WPS3950

Infrastructure and Public Utilities Privatization in Developing Countries

Emmanuelle Auriol*
University of Toulouse I

Pierre M. Picard†
University of Manchester

Abstract

The paper analyzes governments' tradeoff between fiscal benefits and consumer surplus in privatization reforms of noncompetitive industries in developing countries. Under privatization, the control rights are transferred to private interests so that public subsidies decline. This benefit for tax-payers comes at the cost of price increases for consumers. In developing countries, tight budget constraints imply that privatization may be optimal for low profitability segments. For highly profitable public utilities, the combination of allocative inefficiency and critical budgetary conditions may favor public ownership. Finally, once a market segment gives room for more than one firm, governments prefer to regulate the industry. In the absence of a credible regulatory agency, regulation is achieved through public ownership.

World Bank Policy Research Working Paper 3950, June 2006

The Policy Research Working Paper Series disseminates the findings of work in progress to encourage the exchange of ideas about development issues. An objective of the series is to get the findings out quickly, even if the presentations are less than fully polished. The papers carry the names of the authors and should be cited accordingly. The findings, interpretations, and conclusions expressed in this paper are entirely those of the authors. They do not necessarily represent the view of the World Bank, its Executive Directors, or the countries they represent. Policy Research Working Papers are available online at http://econ.worldbank.org.

*Emmanuelle Auriol: ARQADE and IDEI Université de Toulouse I, France. Email: eauriol@cict.fr.
†Pierre Picard, University of Manchester and University of Louvain. Email: Pierre.Picard@man.ac.uk.

1 Introduction

Over the last 25 years low-income countries have reduced their share of state ownership by more than half.[1] In most cases, governments have privatized public assets because of critical budgetary conditions.[2] While international donors and creditors, like the World Bank or the IMF, made privatization programs a condition for economic assistance during the 1980s debt crisis, governments have been keen on using privatization proceeds to relax their budget constraints.[3] Privatization yielded about $50 billion per year in non-OECD countries, no less than one-third of the worldwide proceeds of privatization (Mahboobi, 2000; Gibbon, 1998, 2000). The fiscal benefits of privatization are not limited to the divesture proceeds of state owned enterprises (S0E). They also encompass the possible termination of recurrent, inefficient subsidies to the latter. In particular, when governments hardly discriminate between good and bad projects and/or management teams, they are likely to transfer too many resources to public firms. Privatization eliminates governments' legal obligations to subsidize unprofitable firms. In practice, privatization reforms have resulted in substantial decreases of government subsidies to former SOEs.[4] The present paper aims to study the impact of poor fiscal conditions on the privatization decision in regard to infrastructure and public utilities in low-income countries.

Privatization brings well-known economic costs when industries are characterized by strong economies of scale. By giving up the direct control of firms' operations, governments lose control over prices to the disadvantage of consumers. Private firms benefit from large market power and have large incentives to enter. In practice price increases

[1] According to a study by Megginson and Netter (2001) between 1980 and 1996 alone it went from 16% to 8% of GDP.

[2] This has also been the case in rich countries. For instance, the first Japanese privatizations were initiated in 1982 when the Japanese public deficit reached 41.2% of GDP. Similarly in the U.S. Lopez-de-Silanes *et al.* (1997) show that privatizations have been more likely in states where fiscal constraints were more binding.

[3] Using a panel of 18 developing countries, Davis *et al.* (2000) show that budgetary privatization proceeds have been used to reduce domestic financing on a roughly one-for-one basis.

[4] For instance, the privatisation commission of Burkina Faso reports that government subsidies to SOEs went from 1.42 percent of GDP in 1991 to 0.08 percent of GDP in 1999 as a result of privatisation (AfDB-OECD 2003).

are often organized by the governments. Indeed, they have the choice between auctioning off markets on the basis of either the highest fee payment or the lowest product/service price (see Estache, Foster and Wodon 2002). Guasch (2003) shows in a survey of 600 concession contracts from around the world that in most cases contracts are tendered for the highest transfer or annual fee. Because fee payments rise with the profitability of the privatized firms, many governments choose policies that increase the firms' profitability such as exclusivity periods and price liberalization.[5] Prices are sometimes increased ahead of privatization in order to reduce the SOE financing gaps and attract buyers. This has been for instance the case in Zimbabwe, Kenya and Senegal, where governments increased electricity prices by 10 % after reaching an agreement with Vivendi Universal (see AfDB-OECD 2003). An unaccounted part of price increases stems from the termination of illegal electricity connections (Birdsall and Nellis 2002, Estache, Foster and Wodon 2002, AfDB-OECD 2003).

The present paper studies the privatization decision as the result of the government's cost-benefit analysis where the social benefit obtained from the termination of subsidies to unprofitable public firms and the fiscal benefit from the cash-flows generated by the public firms' divesture are balanced against the loss in consumer surplus induced by the higher prices in privatized industries and to the social cost of the foregone taxable revenues that are available in profitable public firms. To get clear cut results privatization is treated as the move from public ownership with entry and price regulation to private ownership with price liberalization.[6] Privatization is close but not equivalent to *laissez-faire* because entry remains regulated (i.e. through license and entry fees). If, as we show, privatization with

[5]Wallsten (2000) studies the impact of the exclusivity period on the privatization price of twenty telecommunication firms in fifteen developing countries. In his sample, two thirds of the countries chose to allocate exclusivity periods for an average of 7.42 years. They apparently had a very good reason for doing so. According to the author's computations, granting a monopoly in fixed local services would more than double the price private investors pay for the firm. This comes at the cost of high prices and lower network growth relative to privatization without exclusivity periods.

[6]Under the complete contract approach adopted in the paper there exists no difference between public and private ownerships under entry and price regulation. We thus model the difference between the two ownership structures as the choice between regulated public firms and unregulated private ones. This assumption is consistent with empirical evidence.

such price liberalization dominates state ownership with full price regulation, privatization also dominates in more realistic situations where prices are liberalized to a lesser extent and are kept under some governmental control.

The present paper shows that a main factor in privatization decisions is the *opportunity cost of public funds,* which captures the tightness of government budget constraints.[7] The role of budget constraints in the privatization decision is not obvious because, under perfect information, governments should be able, at worst, to mimic the outcomes of private monopolies. However, under asymmetric information between governments and firms, public finance matters and privatization may dominate public ownership because subsidies are socially costly. To illustrate this result consider the specific case where the government cannot finance an infrastructure project (e.g. a road). Privatization is an appealing alternative as it is better to have a privately owned and operated infrastructure, even with monopoly distortion (e.g. a toll), than no infrastructure at all. By continuity the result still holds when the government is able to finance the infrastructure. We hence show that when the profitability of the industry is low, as it is for instance in the case of transport or the water industry, the privatization decision is a monotone function of the opportunity cost of public funds.[8] That is, for low opportunity costs (i.e. for wealthy governments) public ownership dominates privatization, whereas the reverse holds for large opportunity costs (i.e. for financially strapped governments).

Nevertheless, the above monotonic relationship between privatization and tightness of budget constraints breaks down when natural monopolies are sufficiently profitable and when governments are not able to recoup large enough franchise fees or divesture proceeds. In that case, we show that privatization is optimal only for intermediate opportunity costs of public funds. Such situations often stem from the difficulty met by developing countries to attract investors when they auction off profitable SOEs.[9] Indeed, according to

[7]The opportunity cost of public funds is the Lagrange multiplier of the government budget constraint. It captures the tightness of this constraint. It is different from the marginal cost of public funds which is the dead weight loss created by a marginal increase of a specific tax (see Auriol and Warlters 2005).

[8]Trujillo et al. (2003) show that transport privatization leads to a reduced need for public investment.

[9]Country risk analysis is very important in today's global investment strategies because it is the basis of determining future expected returns on investment. Since the perception of business risk tends to be

Trujillo, Quinet and Estache (2002), there exist rarely more than two bidders who participate in developing countries' auctions for major concession contracts. Therefore, SOEs are often sold at a discount (see Birdsall and Nellis 2002).[10] Hence, with underpriced public assets, privatization decisions are non-monotone functions of the opportunity cost of public funds. The intuition goes as it follows: as before, when opportunity costs of public funds are small, the bailouts of firms by governments are cheap and it is optimal to keep regulated publicly owned firms, to set prices close to marginal costs and to subsidize the firms to guarantee a break-even situation. For higher intermediate opportunity costs of public funds, bailout becomes costly and governments prefer to privatize the public firms, cash the divesture proceeds and let private entrepreneurs manage firms. Yet, for high enough opportunity costs of public funds, the privatization decisions differ as governments may find it valuable to 'hold-up' on profitable industries. Governments then prefer not to privatize profitable public firms; they operate the firms by themselves and they possibly set prices close to private monopoly prices to reap the maximal revenues. This non-monotonicity result has potentially important policy implications. That is, while divestiture of profitable public firms may be optimal in developed countries, it is not necessarily so in developing countries where budget constraints are tight and market institutions are weak.

Finally, when firms' profitability substantially rises, the market leaves room for more than one firm. Market liberalization then corresponds to the divestiture of a historical monopoly and the introduction of new entrants. In the framework of the model the divestiture of the historical monopoly is motivated by smaller fixed costs and/or by larger product demand. The mobile and internet segment of the telecommunication industry provides a good illustration of such technical and demand changes. The paper then shows that privatization with price liberalization is no longer optimal. Indeed, when a second

higher in poor countries (see for instance the International Country Risk Guide), this affects negatively the supply and cost of international capital flows for these countries.

[10]For political reasons some public utilities have been sold at a mark up. This is typically achieved by an over-optimistic forecast of future demand (see Trujillo, Quinet and Estache (2002). However these sales have led to rapid renegotiation of the contract terms. It turns out to be a bad deal for the taxpayers because subsidies have been re-introduced.

firm is introduced, the information costs in regulated firms diminish more than the social costs induced by excessive prices and entry prevailing in private Cournot oligopolies. The advantage of private unregulated structures disappears for large, profitable markets. For instance the experience in industrialized countries shows that regulation of access pricing to bottleneck facilities (e.g. fixed-line network) is a key component of successful market liberalization. As illustrated by the empirical evidence, price and entry regulation is a problem in developing countries which usually lack the human resources and the institutions to enforce effective regulation. Since privatization reforms cannot be successful without effective regulation of entry and prices, developing countries are better off at keeping their profitable utilities public as long as they cannot establish credible regulatory bodies.[11]

1.1 Relationship with the literature

It is well-known that public ownership generates inefficiencies because it encourages governments to bail out or subsidize money-losing firms. Such inefficiencies were first coined by Kornai (1980) as the 'soft budget constraint' problem:[12] *"The softening of the budget constraint appears when the strict relationship between expenditure and earnings of an economic unit (firm, household, etc) has been relaxed, because expenditure will be paid by some other institution, typically the paternalistic state."* (Kornai 1980). The author shows that soft-budget constraints explain many inefficiencies occurring in socialist economies such as shortages or low price responsiveness. Since less efficient firms are allowed to rely on government funding, they lack the financial discipline required for efficient management. For instance, under contract incompleteness, soft-budget constraints affect the level of investments made by public managers. The transfer of public to private ownership is therefore often advocated as a remedy for the poor economic performance of public

[11] A major concern with privatization reforms in developing countries is the lack of governments' ability to commit to the concession contracts. For instance, according to a World Bank database on Latin America, the concessions that were granted to private operators following the divestiture of public firms have been renegotiated after an average 2.1 years only (see Laffont 2001).

