to tap revenues from profitable ones. It also yields franchise fees that are extracted ex-ante. Second it relaxes incentive compatibility constraint, which permits to reduce output distortions on high cost firms. The way these two effects play depends on the opportunity cost of public funds. When it is low, fiscal issues are not very relevant. The welfare function is titled toward the consumers' surplus and outsourcing is always preferred as long as the franchise fee is larger than the worst *laissez-faire* profit. For larger value of the opportunity cost outsourcing is preferred if the franchise fee is large enough.

Asymmetric information and governments' financial constraint are strong impediments to public management. These costs add to the internal efficiency ones analyzed in the privatization literature to suggest that privatization and ex-post contracting might be in some cases a better policy than public ownership and traditional regulation. This result seems especially relevant for high technological industries in advanced economies.

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Appendix 1: Proof of Lemma 2

The proof is an application of Jullien (2000) in the particular case of common value adverse selection. We make it here explicit the dynamic programming approach. The program can be written as

$$\max_{Q(.),\Pi(.),\mu(.),\gamma(.)} \int_{\underline{\beta}}^{\overline{\beta}} H_1(\beta, Q, \Pi, \mu, \gamma)\, d\beta$$

where

$$\begin{aligned} H_1(\beta, Q, \Pi, \mu, \gamma) &= [S(Q) + \lambda P(Q) Q - (1+\lambda)\beta Q - \lambda \Pi]\, g(\beta) \\ &\quad + \mu\left(\dot{\Pi} + Q\right) + \lambda\gamma(\beta)\left(\Pi - \Pi^m(\beta)\right) \end{aligned}$$

where $\Pi^m(\beta) \equiv \pi(\beta, Q^m(\beta))$, where $\mu(\beta)$ is the co-state variable of the incentive constraint and where $\gamma(\beta) \geq 0$ is the Lagrange multiplier of the participation constraint. After integrating by part, this program is equivalent to $\max_{Q(.),\Pi(.),\mu(.),\gamma(.)} \int_{\underline{\beta}}^{\overline{\beta}} H_2(\beta, Q, \Pi, \mu, \gamma)$ $d\beta$ where

$$\begin{aligned} H_2(\beta, Q, \Pi, \mu, \gamma) &= [S(Q) + \lambda P(Q) Q - (1+\lambda)\beta Q - \lambda \Pi]\, g(\beta) \\ &\quad - \dot{\mu}(\beta)\Pi + \mu(\beta) Q + \lambda\gamma(\beta)\left(\Pi - \Pi^m(\beta)\right) \end{aligned}$$

with transversality conditions: $\Pi\left(\underline{\beta}\right)\mu\left(\underline{\beta}\right) = \Pi\left(\overline{\beta}\right)\mu\left(\overline{\beta}\right) = 0$. It is easy to check that concavity conditions are respected. So, the following first order conditions $\partial H_2/\partial \Pi = 0$ and $\partial H_2/\partial Q = 0$ are also sufficient:

$$\dot{\mu} = \lambda \left(\gamma \left(\beta \right) - g \left(\beta \right) \right)$$

$$P(Q) + \frac{\lambda}{1+\lambda} P'(Q)Q = \beta - \mu \left(\beta \right)$$

Integrating both sides of the first equality yields $\mu \left(\beta \right) = \lambda \left(\Gamma \left(\beta \right) - G \left(\beta \right) \right)$ where $\Gamma \left(\beta \right) = \int_{\underline{\beta}}^{\beta} \gamma \left(\beta \right) d\beta$. Since $\gamma \geq 0$, Γ is a non decreasing function. By the transversality conditions, $\mu \left(\underline{\beta} \right) = \mu \left(\overline{\beta} \right) = 0$, which implies that $\Gamma \left(\underline{\beta} \right) = 0$ and $\Gamma \left(\overline{\beta} \right) = 1$. Using this result in the second equality gives

$$P(Q) + \frac{\lambda}{1+\lambda} P'(Q)Q = \beta + \frac{\lambda}{1+\lambda} \frac{G \left(\beta \right) - \Gamma \left(\beta \right)}{g \left(\beta \right)} \tag{29}$$

By Assumption **A2** the RHS increases in β whereas the LHS decreases in β by Assumption **A3**. Therefore the solution of (29) is a function $l(\beta, \Gamma)$ that is non increasing in β. Moreover, because the RHS decreases in (29), $l(\beta, \Gamma)$ is a non decreasing function of Γ (see 'potential separation' in Jullien (2000)). The solution is displayed as the bold curve of Figure 3.

