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And management contract as a limit case

Joel Ruet

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Development Studies Institute

London School of Economics and Political Science

Houghton Street

London

WC2A 2AE UK

Tel: +44 (020) 7955 7425/6252

Fax: +44 (020) 7955-6844

Email: d.daley@lse.ac.uk

Web site: www.lse.ac.uk/depts/destin

The Real Option Approach to Privatise a Utility Where Information is Scarce [1]

And management contract as a limit case

Joel Ruet

Marie Curie Research Fellow, DESTIN, London School of Economics, j.ruet@lse.ac.uk

& Associate Researcher, CERNA (Centre for Industrial Economics), Ecole des Mines, Paris, ruet@cerna.ensmp.fr

Summary

Reform of utilities in developing countries is often impeded by information problems, including asymmetries and costly production of hidden information. This constitutes a major drawback for privatisation due to low commitment, a small number of bidders and a low level of monetary offers. We propose to present in this paper a tool to solve these problems on the basis of a real option. Our proposal formalises an idea suggested by Goldberg (2000), who, though in a different context, interpreted some contract clauses as real options in the case of the "sale of an asset of uncertain value".

Key Words: Information, Privatisation and Real Option.

Introduction

In most former command economies and developing countries, the operation of utilities does not follow commercial principles. The reforming of these utilities is consequently often hindered by information problems of a large magnitude that include not only asymmetries but also costly production of hidden information. Literature on corporatisation (for instance, refer to Shirley & Xu, 1997) also explains how weak and bureaucratic information systems impede the proper monitoring of reforms, not only by the state but also by funding agencies. On a pragmatic level, economic literature

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advocates the transfer of ownership for the better enforcement of contracts. For instance, in situations of low enforceability that prevail in command and developing economies, Shleifer (1995), even though he recognises the theoretical pre-eminence of contract enforcement over control structures, favours the transfer of ownership, essentially for better control. However, our paper points out that there is another impact of information problems that persists even after privatisation. Poor information systems and the organisation's or its agents' lack of experience regarding functioning in a commercial environment are a major drawback for such privatisations, the principal elements being low commitment, a small number of private investors and a low level of monetary offers. We propose in this paper a tool to solve this drawback on the basis of a real option. Our proposal formalises an idea suggested by Goldberg (2000), who interpreted some contract clauses as real options in the case of the "sale of an asset of uncertain value".

The model is as follows: the government wants to privatise a utility, but realises that given the current lack of information regarding costs and revenues, the price K_1 would be very low. So it considers a privatisation process in two stages in which:

- At t=0, the state offers to a private firm, which may be a potential buyer, the *option* to buy the utility. At the outset, the buyer pays a premium C for this option; the option has an exercise price of K_2 fixed by the state before starting the process at t=0 (the firm takes this into account when it decides whether it wants to buy the option).
- The potential buyer will manage the utility on the government's behalf during period 1, and invest in the utility in order to restructure its information system and collect private information on the utility's value. During this time, the state restrains itself from privatising the utility (this lock-in clause is covered by the cost C paid by the firm).
- At the end of that predetermined period, when much more information is available about the costs and revenue of the utility, the firm can take a second decision – whether it wants to acquire the utility for the predetermined price K_2.

Chevalier, Lee Bernham, Jean-Paul Faguet as well as for the many comments received during the International Conference of New Institutional Economics, 2002, in MIT, Boston. All inaccuracies remain of course mine.

- If the firm chooses to do so, the state will sell the utility to the firm for K_2. If the firm chooses not to exercise the option, it is no longer valid and the state either enjoys the income from the utility or sells it through a classical privatisation procedure[2,3].

In this article, we have compared direct privatisation and the real option in order to determine how the state can extract the highest value from the sale, and examine how K_2 compares with K_1. Given the initial uncertainty regarding the utility's value, our paper shows that it is advantageous for both the state and the firm to go in for an *option-cum-management contract* in preference to direct privatisation. It then briefly discusses the possibilities of optimising the option parameters (its premium and strike value) in accordance with objectives other than revenue maximisation. We will first take up a simple case instead of discussing the question in general terms (Sections 2 and 3). We will use the model to establish the continuity between management contracts and privatisation (Section 4) and conclude by suggesting ways of modifying the model in case of a multi-zone (or multi-state) privatisation perspective. Prior to this, Section 1 outlines the reasons why we decided to model the uncertainties regarding the value of a utility and linking the existing literature on information and organisations with the example of the State Electricity Boards in India.

I. Utilities of Developing Countries as Goods of Unknown Value: India's Case

Utilities of developing countries are often shown as facing a bi-polar dilemma: prolonging financial losses under public ownership vs. giving up responsibility by transferring control to the private sector, seen as a panacea (refer, among many others, to Niskanen, 1975; Galal & Shirley, 1995; for India, refer to Morris, 2003; or Sinha, 2003). It is argued that the root of the problem in the management of public utilities lies in the fact that "if a complete contract cannot be written in advance between the bureaucrat and the entrepreneur, the bureaucrat can expropriate profits from a business by threatening

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[2] In the first stage, both situations are equivalent in terms of cash flows for the state once the firm has revealed the utility's value.

[3] Clearly, ex ante the state is the master of the game, since it is in a position to fix the values of C and K2 in order to maximise any parameter it wants (its own revenue, the consumers' well-being, etc.).

to shut it down; anticipating expropriation by bureaucrats, entrepreneurs underinvest", as pointed out by Shleifer (1995). More precisely, Shleifer & Vishny (1994) separate the two aspects that should be tackled by reforms: (i) inefficient control structures (control rights and cash flow rights allocation) and (ii) poor enforcement contracts. They point out the theoretical pre-eminence of (ii) over (i), by arguing that "with enforceable contracts – whether they result from Coasian ex post renegotiation or Grossman-Hart style ex ante renegotiation – people arrive at (constrained) efficient outcomes."[4] So "Inefficient control structures do not prevent efficient outcomes so long as contracts are enforced." However, in practice, Shleifer (1995) argues that the "difficulty of enforcing contracts of any kind in many reforming economies suggests that relying on contract enforcement may be a poor strategy for establishing property rights in the first stages of reform." Literature on regulation and contracts enforcement in utilities focuses a great deal on accessibility to information and its credibility. Shleifer (1995) followed by many others then works on (ii) rather than (i) for prescriptive solutions. These measures are mainly intended to shift the control rights from politicians/bureaucrats – as "both use their control rights to produce inefficient outcomes that serve their personal goals" – to firms and, even better, to shareholders.

The problem, however, is that under this particular political economy of reforms, privatisers expect the investor not only to do the job of managing the utility but also bid for the organisations, even though the latter are supposed to be wasteful. This carries a serious risk of low valuation from the outset of the bidding process. Indeed, the selling value represents the ex ante perception of future benefits and therefore the perception of margins for cost-efficiency improvement. In a developing country, assumptions regarding future scenarios are all the less certain (see Levy and Spiller, 1994) and likely to lead to a high variation in valuation between different hypotheses; making the right assumptions is thus a key aspect of the bidding process. Further, when it is a matter of assessing the nature of a utility's present assets, it is important to know how stranded are the former public expenditure and to what extent the poor information system of utilities in developing countries contributes to the decrease

[4] Grossman-Hart style ex ante renegociation concerns re-allocation of control rights.

in their value in the bidders' eyes. The latter question is usually viewed from a post-concession perspective by economic literature (Burns, 1999; Shirley & Xu, 1997; Ménard & Shirley, 1999; Brousseau & M'hand, 1998), but we maintain that there is more to it.