[12] Interesting surveys are available in Kornai (2000) and Kornai, Maskin and Roland (2002).

enterprises (see for instance Dewatripont and Maskin (1995), Schmidt (1996a, 1996b) and Maskin (1999)). By hardening the firm's budget constraint, privatization helps restore investment incentives.[13] Another concern about public ownership is the governments' lack of economic orientation. For instance in Kornai and Weibull (1983), Shleifer and Vishny (1997), Debande and Friebel (2003), governments demonstrate 'parternalistic' or political behaviors as they seek to protect or increase employment; in Shapiro and Willig (1990), governments are malevolent. The main conclusion of the above two strands of literature is that privatization improves the internal efficiency of firms. Empirical evidence supports this result. Megginston and Netter (2001) in a literature review covering 65 empirical studies (some at national level and some across countries) at the firm level conclude that private firms are more productive and more profitable than their public counterparts. The result, which is robust theoretically and validated empirically, is consensual. However, efficiency gains are not automatically passed along to consumers. This is particularly true in increasing returns to scale industries where market power generates significant allocative inefficiency. The deadweight loss created by monopoly pricing is the rationale for setting up public ownership in the first place.[14]

The present paper discusses the privatization decision on infrastructure and public utilities with a special focus on the allocative efficiency issue. For this reason, the paper ignores the moral hazard issue that is discussed at length in the aforementioned papers about soft budget constraints. In contrast the paper belongs to the traditional literature on regulation with adverse selection (see Laffont and Tirole 1993). A utilitarian government maximizes a weighted sum of consumer surplus and transfers from/to firms. To overcome the information asymmetry on the firm's cost parameters the government must offer a menu of incentive contracts. Since the government is residual claimant of the public firms' profit and loss, and since it wants to avoid the threat of service interruption,

[13]On the other hand when governments are able to offer the same contracts to public and to private firms, for instance in the form of bribes to private firms as in Kornai (2001), both structures have the same degree of contract completeness and private or public ownership is irrelevant.

[14]Empirical studies reveal that privatization results in lower prices and higher output in competitive industries. In increasing returns to scale industries changing the ownership structure does not solve the problem of lack of competitive pressure (see Nellis (1999)).

contracts entice the least productive firm to break even. This implies that the more productive firms earn informational rents and that government subsidizes firms losing money. Production is distorted to reduce information costs which in turn diminishes consumer surplus. Privatization reduces the need to subsidize firms losing money.

The paper is organized as follows. Section 2 presents the model and the main assumptions. Section 3 compares the performance of private and regulated monopolies while Section 4 studies the duopoly case. Section 5 derives the optimal industrial policy. Section 6 summarizes our results and offers some concluding remarks.

2 The model

We consider a problem of industrial policy setting. The government has to decide whether an industry characterized by increasing returns to scale should be under public or private control. In line with Laffont and Tirole (1993), we call *regulation regime* the regime in which the government controls the production of a *public firm*. The government's control rights are associated with accountability on profits and losses. That is, it must subsidize the firm in case of losses whereas it taxes the firm in case of profits.

In contrast, we call *private regime* the regime in which the government imposes no control on the operations of a *private firm*, and it takes no responsibility for the firm's profits or losses. That is, no transfer is possible between the government and the private firm once production has begun.[15] Private firms do not pay tax on profit but they pay an entry fee. This is an artifact of the formalization. In the static model below it is optimal for the government to sell the firm ex-ante (i.e. while it is in a position of symmetric information *vis à vis* the firm) rather than to tax its profit ex-post (i.e. once the firm has learned its cost parameter and has an informational advantage). Empirical evidence shows that developing countries rely on entry fees to raise revenues from firms (see Auriol and Warlters (2005)). Entry fees are paid up front and do not require follow up. They

[15]This is of course a simplification. In practice government might transfer some funds to the private sector. However subsidies are lower under privatization than under public ownership which is what matters for the results.

hence fill two purposes: as a tax instrument they have low administrative costs, as a barrier to market entry they are a convenient tool of government's industrial policy.

To keep the analysis simple we consider a linear product demand. However the results are robust to more general demand function.[16] The inverse demand function for $Q \geq 0$ units of the commodity is given by

$$P(Q) = a - bQ$$

where $a > 0$ and $b > 0$ are common knowledge. The gross consumer surplus is therefore

$$S(Q) = \int_0^Q P(x)dx = aQ - \frac{b}{2}Q^2.$$

On the production side there are N firms in the industry. Firm $i \in \{1, ..., N\}$ produces output q_i. The total production in the industry is $Q = \sum_{i=1}^{N} q_i$. Firm $i \in \{1, ..., N\}$ has the following cost function:

$$C(\beta_i, q_i, K) = K + \beta_i q_i,$$

As in Baron and Myerson (1982), the cost function includes a fixed cost $K > 0$, and an idiosyncratic marginal cost β_i. Firm i must make the investment K before discovering β_i. Neither the government nor the competitors of firm i observe this firm-specific cost parameter. The parameter β_i is independently drawn from the support $[\underline{\beta}, \bar{\beta}]$ according to the density and cumulative distribution functions $g(\cdot)$ and $G(\cdot)$. This law is common knowledge. We denote the expectation operator by E, the average marginal cost by $E\beta$, and the variance of marginal cost by $\sigma^2 = \text{var}(\beta)$.

We focus on increasing returns to scale industries. The fixed cost K is large so that the maximal number of firms N that can survive under *laissez-faire* is small. To be more specific we make the following assumption:

A0 $$K \geq \frac{(a - E\beta)^2}{16b} + \frac{\sigma^2}{4b}.$$

Assumption A0 implies that $N \in \{0, 1, 2\}$.[17]

[16] This model with linear demands is analytically tractable. Models with iso-elastic demand functions require numerical simulations but yield similar results. Computations are available on request.

[17] To find out how condition A0 is computed see section 4.1 footnote 25.

The firms are profit maximizer. The profit of firm i is

$$\Pi_i = P(Q)q_i - C(\beta_i, q_i, K) + t_i \tag{1}$$

where t_i is the net transfer that the firm gets from the government (subsidy minus tax and franchise fee).

The government is utilitarian and maximizes the sum of consumer and producer surpluses minus the social cost of transferring public funds to the firm(s). The transfer to the firm(s) can either be positive (i.e. a subsidy), or negative (i.e. a tax). The government's objective function is

$$W = S(Q) - \sum_{i=1}^{N} C(\beta_i, q_i, K) - \lambda \sum_{i=1}^{N} t_i \tag{2}$$

where λ is the opportunity cost of public funds.[18]

The opportunity cost of public funds, λ, drives the results of the paper. This opportunity cost, which can be interpreted as the Lagrange multiplier of the government budget constraint, measures the social cost of a transfer from the government to the firm. For λ close to 0, the government maximizes the net consumer surplus; for larger λ, the government puts more weight on transfers. The opportunity 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 budget, which leads to higher values of λ. As a benchmark case the World Bank (1998) suggests an opportunity cost of 0.9. The value is much higher in countries that are heavily indebted.

[18]The analysis and the results of the paper are consistent with a less optimistic view of government objectives. It is just a matter of interpretation of λ. With a non benevolent government, λ is the weight the government puts on the transfers it can get out of the firms (e.g., bribes).

3 Private versus regulated monopoly

When K is large, a natural monopoly emerges: $N \in \{0, 1\}$. Since there is at most one firm, the firm index can be temporarily dropped. The production of the monopoly is equal to the total production Q. Regulation aims at correcting the distortion associated with monopoly pricing in the *laissez-faire* situation. Regulation theory suggests that, at worse, a benevolent regulator should be able to mimic the choice of a private firm. Hence, welfare should never be smaller under regulation than under *laissez-faire*. Although regulation always dominates *laissez-faire* under complete information, we show that it is not always the case under asymmetric information.

3.1 Private monopoly

The production levels of *private monopolies* (henceforth PM) are not controlled by the government. The government can nevertheless control the entry of private monopolies by auctioning the right to operate. Let $F(\lambda) \geq 0$ be the franchise fee that the private firm pays to the government in order to operate in the product market. The private monopoly contemplates the following sequential choices. First, the monopoly chooses to enter the market by paying the franchise fee $F(\lambda)$ and by making the investment K. If it enters, then nature chooses the marginal cost β according to the distribution $G(\cdot)$. The private firm learns β and chooses a production level Q. After the realization of β the private firm never pays or receives a transfer from the government.

The profit of the private monopoly is

$$\Pi^{PM} = \max_{Q} P(Q)Q - C(\beta, Q, K) - F(\lambda).$$

The optimal production is independent of K and $F(\lambda)$:

$$Q^{PM} = \frac{a - \beta}{2b}. \tag{3}$$

If a is smaller than the firm's marginal cost β, the production level falls to 0. In order to rule out corner solution in the sequel of the paper, we assume that a is not too small:

A1 $$a \geq \max\left\{2\overline{\beta}, \overline{\beta} + \frac{G(\overline{\beta})}{g(\overline{\beta})}\right\}.$$

Substituting Q^{PM} in equations (1) and (2), we get the ex-ante profit and welfare of a private monopoly,

$$E\Pi^{PM} = \frac{1}{2}V - K - F(\lambda), \tag{4}$$

$$EW^{PM}(\lambda) = \frac{3}{4}V - K + \lambda F(\lambda) \tag{5}$$

where

$$V = \frac{E(a-\beta)^2}{2b} \tag{6}$$

The value of operating the firm after the investment is made is measured by V.[19] A monopoly is *privately feasible* if it is ex-ante profitable, i.e. if $E\Pi^{PM} \geq 0$. This requires $\frac{1}{2}V \geq K$ and $F(\lambda) \in [0, \frac{1}{2}V - K]$. Similarly a monopoly is *socially valuable* if it brings ex-ante positive welfare, i.e. if $EW^{PM} \geq 0$. It is easy to check that monopolies are socially valuable but privately infeasible if $\frac{3}{4}V > K > \frac{1}{2}V$. The ex-ante welfare $EW^{PM}(\lambda)$ increases linearly with $F(\lambda)$. The maximal entry fee that the government can collect is the maximum price a risk neutral entrepreneur would agree to pay for the monopoly concession:

$$F^* \equiv \max\{0, \frac{1}{2}V - K\}.$$

In practice international capital flows depend on country risk ratings so that developing countries'government do not collect the maximal fee F^* (see Brewer and Rivoli 1990). Because of the service of their debt, the perception of corruption in the administration and the social instability, the lack of transparency and predictability of their political and judicial institutions, developing countries get bad risk ratings.[20] A consequence of the bad ratings is that private investors, especially foreign ones, are very reluctant to invest in these countries. For instance in 1999 foreign direct investment (FDI) inflows to the

[19] One can check that $V = \frac{(a-E\beta)^2}{2b} + \frac{\sigma^2}{2b}$. It can be separated into two components: the value at the average cost, $(a - E\beta)^2/2b$, and the value of the cost spread, $\sigma^2/2b$.

[20] The ratings combine a range of qualitative and quantitative information. They reflect the ability and willingness of a country to service its financial obligation. There are five different measures of country risk: political risk, financial risk, economic risk, composite risk indices and institutional investor's country credit ratings. The leading rating agencies are Standard and Poor's, Moody's, Euromoney, Institutional Investor, Economist Intelligence Unit, International Country Risk Guide. See for instance Global Risk Assessments web site, www.grai.com/links.htm.

49 least developed countries (10% of the world population) was 0.5% of total world FDI flows. Since less than 10% of this investment was cross-border merger and acquisition (including privatization), privatization proceeds are lower in poor countries than in rich ones, despite sometimes a large number of privatizations.[21] In the context of our model a bad rating translates into a large λ. That is, countries characterized by a large λ are also countries that get low privatization proceeds. To capture this idea we make the following assumption.