INSERT FIGURE 3 HERE

Consider the binding participation constraint: $\Pi(\beta) = \Pi^m(\beta)$ and $\gamma(\beta) > 0$. A necessary condition is that $\dot{\Pi}(\beta) = \dot{\Pi}^m(\beta)$ or, by the envelop theorem, $Q(\beta) = Q^m(\beta)$, which is equivalent to $l(\beta, \Gamma) = Q^m(\beta)$.

We study the intersection of $Q^m(\beta)$ with $l(\beta, \Gamma)$ successively for $\Gamma = 1$ and for $\Gamma = 0$. On the one hand, using expression (5), we find that $l(\beta, 1) > Q^m(\beta)$. So, $l(\beta, 1)$ never intersects $Q^m(\beta)$ and, thus, $\Gamma \left(\beta \right)$ is never equal to 1. On the other hand, if $l(\beta, 0)$ intersects $Q^m(\beta)$, it must intersect at some β_0 that satisfies both conditions (5) and (29), which yields the expression (17) that we write again here:

$$P(Q^m \left(\beta_0 \right)) - \beta_0 = \lambda \frac{G(\beta_0)}{g(\beta_0)} \tag{30}$$

Under Assumptions **A2** and **A3**, this equality accepts a unique solution $\beta = \beta_0$. Indeed, by Assumption **A2,** the RHS of (30) increases in β_0. Also, note that the LHS of (30) is positive and decreases in β_0 iff $P(Q^m(\beta)) - \beta$ is a decreasing function, or by (5), iff $P'(Q^m(\beta))Q^m(\beta)$ is an increasing function. Since Q^m is non increasing in β, this is true under Assumption **A3**: $P''Q + P' < 0$.

We thus have that, for $\beta < \beta_0$, the solution of the program is $Q^o(\beta) = l(\beta, 1) = Q^r(\beta)$ and $\gamma(\beta) = 0$, and that, for $\beta \geq \beta_0$, $Q^o(\beta) = Q^m(\beta) = l(\beta, \gamma(\beta))$ and $\gamma(\beta) > 0$. Also, one can check that $Q^m(\beta) > Q^r(\beta)$ iff $\beta > \beta_0$.

Appendix 2: Proof of Lemma 4

For any $\beta < \beta_0$,

$$\begin{aligned}
\Delta t &= t^o(\beta) - t^r(\beta) \\
&= \int_{\underline{\beta}}^{\beta_0} [Q^r(\beta) - Q^m(\beta)]\, d\beta + \pi(\beta, Q^m(\beta)) - \pi(\beta, Q^r(\beta)) \\
&\quad - \left[\int_{\underline{\beta}}^{\overline{\beta}} Q^r(\beta)\, d\beta - \pi(\beta, Q^r(\beta))\right] \\
&= \int_{\underline{\beta}}^{\beta_0} [Q^r(\beta) - Q^m(\beta)]\, d\beta + \pi(\beta, Q^m(\beta)) - \int_{\underline{\beta}}^{\overline{\beta}} Q^r(\beta)\, d\beta \\
&= \int_{\underline{\beta}}^{\beta_0} Q^r(\beta)\, d\beta + \Pi^m(\beta_0) - \int_{\underline{\beta}}^{\overline{\beta}} Q^r(\beta)\, d\beta \\
&= -\int_{\beta_0}^{\overline{\beta}} Q^r(\beta)\, d\beta + \Pi^m(\beta_0) = \Pi^m(\beta_0) - \Pi^r(\beta_0)
\end{aligned}$$

where we used (21) in the third and fourth equalities and (10) in the last equality. This expression can be re-written as $\int_{\beta_0}^{\overline{\beta}} [Q^m(\beta) - Q^r(\beta)]\, d\beta + \Pi^m\left(\overline{\beta}\right)$ where the first term is positive because $Q^m(\beta) > Q^r(\beta)$ for all $\beta > \beta_0$ (see proof of the Lemma 2).

