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An Option Approach to Water Delegation.

Ephraim Clark *

Gérard Mondello **

Summary

The problem that we address in this paper stems from the trend to delegation in the water management field. The problem that we address refers to the municipality's negotiating disadvantage in the face of some cartelized water management. We discuss the specific characteristics of the delegation auction that render it useless as a tool for collective welfare maximization. We show that the remaining tool for achieving collective welfare maximization, i.e. the municipality's right to revoke delegation and return to direct management, is also ineffective due to a lack of credibility that is essentially financial in nature. Thus, if the credibility of revocation could be restored, the municipality's bargaining power could also be restored. Using standard methods of stochastic calculus, we model the municipality's right of revocation as a call option held by the municipality. We show that the value of this option depends to a large extent on the exercise price, which is partly determined by objective economic criteria and partly by legal and institutional conventions. Based on this we suggest that credibility could be restored by the constitution of a fund at least as large as the effective exercise price.

Key words : Delegation, Water Management, Auctions and bids.

JEL: Q25, O33, G13

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NON TECHNICAL SUMMARY

In this paper we look at delegation irreversibility from the perspective of collective welfare maximization. We discuss the specific characteristics of the delegation auction that render it useless as a tool for collective welfare maximization. We then show that the remaining tool for achieving collective welfare maximization, i.e. the municipality's right to revoke delegation and return to direct management, is also ineffective due to a lack of credibility that is essentially financial in nature. Thus, if the credibility of revocation could be restored, the municipality's bargaining power could also be restored. Using standard methods of stochastic calculus, we model the municipality's right of revocation as a call option held by the municipality. We show that the value of this option depends to a large extent on the exercise price, which is partly determined by objective economic criteria and partly by legal and institutional conventions.

Based on this we suggest that credibility could be restored by the constitution of a fund at least as large as the effective exercise price and that community welfare maximization would occur at the point where the exercise price is determined exclusively by objective economic criteria. Since the delegated firm as a simple agent has the right to resiliate the contract if delegation becomes unprofitable, we then model this right as a put option held by the firm. Its value also depends to a large extent on the exercise price, which is partly determined by objective economic criteria and partly by legal and institutional conventions. Combining the exercise points of the two options enables us to determine the price-profit interval over which delegation will be acceptable to both parties. We conclude that the optimal interval will be the one where the exercise prices are determined entirely by objective economic criteria. Convergence towards this interval can be achieved by restoring the municipality's bargaining power. To this end we suggest a fund financed by the firm that would be available to the municipality for covering the outlay for revoking delegation and going back to direct management.

1. INTRODUCTION

At the municipality level, in France, three main types of water management are at work. The first type, called the "Régie Municipale", is a system of direct management involving the Mayor and its Council where the municipality is in charge of the whole management system, (plants, pipe-network, etc.). The second type, a sort of "Super Régie Municipale", gathers the resources of several municipalities to form an association of communes. The third type is a delegation system whereby the municipality allows a private firm to manage the allocation and the treatment of fresh water and sewage. In France, quantitatively, the delegation system is by far the most popular. Of the 4.400 municipalities of more 2.000 inhabitants, 3.500 of them are under private delegation for fresh water services and 1.750 for waste water treatment. Numerically, however, direct management prevails. Of the 15.500 fresh water services in France, almost 9.000 are municipal services, (régie municipale), but most of them are municipalities with less than 1.000 inhabitants (Margat 1992).

The delegation process has grown by leaps and bounds since the beginning of the 1980's. There are several reasons for this. First of all, the technology of monitoring the safety of the existing pipe network is fully controlled by a small number of large, specialized companies that monopolize the market and constantly raise the technology level.¹ Secondly, the required competencies for water management have become more and more specific thereby making it difficult and costly for the municipalities' personnel to maintain these levels. Third, delegation is linked to budgetary and financial constraints. Indeed, in France, until 1990 it was common to ask the delegated firm to pay admission rights, which were then included in the general budget. Furthermore, since 1968, the municipality can recover the added value tax paid to the suppliers by the delegated firm. Finally, and most importantly, because of a quirk in the French administrative organization there is the problem of the mayor's personal liability in the case of harm when the court judges that the harm was caused by negligence. This potential conflict of interest between the personal interests of the mayor and the well being of the