A2 $F(\lambda) \in [0, F^*]$ is non-increasing and weakly convex in $\lambda \geq 0$.

3.2 Regulated monopoly

Under public ownership, the government, which is accountable for the profits and losses of the firm, monitors the production of the *regulated monopoly* (RM hereafter). The timing is as follows: The government first decides to make the investment K. Second, nature chooses the marginal cost β according to the distribution function $G(\cdot)$. Third, the regulated firm's manager learns β, but the government does not. The government proposes a production and transfer scheme $(Q(\cdot), t(\cdot))$. Finally the regulated firm reveals the information $\widehat{\beta}$ and production takes place according to the contract $(Q(\widehat{\beta}), t(\widehat{\beta}))$. We first study the benchmark case of regulation under symmetric information.

3.2.1 Symmetric information

When the realization of β is publicly observed the government solves $\max_{\{Q,t\}} W$ s.t. $\Pi \geq 0$ with W and Π defined in (2) and (1). Since λ is positive, transfers to the regulated firm are costly and must be reduced down to the break-even point $\Pi = 0$. That is, $t^{RM*} = -P(Q)Q + K + \beta Q$. Substituting this expression in W and maximizing W with respect to Q yields

$$Q^{RM*}(\beta) = \frac{1+\lambda}{1+2\lambda}\frac{a-\beta}{b}. \tag{7}$$

[21] See http://www.ncpa.org/pd/private/oct98ab.html 'Privatization: Privatization Trends in Developing Countries' 1997.

Inserting Q^{RM*} in (2) gives the ex-ante welfare under symmetric information

$$EW^{RM*}(\lambda) = (1+\lambda)\left(\frac{1+\lambda}{1+2\lambda}V - K\right) \tag{8}$$

where V is defined in equation (6). The government invests K in a regulated firm only if (8) is positive. The ex-ante welfare increases in V. It is non-monotonic in λ if $\frac{1}{2}V > K$. That is, it decreases for small λ and increases for large λ. This deserves a comment.

For small λ, the government incurs small social costs of transferring money to the regulated firm. It then chooses quantities that are close to the first best level which means a price that is close to marginal cost. Indeed, $lim_{\lambda\to 0}Q^{RM*} = (a-\beta)/b$ and therefore $P[(a-\beta)/b] = \beta$. At this price, the regulated monopoly cannot recover its fixed cost. The loss is compensated by a transfer to the firm $t = K > 0$. By continuity, the government will subsidize the regulated firm as long as λ remains small enough. In contrast, for large λ, the government is more interested in receiving transfers from the firm than in maximizing consumer surplus. It chooses production to induce a positive profit which is confiscated through taxes. As λ becomes very large, the government seeks the maximal revenue from the state-owned firm. In the limit it chooses the production level of a private monopoly (i.e. $lim_{\lambda\to\infty}Q^{RM*} = Q^{PM} = (a-\beta)/2b$).

3.2.2 Asymmetric information

Under asymmetric information, β is not observed by the government. The government must design the contracts such that the regulated firm reveals its private information. Incentive compatibility constraints are added to the previous problem. By virtue of the revelation principle, the analysis is restricted to a direct truthful revelation mechanism ($\widehat{\beta} = \beta$). To avoid the technicalities of 'bunching' we make the classical monotone hazard rate assumption:

A3 $\quad G(\beta)/g(\beta)$ is non decreasing.

We define the *virtual cost* as

$$v(\beta,\lambda) = \beta + \frac{\lambda}{1+\lambda}\frac{G(\beta)}{g(\beta)}. \tag{9}$$

The virtual cost includes the marginal cost of production, β, and the marginal cost of information acquisition, $\frac{\lambda}{1+\lambda}\frac{G(\beta)}{g(\beta)}$. We deduce that $v(\beta,\lambda) \geq \beta$, and by A3, that $v(\beta,\lambda)$ increases in β and λ. Let

$$V^{RM}(\lambda) = \frac{E(a - v(\beta,\lambda))^2}{2b} \tag{10}$$

This implies that $V^{RM}(\lambda)$ decreases in λ. Following the Baron and Myerson's (1982) approach, we deduce the following lemma, which proof is standard.

Lemma 1 Under asymmetric information, the optimal production and the ex-ante welfare of a regulated monopoly are those of the symmetric information case evaluated at the *virtual cost* $v(\beta,\lambda)$. That is,

$$Q^{RM}(\beta) = Q^{RM*}(v(\beta,\lambda)) \tag{11}$$

$$EW^{RM}(\lambda) = (1+\lambda)\left(\frac{1+\lambda}{1+2\lambda}V^{RM}(\lambda) - K\right) \tag{12}$$

The quantity produced by a regulated monopoly under asymmetric information is the quantity of a regulated monopoly under symmetric information valued at the *virtual cost.* Since $v(\beta,\lambda) \geq \beta$, we deduce that $Q^{RM}(\beta) \leq Q^{RM*}(\beta)$ for any β. Moreover, since $v(\beta,\lambda)$ increases in β, the distortion is higher at larger marginal costs. Indeed by lowering the production of inefficient firms, the government reduces the overall incentive to inflate cost report. Comparing (6) and (10) it is easy to verify that $V^{RM}(\lambda) \leq V$ for all $\lambda \geq 0$. Hence, the ex-ante welfare of a regulated monopoly is lower under asymmetric information than under symmetric information: $EW^{RM}(\lambda) \leq W^{RM*}(\lambda)$. In the next section we compare the welfare levels generated by a private monopoly with those of a regulated monopoly.

3.3 Regulation versus privatization

As a benchmark case we first consider the symmetric information case.

Proposition 2 Under symmetric information, regulated monopoly dominates privately feasible monopoly, whether the latter is franchised or not.

Proof: See Appendix 1.

Proposition 2 is very intuitive. Under symmetric information a benevolent government cannot do worse than a private monopoly because, for any realization of β, it can always replicate the outcome of the private firm. However, it is easy to show that, for large opportunity costs of public funds, a regulated monopoly under symmetric information does not bring much more welfare than a private monopoly when the latter pays the maximal franchise fee, F^*. The welfare function under regulated monopoly then is equal to $EW^{RM*}(\lambda) = ((1+\lambda)/(1+2\lambda))\, V/2 + (1+\lambda)(V/2-K)$, whereas the welfare function under private monopoly is equal to $EW^{PM}_{F^*}(\lambda) = V/4 + (1+\lambda)(V/2-K)$. One can check that the two welfare functions have a common asymptote with slope $V/2-K$ (see figure 1). The welfare of a regulated monopoly coincides with the welfare of a private monopoly for large λ. From this argument, we can infer that the additional cost introduced by the asymmetry of information in the regulated monopoly gives a welfare advantage to the private monopoly for large λ. That is, under asymmetric information, the welfare function of the regulated monopoly has an asymptote with (negative or positive) slope $R^\infty \equiv \lim_{\lambda\to+\infty} EW^{RM}(\lambda)/\lambda$. It is easy to check that

$$R^\infty = \frac{V^{RM}(\infty)}{2} - K \tag{13}$$

is smaller than $\frac{V}{2} - K$. We deduce that privately feasible monopolies can dominate regulated monopolies. Let the fixed cost K satisfy the following condition.

C0 $\qquad \frac{1}{2}V \geq K \geq V\Big(\sqrt{\frac{2B+V^{RM}(\infty)}{V}} - \frac{1}{2}\Big) - B \quad \text{with} \quad B = E\left[\frac{a-\beta}{b}\frac{G(\beta)}{g(\beta)}\right].$

Condition C0 firstly implies that the fixed cost is small enough so that a monopoly is privately feasible (see equation 4). It secondly implies that the fixed cost is large enough to make the government prefer privatization for at least some value of opportunity cost of public funds. The interval defined in condition C0 is non empty. Indeed, it is equivalent to $(\frac{B}{V})^2 + \frac{V-V^{RM}(\infty)}{V} > 0$ which is always true since $V > V^{RM}(\infty)$. Appendix 2 shows how the right hand side of condition C0 is derived.

Proposition 3 *Suppose that assumptions A0 to A3 and C0 hold. Two cases are possible. (i) If* $\lim_{\lambda\to+\infty} F(\lambda) \geq R^\infty$ *then there exists a unique threshold,* $\widehat{\lambda}$*, such that privatization*

dominates regulation if and only if $\lambda > \widehat{\lambda}$.

(ii) If $\lim_{\lambda \to +\infty} F(\lambda) < R^{\infty}$ *then there are two thresholds* $\widehat{\lambda}$ *and* $\widetilde{\lambda}$, $\widehat{\lambda} < \widetilde{\lambda}$, *such that privatization dominates regulation if and only if* $\lambda \in [\widehat{\lambda}, \widetilde{\lambda}]$.

Proof: See Appendix 2.

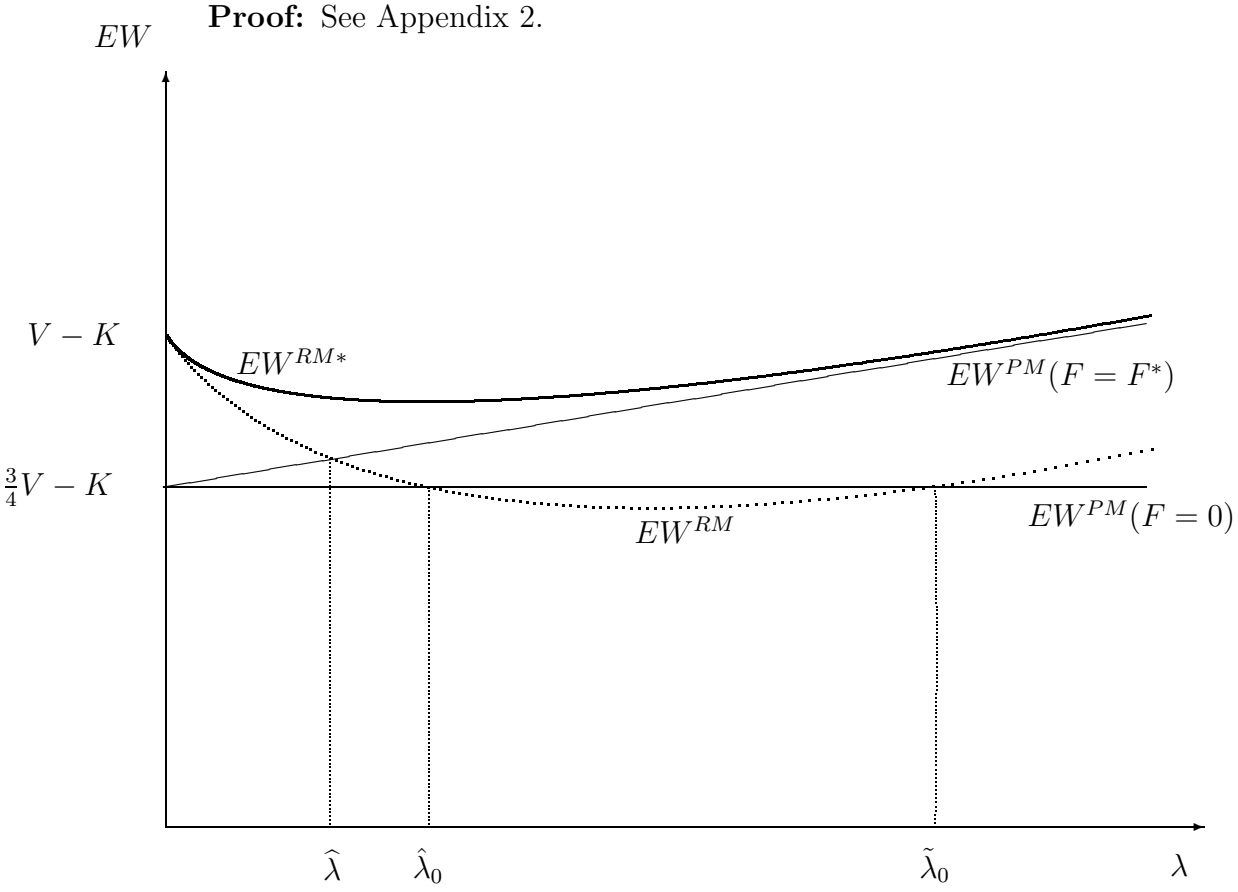


Figure 1: Welfare for Private and Regulated Monopoly

Figure 1 illustrates Proposition 3. The bold solid curve represents the ex-ante welfare of regulated monopoly under symmetric information (RM^*) and the bold dashed curve displays ex-ante welfare under asymmetric information (RM). The ex-ante welfare of regulated monopoly is non-monotone in λ. It is higher for low or high values of λ than for intermediate ones. The thin solid lines represent two boundaries (i.e. $F(\lambda) \equiv F^*$ and $F(\lambda) \equiv 0$) of ex-ante welfare of a private monopoly (PM). Depending on the franchise fee function, $F(\lambda)$, the welfare function associated to a private monopoly varies between these two bounds.