Appendix 3: Proof of Proposition 6

We here detail the proof of condition (28). Adding $\lambda\left(E\Pi_0^o - F\right)$ on both sides of condition (26) we get

$$\left.\begin{array}{l} -\lambda\Delta t G\left(\beta_0\right) + \lambda E\Pi_0^o + \lambda\int_{\beta_0}^{\overline{\beta}} t^r\left(\beta\right) dG(\beta) \\ + \int_{\beta_0}^{\overline{\beta}}\left[W(\beta, Q^m\left(\beta\right), 0, 0, \lambda) - W\left(\beta, Q^r\left(\beta\right), 0, 0, \lambda\right)\right] dG(\beta) \end{array}\right\} > \lambda\left(E\Pi_0^o - F\right)$$

Replacing $E\Pi_0^o$ by it value in (27) and using the identity $\int_{\beta_0}^{\overline{\beta}} t^r\left(\beta\right) dG(\beta) = \int_{\beta_0}^{\overline{\beta}}[\Pi^r\left(\beta\right) - \pi\left(\beta, Q^r\left(\beta\right)\right)]\ dG(\beta)$, the first line on the LHS becomes

$$\lambda E\Pi^m + \lambda\int_{\underline{\beta}}^{\beta_0}[\Pi^r\left(\beta\right) - \Pi^m\left(\beta\right)]dG(\beta) + \lambda\int_{\beta_0}^{\overline{\beta}}\left[\Pi^r\left(\beta\right) - \pi\left(\beta, Q^r\left(\beta\right)\right)\right] dG(\beta)$$

Adding the term $\lambda E\Pi^r - \lambda E\Pi^m - \lambda\int_{\underline{\beta}}^{\overline{\beta}}\left[\Pi^r\left(\beta\right) - \Pi^m\left(\beta\right)\right] dG(\beta)$ $(= 0)$, this expression becomes

$$\lambda E\Pi^r + \lambda\int_{\beta_0}^{\overline{\beta}}\left[\Pi^m\left(\beta\right) - \pi\left(\beta, Q^r\left(\beta\right)\right)\right] dG(\beta$$

which yields the condition (28).

Appendix 4: Linear Example

We consider the linear inverse demand function $P = a - bQ$ a uniform distribution of cost β. Without loss of generality, we normalize $\underline{\beta} = 0$ and we set $\overline{\beta} = \alpha{*}a/2$ where $\alpha \in [0,1]$ is a parameter that indexes the spread of cost distribution. Under linear utility function, profits and welfare are proportional to a^2/b. This allows to normalize the fixed cost and the franchise fee such that $K = kV$ and $F = fV$ where $V \equiv \left[P(Q^m(\beta)) - \beta\right] Q^m(\beta) = \left(12 - 6\alpha + \alpha^2\right) a^2/\left(48b\right)$. So, $E\Pi^m = 0 \iff K = V \iff k = 1$. We can compute that $E\Pi^m/V = (1-k)$, that $\lambda_0 = \frac{2-\alpha}{2\alpha}$ and that welfare under regulation is equal to

$$EW^r/V = 2\frac{12\left(1+\lambda\right)^2 + \alpha^2\left(1+2\lambda\right)^2 - 6\alpha\left(\lambda+1\right)\left(2\lambda+1\right)}{\left(12 - 6\alpha + \alpha^2\right)\left(1+2\lambda\right)} - \left(1+\lambda\right)k$$

Welfare under outsourcing is equal to

$$EW^o/V = \begin{cases} \frac{24+36\lambda-12\alpha(1+2\lambda)+\alpha^2(\lambda+2)(1+2\lambda)}{(12-6\alpha+\alpha^2)(1+2\lambda)} - k + \lambda f & \text{if} \quad \lambda < \lambda_0 \\ \frac{8+3\alpha\left(\alpha^2-6\alpha+12\right)(2\lambda+1)^2}{2\alpha(12-6\alpha+\alpha^2)(1+2\lambda)^2} - k + \lambda f & \text{if} \quad \lambda > \lambda_0 \end{cases}$$

Note first the case in which the franchise fee extracts the whole *laissez-faire* profit: $f = (1-k)$. Then

$$EW^o/V - EW^r/V = \begin{cases} \frac{2(3-\alpha)\lambda}{12-6\alpha+\alpha^2} > 0 & \text{if} \quad \lambda < \lambda_0 \\ \frac{8-12\alpha(1+2\lambda)+6\alpha^2(1+2\lambda)^3-\alpha^3(1+2\lambda)^2(1+6\lambda)}{2\alpha(12-6\alpha+\alpha^2)(1+2\lambda)^2} & \text{if} \quad \lambda > \lambda_0 \end{cases}$$

where the numerator of the second item in this expression is a cubic function of λ. It can be readily be numerically shown that the latter is always positive. Hence outsourcing is always preferred when the franchise fee extracts the whole *laissez-faire* profit.

