WATER MANAGEMENT IN FRANCE: DELEGATION AND IRREVERSIBILITY

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The problem that we address in this paper stems from the trend to delegation in the water management field. It refers to the municipality's negotiating disadvantage in the face of cartelized water management firms that makes delegation, once undertaken, virtually irreversible. We show why the characteristics of the delegation auction render is useless as a tool for collective welfare maximization. We also 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 key variable for the value of this option, and thus for the municipality's position, is the exercise price, which is partly determined by objective economic criteria and partly by legal and institutional conventions. We show that community welfare maximisation occurs 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 abrogate 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

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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.

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I. Introduction

Delegation of water management by municipal authorities to private specialised firms is becoming popular as an alternative to the traditional direct management, public utility or full privatisation. Canada, Germany, Portugal, Greece, Spain, Argentina, Peru, Tunisia, and Morocco, to name but a few, are some of the countries beginning to opt for the delegation system. Although the potential rewards of the delegation system are significant, there are also many obstacles to actually reaping these rewards. One of the main obstacles stems from the nature of the investment and the oligopolistic organisation of the market that tend to make delegation, once undertaken, a basically irreversible decision, thereby rendering it possible for the delegated firm to extract an economic rent from the community it serves. In this paper we analyse the problem of delegation irreversibility and economic rents for the case of France, a country with one of the longest and most widespread experiences of delegation.[1]

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[1] 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

The economic rents stem from the cartelized nature of the French market for water management. The ongoing cartelization of French water management is the result of historical accident and current institutional practice. Beginning in the 19th century, some of the largest French cities such as Paris, Marseille and Lyon adopted the practice of calling in private companies to make heavy infrastructure investments in exchange for the right to manage them. As a consequence, these companies gained valuable expertise in public resource management within the French governance system. Mergers, acquisitions, and failures reduced their number to three giants at the beginning of the 1980s when the delegation process became popular with municipalities. During this period, the three giants benefited from large financial resources and the most advanced technologies acquired by internal R&D and the purchase of patents. This made it possible for them to organize and protect themselves in the face of institutionalized rules and the transparency of information. They also benefited from legislation that excluded, either directly or indirectly, foreign companies from many public infrastructure investments. Potential foreign competition was undeveloped and disorganized and this allowed the French giants to consolidate and extend their position to cover the whole country.

The situation is such that up to now outside firms have found it impossible to beat the cartel on its home territory. Besides the institutional savoir-faire and the network of contacts, penetration of the French market involves having access to the most advanced technologies and a supply of trained locals to manage the service as well as the financial resources to undertake the required expenditures for new investment and indemnities to the former supplier. Although the large foreign firms possess the technological access and financial resources, they are generally lacking the institutional expertise and qualified local personnel. Labor laws and retirement plans make it difficult and costly

inhabitants, 3.500 are under private delegation for fresh water services and 1.750 for wastewater 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).

to recruit the existing personnel in question and in house training is not a viable option because of the cost and lack of expertise. Another important element in the durability of the French cartel is that the cartelized companies supply the municipalities with a wide range of products and services outside the domain of water management such as garbage disposal, sewage, cable TV, etc. Thus, the water management service is often intimately linked with these other services to the extent that in most cases one company or its subsidiaries supplies all the services to a given municipality. For an outside company, beating the cartel's bid on water management means being able to supply many other services at competitive rates as well. Consequently, the historical context and current institutional framework that rules competition in French water management conspire, paradoxically, to maintain and reinforce the position of the cartel of the three dominant companies in the sector.