Proposition 3 establishes that privatization with price liberalization dominates a benevolent regulation under public ownership for (at least) intermediate value of the opportunity cost of the public fund. This result is very robust. As shown in Appendix 2, even with $F(\lambda) \equiv 0$, the interval $[\widehat{\lambda}_0, \widetilde{\lambda}_0]$ where privatization dominates regulation is non empty (see figure 1). In other words, positive franchise fee does not explain the preference for private feasible monopolies even if it fosters it. The intuition for this result is as follows. A private entrepreneur enters the business if his/her firm is ex-ante profitable. After the investment, the private firm makes a large or a low operating profit depending on the realization of technical/demand uncertainties. A private entrepreneur, who bets her own assets (or the shareholders' ones) in the firm, is accountable for these profits and losses. In contrast, under regulation, accountability lies on the government side; the business risk is borne by the government that has to grant ex-post subsidies to unprofitable firms. Under symmetric information, the tightness of government budget plays no role because the government perfectly controls the firm's cost and profit. This is illustrated in figure 1 by the fact that, even for $F(\lambda) \equiv F^*$, $EW^{RM*}(\lambda)$ is always above $EW^{PM}_{F^*}(\lambda)$ $\forall \lambda \geq 0$. However, under asymmetric information, the regulated firm uses the possibility of transfers from the government to acquire a positive informational rent. The government prefers that the private sector takes over when the social cost associated with the rent outweighs the social benefit of controlling the firm's operation. As shown section 5 this ultimately depends on the profitability of the industry.

Positive franchise fees increase the preference for private monopoly. On the one hand, when the franchise fee $F(\lambda)$ is large (i.e. $F(\lambda) \geq R^{\infty}$ $\forall \lambda \geq 0$), the opportunity costs supporting privatization belong to an unbounded range $[\widehat{\lambda}, +\infty)$. The optimal industrial policy is monotone in λ. Regulation is preferred to privatization for $\lambda \leq \widehat{\lambda}$ whereas the reverse holds for $\lambda > \widehat{\lambda}$. On the other hand, when the franchise fee falls below the threshold R^{∞}, regulation re-dominates privatization for large value of λ. The optimal industrial policy then is non monotone in λ. For intermediate value of λ privatization with price liberalization dominates regulation under public ownership. The opposite conclusion holds for lower and larger value of λ. The intuition for this result is as follow. Because many developing countries' governments are constrained by tight budgetary conditions,

they have a weak bargaining position during privatization processes. They sell their public assets at a discount to avoid the embarrassment of unsuccessful sales (see Birdsall and Nellis 2002). In contrast under public ownership they legally seize the firms' profit which provides regular revenue inflows. For instance over the period 1990-95, revenue collected from public firms amounted to 8% of GDP in Bolivia, 2.2% in Brazil, 5% in Chile, 1% in India, 3% in Mexico, 3% in Peru (World Bank 1998). *"On the whole this non-tax revenue is more important for developing than opposed to industrial countries, comprising about 21 percent compared to 10 percent of total revenue."* (Burgess and Stern (1993) page 782). More recently Trujillo et al. (2003) have shown that utilities privatization results in additional public investment. The authors explain the negative impact of utilities privatization on public finances, by the fact that the reduction in current public expenditure plus the tax revenue from the new private firms is not enough to compensate for the loss in non-tax income from public firms. Since in most of the cases utilities privatization also leads to price rises, it hurts both consumers and taxpayers. Governments of developing countries should resist the privatization of their profitable state owned enterprises, which in practice they do. For instance one-third of the privatizations to end 1996 in Africa were liquidations or asset sales of unprofitable firms (Sarbib 1997). Similarly Namibia is one of the few countries in the world without a privatization plan, mainly because its public enterprises are operating at a profit (Harsch 2002).

3.4 Numerical Assessment for $\widehat{\lambda}$

Proposition 3 shows that independently of the privatization proceeds, privatization with prices liberalization dominates a benevolent regulation under public ownership for intermediate value of λ. The relevance of this result depends on what 'intermediate' value means. If it is very high, in practice privatization will never be optimal. In what follows we assess the lowest value of the opportunity cost, $\widehat{\lambda}$, for which privatization becomes attractive. By definition $\widehat{\lambda}$ is obtained when the highest franchise fee F^* applied (see figure 1). It solves $EW^{RM}(\lambda) = EW^{PM}_{F^*}(\lambda)$. This equation is equivalent to

$$4(1+\lambda)^2 V^{RM}(\lambda) = (3+2\lambda)(1+2\lambda)V. \tag{14}$$

Using (9) and (10), we observe that this expression defines a second degree equation in λ. In order to get explicit value for $\widehat{\lambda}$, we make the assumption of a uniform distribution of β over $[\underline{\beta}, \overline{\beta}]$. Still, the conclusions of the simulation are robust to other statistical specifications (e.g. normal distribution). Under the uniform distribution, equation (14) is equivalent to: $4E((1+2\lambda)(a-\beta)-\lambda(a-\underline{\beta}))^2 = (3+2\lambda)(1+2\lambda)E(a-\beta)^2$. Divide the right hand side and the left hand side by a^2. One can then check that $\widehat{\lambda}$ depends on $\underline{\beta}/a$ and $\overline{\beta}/a$ only. Since under the uniform specification the demand intercept a satisfies A1 if and only if $a \geq 2\overline{\beta}$, we get that $0 \leq \underline{\beta}/a < \overline{\beta}/a \leq 0.5$. Table 1 displays $\widehat{\lambda}$ for the various admissible values of $\underline{\beta}/a$ and $\overline{\beta}/a$.

$\widehat{\lambda}$	$\underline{\beta}/a = 0.0$	0.1	0.2	0.3	0.4
$\bar{\beta}/a = 0.1$	1.14	-	-	-	-
0.2	0.71	1.07	-	-	-
0.3	0.52	0.66	0.99	-	-
0.4	0.42	0.48	0.60	0.90	-
0.5	0.35	0.38	0.44	0.54	0.81

Table 1: Minimal opportunity costs $\widehat{\lambda}$ above which privatisation can be preferred

The opportunity cost of public funds is generally assessed to be around 0.3 in industrial countries (see for instance Snower and Warren (1996)) and higher in developing countries. We conclude from the simulation that if demand and cost functions are reasonably approximated by linear functions and satisfy assumption A1, which is an empirical issue, $\widehat{\lambda}$ lies below the range of the opportunity costs prevailing in developing countries. The results in Table 1 also highlight that privatisation is more likely as technological uncertainty rises (i.e. $\widehat{\lambda}$ decreases with $(\overline{\beta}-\underline{\beta})/a$). Indeed larger cost uncertainty implies stronger information asymmetry between firms and governments and hence larger information cost in the regulated structures.

4 Private and regulated duopoly

We next explore the optimal industrial organization when the fixed cost K becomes smaller or equivalently, when the value of operating the firm after investment, V, becomes larger.[22] This is relevant because in the last two decades some industries such as telecommunication have experienced dramatic technological and/or demand changes resulting both in a decrease in fixed costs and an increase in demand. Moreover, for a given industry the demand is generally weaker in developing countries than in industrialized countries, resulting in lower V. That is, for the same population size, the number of consumers and their propensity to pay are higher in rich countries. This difference might again imply different industrial policy. We first study the case of a private duopoly.

4.1 Private duopoly

To simplify the exposition, we rule out franchising in the sequel. The results are nevertheless robust to more favorable specifications of the franchise fee.[23]

A4 $$F(\lambda) \equiv 0 \ .$$

Private duopoly (PD here after) is modeled as Cournot duopoly with asymmetric information between firms. Each firm gets private information on its own marginal cost but it is not informed about the competitor's marginal cost. As in any Cournot game, each firm maximizes its profit taking the other firm's output as given. The timing of the game is as follows: First both firms simultaneously make the investments K. Second, each firm $i \in \{1, 2\}$ learns the realization of its own marginal cost β_i and chooses its

[22] From figure 1, we see that a private monopoly is less likely to be preferred to a regulated monopoly as K/V diminishes. However this result is incomplete. For lower K/V more than one firm may enter the market.

[23] Considering $F > 0$ would reinforce the bias in favor of the private monopoly in Lemma 6 because franchise fees are higher with a private monopoly than with a private duopoly. Empirically Wallsten (2000) finds using panel data of 17 developing countries that exclusivity periods (i.e., temporary monopoly position) can double the firm's sale price (i.e., F) in telecommunication industry.

production level q_i. The equilibrium concept is Bayesian Nash equilibrium:

$$q_i^* \in arg\max_{q_i} E_{\beta_j}\left[(a - b(q_i + q_j^*))q_i - \beta_i q_i\right] \quad \forall i = 1, 2, j \neq i.$$

Due to the linear shapes of the demand and cost functions, firm i's optimal strategy is equal to $q_i^*(\beta_i) = (2a + E\beta - 3\beta_i)/6b$.[24] The existence of a duopoly with both firms producing at the equilibrium requires that $a \geq \left(3\bar{\beta} - E\beta\right)/2$, which is true under assumption A1. Substituting $(q_1^*(\beta_1), q_2^*(\beta_2))$ in (1) and (2), we compute the ex-ante firm profit and the industry welfare of the Cournot duopoly

$$E\Pi^{PD} = \frac{2}{9}V + \frac{5}{18}\frac{\sigma^2}{2b} - K, \tag{15}$$

$$EW^{PD} = \frac{8}{9}V + \frac{11}{18}\frac{\sigma^2}{2b} - 2K. \tag{16}$$

A duopoly is *privately feasible* if the two firms are ex-ante profitable. It means that expression (15) should be positive.[25] A private duopoly is *socially desirable* if it brings more welfare than a private monopoly. That is, if $EW^{PD} \geq EW^{PM}$. Let $K^{PD/PM}$ be the level of fixed cost such that the government is indifferent between a private duopoly and a private monopoly, i.e. $EW^{PD} = EW^{PM}$. From (5) and (16), we compute

$$K^{PD/PM} = \frac{5}{36}V + \frac{11}{18}\frac{\sigma^2}{2b}. \tag{17}$$

Walras (1936) and Spence (1976) have shown in a context of symmetric information that industries with increasing returns to scale were characterized by excess entry. The next result shows that the presence of asymmetric information does not alter this result of wasteful competition.