A serious problem: *absence* of information in an administered context

Besides regulatory risks and information asymmetry between the seller and the buyer, that have already been analysed in classical literature, we would like to draw attention to another kind of uncertainty regarding information that may create a problem in the utilities of some developing countries and those in a state of transition. An initial understanding of this problem can be obtained from the writings of Jiahua Che & Yingyi Qian (1998). They have developed a formal model in which governments expropriate "observable" benefits at the end of the process and where there is a possibility of *hidden profits*; Jiahua & Yingyi prefer to call them "unobservable profits". Jiahua & Yingyi depart from the classical perception of information asymmetry in the sense that this asymmetry is no longer between the state and the public, nor between the firm and the state, nor intra-firm. It is a general asymmetry between all these levels that gives rise to a system of crossed-asymmetries. As many writers on Chinese reforms have pointed out, this occurs because property rights are diluted between different levels within the organisation and more or less shared as against being appropriated according to the type of asset. So according to the definition proposed by Jiahua & Yingyi ownership "provides the owner with the control rights over a firm's books and accounts, thereby allowing him to hide and receive unobservable parts of the revenue". They then go on to deal with "insecure property rights".

We wish to model a similar case where the information system has initially been designed for purposes other than the identification of costs and benefits, cost-efficiency, or tracking commercial parameters. Cyert & March (1963) recall that, although recurring general features related to the fixing of rights and duties can be observed in all organisations, every organisation has its own type of information system. The latter is consubstantial and even specific to the type of activity and to the organisation's goals. Cyert and March actually generalise on the basis of the work done by Simon (1947) on government organisations. Information systems are structured locally (at the level of organisational units) and then more or less coordinated with or integrated into a larger information system (at the level of the entire organisation), depending on the nature of goals, the modes of sanction in decision-making and the modes of control (checks) to which the organisation is subjected. In other words, *information is not produced per se* but (i) locally produced only along certain lines (information will be produced on some parameters while some others will not even be considered) and (ii) there is a selection between the kind of information that will be maintained for local use and the information that will be integrated for use by the hierarchy. These approaches receive a fully formalised treatment in the works of James March (1978 & 1987). As far as utilities are concerned, Figueiredo, Spiller and Urbiztondo (1999) and Iyer (1992) have provided examples in support of this this argument. In particular, in organisations that are managed more along administrative and political lines than in view of costs, this allows room for production of information that is quite different from what is expected by private enterprises. For instance, there may be situations where information about some costs is either not produced (because decision-making organs deal with public expenditure and ex post facto renegotiation under soft budget constraints) or it remains local and particularly because it is not integrated in a way that would take into account all the costs linked to a decision, from the perspective of *all* the units of the organisation. Some information may be produced ex post, only for disciplinary control, and it may not be compared to 'commercial' parameters, or the latter may simply not exist. Further, different localised systems of information may produce different figures of the same magnitude that are used in different situations or under different types of arbitrage. In such a case, a part of the information required by a private firm may become structurally unobservable or at least not observable when there are other competing information sources. Adopting this framework, we will deal with a problem that is quite different from simple information asymmetry.

Let us illustrate this through the example of the privatisation of electricity distribution in India's capital, Delhi. Until its privatisation, power was generated and distributed by the Delhi State Electricity Board (SEB), a vertically integrated body that had functioned for a long time as a department of the Ministry of Power and later administered by a "Board of Members", still dependent on the state and having all the characteristics as well as the status of a government department (Ruet, 2004). SEBs in India, like utilities in many other developing countries, have been used for political purposes of land integration and inter-sectoral or social redistribution (Chakrabarti, 1987). They have not been exempt from populist tariff measures and electoral timeframes leading to cost-ineffective technical choices, clientelism in job appointments and non-payment of dues owed to other public sector undertakings (Quraishi, 1998; World Bank, 1997; Government of India, 1998, together with other reference material on a situation that is very well documented today).

The present cost-inefficiency of these measures is less important for us than their structural impact on the information system that the SEBs have developed over a period of time. Since they have been assigned these kinds of goals, they have never focused on cost-efficiency and their budgetary and reporting systems have developed along modes other than those directed towards development and production of cost-oriented information. For instance, it is possible to change decision-making in SEBs presently based on the style public accounting followed in government departments. Budgets are not really allocated to field units, nor appropriated by them; 'budgets' are really provisions to be spent ex post, only after obtaining hierarchical sanctions (Ruet 2001 & 2002). In view of this style of public accounting practised in the SEBs, the book-currency budget or paper budget simply precludes decentralisation of decision-making down to the local units where it would be efficient and prevents project-based evaluation. It structurally revolves around technical sanctions and not cost-benefit analyses. This system did have a rationale at one time. Indeed, all these aspects are peculiar to a developing country where information is costly in relative terms, qualified human resources are scarce and where *standardised* schemes (not needing any cost-benefit comparisons) are preferred at a time when the country needs to build its infrastructure. But after this phase of expansion is over and when network industries have attained maturity, the management of utilities should be based on a more decentralised, local-specific and cost-efficiency centred decision-making process. In such a context, there is no real procedural need for developing an information base to measure local inefficiencies. The centralised system, despite having objectively become the very core of cost-inefficiency, had also procedurally legitimised the absence of project-based cost-benefit analysis. Indeed, monitoring could be done by adjusting the variables of global public expenditure.

In practice, the reporting system has been formulated keeping in mind the standardised, centralised, *technical* and *administrative* needs. The information system in SEBs can be described as non-integrated, meaning that it does not openly reveal the balance between inputs and outputs or compare the quantum of energy delivered with the energy billed or the energy that is paid for. Technical issues (repairs), physical measures (energy), commercial aspects (billing, revenue) are neither juxtaposed in any report nor are they shown under their respective heads in the accounts. The accounting system itself is filled with statements and statistical information instead of accounting entries (Ruet, 2004). Indeed, in the Indian case, most of the energy consumption has not been metered for a long time, not only at the customers' level but also at the level of transforming substations and feeders. As a matter of fact, apart from localised energy audits, no SEB in India has till date the means of knowing the exact level of energy losses. Further, in order to allow and hide malpractices and bribes, there is mis-reporting about the amount of energy charged against a substantial number of unmetered consumers. Finally, even the billing and dues are rarely monitored strictly by the accounting wings of SEBs[5] (see World Bank, 1997, Government of India, 1998 and Government of Andhra Pradesh, 1996). In such a situation, where the information system does not allow a comparison between energy quantities and money receivable nor allocates costs to decisions (see Ruet, 2002), assessment of losses depends on astute assumptions. Further, even estimating the time needed for improving the information system and then allowing implementation of information-based managerial tools demands a great deal of skill.

In this context, the very reasons which were found to be at the root of cost-inefficiency have also led to the continuation of a stringent deficit of information regarding costs. This scenario obviously has a strong impact in a case of straight away privatising such utilities because evaluating the organisation would mean assessing the level of initial losses, the shape of the consumers' portfolio, the technical

[5] Especially, dues to be collected or receivables can seldom be related to specific consumers or to clearly identified periods of time.

status of equipment and so on. No information of this kind is available and this raises several problems, especially when privatisation processes neglect this aspect (some of the first notable exceptions in the literature can be found in Jones, Tandon & Vogelsang, 1991; Vernon, 1991; or Nellis, 1991, though the latter refers more explicitly to management contracts). But what is worse, even if they were to be estimated through audits, the margins of progress related to the modification of internal managerial structure would still remain unknown. For instance, knowing how fast cost centres (then profit centres) can be established, that is how fast the public accounting system can be replaced with project-based analytical accounting, would turn out to be a key parameter for evaluating such utilities. However, information regarding the level or the perception of costs by agents or their capacity to make cost-based decisions cannot be assessed given the current lack of records of such behaviour. In other words, and to explicitly compare with privatisation, the informational investment is of two kinds and we model one. Indeed, before any privatisation, the government has to invest in reforming the utility's accounts in order to prepare it for privatisation. This constitutes a first type of informational investment, that relates to minimal standard requirements for valuation and to a minimal conversion from public accountancy rules to commercial accountancy rules. On the first order, this investment is to be done in a similar manner by the government whether one considers selling the utility or selling an option to buy. What we model is thus not discriminate at this level. However, there is a second type of informational investment which is necessary, and which is more directly related to industrial processes and commercial procedures, and is usually both heavier and more time consuming. The final profits and hence value of the utility are related to the success of these investments. The crux of our model is thus that:

- (i) the *control rights* over this investment is transferred to the private in a case of option compared to a direct privatisation, and
- (ii) even if the sequence in the valuation process is maintained, the valuation of the option is done knowing that the investor shall nor fear asymmetric information, nor a 'bad surprise': the investor deals with conditional probabilities.