¹ In France, for example, La Compagnie Générale des eaux, the Lyonnaise des Eaux-Dumez, and the SAUR linked to the Bouygues Group are the main leaders that also control a large network of subsidiaries.

community goes a long way to explaining the swing to delegation (see Clark and Mondello, 1996).²

The problem that we address in this paper stems from the trend to delegation. The problem is not delegation itself, which, if properly administered in an atmosphere of fair competition, can lead to improved quality and lower costs for municipal consumers. Unfortunately, as the Cour des Comptes concluded in its report of January 1997, because of the French governance tradition, fair competition is seldom achieved in the French water management system. Thus, the problem that we address refers to the municipality's negotiating disadvantage in the face of the cartelized water management firms and, more precisely, to the fact that once a municipality has opted for delegation, the decision is, for all practical purposes, irreversible with the delegated firm able to extract a long term economic rent to the detriment of the municipality.

The problem can be resumed as follows. In a delegation contract, a municipality temporarily cedes its management powers to a private firm. In France, the Law allows partial or total delegation of water management but not a full privatization of the water supply as in the United Kingdom, for example. The contract is long term but provides for the opportunity to renegotiate the terms. Theoretically, at the contract's maturity, the municipality keeps control of the delegation allocation and may choose among competitors or revoke delegation in favor of direct management. Thus, the procedure appears competitive. In fact, however, because of numerous factors that we will discuss in the following sections, the auction is not really competitive and the threat of revocation has no credibility, thereby rendering the initial delegation effectively irreversible.

In this paper we look at delegation irreversibility from the perspective of collective welfare maximization. We discuss the specific characteristics of the delegation auction that render it useless as a tool for collective welfare maximization. We then show that the remaining tool for achieving collective welfare maximization, i.e. the municipality's right to revoke

² The French law of 1992 on Water increased the liability of the municipalities. They are now responsible for protecting the water supply, managing the rivers, and reducing pollution. In most cases, adequate standards of fresh water safety have been met. However, because of population changes (tourism, migratory flows, sociological changes), the obsolescence of the pipe network, and, above all, the trend to higher standards of quality, this equilibrium is in danger. Furthermore, the high complexity of urban management and the interdependency of individual water networks have made water management riskier and far less secure than in the past.

delegation and return to direct management, is also ineffective due to a lack of credibility that is essentially financial in nature. Thus, if the credibility of revocation could be restored, the municipality's bargaining power could also be restored. Using standard methods of stochastic calculus, we model the municipality's right of revocation as a call option held by the municipality. We show that the value of this option depends to a large extent on the exercise price, which is partly determined by objective economic criteria and partly by legal and institutional conventions. Based on this we suggest that credibility could be restored by the constitution of a fund at least as large as the effective exercise price and that community welfare maximization would occur at the point where the exercise price is determined exclusively by objective economic criteria. Since the delegated firm as a simple agent has the right to resiliate the contract if delegation becomes unprofitable, we then model this right as a put option held by the firm. Its value also depends to a large extent on the exercise price, which is partly determined by objective economic criteria and partly by legal and institutional conventions. Combining the exercise points of the two options enables us to determine the price-profit interval over which delegation will be acceptable to both parties. We conclude that the optimal interval will be the one where the exercise prices are determined entirely by objective economic criteria. Convergence towards this interval can be achieved by restoring the municipality's bargaining power. To this end we suggest a fund financed by the firm that would be available to the municipality for covering the outlay for revoking delegation and going back to direct management. The innovative feature of this paper, then, is to treat the delegation problem in terms of call and put options so that uncertainty and intertemporal choice are integral elements of the analytical framework. The resulting contribution to the literature is the identification of the precise role that revocation costs play in the mechanism of irreversibility.

The rest of the article is organized as follows. In section 2 we discuss the delegation procedure and irreversibility and in section 3 we develop the model. Section 4 contains our suggested solutions and section 5 summarizes and concludes.

2. THE DELEGATION PROCEDURE

A municipality typically recruits potential competitors through a public tender. This is done by announcements in the official press such as the " Journal Officiel ". Then, once the competitors have made their bids, which might be legally binding, the Mayor, who has preponderant discretionary power, and his Council list the firms whose bids have been accepted for consideration. Unqualified or financially weak firms are dismissed out of hand. When the winning bid has finally been chosen, any remaining details are ironed out and the delegation contract is signed.