Lemma 4 Under asymmetric information there is excessive entry. Privately feasible duopolies are socially undesirable whenever $\frac{5}{36}V + \frac{11}{18}\frac{\sigma^2}{2b} \leq K \leq \frac{2}{9}V + \frac{5}{18}\frac{\sigma^2}{2b}$.

[24] For more on Cournot competition under asymmetric information see Sakai (1985), Shapiro (1986) and Raith (1996).

[25] More generally the expected profit of N firms playing a generalized Cournot competition is $E_N\Pi^i = \frac{2V}{(N+1)^2} + \frac{(N-1)(N+3)}{2(N+1)^2}\frac{\sigma^2}{2b} - K$ with $N \geq 1$. We deduce that if $\frac{V}{8} + \frac{3}{8}\frac{\sigma^2}{2b} \leq K \leq \frac{2V}{9} + \frac{5}{18}\frac{\sigma^2}{2b}$ then $N \in \{0, 1, 2\}$. This yields assumption A0.

The set of values of fixed costs defined by the condition in Lemma 4 is not empty. One can indeed show that that condition is equivalent to $a > E\beta + \sqrt{3}\sigma$ which is true under A1. Therefore, the ex-ante welfare is higher if a private monopoly is legally set and if entry is prevented. Indeed, firms do not internalize the social cost of the investment duplication in their entry decision. As a result they enter too often in the industry.

4.2 Regulated duopoly

Many contributions in procurement and regulation theory emphasize the idea that despite sub-additive cost functions, it can be optimal to have several producers in a regulatory setting. A regulated duopoly can be better than a regulated monopoly because it increases the variety of products, lowers transportation costs, or because it reduces prices through (yardstick) competition. In the present model, the firms' marginal cost are independent and identically distributed. The benefit of choosing a regulated duopoly originates from the *sampling gain* as first analyzed by Auriol and Laffont (1993).

4.2.1 The sampling effect under symmetric information

The timing is the same as for a regulated monopoly with the following differences: the investment K is made in the two regulated firms (henceforth RD) and the marginal cost parameters β_i with $i \in \{1, 2\}$ are independently drawn. Under symmetric information the transfers t_i^* to the regulated firms $i \in \{1, 2\}$ which are socially costly, are reduced until firms break even: $t_i^* = -(a - bQ)q_i + \beta_i q_i + K$. Substituting this expression into the welfare function yields

$$W^{RD*} = S(Q) + \lambda P(Q)Q - (1 + \lambda)(\beta_1 q_1 + \beta_2 q_2 + 2K).$$

The welfare function is linear in q_1 and q_2. Optimizing it with respect to q_i we deduce that $q_i^* = Q^{RD} > 0$ if $\beta_i = min\{\beta_1, \beta_2\}$ and $q_i^* = 0$ otherwise. The optimal production level coincides with the level of the regulated monopoly defined in equation (7): $Q^{RD*}(\beta_1, \beta_2) = Q^{RM*}(min\{\beta_1, \beta_2\})$. Monitoring a regulated duopoly is equivalent to monitoring a regulated monopoly for which the investment level is $2K$ and the marginal

cost is distributed as $\beta^{min} = min\{\beta_1, \beta_2\}$, that is, with the law:

$$g^{min}(\beta) = 2(1 - G(\beta))g(\beta). \tag{18}$$

The ex-ante welfare of the regulated duopoly under symmetric information is

$$EW^{RD*}(\lambda) = (1 + \lambda)\left(\frac{1 + \lambda}{1 + 2\lambda}V^{min} - 2K\right) \tag{19}$$

where

$$V^{min} = \int_{\underline{\beta}}^{\bar{\beta}} \frac{(a - \beta)^2}{2b} g^{min}(\beta)d\beta. \tag{20}$$

The facts that $g^{min}(\cdot)$ stochastically dominates $g(\cdot)$ and that $(a - \beta)^2/2b$ decreases in β imply that $V^{min} > V$. Then comparing (8) and (19), the ex-ante welfare is larger under a regulated duopoly than under a regulated monopoly if the *sampling gain*, measured by $(V^{min} - V)\ (1 + \lambda)\ /\ (1 + 2\lambda)$, is larger than K, the duplicated investment.[26]

4.2.2 Asymmetric information

Under asymmetric information, the two regulated firms must be enticed to reveal their private information to the government. By the revelation principle, the analysis is restricted to direct revelation mechanisms. The equilibrium is defined as truthful Bayesian Nash equilibrium. Each firm $i \in \{1, 2\}$ sets its revelation strategy $\widehat{\beta}_i$ such that it maximizes the expected profit given the cost distribution of the competitor $j \neq i$. Let

$$V^{RD}(\lambda) = \int_{\underline{\beta}}^{\bar{\beta}} \frac{(a - v(\beta, \lambda))^2}{2b} g^{min}(\beta)d\beta. \tag{21}$$

The following lemma presents the structure of production and the welfare level of the duopoly under asymmetric information.

[26]Only one firm produces at the equilibrium. This is an artifact of the assumption of constant marginal costs which is used to isolate the sampling effect. Models with non-constant marginal costs yield qualitatively similar results (see Auriol and Laffont 1993). Finally we assume that the government shuts down the least efficient regulated firm for the sake of readability. It could instead transfer the best technology to all regulated firms and share the optimal production Q^{RD*} among them. The analysis would be unaltered.

Lemma 5 Under asymmetric information, only the firm with the lowest marginal cost produces. Output and welfare levels are the levels obtained under symmetric information evaluated at the virtual cost:

$$Q^{RD}(\beta_1, \beta_2) = Q^{RM}\left(v(\beta^{min}, \lambda)\right), \tag{22}$$

$$EW^{RD}(\lambda) = (1+\lambda)\left(\frac{1+\lambda}{1+2\lambda}V^{RD}(\lambda) - 2K\right). \tag{23}$$

Proof: The proof is similar as in Auriol and Laffont (1993) Proposition 2.

Monitoring a regulated duopoly is equivalent to monitoring a regulated monopoly for which the investment level is $2K$, the marginal cost is $v(\beta^{min}, \lambda)$ and β^{min} is distributed according to $g^{min}(\cdot)$. Let $K^{RM/RD}(\lambda)$ be the value of the fixed cost such that the government is indifferent between a regulated monopoly and a regulated duopoly, i.e. such that $EW^{RM}(\lambda) = EW^{RD}(\lambda)$:

$$K^{RM/RD}(\lambda) = \frac{1+\lambda}{1+2\lambda}\left(V^{RD}(\lambda) - V^{RM}(\lambda)\right) \tag{24}$$

Under asymmetric information, the sampling gain is measured by $K^{RM/RD}(\lambda)$. Since the distribution function $g^{min}(\beta)$ stochastically dominates $g(\beta)$ and since $(a - v(\beta, \lambda))^2/2b$ decreases in β we deduce that $V^{RD}(\lambda) \geq V^{RM}(\lambda)$. However the larger λ is, the lower is the impact of the sampling gain and the smaller is the government's preference for regulated duopoly.

4.3 Private versus regulated duopoly

We have seen in Section 3 that private monopoly can be preferred to regulated monopoly. By extension, private duopoly could also be preferred to monopoly or regulated duopoly. However, excess entry and weak competition in private Cournot duopolies will generally preclude this structure from being socially desirable. To be more specific let $K^{RD/PD}(\lambda)$ be the value of the fixed cost such that regulated duopoly is equivalent to private duopoly, i.e. such that $EW^{RD}(\lambda) = EW^{PD}$. The government prefers a regulated duopoly to a private duopoly if and only if $K \leq K^{RD/PD}(\lambda)$. On the other hand, if $K \geq K^{PD/PM}$ defined in equation (17), the government prefers a private monopoly to a private duopoly.

We deduce that if

C1 $$K^{RD/PD}(\lambda) \geq K^{PD/PM}$$

a private duopoly is never preferred by the government. Appendix 3 shows that assumption C1 holds if the demand parameter a is not too small. For instance if β_i is uniformly distributed over $[0, \overline{\beta}]$ then assumption A1 implies condition C1.

Lemma 6 Under assumption C1 a private duopoly is never optimal.

We now turn to the study the optimal industrial policy.

5 Optimal industrial policy

Under complete information, the government can always replicate the production decisions of private firms so that privatization is never optimal. The optimal industrial policy varies from no production, regulated monopoly to regulated duopoly according to whether the investment cost K is large, medium or small. Under asymmetric information, information costs alter this result. That is, let $K^{RM}(\lambda)$ be the value of the fixed cost such that the government is indifferent between a regulated monopoly and no production (i.e. such that $EW^{RM}(\lambda) = 0$). It is easy to check that

$$K^{RM}(\lambda) = \frac{1+\lambda}{1+2\lambda} V^{RM}(\lambda). \tag{25}$$

Similarly let $K^{RM/PM}(\lambda)$ be the value of the fixed cost such that the government is indifferent between a regulated monopoly and a private monopoly (i.e. such that $EW^{RM}(\lambda) = EW^{PM}$). It is easy to check that

$$K^{RM/PM}(\lambda) = \frac{(1+\lambda)^2}{\lambda(1+2\lambda)} V^{RM}(\lambda) - \frac{3V}{4\lambda}. \tag{26}$$

We deduce the next result.

Proposition 7 Suppose that assumptions A0 to A4 hold. Under condition C1, the optimal industrial policy under asymmetric information is to set:

- no production if $K > \max\left\{\frac{V}{2}, K^{RM}(\lambda)\right\}$;
- a private monopoly if $K^{RM/PM}(\lambda) < K \leq \frac{V}{2}$;
- a regulated monopoly if $K^{RM/RD}(\lambda) < K \leq \min\left\{K^{RM/PM}(\lambda), \frac{V}{2}\right\}$ or if $\frac{V}{2} \leq K < K^{RM}(\lambda)$;
- a regulated duopoly if $K \leq K^{RM/RD}(\lambda)$.