Whether the financial burden on this type of informational investment is borne by the State or the investor is relevant only at the second order (and even not at all if we assume on this point no transaction costs on the sharing of the benefits); in other words it is really an issue of control rights more than cash flow rights, as theory of property rights predicts.

In Delhi, privatisation did take place in spite of this lack of information. The Delhi Vidyut Board (DVB) and the Delhi Electricity Regulatory Commission have tried to collect some of the requisite information. Before privatisation, they agreed on and publicly acknowledged a 54% level for energy losses for the capital city after a series of (localised) energy audits. However, it took a long time to establish this transparency. Until 2000, the Delhi SEB used to declare 23% energy losses, then as a first step, it gradually admitted it to be 43% in 2001 and, finally, only at the time of privatisation did it admit that the actual losses were 54%. This illustrates how, in addition to the classical regulatory risks (tariff issues, technical regulations, etc.) that can be foreseen and provided for, serious uncertainties may still persist. Indeed, in a context where metering and reporting are relatively costly (at the consumer level) and are partly subverted in an administrative, influence-seeking and leakage-hiding scenario (which encourages the absence of metering even at the substation level as well as widespread mis-reporting), there are two interrelated problems in the evaluation of utilities. One is dealt with in the classical manner, and we will mention it only briefly, while focusing more specifically on the second:

- Even when regulation tries to insulate the investor from the initial conditions and regulatory risks (which was attempted in Delhi), it will be very difficult to make the Regulatory Commission acknowledge ex post that the initial levels were assessed incorrectly. This may have happened in Delhi in the case of the Central East company which claims that, with a figure of 61.89 % for energy losses in 2002-03, it has not underachieved, but has in fact revealed the actual figure of losses instead of the earlier assessment of 57.2%. Whether the DERC acknowledges this or not is vital for the financial strength of the company, while a strict check is vital for the regulatory process. Another example will be the Regulatory Commission’s assessment of capital expenditures and asset creation to be repaid under a cost-plus principle through tariff demands; DERC (2003, pp 69 to 73) claims that the Commission is sovereign in this matter. So it is not possible to insulate investors fully against regulatory risks.

- What is more central to our paper is the fact that valuation depends on *progression margins*, as well as on *hypotheses on the speed of restructuring of the reporting system*, diffusion of managerial tools and the staff's ability to adapt to them. The main difficulty is that this has to be assessed on the basis of a reference scenario where nothing similar has occurred earlier and there is, therefore, neither any benchmark nor any way of anticipating the 'reasonable' adapting capacities of the SEB's agents or extrapolate on them. This second aspect makes it almost impossible to foresee and assess the dynamics of change. We will take special note of the effect the internal organisation can have on decision-making.

Compared to a situation where a public enterprise having a minimal information about costs and few cost-based decision-making processes is being privatised, the scenario in Indian SEBs is quite different. In the former case, the costs would provide an estimate for progression by treating other companies as benchmarks. The existence of cost-based procedures would ensure that, even if the system of internal incentives were changed, the behaviour of employees would tentatively favour cost reduction. In the case of Indian SEBs, on the other hand, benchmarking is simply impossible and there is no way to anticipate how workers and staff will react to an economic system of incentives when they have always been subjected to a centralised administrative system. Without going into greater detail, we may state that the importance of the internal organisation in decision-making has been widely established in economic literature (Ménard & Clarke, 2000; Williamson, 1994 & 1999). But anticipating how much and how fast a change in the internal structure would lead to a change in behaviour is still very difficult. It is just impossible to reform overnight the structuring role of accounting norms and procedures in decision-making regarding cost-efficiency and, more specifically, the "elusive link between information and decision-making" (March, 1987).

To sum up, the privatisation of such utilities is characterised by the extreme uncertainty about their present shape and situation, doubled with a radical impossibility of foreseeing their development on the profit front, even if political and regulatory risks are taken care of. Since the value is determined by present assets and future incomes, what we have here is *a good of uncertain value*.

Dealing with goods of uncertain value

While discussing legal judgements in the case of US land transactions involving a land seller and a land developer, Goldberg (2000) deals with the problem of "production and transfer of information regarding the sale of an asset of uncertain value". Typically, in the first case described in his paper, a piece of land is sold, whose exact value will be known only after the buyer invests some money in gathering specific information about the real estate market. Goldberg points out that in this particular case, since his job is in the real-estate field, "the buyer is the most efficient provider of certain pre-sale information". He further argues that in such a case "the parties might agree to give the buyer the option to buy while he collects further information", granting the buyer a "lock-up provision". In order to establish and explain the rationale for selling such an option, Goldberg discusses how other modes of contracting collection of information (where for instance the seller would just pay or repay the buyer for collecting information), run the risk of being stained with moral hazard. Further, unless the buyer has an option to buy, he bears a risk of expropriation if he has no guarantee he can benefit by the outcome of his effort. In short, in such a scenario, *a mechanism of value creation arises* from the fact that "if the new information sufficiently enhanced the seller's credibility, the seller could receive more from the enhanced sale price of land than he would from the payment to the prospective buyer" according to Goldberg. He adds, "that is, the exercise price of the option is higher because the buyer and seller know that if the property turns out to be less desirable, the buyer can walk away".

Let us briefly discuss the scope and relevance of real options in economic transactions, even though they have not been advocated for reforming utilities in developing countries. Goldberg points out that "real estate transactions routinely make the transaction contingent upon information that would be developed after the contract has been entered into". Since Kester (1984) has demonstrated the value of integrating dynamic options to exit from or speed up or reframe a project, the field of application of real options has mushroomed. For instance, in the mining and oil industries, the real value of a mine or an oilfield is known only after it is developed, its production stabilised and after further information is collected as the mine or oilfield is being operated. Developing such information beforehand is costly unless it is balanced by returns and guarantees for these returns. This information is usually developed by the concessionary company and not by the country granting the concession contract. As a matter of fact, Galli & Armstrong (1997 & 1997a) and Armstrong, Bailey & Couët (2003), cite examples of the use of real options to evaluate the opportunity of developing further pre-sale information, and to frame relevant contracts in the oil industry. Real options are used in fields diverse as R&D, pharmaceuticals, biotechnology, IT and aircraft sales. We will propose yet another application.