The problem of delegation irreversibility is a consequence of the public authorities' negotiating disadvantage in the face of the cartelized water management firms. It can be described 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 privatisation of the water supply as in the United Kingdom, for example. The contract is long term, it is determined by an auction and it provides for the ongoing opportunity to renegotiate prices and terms. At the contract's maturity, the municipality retains control of the delegation allocation and may choose among competitors or revoke delegation in favour of direct management. Although the procedure appears equitable and competitive, in fact, as the Cour des Comptes concluded in its report of January 1997, because of the French governance tradition that is extremely exacting with respect to the municipalities' duties and obligations and that also allows de facto cartelization, fair competition is seldom achieved. Changing this situation through legislation is not feasible in the foreseeable future since it would require a major overhaul of the French governance system with significant effects far outside the realm of water management. Furthermore, in spite of

the municipalities' inherent disadvantage, this same system pushes them to opt increasingly for delegation. First of all, the technology of monitoring the safety of the existing pipe network is fully controlled by a de facto cartel of a small number of large, specialised companies that monopolise the market and limit the municipalities' access.[2] Secondly, the required competencies for water management have become more and more specific thereby making it difficult and costly for the municipalities to find and retain qualified personnel. Finally, and most importantly, because of a quirk in the French administrative organisation 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. Clark and Mondello (2000) have shown that this potential conflict of interest between the personal interests of the mayor and the well being of the community goes a long way to explaining the swing to delegation.[3] The result of all this is 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 in the form of excessively high prices to the detriment of the municipality.[4]

We look at delegation irreversibility from the perspective of collective

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[2] In France, for example, La Compagnie Générale des Eaux (Vivendi), 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.

[3] The French law of 1992 on Water increased the liability of the municipalities. They are now responsable 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 inter-dependency of individual water networks have made water management riskier and far less secure than in the past.

[4] In section IV we define the firm's rent, as the difference between the firm's income due to inflated cartelized prices and what the income would be if prices were determined by the true market value of the resources.

welfare maximisation and discuss the specific characteristics of the delegation auction that render it useless as a tool for collective welfare maximisation. We then show that the remaining tool for achieving collective welfare maximisation, 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. Consequently, the conditions for optimal contract bargaining are absent. Laffont-Tirole (1993), for example, have shown that ex-post-observed variables such as auditing may be useful in finding the optimal contract. However, for the auditing to be effective, a means of enforcement is required, a condition that is not satisfied in the present case. Mc Afee - Mc Millan (1987, 1988) combine competitive auctions with incentive contracts to find the optimal contract. In this case, the auction must be competitive for the incentive contracts to be effective, another condition that is not satisfied in the present case. Thus, we argue that if the credibility of revocation could be restored, the municipality's bargaining power could also be restored. Revocation would be the enforcement tool in the Laffont-Tirole paradigm and the firms would be truly competing with the municipality in the Mc Afee - Mc Millan paradigm.

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 maximisation 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 abrogate 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. 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 specific role that revocation costs play in the mechanism of irreversibility and the identification of the key variables that should be the focus of negotiations.

The rest of the article is organised as follows. In section II we discuss the delegation procedure and irreversibility and in section III we develop the model. Section IV contains our suggested solutions and section V summarises and concludes.

II. The Delegation Procedure

Once a municipality has decided on delegation, it 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.[5] Unqualified or financially weak firms are dismissed out of hand. The Council has a strong advisory role but the

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[5] Tight administrative controls and strict anti-corruption laws eliminate the potential agency conflict whereby the mayor colludes with the firm in the initial auction or during the renegotiation process. The municipality has no reason to collude with the firm either. Entry prices " droits d'entrée " in bidding are prohibited by law and the municipality has no authority to tax the delegated firm.

winning bid is chosen by the mayor. When this has been done, 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 they are still ongoing after more than 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 on certain specific items, the most important of which is prices, where, in the absence of an agreement, the municipality has the right to revoke the delegation contract and revert to direct management for the remaining life of the contract. 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 utility regulator (buyer) maximises the collective welfare and minimises the associated costs. Unfortunately, as we have already mentioned and as the Cours des Comptes (1997) and other studies have shown, this is not the case due to the fact that the French water procurement auction is characterised by a small number of cartelized sellers.[6] This is true for the initial auction as well as for subsequent negotiations and auctions once delegation has been undertaken. Thus, in the municipality's negotiations with the delegated firm there is no scope for a better deal with an alternative supplier.