Comparing welfare under regulation and outsourcing yields the following normalized level of fixed cost above which outsourcing is preferred:

$$k(\lambda, f, \alpha) = \begin{cases} \frac{3(2-\alpha)^2}{(12-6\alpha+\alpha^2)} - f & \text{if} \quad \lambda < \lambda_0 \\ \frac{\left(-8+\alpha^3(1+2\lambda)^2(1+8\lambda)-6(1+4\lambda)\alpha^2(1+2\lambda)^2+12\alpha(2\lambda+1)\left(4\lambda^2+2\lambda+1\right)\right)}{2\alpha(12-6\alpha+\alpha^2)\lambda(1+2\lambda)^2} - f & \text{if} \quad \lambda > \lambda_0 \end{cases}$$

When the franchise fee is set to zero we get

$$k(\lambda, 0, \alpha) = \begin{cases} \frac{3(2-\alpha)^2}{(12-6\alpha+\alpha^2)} & \text{if} \quad \lambda < \lambda_0 = \frac{1}{2} \\ \frac{-8+\alpha^3(1+2\lambda)^2(1+8\lambda)-6(1+4\lambda)\alpha^2(1+2\lambda)^2+12\alpha(2\lambda+1)\left(4\lambda^2+2\lambda+1\right)}{2\alpha(12-6\alpha+\alpha^2)\lambda(1+2\lambda)^2} & \text{if} \quad \lambda > \lambda_0 = \frac{1}{2} \end{cases}$$

This yields the curves displayed in the figure.

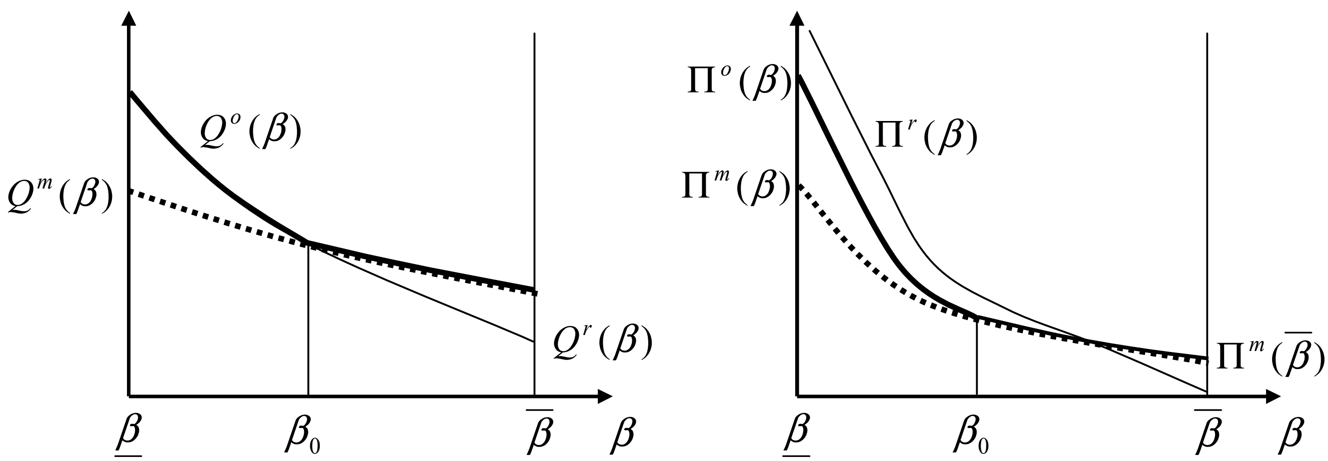
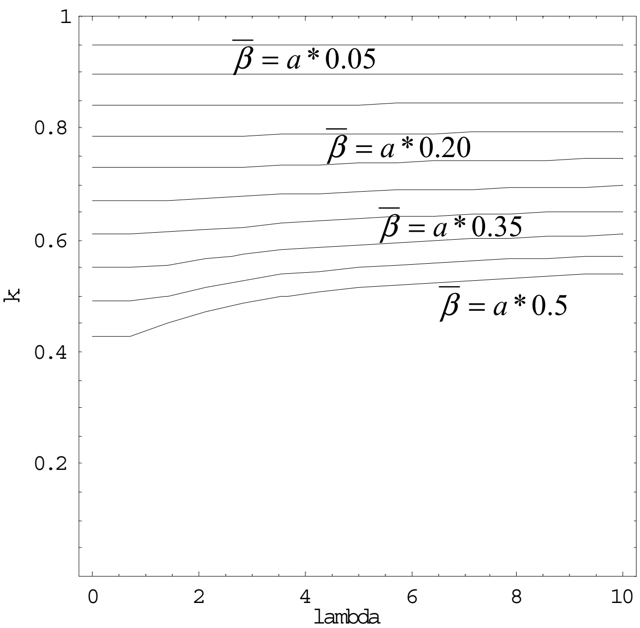
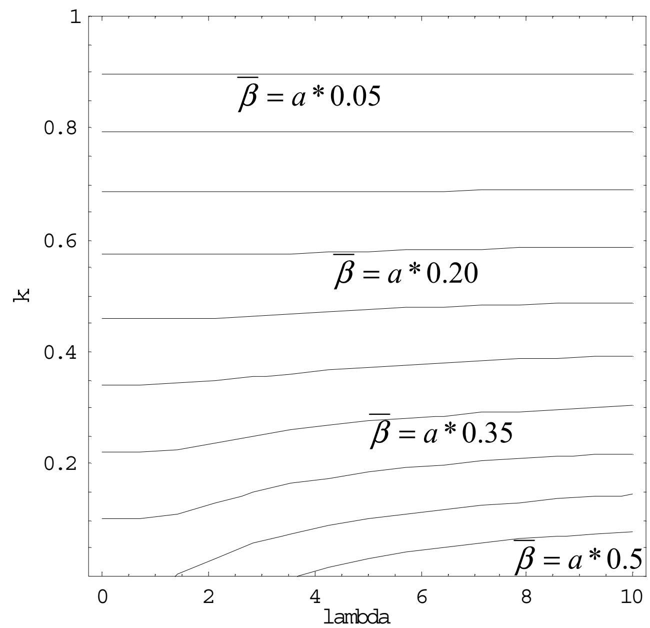