II. Simplified Model: The Use of the Real Option to Reveal the Potential of a Good of Unknown Value

Assumptions and notations

Let X_n denote the cash flow in the nth period from (n-1)T to nT. As these are uncertain, they will be modelled as random variables. Since, the government fixes the tariffs in the public sector, we will assume that they are fixed so as to ensure that cash flows will always be positive. Similarly, under the present regulatory regimes, various systems of pass-through and cost-plus also help in the case of private ownership. And this can also be contractually ensured under a management contract form. [6] Moreover, they are assumed to be independent, identically distributed with mean M and variance σ^2. Let F and f respectively denote their cumulative distribution and their density. At the end of the first time period 1, more information will be available. Subsequent cash flows X_m for $m \geq 2$ will be known then (i.e. zero variance). Let X denote this value. Very little is known about its distribution. But we are prepared to assume that its minimum possible value is 0 and that the government would intervene to change tariffs if it was too high. Let X_{max} denote the maximum that is politically acceptable. We

[6] This assumption can actually be relaxed in most cases unless we also compute the tax on profits in which case positive profits simplify the mathematical expressions. However, even in this latter case, this assumption does not alter the general nature of the results.

assume that the prior distribution of X is F (i.e. the same as for X_1)[7]. The firm also has to invest I in order to restructure the utility's information system.

The choice of the discount rate is important when computing the present value. We assume that the government can borrow at the (local) risk free rate i_1 whereas the firm's weighted average cost of capital (WACC), i_2, is higher than i_1. The firm would use its WACC to discount risk free cash flows but increase the discount rate as a function of the variance of uncertain cash flows. If $\beta(\sigma_1)$ denotes the risk loading, then its discount rate would drop from $i_2 + \beta(\sigma_1)$ (with no additional information) to i_2 after additional data becomes available.

When computing the various discounted cash flows, we will often need sums of the discount factors. To simplify the notation, let S(i,n) denote the sum

$$S(i,m) = \sum_{n=m}^{\infty} \frac{1}{(1+i)^n} = \frac{1}{i(1+i)^{m-1}}$$

So

$$S(i,1) = \frac{1}{i} \quad \text{and} \quad S(i,2) = \frac{1}{i(1+i)}$$

Simple Model

In order to clarify the mechanism in action, let us first consider a very simple version of the model. We will consider and compare two different strategies of reform: one the one hand, the state decides to privatise at t=O. On the other hand, the state decides at t=0 to sell a buying option to a firm. The firm realises the investment made for collecting information and bears X_1, the cash flow of the first period of the privatisation/management contract (the potential losses of the first year of operation[8]). Let us combine the investment to be made for collecting information and the initial loss X_1. X_1 is included in I.

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[7] The simplest choice is to let both distributions be uniform between 0 and X_{max}. In Bayesian analysis this corresponds to a non-informative prerequisite. However, until the numerical analysis is done, we will retain an unspecified form for f.

[8] This allows us to relax the above-mentioned condition that is credible to a limited extent during the first year.

Then at end of period 1 the firm knows the value of X and decides whether it wants to exercise the option or not. We consider that the model is simple because we have assumed that the risk-free rate is the same for the state and the firm, equal to i. The firm uses a risk prime $\beta(\sigma_1)$ since future cash flows are uncertain. The function β increases with σ_1. Further, in this simple version σ_1 is considered as equal to 0 after period 1, when the profits are fully known thanks to I. The latter two hypotheses (where i is common and β=0 after period 1) will be relaxed later in the fully developed version of the model.

Immediate privatisation (at t=0)

Since privatisation occurs before the possibility of realising the investment on information-collection is clear, there is uncertainty, seen from t=0, regarding all cash-flows (in practice they will be known at the end of t=1, but since privatisation takes place at t=0, they have to be discounted by β in addition to i).

Firms make a bid only if their NPV is positive. Competition between firms leads to the selling price by solving the following equation:

$$E\left(\sum_{2}^{\infty}\frac{X}{(1+i+\beta(\sigma_1))^n}\right)-I-K_1=0$$

$$\frac{1}{1+i}\cdot\frac{M}{i+\beta(\sigma_1)}-I-K_1=0 \text{ where M is the mean of X.}$$

The net present value for the state, on the other hand, is K_1.

$$\boxed{K_1=\frac{M}{(1+i)(i+\beta(\sigma_1))}-I} \quad (1),$$

where I includes X_1.

With an option (purchase at t=0 and exercised at end of period 1)

Buying and exercising the options happens at two different times. At t=0, the firm buys the option if, and only if, the expected gains, seen from t=0, are equal to 0 (or >0, but with a hypothesis of perfect competition, it is equal to 0). The corresponding cash flows are still discounted by using the term $i+\beta(\sigma)$, since related cash flows are uncertain as seen from t=0.

At the end of period 1, the firm takes the decision to exercise its option by considering only the future results (and no longer what was spent at t=0). Seen from end of period 1/beginning of period 2, in our simplified version, uncertainty disappears completely and the series (X_n) gets a certain value of X_2. For the second decision (whether to exercise the option or not) the firm only considers certain values at t=1. Importantly, seen from t=0, it knows that the second decision to exercise the option will be linked only with certain values and it cannot afford to lose money at that time.

The firm exercises the option at beginning of period 2 if and only if: $-K_2 + \frac{X_2}{i} > 0$

$$\boxed{X_2 > iK_2} \quad (2)$$

and with denoting $k_2 = iK_2$, $\boxed{X_2 > k_2}$ (2 bis)

The probability that the firm will exercise the option is 1- $F(k_2)$ = p ($X_2 > k_2$), while the probability that it will not exercise the option is $F(k_2)$ = p ($X_2 \le k_2$). This is independent of the value of C.

Conversely, the value C of the option depends on K_2 and can be calculated from t=0. Let us therefore calculate the expected present value for the firm as E(PVfirm).

Ex post, if the firm exercises the option, its EPV at t=0 is:

$$E(PVfirm) = \sum_{2}^{\infty} \frac{X}{(1+i)^n} - \frac{K_2}{1+i} - I - C$$

Conversely, ex post, if the firm does not exercise the option, its EPV at t=0 is:

$$E(PVfirm) = -I - C$$

Ex ante,

$$E(PVfirm) = F(k_2)\cdot(EPV / X < k_2) + (1 - F(k_2))\cdot(EPV / X > k_2)$$

On the basis of the last three equations, we get the following ex ante revenue of the firm:

$$E(PVfirm) = -I - C + (1 - F(k_2))\cdot\left[S(i,2)E(X / X > k_2) - \frac{K_2}{1+i}\right]$$

$$E(PVfirm) = -I - C + (1 - F(k_2))\cdot\left[S(i,2)E(X / X > k_2) - i\frac{K_2}{i(1+i)}\right]$$

$$\boxed{E(PVfirm) = -I - C + S(i,2)\cdot(1 - F(k_2))\cdot(E(X / X > k_2) - k_2)} \quad (3)$$

The firm will buy the option ex ante and enter into a contract if, and only if, its EPV is positive or nil (and with perfect competition, when it is nil).

C solves equation E(PVfirm)=0 and we get the "value" of the option, C*, the limit above which the firm does not buy the option (though this equation does not help to calculate the firm's NPV, which is deduced after a prior optimisation by the state of its own revenue, as it is explained later in this paper):

$$\boxed{C^* = -I + (1 - F(k_2))\cdot\left[S(i,2)E(X / X > k_2) - \frac{K_2}{1+i}\right]} \quad (4)$$

This equation allows us to formalise and describe a problem raised by Goldberg (2000) in his article. It shows that the seller ultimately bears some of the information-collection cost in the negotiated *call* price, and not necessarily in the exercise price, as Goldberg indicates[9]. However Goldberg's intuition is right in the sense that, one way or another, the seller has to bear the cost of I. Still, we can, conclude with Goldberg that "the buyer bears all the direct costs of information production and, therefore, has the incentive to economize". The real option model is economically advantageous in these respects, and does not involve any moral hazards.