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 favour of direct management, however, municipalities are hampered by a host of obstacles that empty the threat of any practical

[6] Nowak (1995), for example, has shown that only part of the 20% to 30% jump in the cost of purifying and supplying water when delegation is substituted for direct management can be explained by technological factors.

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. These indemnities are contractual and relate to the undepreciated value of the firm's investment in infrastructure and technology.[7] Fourth, 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 three obstacles are essentially financial in nature in the sense that they can be expressed in terms of a monetary equivalent. The fourth is less clearly so. Clark and Mondello (2000), however, have shown that the mayor's personal liability and that of the municipality, if damages exceed the total value of the mayor's net worth, 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 monetary equivalent equal in value to the value of the insurance policy protecting the mayor. Thus all four 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 which depends directly on the municipality's capacity to generate the necessary funds. Unfortunately, the municipality access to financial markets for the purpose of water management is restricted

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[7] As we will see below, this is a key element in the firms' bargaining power and one of the reasons why they constantly switch to newer and costlier technologies, even before the old ones have been fully depreciated.

by law.[8] In fact, borrowing for the purpose of revocation payments is prohibited.

The situation can be summarised 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 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. This is because municipality access to financial markets for the purpose of water management is restricted by law.

To give a graphical 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]:

Graph 1

B ─────────────────⟶ [Si], (i = 1, ..., n)

where sellers [Si], (i = 1, ..., n) are identified with their optimal strategies reflected in their bids. In a bilateral monopoly, [S], the relationship is graph [2]:
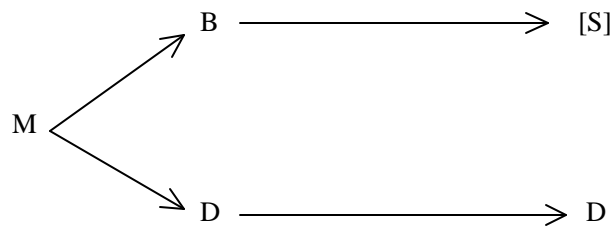
Graph 2

B ─────────────────⟶ [S]

In this situation, the municipality has few weapons at its disposal. Those that do exist are very weak, which makes traditional analysis inapplicable. As we mentioned, the required competition for the Mc Afee - Mc Millan (1987, 1988) paradigm is absent and there is no enforcement mechanism for the

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[8] See Cours des Comptes (1997), p. 84, 91.

Laffont-Tirole (1993) paradigm. 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 restores the element of competition. Revocation is the enforcement mechanism. If the municipality's direct management threat is credible, it can use this threat to negotiate the price and quality that minimise 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.

III. 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 analyse 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. We then go to the particular case in point where water management has been delegated to a private firm and analyse successively the municipality's position and the firm's position.

A. Valuing the Water Management Project as an Infinitely Lived Investment

Given the essential nature of water in all facets of human activity, water management and supply is a requirement for any organised society. It is an indispensable activity that must exist as long as the society itself exists. In this sense, water management and supply does not depend explicitly on time and, 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:[9]

$$dx(t) = a\ x(t)\ dt + s\ x(t)\ dz(t) \tag{1}$$

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 operating costs. These costs should include the insurance premium for liability coverage. As we mentioned above, this liability is unlimited and in the case of negligence engages personal responsibility for the mayor-municipality in the case of direct management and for the firm in the case of delegation. In the absence of market imperfections where both municipality and firm have equal access to technology and expertise, the

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[9] 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.

liability is the same for both. 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. Finally, we assume that within the output capacity of the investment operating costs are constant.[10]

The required risk adjusted rate of return on $x(t)$ can be found by applying the CAPM directly to $x(t)$.[11] The required rate of return will be given by

$$\mathbf{m} = r + \mathbf{l}\ \mathbf{s}\ \mathbf{r}_{x,m} \tag{2}$$

where r is the riskless rate of interest, $\mathbf{l}$ is the market price of risk, $\rho_{x,m}$ is the correlation coefficient of the percentage change in $x(t)$ with the market rate of return and $\mathbf{m} > \mathbf{a}$. Let $\mathbf{m} - \mathbf{a} = \mathbf{d} > 0$, 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:

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[10] This assumption implies that either there is a single given technology or that technology changes affect water quality but not cost. Technology and changes in technology, while important in a more general context, are only peripheral to the problem at hand. Furthermore, the great majority of operating costs in water management accrue to depreciation, which is fixed or has a fixed schedule, and skilled labor. Because of social legislation that eliminates temporary layoffs and the specialized skills required for water management that make temps a limited commodity, labor costs are also fixed for all practical purposes. Thus, variable operating costs are a small percentage of total operating costs. Consequently, the assumption of constant operating costs is not too unrealistic. Since this assumption simplifies the mathematics and makes the model more intuitively appealing, we have much to gain and little to lose by it.

[11] In France $x(t)$ is directly observable in so far as water companies are required by law to furnish the authorities with regular, detailed information on quantities and prices. If $x(t)$ were not directly observable, a spanning asset could be substituted. An alternative method in the absence of a reliable spanning asset is to assume risk neutrality.

$$\frac{\boldsymbol{s}^2}{2} V''(x(t)) \, x(t)^2 \; + \; (r - \boldsymbol{d}) \, V'(x(t)) \, x(t) \; - \; r \, V(x(t)) \; + \; x(t) \; - \; c \; = \; 0 \qquad (3)$$

The solution to (3) is:

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

where $\boldsymbol{g} > 1$ (because $\boldsymbol{d} > 0$) and $\boldsymbol{g}_2 < 0$ (because $r > 0$) are the roots to the quadratic equation in $\boldsymbol{g}$:

$$\boldsymbol{g}_{1,2} = \frac{-(r - \boldsymbol{d} - \frac{\boldsymbol{s}^2}{2}) \pm \sqrt{(r - \boldsymbol{d} - \frac{\boldsymbol{s}^2}{2})^2 + 2\boldsymbol{s}^2 r}}{\boldsymbol{s}^2}$$

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

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

This condition implies $A_2 = 0$.

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

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

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

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

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 (x) is discounted at the risk adjusted rate and cost (c), because it is constant, is discounted at the riskless rate.

B. 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 favour of direct management. We start from the situation of delegation where water management and supply is handled by a private firm and present the municipality in the position of the owner 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 to $x(t)$. Using standard methods as before yields the following differential equation:

$$\frac{\pmb{s}^2}{2} F''(x(t))\, x(t)^2 + (r - \pmb{d})\, F'(x(t))\, x(t) - r\, F(x(t)) = 0 \tag{8}$$

The solution to (8) is:

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

The first boundary condition is

$$F(0) = 0 \tag{10}$$

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

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

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:

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

Thus, the solution to (9) is:

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

where

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

and

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

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 excercise is profitable, thereby making exercise less likely. [12]

C. 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 terminate 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:

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[12] $\dfrac{\partial F}{\partial I} = \dfrac{(g_1 - 1)^{g_1 - 1}}{(d g_1)^{g_1}}(1 - g_1)\left[\dfrac{c}{r} + I\right]^{-g_1} < 0$ because $(1 - g_1) < 0$

and

$\dfrac{\partial x^*}{\partial I} = \dfrac{g_1 d}{g_1 - 1} > 0$ because $d > 0$ and $g_1 > 1$

$$\frac{s^2}{2}W''(x(t))x(t)^2 + (r-d)W'(x(t))x(t) - rW(x(t)) + x(t) - c = 0 \quad (14)$$

whose solution is:

$$W = \frac{x}{d} - \frac{c}{r} + D_1 x^{g_1} + D_2 x^{g_2} \tag{15}$$

The only difference between (15) and (4) are the constants. In the absence of speculative bubbles, as $x \to \infty$, the value of the abandonment option goes to 0 and, therefore, $D_1 = 0$. For the value matching condition, define S, the project's net salvage value, as equal to gross salvage value less the abandonment costs. Gross salvage value is basically contractual and comprised of the undepreciated value of the firm's investment in infrastructure and technology. Abandonment costs are also basically contractual and include cash penalties as well as certain costs associated with assuring the transition from one management to another. Since the abandonment option is a put, net salvage value represents the exercise price.[13] Thus, the value matching condition is $W(x^{**}) = S$ 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 $g_2 < 0$

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

and

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

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[13] The firm gives up the project and receives the salvage value.