The contract itself between the municipality and the firm is a classical one based on a long term relationship. French Law tends to limit the contract to twelve years but the record shows that in most cases their effective duration is over thirty years. At the contract's expiry, a new negotiation process is opened which may or may not include a public tender. During the contract's life, the Law also allows for limited renegotiation bearing not on the allocation process itself but on certain specific items, the most important of which is prices. In France as in most of Europe, the fundamental principle of water pricing is that it be high enough to cover the costs incurred by the water management system.

The foregoing description of the delegation process looks like a competitive auction in the context of traditional public procurement theory through which a public utilitarian regulator (buyer) maximizes the collective welfare and minimizes the associated costs. Unfortunately, the French water procurement auction is characterized by a small number of cartelized sellers, thereby rendering it all but useless as a tool for collective welfare maximization. Furthermore, these sellers typically supply the municipality with a whole set of services related in one way or another to the water system. Thus, the transparency of the auction is clouded by interlocking cost-benefit tradeoffs with the related services. When the regulator changes his water management delegate, he is effectively changing his supplier for a whole range of indispensable services with net losses and gains for the municipality extremely difficult, if not impossible, to ascertain. This makes cutting the umbilical cord in favor of another supplier very difficult. Since the alternative suppliers are cartelized, the new deal is not likely to be better than the old one and it might even be worse.

Thus, the only real source of municipality bargaining power is the threat to revoke delegation and return to direct management. When it comes to revoking delegation in favor of direct management, however, municipalities are hampered by a host of obstacles that empty the

threat of any practical credibility. First, technologies are controlled by the cartelized firms and the newest of these are not available on economically reasonable terms to the municipalities. Second, if at one time the municipalities had the personnel with the competencies for modern water management, these competencies will likely have all but vanished by the time a 12 year delegation contract has expired. Hiring or training the necessary personnel would be a costly and time consuming exercise. Third, undertaking direct management would entail costly expenditure in the form of new investment and indemnities to the former supplier. Fourth, the municipality would lose its fiscal advantages associated with value added tax and other taxes paid by the delegated firm. Fifth, and perhaps most importantly in practice, the mayor would become directly personally liable for any damages deemed by the courts due to negligence on the part of the municipality.

In order for the direct management option to be credible these obstacles must be overcome. The first four obstacles are clearly of a financial nature. The fifth is less clearly so. Clark and Mondello (1996), however, have shown that the mayor's personal liability can be estimated as the value of an insurance policy guaranteeing all losses in the case of municipal negligence. The liability obstacle can therefore be reduced to a financial problem equal in value to the value of the insurance policy protecting the mayor. Thus all five obstacles can be viewed as financial in nature thereby making it possible to view the credibility of the direct management option in terms of a financial solution.

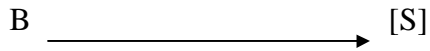
The situation can be summarized as follows. The bilateral monopolistic (or stable cartel) situation of the municipality (buyer) and firm (seller) can be broken if it is admitted that the the municipality can do the job itself. At the present, in most cases, renewal of direct management is not a credible threat because the municipality does not have the financial means to free itself from the long term relationship established by the firm.

To give a more rigorous example taken from traditional public procurement choice, the Buyer (B) has to choose a seller (S) among n firms. The choice may be roughly described by the following graph [1]:

B \longrightarrow [Si], (i=1,...,n)

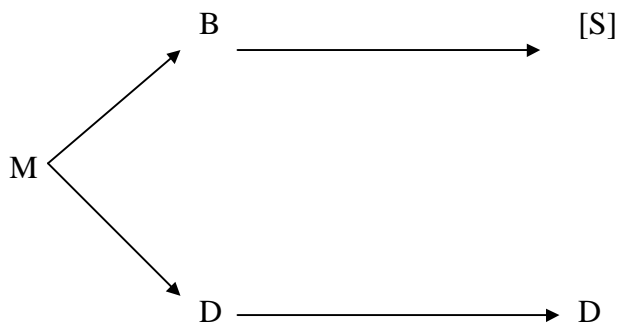
graph [1]:

where sellers $[S_i]$, ($i=1,\dots,n$) are identified with their optimal strategies. In a bilateral monopoly, $[S]$, the relationship is (graph[2]):



graph[2]:

In this situation, the municipality has few weapons at its disposal. Those that do exist are very weak. Laffont-Tirole (1993), for example, have shown that ex-post-observed variables such as auditing may be useful in finding the optimal contract. The municipality's weak position is weakened further by the large size of the investments that must be made. Consequently, S is the leader in the negotiation process and its rent is at its maximum level. When a new choice is introduced, however, the situation looks like this:



graph[3]

In this graph the municipality has two choices. It can act as a buyer (B) or it can manage directly (D). This possibility changes the nature of the exercise. If the municipality's direct management threat is credible, it can use this threat to negotiate the price and quality that minimize the firm's rent. This will be the case as long as it is clear when it is optimal for the municipality to exercise its option to manage directly and as long as the option can be exercised any time bidding takes place. In the following section we develop a model that corresponds to these conditions.

3. THE MODEL

The key to effective municipal bargaining resides in the credibility of the option to revoke delegation and renew direct management. In the preceding section we showed that the

credibility issue is essentially financial in nature. In this section we combine the concept of the option to revoke and financial credibility to analyze the dynamics of delegation irreversibility. To this end we use well known methods of stochastic calculus to develop a model that explicitly defines the role of financial credibility and determines the bargaining limits on municipality and firm. We start with the general case of water management in the absence of market imperfections.

3.1 Valuing the Water Management Project as an Infinitely Lived Investment

Given the essential nature of water in all facets of human activity, water management, for all practical purposes, can be considered as an infinitely lived investment. Let $x(t)$ represent income from the water management project calculated as the unit price multiplied by the number of units sold. Suppose that $x(t)$ follows geometric Brownian motion:³

$$dx(t) = ax(t)dt + Sx(t)dz(t) \quad (1)$$

where a is the rate of growth in income, S is the standard deviation of $dx(t)/x(t)$ and $dz(t)$ is a Wiener process with zero mean and variance equal to dt . Let c represent variable operating costs that include the insurance premium for liability coverage (for the the mayor's personal liability in the case of direct management and for corporate liability in the case of delegation) and assume that they are constant.⁴ It should be clear that liability insurance is necessary for the firm as well as for the mayor and since both liabilities are unlimited, they should both have the same cost. Thus, the obstacle to renewing direct management due to the mayor's personal liability is subsumed in the cost side of the investment's cash flows. The required risk adjusted rate of return on $x(t)$ can be found by applying the CAPM directly to $x(t)$ or to a spanning asset in the case that $x(t)$ is not directly observable.⁵ The required rate

³ Although price is basically a result of negotiation between firm and municipality, the stochastic element of the evolution of $x(t)$ arises from changes in population, weather, social habits, and the like.

⁴ Operating costs are not an issue in the delegation paradigm described above. Furthermore, variable operating costs in water management are well known and generally stable. The assumption of constant variable operating costs simplifies the mathematical manipulations and makes the model more intuitively appealing. Thus we have much to gain and little to lose by the assumption.

⁵ An alternative method in the absence of a spanning asset is to assume risk neutrality.

of return will be given by :

$$m = r + \lambda \sigma_{x,m} \quad (2)$$

where r is the riskless rate, λ is the market price of risk, $\sigma_{x,m}$ is the correlation coefficient of the percentage change in $x(t)$ with the market rate of return and $m > a$. Let $m - a = d > 0$, which can be interpreted as a dividend or convenience yield derived from actually owning the investment.

The value of the investment project, $V(x(t))$, can then be found by setting up a hedge portfolio with a long position of one unit of the investment and a short position in $V'(x(t))$ units of $x(t)$. Using standard methods in stochastic calculus gives the following differential equation:

$$\frac{\sigma^2}{2} V''(x(t))x(t)^2 + (r-d)V'(x(t))x(t) - rV(x(t)) + x(t) - c = 0 \quad (3)$$

The solution to (3) is:

$$V = \frac{x(t)}{d} - \frac{c}{r} + A_1 x(t)^{g_1} + A_2 x(t)^{g_2} \quad (4)$$

where $g_1 > 1$ (because $d > 0$) and $g_2 < 0$ (because $r > 0$) are the roots to the quadratic equation in g :

$$g_{1,2} = \frac{-(r-d - \frac{\sigma^2}{2}) \pm \sqrt{(r-d - \frac{\sigma^2}{2})^2 + 2\sigma^2 r}}{\sigma^2}$$

The constants A_1 and A_2 depend on the boundary conditions. The first boundary condition is straightforward. When income is equal to zero, the investment has no value:

$$V(0) = 0 \quad (5)$$

This condition implies $A_2 = 0$.