If we now calculate the state's revenue, we get

[9] Indeed, the way we have designed the model, the second decision, to be made ex post, is independent of the decision to buy the option. The investment I made during the second stage is considered lost.

$$\boxed{E(PVstate) = C + S(i,2)\cdot\left[(1-F(k_2))\cdot k_2 + F(k_2)\cdot E(X/X<k_2)\right]} \quad (5)$$

Total expected value and creation of value in comparison with direct privatisation

The central question raised by this model is whether privatisation generates overall value by capitalising on the information obtained, that is by privatising only if profitable. Let V denote the total expected present value for the project (i.e. firm + government).

In case of direct privatisation $\boxed{V_0 = \frac{M}{(1+i)(i+\beta(\sigma_1))} - I}$

By adding equations (3) and (5) we get the total net present value for the state and the firm in case of using option:

$$E(PVtot) = -I + S(i,2)\cdot\left[(1-F(k_2))E(X/X>k_2) + F(k_2)E(X/X<k_2)\right]$$

$$E(PVtot) = -I + S(i,2)\cdot E(X)$$

That is, in case of using option, $\boxed{V_1 = \frac{M}{(1+i)\cdot i} - I}$ (6)

We get the creation of value: $\boxed{\Delta V = \frac{M}{1+i}\cdot(\frac{1}{i} - \frac{1}{i+\beta(\sigma_1)})}$ (7)

With $\beta(\sigma_1) > 0$, we get $\Delta V > 0$.

Hence proposition 1:

Using an option does create an ex ante value by ensuring ex post that decisions taken by the firm after period 1 are risk-free from the information point of view (once again, we are not dealing with classical regulatory and business risks here).

The amount of value creation is equal to the difference between a risk-free and a risky scenario (with a factor $\beta(\sigma_1)$), discounted from period 1, since the creation of information occurs at t=1.

If we study the sensitivity of this result to the assumptions we have made, the principal assumptions that matter in the discussion are:

- We have taken σ_2 as equal to 0; a positive value for σ_2 simply lowers the profit but does not alter the mechanism of value creation.
- We have made some calculations by equating C to C^*, whereas the state, in framing the rules of the game, has many other ways to fix it (similarly for K_2). At the first stage, since these two values correspond to financial transfers from the firm to the state, this does not *directly* alter the total expected value, but only the respective values and the share in value creation, which we shall discuss in the next sub-section.
- However, the level of C and K_2 are not totally neutral in the way the game is conducted and they have an *indirect* influence. Having higher control rights, the state decides these parameters and the game is determined (in expected value) once the firm has made assumptions regarding the form of distribution f and therefore F. But in this case, C and K_2 must be in a certain range for the firm to agree to play the game; there are some conditions that are necessary for the firm, which may be relaxed into sufficient conditions. They are *dependent on the form of the distribution for X*, and the state must take the firm's anticipation into account in order to fix these values, which we shall discuss later in the paper (especially, when the distribution is neither uniform nor Gaussian, the time of distribution is important).
- Further, it is interesting to see what happens in case the firm finds that $X<iK_2$: it will not exercise the option and two possibilities are likely to occur. Either the state will run the utility or it will propose a bid to the firm, free from the option clauses. In the model, we have equated in the State

NPV the value after period 1, taking into account this value of X. This is true only under strict conditions: if the state runs the firm, it implies that the state (i) has this information on X and (ii) it is able to update this value (which means that it is as efficient as the firm), which may not be the case. In order to solve this problem and to have a model where we can really compare equivalent final scenarios, we will assume that the game is as follows: if $X<iK_2$ (if the firm does not exercise its option), then the state goes in for a classical bidding process and, because of competition, gets the actual value corresponding to the actual X. So what happens in such a case? If the firm is finally able to manage the utility by knowing X, value creation is maintained and the social benefit remains identical to our simple model. However, in terms of a share of the profits of the private firm, an identical share supposes that (i) there is no asymmetrical information between the initial firm and the state (the firm has no opportunity to 'bluff', nor (ii) are there any asymmetries between the firm that has been awarded the contract and other potential buyers at stage 2. If one of these conditions is not fulfilled (if we are in the presence of newly created private information), the *allocation* of profits is changed. But, if privatisation is allowed even if the option is not exercised, the *results of the creation of value stand true.* We will deal later with the competition issue in this paper.

<u>Share in value creation</u>

Let us now compare the net present value for the state (in direct privatisation the state gets K_1).

Let us recall that here we assume $C=C^*$ (refer to prior discussion).

For the state,

$$\Delta E(PVstate) = C + (1 - F(k_2)) \cdot \frac{K_2}{1+i} + F(k_2) \cdot \left[S(i,2) E(X / X < k_2) \right] - K_1$$

If we replace C with equation (4), we get:

$$\Delta E = -I + (1-F(k_2))\cdot\left[S(i,2)E(X/X>k_2) - \frac{K_2}{1+i}\right] + (1-F(k_2))\cdot\frac{K_2}{1+i} + F(k_2)\cdot\left[S(i,2)E(X/X<k_2)\right] - K_1$$

that simplifies into:

$$\Delta E = -I - K_1 + S(i,2)\left[(1-F(k_2))E(X/X>k_2) + F(k_2)\cdot E(X/X<k_2)\right]$$

With equation (1) we get:

$$\Delta E = -\frac{M}{(1+i)(i+\beta(\sigma_1))} + S(i,2)\cdot M$$

$\boxed{\Delta E = \frac{M}{1+i}\cdot(\frac{1}{i} - \frac{1}{i+\beta(\sigma_1)})}$ (8) that is equal to equation (7) since we took $C=C^*$. In our simple model, the state extracts all the value creation. Obviously, with $\beta(\sigma_1) > 0$, we again get $\Delta E > 0$.

In relative terms, let us assess the magnitude of the value creation compared to what the state would initially get and also compared to what it would like to get, expecting M as a mean of X and with a totally risk-free discount (M/i) right from t=0.

- Compared to what the state would expect (more a psychological threshold), equation (7) can be expressed as:

$$\Delta E = \frac{1}{1+i}(1 - \frac{i}{i+\beta(\sigma_1)})\cdot\frac{M}{i}$$

The option model has never been used, but the experience gained in the course of direct privatisation in Delhi shows that there was a 60% difference between what the state expected and what it got by privatising the distribution of electricity, on the basis of which we can assess the factor $\frac{i}{i+\beta(\sigma_1)}$ to be roughly equal to 0.4. Experience shows that after one to two years a lot of additional public information is known; with i=0.16 as is generally considered for the power sector in India, we get β=0.23 and $\frac{\Delta E}{M/i}$ is equal to 0.52. The state can get 52% more than its initial objective thus improving its result from 40 to 92%.

- Let us be more precise and explain the option scenario in the case of direct privatisation; in relative terms for $\frac{\Delta E}{E_0}$ from equations (1) and (7), we get:

$$\frac{\Delta E}{E_0} = \frac{\frac{M}{1+i} \cdot (\frac{1}{i} - \frac{1}{i+\beta(\sigma_1)})}{\frac{M}{(1+i)(i+\beta(\sigma_1))} - I} = \frac{1 - \frac{i}{i+\beta(\sigma_1)}}{\frac{i}{i+\beta(\sigma_1)} - \frac{iI}{M}(1+i)} = \frac{0.6}{0.4 - 0.185 \cdot (I/M)}$$

The higher M (the lesser the information), the more interesting is the option strategy that allows us to safeguard the values of X. We can compute this value in accordance to the ratio I/M.