Proof. See Appendix 4 ■

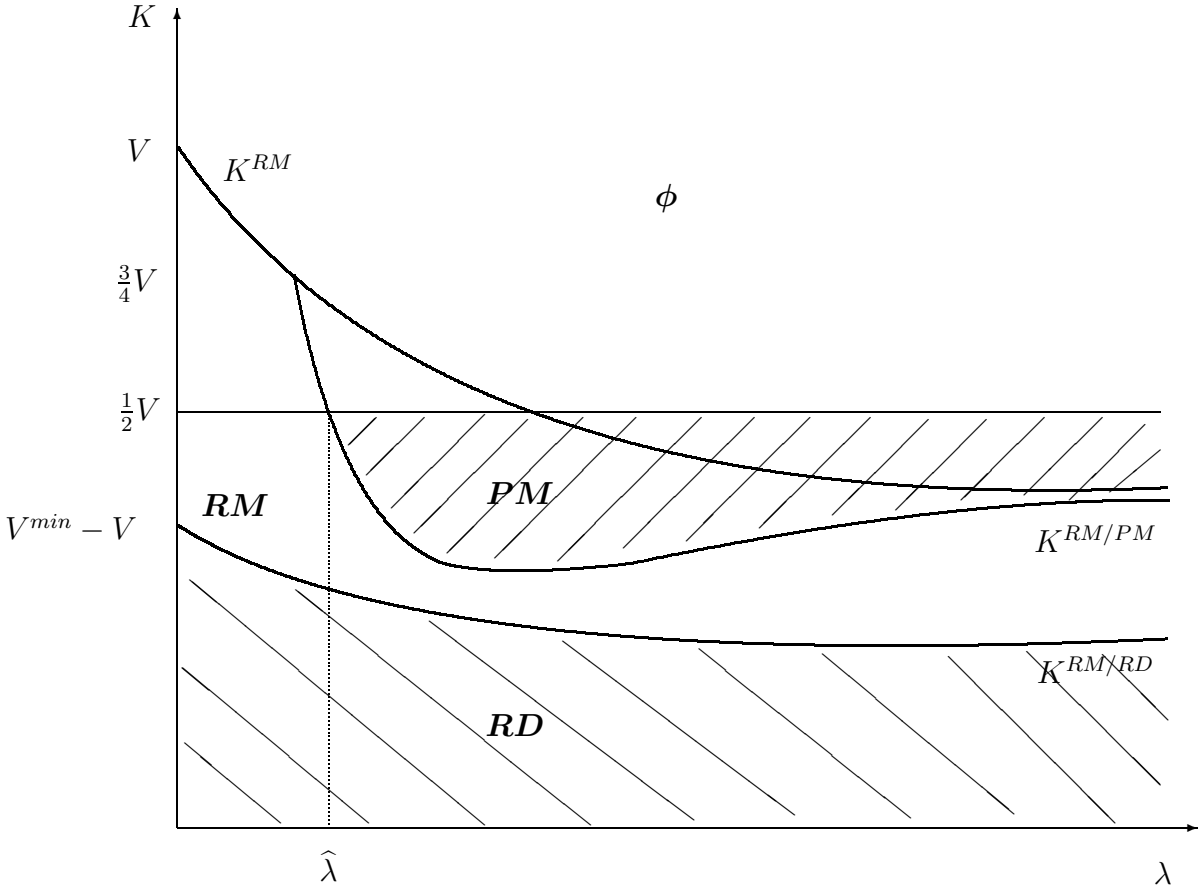


Figure 2: Optimal Industrial Policy

Figure 2 illustrates Proposition 7 in (λ, K) space. It allows to consider three types of market organization in function of the profitability of the infrastructure project or of the utility.

The first case occurs when the ex-ante profitability of the infrastructure project or of the industry is low (i.e. for $K \geq K^{RM}(+\infty)$). When K is large there is room for at most one firm. The optimal industrial policy then is monotone in the opportunity cost of public funds. We distinguish two cases. First when K is larger than $V/2$ the project is not privately feasible. Depending on λ being either low or high the optimal industrial policy is public ownership (in wealthy countries) or no production (in poor countries). In figure 2 public, regulated monopolies that are desirable under asymmetric information are depicted by the white area denoted RM, no production corresponds to the area denoted $\emptyset$. Second when K falls below $V/2$, the project becomes privately feasible for one firm. Regulation is preferred to privatization if $\lambda \leq \widehat{\lambda}$ and it is the reverse otherwise. When K is close to $V/2$ private monopoly is preferred for large λ simply because it is feasible whereas regulated monopoly is not. By continuity private monopoly dominates regulated monopoly for lower values of the fixed cost. This situation is denoted PM and is represented by the hatched area above the curve $K^{RM/PM}$.

Because developing countries have large opportunity costs of public funds, they may implement industrial policies that strongly differ from those implemented in advanced economies. There are for instance a public good aspect and externalities associated to sunk cost investment such as infrastructure (e.g., a road). As recommended by standard economic theory wealthy nations subsidize the construction of the infrastructure and let people use it at marginal cost (e.g., for free). With a low opportunity cost of public funds this policy maximizes welfare. On the other hand many developing countries plagued by financial problems have started build-operate-and-transfer (BOT) programs. In such programs, a private firm finances the sunk cost of an infrastructure, for instance a highway, in exchange for a 10-30 years licence to exploit it in a monopoly position. Clearly, a privately owned and operated infrastructure, even with the monopoly distortion (e.g., a toll), is a better solution than no infrastructure at all, which is, in the absence of public financing, the alternative to privatization. Water supply, which typically is provided worldwide through public ownership, could be a good candidate for such type of privatization. This is at least what is advocated by Brook Cowen and Cowen (1998). In developing countries tariffs are so low that on average they do not cover half of the total cost (World Bank

1994). This precludes public investment, and large fraction of the population in cities has no formal water hook-up. To increase access some countries have chosen to implement BOT contracts. China, Malaysia, Thailand implemented it in water, and Chile, Mexico, in sanitation (World Bank 1997). The drawback of such privatization policy is that it increases inequality. That is, rise in public utility tariffs (to reach costs recovery level), recovery of unpaid bills and termination of illegal connexion hurt the poor. On the other hand, extension of the network favor those who are wealthy enough to access the new infrastructure. Empirical studies hence suggest that the reforms have worsened wealth and income distribution (see for instance Chisari, Estache and Romero 1999, Birdsall and Nellis 2002, Estache, Foster and Wodon 2002, Estache 2003). This in turn might explain why privatizations are so unpopular.[27] Privatization is a good alternative to the absence of public funds if it leads to an increase of available infrastructure such as roads, railroads, or distribution networks. Nevertheless the reforms have to be accompanied by subsidies in direction of the poor (either directly from government, or international institutions, or from the wealthy part of the consumers through cross-subsidies) to constitue genuine Pareto improvement. Last, but not least, governments with bad country risk ratings might find impossible to attract international investors on low profitability projects. They should rather target national private investors or national NGOs which are better informed on local profitability and risk.

The second case occurs when K belongs to $[V^{min} - V, K^{RM}(+\infty)]$. When K lies in this interval the market offers good ex-ante prospects to one firm. Production (with a monopoly) is always optimal. However, contrary to the low profitability case, the optimal industrial policy is non monotone in λ. This is illustrated Figure 2 by the fact that the curve denoted $K^{RM/PM}(\lambda)$ is non monotone in λ. Let $\underline{K}^{RM/PM}$ denote the minimum of $K^{RM/PM}(\lambda)$. For $\underline{K}^{RM/PM} \leq K \leq K^{RM}(+\infty)$, as λ increases, the optimal industrial policy successively becomes public ownership, then privatization and finally public ownership. Indeed when λ is very large the government seeks the maximal revenue from the firm.

[27]For instance 63% of people surveyed in 2001 in 17 countries of Latin America disagreed or strongly disagreed with the statement "The privatization of state companies has been beneficial" (The Economist July 28-August 3 2001, p38). There is a widespread perception that they have been hurting the poor, notably through increase in tariff and unemployment, while benefiting the powerful and wealthy.

Privatization which generates low proceeds (because of the high λ) is not appealing. It is better to keep the profitable firm public while fixing its price close to monopoly level. This generates more revenue. The traditional fixed-line and long distant segment of the telecommunication industry illustrates this non monotonicity result: "*A PTT[Post and Telecommunication Company]'s yearly revenues (especially charges from international call) were used by governments to subsidize mail service, or to ease yearly budget deficits. Given this public convenience and necessity, the interests of third world governments are often diametrically opposed to telecom policies of privatization and network deregulation favored by wealthy nations.*" (Anania 1992).

Finally, when $V/2$ is much larger than K (i.e. when $K \leq V_{min} - V$), markets offer good ex-ante prospects to more than one firm. Lemma 6 then shows that a private Cournot duopoly is never optimal. The negative impact of market power and excessive entry are too strong compared to the positive effects (here the 'sampling gains') of a regulated duopoly. In other words, the advantage of private structures with liberalized prices disappears once the market allows the entry of more than one firm (i.e. when it is very profitable). This result may look at odds with theories where private structures perform better with larger number of entrants (see for instance Vickers and Yarrow (1991) and Segal (1998)). A basic difference in our model lies in the intensity of competition that exists within private and regulated structures. Under privatization, private firms compete in quantities so that the addition of a firm does not fully eliminate market power and profits. In contrast, under the regulation regime, information costs dramatically fall when a second firm is added in the regulated market. Regulation is then more attractive. This result is congruent with the theory of adverse selection in which a rise in the number of agents reduces the cost of information revelation (see Auriol and Laffont (1993)).[28] The case where regulated duopoly is preferred to regulated monopoly is depicted by the hatched area below the curve $K^{RM/RD}$ denoted RD.

[28]If we had considered that firms operating in the same industry have correlated costs, we would have used this correlation to implement yardstick competition, reducing further the cost of information revelation (see Auriol and Laffont 1993).

This last result sheds light on the link between market liberalization, on the one hand, and technological and/or product demand changes, on the other hand. Market liberalization, often referred to as 'deregulation', corresponds to the divestiture of the historical monopoly and the introduction of new entrants. As shown in Proposition 7 this is not equivalent to *laissez-faire*. In practice prices and entry remain regulated to protect consumers against collusion and predatory behavior (through licences and price caps for instance). This is important because in profitable industry the consumer surplus is high. Monopoly pricing then has more impact on welfare than it has on low profitability industry. In the framework of our model the divestiture of the historical monopoly is motivated by a drop of the ratio K/V. That is, by smaller fixed costs and/or by larger product demand. In figure 2 this corresponds to a downward shift, where industry structures move from regulated monopoly to regulated duopoly. The mobile and internet segment of the telecommunication industry provides an example of such a drop. Introduction of wireless technologies has significantly reduced the fixed costs to operate networks whereas the demand for communication has steadily increased. Consistently with our model, many developed and developing countries have deregulated their domestic telecommunication industry. Wallsten (2000), who studied telecom reforms in Africa and Latin America, found that privatization by itself does not yield improvements but that privatization combined with an independent regulator does.[29] Similarly Estache (2002), shows that technical/productive efficiency gains generated by Argentina's 1990s utilities privatization have not been transmitted to consumers. According to the author the benefits were captured by the industry because of inefficient regulation. The lesson to be drawn here is that privatization, being defined as a move from regulation to *laissez-faire,* is not optimal. When the ratio K/V is low, the consumer surplus is large.[30] Regulation then is a key component of successful privatization reforms.

To conclude we need to assess the empirical relevance of the arguments developed in the paper. The first argument that can be tested concerns the reasons that trigger

[29]For more on the telecommunications reforms in developing countries see Auriol (2005).

[30]For instance Fuss, Meschi and Waverman (2005) estimates that in a typical developing country, an increase of ten mobile phones per 100 people boosts growth by 0.6 percentage points. The growth dividend is similar to that of fixed-lines phones in developed countries in the 1970s.

privatization. On the one hand privatization increases productive efficiency. This provides a first rationale for privatizing, the *efficiency* argument. On the other hand in profitable increasing returns to scale industries allocative inefficiency combined with the critical budgetary conditions found in most developing countries favor public ownership. It is an effective way to combine the regulation of the industry with a maximal level of taxation. In contrast when profitability is low privatization is a better option. This is the *public revenue* rationale of privatization which is explored in the present paper. Li, Li, Lui and Wang (2001) based on a data set from privatizations in China test whether government privatizes in order to enhance production efficiency, the 'efficiency' argument, or to increase its revenue, the 'revenue' argument. They conclude "*our tests based on the data set from China reject the efficiency theory and yield support for the revenue theory.*" Warlters (2004) and Auriol and Tuske (2005) also find that macro economic variables, such as the introduction of a VAT system, country risk ratings, or the level of public debt significantly influence the probability of infrastructure privatization. The macro economic rationale works also for developed countries. Bortolotti, Fantini and Siniscalco (2003) analyze panel data for privatization around the world. They consider any type of industry (i.e. competitive and oligopolistic ones) and any type of countries (i.e. rich and poor). They find that privatization is more likely in wealthy democracies with right-wing governments, high debt, liquid stock markets and a legal system that protects shareholders.