If we rule out speculative bubbles, the second boundary condition is:

$$V'(\infty) < \infty \quad (6)$$

which implies that $A_1 = 0$. Thus, the solution to (4) is:

$$V = \frac{x}{d} - \frac{c}{r} \quad (7)$$

Equation 7 says that the value of the water management project in the absence of market imperfections is equal to the present value of the net cash flows where income is discounted at the risk adjusted rate and expenditure, because it is known with certainty, is discounted at the riskless rate.

3.2 Valuing the Municipality's Option to Revoke Delegation

Having determined the value of the basic investment in water management, we now price the value of the option to revoke delegation in favor of direct management. We present the general case of an American style option that can be exercised at any moment. In this way we bring out the role of the relevant variables and set the stage for the contractual paradigm that we propose as a solution to the current status quo of irreversibility.

The commune is theoretically in the position of being able to reclaim the right to manage the water itself. It will do so if the level of income associated with the project warrants it. In other words, the commune has an option to reclaim the investment for itself. In order to value this option, noted as $F(x(t))$, we proceed as before by setting up a hedge portfolio with one unit of the option to invest and a short position in $F'(x(t))$ units of $x(t)$. Using standard methods as before yields the following differential equation:

$$\frac{\sigma^2}{2} F''(x(t))x(t)^2 + (r-d)F'(x(t))x(t) - r = 0 \quad (8)$$

The solution to (8) is:

$$F = B_1 x(t)^{g_1} + B_2 x(t)^{g_2} \quad (9)$$

The first boundary condition is

$$F(0) = 0 \quad (10)$$

which implies that $B_2 = 0$.

The second boundary condition depends on income and the cost of exercise. There will be a value of $x(t)$, noted x^* , where it will be optimal for the commune to exercise its option. At this point it will receive the value of the investment less the cost of exercising the option. This cost is equal to the amount necessary to overcome the four remaining obstacles to renewing direct management that were mentioned above (technology costs, recruiting costs, investment costs and indemnities, loss of fiscal advantages). Thus, the value matching condition is

$$F(x^*) = V(x^*) - I \quad (11)$$

where I is the exercise price, i.e. the cost of revoking delegation. The smooth pasting condition that makes it possible to find x^* jointly with $F(x(t))$ is:

$$F'(x^*) = V'(x^*) \quad (12)$$

Thus, the solution to (9) is:

$$F = B_1 x(t)^{g_1} \quad (13)$$

where :

$$x^* = \frac{g_1}{g_1 - 1} d \left[\frac{c}{r} + I \right]$$

and

$$B_1 = \frac{(g_1 - 1)^{g_1 - 1} \left[\frac{c}{r} + I \right]^{1 - g_1}}{(dg_1)^{g_1}}$$

It is important to remember that one obstacle to delegation revocation, the cost of the mayor's personal liability, is the same for both firm and municipality and is included in operating costs. The key variable for the municipality, then, as we explained above, is I and its

role is clear. From x^* and B_1 we can see that a higher I lowers the value of the option and raises the level of income where exercise is profitable, thereby making exercise less likely.⁶

3.3 Valuing the Project with the Abandonment Option

To make the contractual paradigm complete, we now present the value of the water management project from the point of view of the firm, which differs from that of the municipality in two ways. The first difference stems from the fact that the firm can drop the project if it feels that the project is no longer worth operating. The municipality does not have this option since by law it is obliged to assure the supply of water to the area it administers. The second difference is due to the revocation option of the preceding paragraph that the firm effectively issues the municipality when it accepts the delegation contract.