I/M	ΔE/E0
0	1,50
0,05	1,54
0,1	1,57
0,15	1,61
0,2	1,65
0,25	1,70
0,3	1,74
0,35	1,79
0,4	1,84
0,45	1,89
0,5	1,95

For a likely I being to the tune of 5 to 15% of the expected annual profit, the likely profit of an option strategy is to the tune of 50 to 60% of the initial bid value.

Fixing the value of K_2

K_2 is actually fixed by the state prior to the game. Let us examine what happens if it fixes it in order to maximise its revenue. Equation (5) expresses it as:

$$E(PVstate) = C + S(i,2)\left[k_2 \cdot (1 - \int_0^{k_2} f(x)dx) + \int_0^{k_2} f(x)dx \cdot \frac{\int_0^{k_2} xf(x)dx}{\int_0^{k_2} f(x)dx} \right],$$

that simplifies into: $E(PVstate) = C + S(i,2) \cdot \left[k_2 \cdot (1 - \int_0^{k_2} f(x)dx) + \int_0^{k_2} xf(x)dx \right]$

and where K_2 is fixed by maximising on k_2 the state's revenue on condition that the firm's revenue is positive or nil. The condition is expressed in the two equivalent forms:

$$\underset{K_2/[-I-C+S(i,2)\cdot(1-F(k_2))\cdot(E(X/X>k_2)-k_2)]\geq 0}{Max} \left\{ C + S(i,2) \cdot \left[(1-F(k_2)) \cdot k_2 + F(k_2) \cdot E(X/X<k_2)\right] \right\} \quad (8)$$

or:

$$\underset{k_2/\left[-I-C+S(i,2)\cdot(\int_{k_2}^{\infty} xf(x)dx - k_2)\right]\geq 0}{Max} \left\{ C + S(i,2) \cdot \left[k_2 \cdot (1 - \int_0^{k_2} f(x)dx) + \int_0^{k_2} xf(x)dx \right] \right\} \quad (8\text{ bis})$$

Since this maximisation is distribution-specific, we will show such optimisation in a more elaborate version of the model with a specified distribution for X.

III. Complete Model: Management Contract of a Developing Country Utility as a Lock-out Option

We will now follow the same principles of modelling, while relaxing some hypotheses, so that it is applicable to as many cases as possible. In particular, we will consider that after t=1, the variance of the distribution has been reduced. More precisely, we will assume that the subsequent cash flows X_m for $m \geq 2$ will have the mean M_2 and the variance $\sigma_2^2 < \sigma_1^2$. The mean M_2 is still not fully known; it is a random variable with a mean M_1 and a variance $\sigma_2^2 - \sigma_1^2$. Further, we will take a risk-free discount rate that is different for the state and for the firm, i_S and i_F. Finally, we will include the possibility for the State to levy taxes on profits at the rate λ (here we make the additional hypothesis that $X_n > 0$ for all n). We will now differentiate between I and X_1 and, in particular, during the first stage in the option case when the firm operates the utility under a management contract scheme. It receives a share α of the cash flow X_1. The government is not averse to risks.

Immediate Privatisation

In the case of direct privatisation by the government, the cash flow generated would be:

$$X_1, \quad X_2, \quad \ldots, X_n, \quad \ldots$$

<u>Present value for the firm</u>

For the firm, the present value after tax of these cash flows less the initial acquisition cost[10] would be

$$(1-\lambda)\sum_{1}^{\infty}\frac{X_n}{(1+i_F+\beta(\sigma_1))^n} - I - K_1 = 0$$

At the outset, the prior mean of all the X_n is M_1, so the expected present value after tax will be

[10] To simplify the computation, we will ignore the tax implications of investing K_1 at time 0 or K_2 at time 1.

$$\boxed{(1-\lambda)\sum_{1}^{\infty}\frac{M_1}{(1+i_F+\beta(\sigma_1))^n}-I-K_1=(1-\lambda)M_1S(i_F+\beta(\sigma_1),1)-I-K_1} \quad (9)$$

Obviously the firm will only purchase the SEB if

$$\boxed{K_1<(1-\lambda)M_1S(i_F+\beta(\sigma_1),1)-I} \quad (10)$$

Present value for the government

For the government, the (present) value of the received cash flows will be

$$\boxed{\lambda\sum_{1}^{\infty}\frac{M_1}{(1+i_S)^n}+K_1=\lambda M_1S(i_S,1)+K_1} \quad (11)$$

Total Present Value of Privatisation

Let V_0 be the total expected present value of privatisation (i.e. for firm + government)

$$\boxed{V_0=(1-\lambda)M_1S(i_F+\beta(\sigma_1),1)+\lambda M_1S(i_S,1)-I} \quad (12)$$

Two-stage Privatisation

The firm will exercise its option to acquire the utility if the updated mean M_2 is sufficiently high. Let M_{crit} denote this critical value which will depend on the level of variance reduction. So the two cases have to be considered in accordance with the firm's decision.

If the firm exercises its option to acquire the utility at the end of period 1

For the firm, the present value after tax of these cash flows less the acquisition cost less the investment would be[11]

$$-I-K_1+(1-\lambda)\left[\frac{\alpha X_1}{1+i_F+\beta(\sigma_1)}+\sum_{2}^{\infty}\frac{X_n}{(1+i_F+\beta(\sigma_2))^n}\right]-\frac{K_2}{(1+i_F+\beta(\sigma_2))}$$

Given the new information after period 1, the mean of X_n changes to M_2, so the expected present value after tax becomes:

$$\boxed{-I-K_1+(1-\lambda)\left[\frac{\alpha M_1}{1+i_F+\beta(\sigma_1)}+M_2S(i_F+\beta(\sigma_2),2)\right]-\frac{K_2}{(1+i_F+\beta(\sigma_2))}}$$

Similarly, for the government, the present value of cash flows received is

$$\boxed{(1-\alpha(1-\lambda))\frac{M_1}{1+i_S}+K_1+\lambda M_2S(i_S,2)+\frac{K_2}{(1+i_S)}}$$

<u>If the firm does not exercises its option at time T</u>

The firm receives only the first cash flow after paying the investment I and the premium K_1. So the present value would be

$$\boxed{(1-\lambda)\alpha\frac{M_1}{i_F+\beta(\sigma_1)}-I-K_1}$$

Similarly the present value for the government is

$$\boxed{(1-\alpha(1-\lambda))\frac{M_1}{i_S}+K_1+M_2S(i_S,2)}$$

[11] We have not computed the tax on investment nor on the purchase of the option.

To decide whether it should exercise its option, the firm will compare the two present values. That is, it will exercise its option if

$$(1-\lambda)M_2 S(i_F+\beta(\sigma_2),2)-\frac{K_2}{(1+i_F+\beta(\sigma_2))}>0$$

That is if

$$M_2 > M_{crit} = \frac{K_2}{(1-\lambda)(1+i_F+\beta(\sigma_2))S(i_F+\beta(\sigma_2),2)}$$

$$\boxed{M_2 > M_{crit} = \frac{(i_F+\beta(\sigma_2))K_2}{(1-\lambda)}}$$ (13) Let us denote $M_{crit} = \kappa K_2$.

The value of M_{crit} depends only on the firm's discount rate since, once the value of K_2 is fixed by the state, the firm only has to choose whether to exercise the option or not. It obviously depends on λ. Conversely, in the model we have followed, it does not depend on α since in both cases the firm co-manages the utility only during period 1. If we model the game differently, by allowing the firm at t=1 to either buy the utility by exercising the option *or to go on managing it even after giving up the option*, then the value of α intervenes[12].