Thus, the value of the abandonment option is equal to $D_2 x^g$, 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.

IV. Using the Model

We can use the foregoing discussion to shed some light on the delegation problem. First of all, where revocation is a credible threat, 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 financial resources necessary for revocation available. This could be done by providing for a fund or a financing mechanism. The details would have to be worked out but the only requirement is that the fund should be large enough to make the exercise threat credible. This would increase the municipality's bargaining power by making revocation credible and incite the firm to avoid levels of income that could provoke revocation.[14]

A second consideration involves the actual levels of 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. The optimal interval occurs where

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[14] Greater bargaining power for the municipality (i.e. a credible threat of revocation) would probably give the firm an enhanced incentive to hide income, which might generate a need for increased audits and other enforcement mechanisms and their associated costs if the ongoing auditing system was seen to be deficient in some way.

I and *S* represent their economic values. Because of the cartelized nature of the market, however, 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 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, plant and infrastructure are not available at their economic value. Their cost is inflated by the cartelized firms.[15] 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 realises 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. The same phenomenon is at work in the abandonment option since the exercise price of the firm's option to abandon (the project's net salvage value) depends on the same inflated cartelized prices.

Once the credibility issue has been overcome, however, the municipality's increased bargaining power should make it possible to reduce or at least limit the level of the firm's rent.[16] In this scenario, the credibility of the revocation option obliges the firm to establish a reserve price somewhere below x^* because the firm knows that the municipality can and will revoke if its income rises above the critical level. Eliminating the rent altogether, however, requires that x^* be determined by the economic values of *I* and *S*. To this end, the municipality should concentrate its efforts on reducing *I* rather than on a given price for water itself.[17] This is because a lower *I* will drive down x^* and

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[15] Legally, the municipality is required to pay "fair" value for the assets. The difficulty is working out what "fair" value is. In practice it is usually defined as the undepreciated book value.

[16] In terms of game theory, the municipality will have regained its first mover advantage. The firm, as follower, will then incorporate the Stackelberg leader's preferences in its best response function.

[17] 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.

the firm will be obliged to lower the price on its own in order to avoid revocation. The firm, of course, will resist all attempts to eliminate its rent and in the actual state of affairs, the municipality has no means of obliging the firm to cooperate.

The problem, then, is to create a situation whereby community welfare would be maximised while giving the firm a fair deal. The foregoing model can be used to gain some insight into how a situation like this could be achieved.

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

$$W \text{ - } F \; = \frac{x}{d} - \frac{c}{r} + D_2 x^{g_2} - B_1 x^{g_1} \tag{17}$$

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. From (17) we can see that this will be the case when $D_2 x^{g_2} = B_1 x^{g_1}$ is calculated where S and I represent the economic values. The credibility of municipal revocation restores the bargaining process and the relationship between the two options pinpoints the key variables that should be the subject of the negotiations. Thus, a fair deal for both firm and municipality can be achieved by determining the economic values of S and I and then striking a bargain that equalises the two option values. This can be seen by an example.

In practice we can define *I* and *S* by

I = contractual indemnities (undepreciated value of investment in technology
        and infrastructure) + training and hiring costs +
        + cost of procuring new technology

S = gross salvage value – abandonment costs
    = contractual indemnities – (training and hiring costs +
        + contractual cash penalties)

Start from *S*. Contractual indemnities and contractual cash penalties are observable, the first from the balance sheet and the second from the delegation contract. They do not, however necessarily represent economic values.[18] Training and hiring costs can also be estimated in large part from the firm's accounts, relating to salaries, training, etc. For *I*, the cost of procuring new technology is a monopolistic price imposed by the firm. However, in most cases the market price will be reflected in the price paid by the firm if the technology was acquired abroad or in the price charged by the firm in markets where it does not wield cartelized power if the technology was developed by the firm itself.