Thus, although the water management project from the commune's standpoint is, for all practical purposes, an infinitely lived investment, as a simple agent, the delegation firm is in the position of being able to resiliate the contract and turn water management back over to the commune if delegation is no longer in its interest. This will be the case if income falls too low. To determine the value of this abandonment option and the level of income where abandonment is advantageous, we proceed as before. Let $W(x(t))$ represent the value of the investment that includes the abandonment option. Build a hedge portfolio consisting of one unit of the investment $W(x(t))$ and a short position of $W'(x(t))$ units of income. Using the same methods in stochastic calculus as before gives the following differential equation:

$$\frac{\sigma^2}{2}W''(x(t))x(t)^2 + (r-d)W'(x(t))x(t) - rW(x(t)) + x(t) - c \quad (14)$$

whose solution is:

$$W = \frac{x}{d} - \frac{c}{r} + D_1x^{g_1} + D_2x^{g_2} \quad (15)$$

$$^6 \frac{\partial F}{\partial I} = \frac{(g_1 - 1)^{g_1 - 1}}{(dg_1)^{g_1}} (1 - g_1) \left[\frac{c}{r} + I \right]^{-g_1} < 0 \text{ because } (1 - g_1) < 0$$

and

The only difference between (15) and (4) are the constants. In the absence of speculative bubbles, as $x \rightarrow \infty$, the value of the abandonment option goes to 0 and, therefore, $D_1 = 0$. For the value matching condition, assume that the project's net salvage value, which also represents the exercise price, is estimated as equal to S . Then $W(x^{**}) = S$ and the smooth pasting condition is $W'(x^{**}) = 0$. Solving for x^{**} and D_2 gives:

$$x^{**} = \left[S + \frac{c}{r} \right] \frac{dg_2}{g_2 - 1}$$

where $x^{**} > 0$ because $d > 0$ and $g_2 < 0$

$$D_2 = -\frac{x^{**1-g_2}}{dg_2}$$

Thus,

$$W = \frac{x}{d} - \frac{c}{r} + D_2 x^{g_2} \quad (16)$$

Thus, the value of the abandonment option is equal to $D_2 x^{g_2}$, the difference between the value of the project with the option and its value without the option. Since it is a put option, its value increases as the exercise price increases. This can easily be verified by taking the first partial derivative of the option with respect to S .

4. USING THE MODEL

We can use the foregoing discussion to throw some light on the delegation problem. First of all, negotiation between the municipality and the delegated firm can take place between x^* and x^{**} . Within this range, the firm remains as manager while outside this range the municipality becomes manager - by design at x^* and by obligation at x^{**} . In order for the municipality to become manager at x^* , however, it must have the financial resources to make the exercise effective. Up to now, this has not been the case and therefore the option has been basically worthless. The solution to the problem involves making the resources necessary for revocation available. This could be done by providing for a fund or a financing mechanism