Figure 1: Output and Profit under Regulation, Laissez-Faire and Outsourcing.



Franchise fee F=0



Franchise fee F=0.5* $E\Pi^m$

Figure 2: Outsourcing v/s Regulation for Linear Demand Functions (P=a-bQ) and Uniform Cost Distributions (0, $\overline{\beta}$); k=K/V.

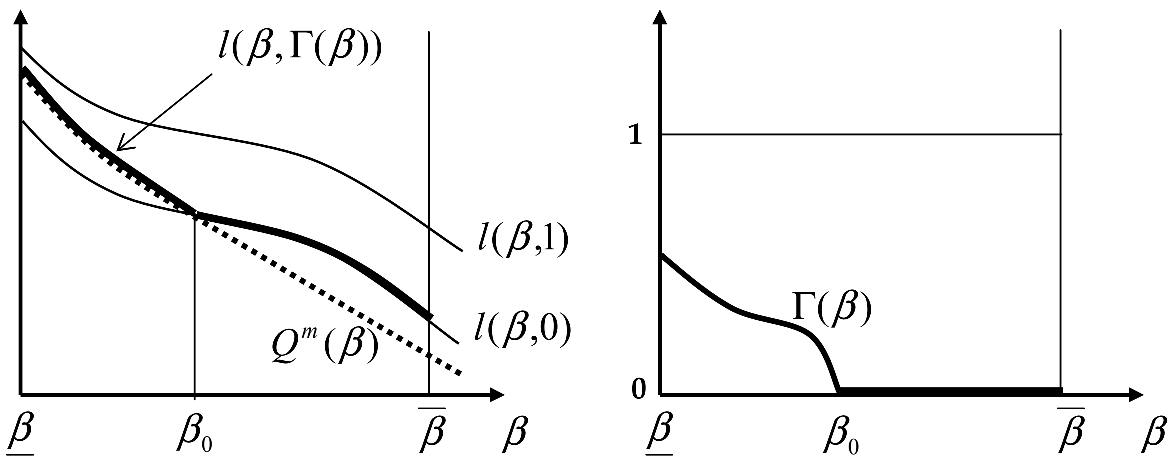


Figure 3: Output levels and shadow value of participation constraint Γ(β)