To illustrate what this condition corresponds to graphically, we will plot the acceptance region as a function of the K_2 and λ, for the values of discount rates given in table 2.

	i_S	i_F	$i_F + \beta(\sigma_1)$	$i_F + \beta(\sigma_2)$
Value	5%	16%	39%	20%

Table 2: Typical values for discount rates

[12] Without demonstration, we get in the latter case $M_{crit} = \frac{K_2}{(1-\lambda)(1-\alpha)(i_F+\beta(\sigma_2))}$.

Insert figure A here.

If we know the form of distribution F of X, we can calculate the probability of the firm exercising its option. It is just 1- F(M_{crit}). We can also compute the conditional mean of X depending on whether the option is exercised or not. These can be written as E[M_2| M_2>M_{crit}] and E[M_2| M_2<M_{crit}]. They can be computed by integration.

In the case of a two-stage privatisation, the expected value from the company's point of view is just the average of the values for the two cases according to their respective probabilities. Substituting the conditional mean of the cash flows in the case where the company exercises its option gives

$$E(PV_{firm}) = -I - K_1 + (1-\lambda)(\alpha \frac{M_1}{1+i_F+\beta(\sigma_1)} + (1-F(\kappa K_2))E(M_2 / M_2 > \kappa K_2)S(i_F+\beta(\sigma_2),2)) - \frac{(1-F(\kappa K_2))K_2}{(1+i_F+\beta(\sigma_2))} \quad (14)$$

Similarly the expected present value to the government (at time 0) is

$$E(PV_{state}) = \left[(1-\alpha(1-\lambda))\frac{M_1}{1+i_S} + K_1 + \lambda E(M_2/M_2 > \kappa K_2)S(i_S,2) + \frac{K_2}{(1+i_S)}\right](1-F(\kappa K_2)) + \left[(1-\alpha(1-\lambda))\frac{M_1}{1+i_S} + K_1 + E(M_2/M_2 < \kappa K_2)S(i_S,2)\right]F(\kappa K_2) \quad (15)$$

Total expected value and creation of value in comparison with direct privatisation

The total net present value is equal to:

$$V_1 = E(PV_{tot}) = -I + (1-\lambda)(\alpha \frac{M_1}{1+i_F+\beta(\sigma_1)} + (1-F(\kappa K_2))E(M_2/M_2>\kappa K_2)S(i_F+\beta(\sigma_2),2))$$
$$-\frac{(1-F(\kappa K_2))K_2}{(1+i_F+\beta(\sigma_2))} + (1-\alpha(1-\lambda))\frac{M_1}{1+i_S} + \left[\lambda E(M_2/M_2>\kappa K_2)S(i_S,2) + \frac{K_2}{(1+i_S)}\right](1-F(\kappa K_2)) +$$
$$\left[E(M_2/M_2<\kappa K_2)S(i_S,2)\right]F(\kappa K_2)$$

To be compared to $V_0 = (1-\lambda)M_1 S(i_F+\beta(\sigma_1),1) + \lambda M_1 S(i_S,1) - I$

In order to compare these two values, V_0 can be broken up into contributions from period 1, on the one hand, and periods t>1, on the other hand:

$$V_0 = (1-\lambda)\left[\frac{M_1}{1+i_F+\beta(\sigma_1)} + M_1 S(i_F+\beta(\sigma_1),2)\right] + \lambda\left[\frac{M_1}{1+i_S} + M_1 S(i_S,2)\right] - I$$

The difference between V_1 and V_0 is obviously positive since:

- during period one, the same valorisation (M_1) occurs in both cases and in the second case, a share (1-α(1-λ)) is even valorised by the state at a more beneficial discount rate,
- during periods strictly higher than 1, if we similarly break up the contributions to V_0 from among the cases where $M<M_{crit}$ and $M>M_{crit}$,[13] we see that, at the higher stage of distribution, the risk-free discount rate used by the firm is definitely favourable to a higher valuation of the utility (the financial transfer linked to the exercise of the option even adding to the NPV since the state values it at i_F), while the same applies, without transfer, to the lower part of the distribution. Similarly, all tax mechanisms are favourable to period 1.

Hence <u>proposition 2:</u>

Generally speaking, where a prior management contract allows the reduction of the variance in profit distribution, using an option does create an ex ante value by ensuring ex post that decisions by the firm

[13] The condition necessary for this is the hypothesis we adopted initially that the mean M_2 is a random variable with *same* mean M_1.

after period 1 are risk-free from the information point of view (once again, we have not dealt here with the classical regulatory and business risks).

The amount of value creation is linked to (i) the difference between the state's risk-free discount rates and those of the firm and (ii) the difference between a reduced risk and a risky scenario (with a factor $\beta(\sigma_1)$ reducing to a lower $\beta(\sigma_2)$), discounted from period 1, since the creation of information occurs at t=1.

These two elements, however, are not of the same nature: the difference in risk-free discount rates between the state and the firm are merely an accounting device linked to a financial transfer and not to the creation of value. On the other hand, the investment in information makes it possible to specify some private information leading to a value creation by the firm which will benefit the state.

<u>A practical example of the fixation of the strike value for the option in a no-tax scenario and with uniform distribution</u>

Let us assume that the state optimises its discounted NPV as obtained from equation (15) in order to fix the value of K_2. However, a part of its NPV comes from financial transfers or from continuing to enjoy the profits made by the utility in case the option is not exercised. Both these situations do not economically correspond to the mechanism of private information creation and value creation through the latter. We therefore prefer to look at a more economic criterion and we will retain only the outcome of the selling value at beginning of period 2 (considering the case where the option is exercised because the firm has been able to create a value higher than K_2). The other case, where the firm does not exercise its option, is more likely to raise the problem of asymmetric information. Since the investment I has been realised by the firm, it is not sure whether the state would be able to capitalise on it if the firm exits without exercising the option. In that case, a bidding mechanism may take different forms and the game would have to be defined more precisely in order to cope with this asymmetry (among others: who would be allowed to bid, under which process, through a direct bidding or for a new revaluated option). We do not wish to enter into these details in the present article as they either relate to classical information asymmetry or practically lead to another round of the option mechanism we have described here.

In other words, *in the case of value creation through private information, the cash flows directly associated with the privatisation, in case the option is exercised, are a good proxy for the economic efficiency of the privatisation*. As far as considerations of political economy are concerned, this is also in line with what Shleifer & Vishny (1994) propose for modelling politicians' motives for privatising utilities.

In such a case (and neglecting further taxes), we will no longer consider the net present value but only cash flows. The revenue optimised by the state simplifies considerably into:

$$R = (\frac{K_2}{(1+i_S)} + C)(1 - F(M_{crit})) + CF(M_{crit}) \; E(PV_{State}) = \frac{K_2(1 - F(\kappa K_2))}{1+i_S} + C$$

Maximising R leads to fixing the strike value of the option, K_2, for solving the following equation:

$$1 = F(\kappa K_2) + \kappa K_2 f(\kappa K_2) \qquad (16)$$

In that case, we can calculate the expected present value (before tax) for the firm, that is:

$$E(PV_{firm}) = \frac{M_1}{1+i_F+\beta(\sigma_1)} - I - C + \left[S(i_F + \beta(\sigma_2),2) E(M_2 / M_2 > \kappa K_2) - \frac{K_2}{1+i_F+\beta(\sigma_2)} \right] (1 - F(\kappa K_2))$$

Keeping this value positive for the firm allows the state to fix the value of the premium C that it can extract.