A more subtle implication of the model arises while focusing on profitable infrastructure and public utilities. Depending on the value of λ privatization might be the optimal policy in a rich country while it is not necessarily the same in a poor one. Under the paper assumptions the critical value $\widehat{\lambda}$ lies in the range of the opportunity cost of public funds generally retained for developed economies (i.e. $\widehat{\lambda} \in [0.35, 1.10]$ table 1).[31] If the model assumptions are empirically relevant we should observe that the probability to privatize profitable infrastructure and public utilities in developing countries decreases with the opportunity cost of public funds.[32] Warlters (2004) was the first to check empirically

[31]The critical value $\widehat{\lambda}$ is the same in figure 1 and 2. Indeed $\widehat{\lambda}$ in figure 2 is such that $K^{RM/PM}(\lambda) = \frac{V}{2}$. It is easy to check that this equation is equivalent to equation (14).

[32]The prediction is reversed for advanced economies (see figure 2) as suggested by Bortolotti, Fantini and Siniscalco (2003) where the probability of privatization increases with the level of debt.

this result. He studied the determinants of infrastructure privatization using probit regressions with panel data covering 155 developing countries for the years 1984-1998. He concludes that '*infrastructure privatization is more likely when the shadow cost of public funds falls.*' Auriol and Tuske (2005) find similar results while focusing on the telecommunication industry. The probability of privatization of the fixed access and long distance segment decreases with country risk rating. When controlling for firms' characteristics, the privatization probability increases with the level of total telephone subscribers, the number of main telephone lines in the largest city, the percentage of digital main lines, and the level of annual telecom investment. This suggests that efficient firms are sold more often than less efficient ones which contradicts the idea that governments use privatization to improve firms' efficiency.[33] On the other hand the macro-economic argument seems empirically supported. Developing countries' governments that are concerned with solving critical financial problems regard privatization as a useful fiscal instrument.

6 Conclusion

The present paper shows that countries' privatization decisions non-trivially depend on their development stages. Such an argument is particularly decisive in developing economies constrained by bad macro-economic conditions and poorly performing tax systems. On the one hand, for low-profit natural monopolies, privatization always dominates regulation for intermediate and large values of opportunity costs of public funds. Privatization is indeed Pareto improving when it leads to the creation of an infrastructure that would otherwise not have existed. Numerical simulations suggest that the 'intermediate' values compatible with the model, are in the range of those of developing countries. On the other hand, for more profitable natural monopolies, the privatization decision is a non monotone function of the opportunity costs of public funds. Indeed developing countries plagued with financial problems are tagged with bad country risk ratings and are unable to attract international capital flows. Privatization does not yield large divesture proceeds. Since public firms are sold at a discount, governments in need of cash should preferably keep

[33] On the other hand it is consistent with the idea of maximizing the sale revenue.

profitable public firms under their direct control. They can then choose monopoly prices and legally capture firms' profits. Such a policy maximizes their revenues. Finally, the advantage of private structures with liberalized prices disappears once the market offers room for more than one firm. Technological and demand changes explain the destitution of historically regulated monopolies and the creation of oligopolies. They induce some form of competition which still requires efficient regulation.

References

AfDB-OECD (2003), "African Economic Outlook", OECD.

ANANIA, L. (1992), "The Protean Complex: Are Open Networks Common Markets?", in the *Economics of Information Network* Ed by C. Antonelli, North-Holland.

AURIOL, E. and J.J. LAFFONT (1993), "Regulation by Duopoly", *Journal of Economics and Management Strategy*, 3, 507-533.

AURIOL, E. (2005), "Telecommunication Reforms in Developing Countries", forthcoming in *Communication & Strategies*

AURIOL, E. and A-M TUSKE (2005), "Privatization Decision in Developing Countries: The case of telecommunication industry", mimeo. Toulouse.

AURIOL, E. and M. WARLTERS (2005), "Taxation Base in Developing Countries", *Journal of Public Economics*, 89(4), 625-46.

BARON, D. and R. MYERSON (1982), "Regulating a Monopolist with Unknown Costs", *Econometrica*, 50, 911-930.

BIRDSALL, N. and J. NELLIS (2002), "Winners and Losers: Assessing the distributional impact of privatization", the Center for Global Development, Working Paper Number 6.

BORTOLOTTI, B., FANTINI, M., and SINISCALCO, D. (2003), "Privatization around the world: evidence from panel data", *Journal of Public Economics*, 88, 305-332.

BREWER, L.T., and P. RIVOLI (1990), "Politics and Perceived Country Creditworthiness in International Banking", *Journal of Money, Credit and Banking*, 22(3), 357-369.

BROOK COWEN P. and T. COWEN (1998), "Deregulated Private Water Supply: A Policy Option for Developing Countries", *Cato Journal*, Vol. 18, No 1, pp 21-41.

BURGESS and STERN (1993), "Taxation and Development", *Journal of Economic Literature*, vol 31 (2), pp. 762-830.

DEBANDE, O. and G. FRIEBEL, "A Positive Theory of Insider Privatization", WDI, University of Michigan, DP 37.

DEWATRIPONT M. and MASKIN E. (1995), "Credit and Efficiency in Centralized and Decentralized Economies", Review of Economic Studies, 62(4), pp 541-56.

DAVIS, J., OSSOWSKI, R., RICHARDSON, T. and BARNETT, S. (2000), "Fiscal and

Macroeconomic Impact of Privatization", *I.M.F. Occasional Paper*, 194.

CHISARI, O. A. ESTACHE , C. ROMERO (1999), "Winners and Losers from the Privatization and Regulation of Utilities: Lessons from a General Equilibrium Model of Argentina", *The World Bank Economic Review* May 13,2, pp. 357-378.

ESTACHE A., V. FOSTER, and Q. WODON (2002), "Accounting for Poverty in Infrastructure Reform, Learning from Latin America's Experience", World Bank Institute Development Studies.

ESTACHE A. (2002), "Argentina's 1990's utilities privatization: a cure or a disease", Working Paper World Bank.

ESTACHE A. (2003), "On Latin America's Infrastructure Privatization and Its Distributional Effects", Working Paper World Bank.

ESTACHE A. (2005), "Experiences in Latin American PPPs", *Infrastructure Journal*, pp. 21-26.

FUSS, M., M. MESCHI and L. WAVERMAN (2005), "The Impact of Mobile Phones on Economics Growth in Developing Countries", *The Economist*, March 12th, p.p. 78.

GUASH, J-L., J-J LAFFONT, S. STRAUB (2003), "Renegotiation of Concession Contracts in Latin America", World Bank Policy Research Working Paper 3011,Washington D.C.

GUASH, J-L. (2004), "Granting and Renegociating Infrastructure Concessions", the World Bank Institute of Development Studies, Washington D.C.

GIBBON H. (1998), "Worldwide Economic Orthodoxy", *Priv. International*, 123, p, 4-5.

GIBBON H. (2000), "Editor's Letter", Privatization Yearbook, London: Thomson Financial, p.1.

HARSCH E. (2002), "Privatization Shifts gears in Africa", *Africa Recovery, United Nation.* (www.un.org/ecosocdev/geninfo/afrec/vol14no1/privat1.htm)

KORNAI J. (1980), "Economics of Shortage", Amsterdam, North-Holland.

KORNAI J. (2000), "What the Change of System from Socialism to Capitalism Does and Does Not Mean", *Journal of Economic Perspectives,* 4(1), 27-42.

KORNAI J. (2001), "Hardening the Budget Constraint: The experience of the post-socialist countries", *European Economic Review*, 45, 1573-99.

KORNAI J., MASKIN E. and ROLAND G. (2002), "Understanding the Soft Budget Constraint', Discussion Paper, University of California, Berkeley.

KORNAI J. and J. WEIBULL (1983), "Paternalism, Buyers' and Sellers' Markets", *Mathematical Social Sciences*, 7:153-69.

LAFFONT, J.J. (2001), "Enforcement, Regulation and Development", mimeo IDEI Toulouse.

LAFFONT, J.J. and J. TIROLE (1993), *A Theory of Incentives in Procurement and Regulation*, MIT press.

LOPEZ DE SILANES, F., SHLEIFER, A. and VISHNY, R., (1997), "Privatization in the United States", *Rand Journal of Economics*, 28, p. 447-71.

MAHBOOBI L. (2000), "Recent Privatization Trends", OECD, *Financial Market Trends*, 76, p. 43-64.

MASKIN, E. (1999), "Recent Theoretical Work on the Soft Budget Constraint", *American Economic Review*, 89(2), 421-25.

MEGGINSON W. and NETTER J. (2001), "From State to Market: A Survry of Empirical Studies on Privatization", *Journal of Economic Literature* , 39, p. 321-89.

NELLIS, J. (1999), "Time to Rethink Privatization In Transition Economies?", International Finance Corporation, *Discussion Paper 38*.

RAITH M. (1996), "A General Model of Information Sharing in Oligopoly", *Journal of Economic Theory*, 71(1), pages 260-88.

SAKAI, Y. (1985), "The Value of Information in a Simple Duopoly", *Journal of Economic Theory*, 36(1), 36-54.

SARBIB, J-L. (1997), "Privatization In Africa: Present and Future Trends", African Development Bank Group, 1997 Annual Meeting Symposium on 'Private Sector Development In Africa'.

SCHMIDT, K (1996-a), "The Costs and Benefit of Privatization- An Incomplete Contracts Approach", *J. of Law, Economics and Organization*, Vol. 12 1-24.

SCHMIDT, K (1996-b), "Incomplete Contracts and Privatization", *European Economic Review*, Vol. 40 569-580.

SEGAL, I (1998), "Monopoly and Soft Budget Constraint", *Rand Journal of Economics*, 29(3), 569-609.

SHAPIRO C. (1986), "Exchange of Cost Information in Oligopoly", *Review of Economic Studies*, 53(3), p 433-46.

SHAPIRO C. and WILLIG R. (1990), "Economic Rationale for the Scope of Privatization", DP 41, Princeton University.

SHLEIFER, A. and R. VISHNY (1997), "A survey of Corporate Governance", *Journal of Finance*, vol 52 (2) pp. 737-83

SNOWER A. and WARREN R. (1996), "The Marginal Welfare Cost of Public Funds: Theory and Estimates", *J. of Public Economics*, 61, 289-305.

SPENCE M. (1976), "Product Selection, Fixed Costs, and Monopolistic Competition", *Review of Economic Studies*, 43(2), 217-35.

TRUJILLO, L., E. QUINET and A. ESTACHE (2002), "Dealing with Demand Forecasting Games in Transport Privatization", *Transport Policy*, 9, pp. 325-334.

TRUJILLO, L., N. MARTIN, A. ESTACHE and J. CAMPOS (2003), "Macroeconomics Effects of Private Sector Participation in Infrastructure", in Easterly and Serven *The Limit of Stabilization*, Stanford University Press, pp. 139-170.

VICKERS J. and YARROW G. (1991), "Privatization: an Economic Analysis", *MIT Press*.

WALLSTEN, S. (2000), "An econometric analysis of Telecom Competition, Privatization and Regulation in Africa and Latin America", forthcoming *J. of Industrial Economics*.

WALRAS, L. (1936), "Etudes d'Economie Politique Aplliquée: Théories de la Richesse Sociale", Lausannes F. Rouge.

WARLTERS, M. (2004), "Infrastructure Privatization and the Marginal Cost of Public Funds", mimeo, Toulouse.

WORLD BANK (1994), "World Development Report 1994: Infrastructure for Development" New York: *Oxford University Press*.

WORLD BANK (1997), Toolkits for Private Participation in Water and Sanitation. Washington D.C. World Bank.

WORLD BANK (1998), "World Development Indicators", Washington D.C. World Bank..