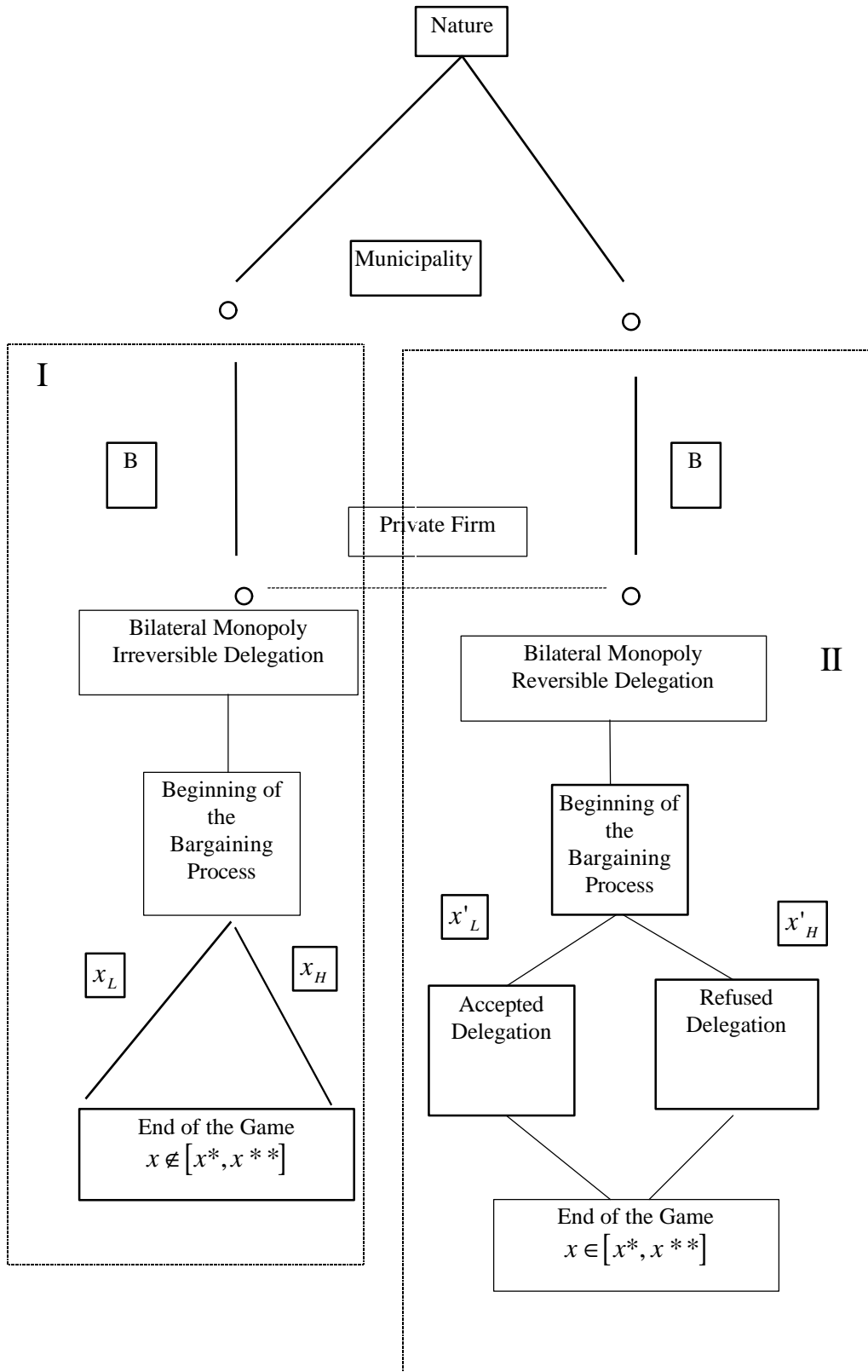
$$\frac{\partial x^*}{\partial d} = \frac{g_1 d}{g_1 - 1} > 0 \text{ because } d > 0 \text{ and } g_1 > 1.$$

when the delegation contract is signed. The details would have to be worked out but the only requirement is that the fund would have to be large enough to make the exercise threat credible. Where the exercise price is outrageously out of line (the usual case in France), the fund could be financed in part or in whole by the firm. This would increase the municipality's bargaining power by lowering the its net cost of revocation and inciting the firm to avoid levels of income that could provoke revocation.

A second consideration involves the length of the interval between x^* and x^{**} . We have seen that x^* and x^{**} depend on the exercise prices, I and S . A higher (lower) exercise price lowers (raises) the value of the option to revoke and raises (lowers) the value of the option to abandon. Suppose for the moment that the exercise price of the firm's option to abandon (the project's salvage value) is determined on the basis of the market value of the equipment and infrastructure it has installed less the closedown costs. We know, however, that because of the cartelized nature of the market, the exercise price of the option to revoke is much higher than the economic value of the resources in question. For example, the economic value of the technology is equal to the marginal cost of the technology to the delegated firm. The economic value of the water management personnel is equal to the salary paid by the delegated firm and the economic value of the physical plant and infrastructure is equal to their market value. In practice, since there is no real market, technology, personnel, and plant and infrastructure are not available at their economic value. Their cost is inflated by the cartelized firms. This lowers the value of the option and raises the level of x^* . It also generates the firm's rent, which is equal to the income it realizes between the level of what x^* should be if I were determined by the economic value of the resources and what it actually is due to inflated cartelized prices.

Once the credibility issue has been overcome, however, the municipality's increased bargaining power should make it possible to reduce or eliminate the firm's rent. In this scenario, the credibility of the revocation option makes it possible for the municipality to establish a reserve price somewhere below x^* . The bargaining process can then be described by figure 1.⁷

⁷ See Carey (1993).



The area labelled **I** represents the current situation where the firm knows that the municipality is unable to manage directly. x^* and x^{**} represent the income levels defined by the economic value of the exercise prices. Since the actual exercise price imposed by the firm is higher than the economic exercise price, the firm will realize a rent when income rises above x^* . Furthermore, since the revocation threat is not credible, there is no real limit on how high income can rise and the tendency will be towards higher prices and higher rents.