In the case of a uniform distribution between 0 and X_{max}:

As $F(\kappa K_2) = \frac{\kappa K_2}{X_{max}}$ and $f(\kappa K_2) = \frac{1}{X_{max}}$ and, without tax, as

$\kappa = i_F + \beta(\sigma_2)$, equation (16) provides:

$$\boxed{K_2 = \frac{X_{max}}{2\kappa} = \frac{X_{max}}{2(i_F + \beta(\sigma_2))}} \qquad (17)$$

The firm's EPV becomes:

$$E(PV_{firm}) = \frac{X_{\max}}{2(1+i_F+\beta(\sigma_1))} - I - C + \frac{1}{2}\left[\frac{3}{4}S(i_F+\beta(\sigma_2),2)X_{\max} - \frac{1}{2}S(i_F+\beta(\sigma_2),2)X_{\max}\right]$$

$$\boxed{E(PV_{firm}) = \frac{X_{\max}}{2(1+i_F+\beta(\sigma_1))} - I - C + \frac{1}{8}S(i_F+\beta(\sigma_2),2)X_{\max}}$$

The maximum C the state can charge is:

$\boxed{C = \frac{X_{\max}}{2(1+i_F+\beta(\sigma_1))} + \frac{1}{8}S(i_F+\beta(\sigma_2),2)X_{\max} - I}$, that sets the ex ante nil profit for the firm.

Let us compare V_0 and V_1 in order to assess the value creation.

$$V_0 = (1-\lambda)\frac{X_{\max}}{2}S(i_F+\beta(\sigma_1),1) + \lambda\frac{X_{\max}}{2}S(i_S,1) - I$$

$$V_1 = (1-\lambda)(\alpha\frac{X_{\max}}{2(1+i_F+\beta(\sigma_1))} + \frac{3X_{\max}}{8}S(i_F+\beta(\sigma_2),2)) - \frac{X_{\max}}{4(1+i_F+\beta(\sigma_2))(i_F+\beta(\sigma_2))}$$
$$+(1-\alpha(1-\lambda))\frac{X_{\max}}{2(1+i_S)} + \lambda\frac{3X_{\max}}{8}S(i_S,2) + \frac{X_{\max}}{4(1+i_S)(i_F+\beta(\sigma_2))} + \frac{X_{\max}}{8}S(i_S,2) - I$$

V_1 decreases when α increases, which is explained by the fact that the State has a lower risk-free discount rate in any case. In order to really assess the effect of the option alone in terms of value creation, we set α=1. The tax too has a similar effect, therefore we set λ=0, without any loss of generality.

In such a case, we get for V_0 and V_1:

$$V_0 = \frac{X_{\max}}{2}S(i_F+\beta(\sigma_1),1) - I$$

$$V_1 = \frac{X_{\max}}{2(1+i_F+\beta(\sigma_1))} + \frac{3X_{\max}}{8}S(i_F+\beta(\sigma_2),2)) + \frac{X_{\max}}{4(i_F+\beta(\sigma_2))}(\frac{1}{1+i_S} - \frac{1}{1+i_F+\beta(\sigma_2)})$$
$$+\frac{X_{\max}}{8}S(i_S,2) - I$$

We again find that the trade-off between immediate and two-step privatisation is clear. It depends on the two discount rates and on the risk loads $\beta(\sigma_1)$ and $\beta(\sigma_2)$, but not on the investment I.

	i_S	i_F	$i_F + \beta(\sigma_1)$	$i_F + \beta(\sigma_2)$
Value	5%	16%	39%	20%

With the usual values we have adopted for discount rates, we find:

$V_0 = 1.28\ X_{max}\text{-}I$

$V_1 = 4.45\ X_{max}\text{-}I$[14]

With the expected annual benefit being equal to $X_{max}/2$, the option allows extraction up to nearly six times the annual return, more than is offered by privatisation.

Conclusion: Discussion on the Value of C with Respect to Competition and the Pure Management Contract as a Limit case when there is an Option to Privatise

In case there is an information-related problem when a utility is being privatised, as it often happens in developing countries, real options accompanied by a preliminary management contract can help in the collection of private information. Provided there is a political choice to privatise, this technical tool helps in increasing the selling value of the utility by a large amount and may even serve to identify the firm that may turn out to be the most efficient operator of the utility. The latter can be obtained principally by correctly setting the value of the call for the option and the strike value, thus allowing some more refined economic choices.

[14] This value is partly derived from the fact that, in case the firm does not exercise the option, the utility is valorised at the risk-free rate proposed by state. If we want the game to end very symmetrically, that is, make the state privatise in any case, the firm rate with the second risk load has to be taken into account for calculating V_1. We then get V_1=2.69 X_{max}-I. This value actually measures the role of just the option.

In fact, the value of the call, C, can be nil in actual practice. Indeed, if we go back to Goldberg's description (2000) of lock-up clauses, the purchase of the option would actually correspond to "two intertwined transactions". As Goldberg points out, "In the first, the buyer purchases an option: he pays a positive price to induce the seller to take the property off the market for a period of time." This is the lock-up clause. Conversely, "in the second, the seller pays the buyer to develop some information about the commercial prospects of the property". In conditions where the buyer is (i) ready to pay more with this information, and (ii) is best placed to produce it, which, as we have explained is what happens in the case of many public utilities in developing countries, then, paraphrasing Goldberg, "the netting of these two transactions could easily result in the buyer paying nothing"; as a result, we get C=0. Finally, fixing the value of C may be useful in a competitive bidding process: a strictly positive value for C would then help the state to select the highest bidding firm. In addition to the increase in the state's revenue, a higher C would mean *inter alia* a higher anticipation by the highest bidding firm of its ability to generate information. That is, a bid on C can serve as a means of revealing a proxy for the efficiency of firms in information building.

Fixing the strike value, on the other hand, should be independent of the value of C. Indeed, although these values are linked formally – the firm at t=0 decides whether to buy the option based on its anticipation of the distribution of revenues – the form of the distribution opens the door ex ante to too many possibilities. This anticipation could turn out to be the essential element of the initial valuation, if the state chooses to fix the value of C arbitrarily high (in such a case, only the firms who are very optimistic a priori about the possible high-range part of the utility's value would be interested). Such a valuation is most vulnerable to fluctuation and is not selective in terms of information-creation capacities. Optimally, the state should not focus on this parameter and should aim at contracting with firms that are sure on their own capacities and not just generally optimistic about a good regarding which they have no information.

A last point we would like to discuss briefly is: what happens if the firm that is most efficient in creating information ex ante (the one which will give the highest C) does not turn out to be the most efficient in operating the utility ex post (that is, in expecting a high revenue from period 2 onwards). This corresponds to something we have not modelled here. There is a difference between a firm's relative efficiencies and, even with similar information, different firms would not necessarily generate the same revenue. In such a case, it is advantageous for the state to fix a higher strike value, particularly because the ratio between public and private information is higher after period 1. In this last scenario, the managing firm might not exercise its option whereas, if enough information has become public, other firms would be ready to offer a price closer to the value of K_2. Modelling such scenarios presents no specific difficulty and does not alter the general nature of the real option we have described.

To sum up, as far as these two aspects are concerned, we would propose that when implementing the real option mechanism, the ex ante competition should take place on the value of C and the state should not hesitate to assign a slightly higher value for K_2, in order to target ex post the most efficient operating company and also to bring out the highest social value of the utility.

Finally, we will point out that our model can serve as a formal model to unite within the same framework all the classical tools of management contracts and privatisation. A pure management contract is an option where the call is equal to 0, or even a negative figure, while the strike has a very high value, so that in practice the firm will never buy the utility. Pure privatisation is an option where the call is equal to the selling value of the utility, the first period tends to be zero and the value of the strike is also set to zero, so that in actual practice the two decisions of our model occur at the same time, the second one being straightforward as compared to the first. In between these two extreme cases, we believe that a real option mechanism for reforming utilities offers all the flexibility of the continuum.

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