Appendix 1: Proof of Proposition 2

We have to show that $(1+\lambda)\left(\frac{1+\lambda}{1+2\lambda}V-K\right) \geq \frac{1}{2}V-K+\lambda F(\lambda) \quad \forall\lambda \geq 0$ The maximal franchise fee, denoted F^*, is equal to the firm's ex-ante profit, i.e. $F^* = \frac{1}{2}V-K$. Therefore the above inequality is satisfied if $\forall\lambda \geq 0$ $(1+\lambda)\left(\frac{1+\lambda}{1+2\lambda}V-K\right) \geq \frac{3}{4}V-K+\lambda\left(\frac{1}{2}V-K\right)$, or equivalently if $4(1+\lambda)^2 \geq (3+2\lambda)(1+2\lambda)$ which is always true $\forall\lambda \geq 0$.

Appendix 2: Proof of Proposition 3

Step 1: Regulation is preferred to privatization if and only if $EW^{RM}(\lambda) \geq EW^{PM}(\lambda)$. By virtue of equation (12) this inequality is equivalent to

$$\frac{(1+\lambda)^2}{1+2\lambda}V^{RM}(\lambda)-(1+\lambda)K \geq \frac{3}{4}V-K+\lambda F(\lambda). \tag{27}$$

Developing $V^{RM}(\lambda)$ defined in equation (10) one can check that:

$$V^{RM}(\lambda) = \frac{1+2\lambda}{(1+\lambda)^2}V+\frac{\lambda^2}{(1+\lambda)^2}V^{RM}(\infty)-\frac{\lambda}{(1+\lambda)^2}B \tag{28}$$

where terms $V = E\left[(a-\beta)^2/(2b)\right]$, and $V^{RM}(\infty) = E\left[\left((a-\beta-\frac{G(\beta)}{g(\beta)})^2\right)/(2b)\right]$, and $B = E\left[G(\beta)(a-\beta)/(g(\beta)b)\right]$ are all positive by virtue of assumption A1. Substituting (28) in (27) and dividing the right and left hand side by λ, we get after some straightforward computations:

$$\frac{V}{4\lambda} \geq \frac{B}{1+2\lambda}-\frac{\lambda}{1+2\lambda}V^{RM}(\infty)+K+F(\lambda). \tag{29}$$

It is easy to check that the left hand side of (29), denoted $LHS(\lambda)$, is a decreasing and convex function of λ. Similarly, under the assumption A2 the right hand side of (29), denoted $RHS(\lambda)$, is decreasing and convex. The following proof relies on the property that two decreasing and convex functions can intersect only once, twice or none.

Step 2: For $\lambda = 0$, expression (29) is equivalent to $V \geq 0$ which is always true. We deduce that for λ small enough regulation dominates privatization.

For $\lambda \to +\infty$ two cases hold: either $\lim_{\lambda\to+\infty} LHS(\lambda) > \lim_{\lambda\to+\infty} RHS(\lambda)$, which is equivalent to $F(+\infty) < R^\infty$, or $\lim_{\lambda\to+\infty} LHS(\lambda) \leq \lim_{\lambda\to+\infty} RHS(\lambda)$, which is equivalent to $R^\infty \leq F(+\infty)$ where $R^\infty = \frac{V^{RM}(\infty)}{2}-K$.

Consider first the case $R^{\infty} \leq F(+\infty)$. This condition implies that for λ large enough privatization is preferred to regulation. Since it is the reverse for λ low enough, we deduce that $LHS(\lambda)$ and $RHS(\lambda)$ cross once and only once. This proves part (i) of proposition 3.

Step 3: Consider next the case $R^{\infty} > F(\infty)$. This condition implies that for large enough λ, regulation is preferred to privatization. Since this is also true for low enough λ, we deduce the following possibilities: first, $LHS(\lambda)$ and $RHS(\lambda)$ never cross, in which case regulation is always preferred to privatization, second, they cross twice which yields part (ii) of proposition 3. This ultimately depends on K.

Step 4: To complete the proof of proposition 3 we need to show that there are at least some values of the parameters such that $LHS(\lambda)$ and $RHS(\lambda)$ cross twice. Since privatization is less attractive for smaller franchise fees, a sufficient condition is that $LHS(\lambda)$ and $RHS(\lambda)$ crossing twice for $F = 0$. Simplifying expression (29) and using $F = 0$, we get that privatization is preferred to oublic ownership if and only if

$$P(\lambda) = (V^{RM}(\infty) - 2K)\lambda^2 + (V/2 - B - K)\,\lambda + V/4 < 0. \tag{30}$$

Inequality (30) is satisfied for $\lambda \in (\widehat{\lambda}(K), \widetilde{\lambda}(K))$ with $0 < \widehat{\lambda}(K) < \widetilde{\lambda}(K)$ under three conditions:

(a) $(V/2 - B - K)^2 > V(V^{RM}(\infty) - 2K)$.

(b) $V/2 - B - K < 0$

(c) $V^{RM}(\infty) - 2K > 0$

Condition (a) yields a positive discriminant for $P(\lambda) = 0$ and thus implies the existence of two roots $\widehat{\lambda}(K)$ and $\widetilde{\lambda}(K)$; condition (b) and (c) imply positivity for both roots of $P(\lambda) = 0$; finally since $P(0) > 0$ and $\lim_{\lambda \to +\infty} P(\lambda) > 0$ under (c), we have that $P(\lambda) < 0$ for $\lambda \in (\widehat{\lambda}(K), \widetilde{\lambda}(K))$.

Conditions (b) and (c) are satisfied if and only if $K \in (V/2 - B, V^{RM}(\infty)/2)$. This interval is not empty since $V^{RM}(\infty) = V - B + E\left[(G(\beta)/g(\beta))^2/(2b)\right]$. Then, observe that the left hand side of condition (a) is equal to zero at $K = \frac{V}{2} - B$ and increases for larger K. Similarly the right hand side of condition (a) decreases with K and is equal to

zero at $K = V^{RM}(\infty)/2$. Hence there exists a unique $\widehat{K} \in (V/2 - B, V^{RM}(\infty)/2)$ such that $(V/2 - B - K)^2 = V(V^{RM}(\infty) - 2K)$. Solving this equation one can check that

$$\widehat{K} = V\Big(\sqrt{\tfrac{2B+V^{RM}(\infty)}{V}} - \frac{1}{2}\Big) - B.$$

To conclude we have just shown that conditions (a), (b) and (c) are satisfied for any $K \in (\widehat{K}, \frac{V^{RM}(\infty)}{2})$, which is a non empty set. Finally note that, because $F(\infty) \geq 0$, $K \leq \frac{V^{RM}(\infty)}{2}$ (i.e., condition (c)) is implied by the condition $R^{\infty} > F(\infty)$ (i.e., condition (ii) in Proposition 3).

This complete the proof of proposition 3. It is independent of the cost distribution.

Appendix 3: Condition C1

Lemma 6 is true as soon as $K^{RDI/PD}(\lambda) \geq K^{PD/PM}$. This is equivalent to

$$\frac{18(1+\lambda)^2}{(1+2\lambda)(16+5\lambda)} V^{RDI}(\lambda) \geq V + \frac{1+2\lambda}{16+5\lambda}\frac{11\sigma^2}{2b}.$$

Let $v(\beta, \lambda)$ be the virtual cost $\beta + \frac{\lambda}{1+\lambda}\frac{G(\beta)}{g(\beta)}$. Simplifying by $2b$, C1 is equivalent to:

$$\frac{18(1+\lambda)^2}{(1+2\lambda)(16+5\lambda)} E_{\beta^{min}}\left[(a - v(\beta,\lambda))^2\right] \geq E_{\beta}\left[(a-\beta)^2\right] + \frac{(1+2\lambda)11\sigma^2}{16+5\lambda}.$$

Let $h(\lambda) = \frac{18(1+\lambda)^2}{(1+2\lambda)(16+5\lambda)} - 1 = \frac{2-\lambda+8\lambda^2}{(1+2\lambda)(16+5\lambda)} > 0 \ \forall \lambda \geq 0$. Let also $\Phi(\lambda) = E_{\beta^{min}}\left[v(\beta,\lambda)^2\right] + \frac{E_{\beta^{min}}\left[(v(\beta,\lambda)^2\right] - E_{\beta}\left[\beta^2\right]}{h(\lambda)} - \frac{(1+2\lambda)11\sigma^2}{(16+5\lambda)h(\lambda)}$. The condition C1 is equivalent to:

$$a^2 - 2a\left[E_{\beta^{min}}\left[v(\beta,\lambda)\right] + \frac{E_{\beta^{min}}\left[v(\beta,\lambda)\right] - E\beta}{h(\lambda)}\right] + \Phi(\lambda) \geq 0.$$

This condition, which requires that a is large enough, is not very strong. For instance, one can check that with an uniform distribution over $[0, \overline{\beta}]$, and with the convention that $a = A\overline{\beta}$, condition C1 is equivalent to: $H(A) = 12A^2(8\lambda^2 - \lambda + 2) + 12A(4 - 7\lambda)(1 + 2\lambda) + (1+2\lambda)(44\lambda - 59) \geq 0$. Under the assumption A1 (i.e. $A \geq 2$), it is easy to check that $H(A)$ is increasing in A for all $\lambda \geq 0$. We deduce that $H(A) \geq H(2) = 136\lambda^2 - 98\lambda + 133 > 0$ $\forall \lambda \geq 0$. So, for a uniform distribution, assumption A1 is a sufficient condition to get C1. More generally, let

$$a^l \equiv E_{\beta^{min}}\left[v(\beta,\lambda)\right] + \frac{E_{\beta^{min}}\left[v(\beta,\lambda)\right] - E\beta}{h(\lambda)}$$

$$+\left\{\left[E_{\beta^{min}}\left[v(\beta,\lambda)\right]+\frac{E_{\beta^{min}}\left[v(\beta,\lambda)\right]-E\beta}{h(\lambda)}\right]^2-K(\lambda)\right\}^{1/2}.$$

If a is larger than a^l condition C1 is satisfied.

Appendix 4: Proof of Proposition 7

First of all recall that $K^{RM/RD}(\lambda)$, defined equation (24), is the value of the fixed cost such that the government is indifferent between a regulated monopoly and a regulated duopoly (i.e. such that $EW^{RM}(\lambda) = EW^{RD}(\lambda)$). A regulated monopoly is preferred to a regulated duopoly if and only if $K \geq K^{RM/RD}(\lambda)$ defined equation (24). Similarly a regulated monopoly is preferred to no production whenever $K \leq K^{RM}(\lambda)$, defined equation (25). It is preferred to privatisation whenever $K \leq K^{RM/PM}(\lambda)$, defined equation (26). Comparing equations (25) and (26) one can check that $K^{RM}(\lambda) > K^{RM/PM}(\lambda)$. Moreover using the fact that $g^{min}(\beta) \leq 2g(\beta)$, one can check that $V^{RD}(\lambda) < 2V^{RM}(\lambda)$ so that $K^{RM}(\lambda) > K^{RM/RD}(\lambda)$. We deduce that if $K > K^{RM}(\lambda)$ regulation is never optimal. On the other hand if $K > \frac{V}{2}$ privatisation is not possible. Putting all the pieces together yields the result.

7 Acknowledgement

Pierre Picard's work has been supported by a grant "Actions de Recherche Concertées" n° 93/98-162 of the Ministry of Scientific Research of the Belgian French Speaking Community. We are grateful to Amir R. and Michael Warlters for improvements of the paper. We are especially indebted to Antonio Estache for detailed, insightful comments and very helpful references. Any remaining errors are our own.