The area labelled **II** represents the situation where a fund has been established and revocation is credible. Here, x^* represents the income level defined by the cartelized conditions and not by economic values. The firm knows that the municipality can and will revoke if the firm's conditions are too demanding. This will drive the firm to temper its demands and drive income within the interval (x^*, x^{**}) . The actual bargaining process is outside the scope of this paper but the model developed in the preceeding section has made it clear that the municipality should concentrate its negotiations on reducing I rather than on a given price for water itself.⁸ This is because a lower I will drive down x^* and the firm will be obliged to lower the price on its own in order to avoid revocation.

The problem, then, is to negotiate an agreement involving technology costs, recruiting costs, investment costs and indemnities that maximize community welfare while giving the firm a fair deal. The foregoing model can be used to gain some insight into exactly what an agreement of this type would look like. Start from the firm's net position, remembering that the firm's net position is not :

$$W = \frac{x}{d} - \frac{c}{r} + D_2 x^{g_2}.$$

The net position must include the value of the call option that was effectively issued to the municipality when the firm accepted the delegation contract. When the value of the option is deducted from the value of the investment the firm's net position is

$$W - F = \frac{x}{d} - \frac{c}{r} + D_2 x^{g_2} - B_1 x^{g_1} \quad (17)$$

From equation 7 we know that the economic value of the water management project in the absence of market imperfections is equal to the present value of the net cash flows discounted at the risk adjusted rate. From (17) we can see that this will be the case when $D_2 x^{g_2} = B_1 x^{g_1}$.

⁸ The level of I depends, as we have seen, on technology costs, recruiting costs, investment costs and indemnities, and loss of fiscal advantages. Only fiscal advantages are outside the contractual sphere of firm and municipality.

Thus, a fair deal for both firm and municipality can be achieved by striking a bargain that equalizes the two option values. The firm will also have an incentive to negotiate in good faith. Suppose, for example, that the firm wants to overvalue the salvage value in order to justify the high price it puts on the value of the plant and infrastructure. This would raise the value of the abandonment option. For the option to revoke to rise by a similar amount, the firm would have to agree to supply the technology and/or the personnel at a correspondingly reduced price. If, on the other hand, the firm tried to lower the value of the two options by undervaluing the salvage value, the municipality would have a strong basis for questioning the price that the firm asks it to pay in the case of revocation.

5. CONCLUSION

In this paper we look at delegation irreversibility from the perspective of collective welfare maximization. We discuss the specific characteristics of the delegation auction that render it useless as a tool for collective welfare maximization. We then show that the remaining tool for achieving collective welfare maximization, i.e. the municipality's right to revoke delegation and return to direct management, is also ineffective due to a lack of credibility that is essentially financial in nature. We argue that if the credibility of revocation could be restored, the municipality's bargaining power could also be restored. Using standard methods of stochastic calculus, we model the municipality's right of revocation as a call option held by the municipality. We show that the value of this option depends to a large extent on the exercise price, which is partly determined by objective economic criteria and partly by legal and institutional conventions. Based on this we suggest that credibility could be restored by the constitution of a fund at least as large as the effective exercise price and that community welfare maximization would occur at the point where the exercise price is determined exclusively by objective economic criteria. Where the exercise price is clearly out of line (the usual case in France) we suggest a fund financed in part or in whole by the firm.

Since the delegated firm as a simple agent has the right to resiliate the contract if delegation becomes unprofitable, we then model this right as a put option held by the firm. Its value also depends to a large extent on the exercise price, which is partly determined by objective economic criteria and partly by legal and institutional conventions. Combining the exercise points of the two options enables us to determine the price-profit interval over which delegation will be acceptable to both parties. While the optimal interval will be the one where the exercise prices are determined entirely by objective economic criteria, we show that a fair

deal for both municipality and firm can be achieved by negotiating an exercise price for the revocation option that would equate its price with that of the firm's option to abandon. The innovative feature of this paper, then, is to treat the delegation problem in terms of call and put options so that uncertainty and intertemporal choice are integral elements of the analytical framework. The resulting contribution to the literature is the identification of the precise role that revocation costs play in the mechanism of irreversibility.

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