Consider the following information where the value of *S* includes 15 in net investment, 2 in training and hiring and 3 in cash penalties while *I* has the same figures for net investment and training and hiring and 8 for the cost of procuring the new technology. Suppose that the cost of procuring the new technology represents the cartelized price and not the market price.

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[18] The undepreciated value of investment in technology and infrastructure is not necessarily the economic value but in many cases might be the only estimate available. Cash penalties should be estimated based on the economic costs to the municipality of assuming responsibility for water management when the firm abandons. The effort should be made to determine these costs and use them in valuing the abandonment if they differ from the contractual cash penalties that can be observed in the delegation contract.

Table 1. Initial Parameters

a	m	R	s	S	I	c	x
0	8%	5%	10%	$15 - 2 - 3 = 10$	$15 + 2 + 8 = 25$	1	4

Using this information in equations 4, 13 and 16, we find that $g_1 = 8.2167$, $g_2 = -1.217$, $B_1 = 0.0000572$, $D_2 = 18.9266$, $x^* = 4.0988$ and $x^{**} = 1.31745$. The value of x that gives $D_2 x^{\gamma_2} = B_1 x^{\gamma_1}$ is 3.8436. This figure is lower than the current level of x, which is at 4, but 4 is very close to x^*. Thus, even with the cartelized price of technology, revocation credibility puts pressure on the firm to lower its price or at least not to raise it in order to avoid hitting the exercise limit.

Now suppose that the market price for technology is 5 and not 8. In this case $B_1 = 0.00010159$, $x^* = 3.8256$ and the value of x that gives $D_2 x^{\gamma_2} = B_1 x^{\gamma_1}$ is 3.6195. The firm's rent is equal to 0.3805 (4 – 3.6195) and even though the revocation credibility effectively caps the price the firm charges for its water or puts downward pressure on it, in the absence of any new developments, it is unlikely that the rent will be completely eliminated. If, however, the municipality were only liable for the market price of the technology and not the cartelized price, the firm's rent could be totally eliminated. A common fund financed at the national or regional level could be set up for this purpose. In the case of revocation, the municipality would be liable for the market value of the technology and the compensation fund would make up the difference. Thus the municipality would establish x^* based on economic values and revoke accordingly. In fact, the compensation fund would not even have to be used in order to be effective. Its mere existence and the threat of revocation would drive the firms' pricing policy to eliminate the rent. Ideally, the firms would finance the compensation fund themselves to make up for their cartelized technology pricing that distorts

prices. In practice, however, this might be difficult to achieve and it is more likely that financing the compensation fund would have to be handled on a national or regional level.

In the context of revocation credibility a compensation fund there would probably be a need for improved auditing as a means for determining the economic values of the elements of I because once the system came into operation the firms would do all they could to inflate values in order to raise x^*. Besides the cost of technology, the auditing would also have to address the problem of overinvestment and the practice of carrying obsolete investments on the books.

V. Conclusions

In this paper we look at delegation irreversibility from the perspective of collective welfare maximisation. We discuss the specific characteristics of the delegation auction that render it useless as a tool for collective welfare maximisation. We then show that the remaining tool for achieving collective welfare maximisation, 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 maximisation would occur at the point where the exercise price is determined exclusively by objective economic criteria. To this end, we suggest a compensation fund that would reimburse the municipality for the difference between the cartelized price and the economic value.

Since the delegated firm as a simple agent has the right to abrogate 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. The exercise points of the two options 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 is achieved at the value of x that equates the values of the two options. 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 specific revocation costs and the role they play in the mechanism of irreversibility and economic rents.

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