Concession Length and Investment Timing Flexibility

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Summary

When assigning a concession contract, the regulator faces the issue of setting the concession length. Another key issue is whether or not the concessionare should be allowed to set the timing of new investments. In this paper we investigate the impact of concession length and investment timing flexibility on the “concession value”. It is generally argued that long-term contracts are privately valuable as they enable a concessionaire to increase her overall discounted returns. Moreover, the real option theory suggests that investment flexibility has an intrinsic value, as it allows concessionaires to avoid costly errors. By combining these two conventional wisdoms, one may argue that long- term contracts, which allow for investment timing flexibility, should always result in higher concession values. Our result suggests that this is not always the case. Firstly, investment flexibility does not always increase the concession value. Secondly, long-term contracts do not necessarily increase the concession value.

Keywords: Concession contracts, Real option theory, Investment timing flexibility, Water utilities

JEL Classification: D81, G31, L95

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1 Introduction

In recent years there has been a significant increase of private sector participation in the provision of public utilities. Besides the evident failure of many state-provided services, this process has been driven by the need for increased capital investments and the lack of public financial resources (Dosi and Muraro, 2003).

In this context, concessions play a key role, in those sectors (*e.g.* water services) where natural monopoly conditions persist, and "competition for the market" is the only viable option to achieve efficiency gains. Under concession contracts, the goverment retains ownership of the infrastructure but transfers all risk and responsibility for running the utility, including responsibility for financing investments (Marin, 2002).

When assigning a concession contract, the regulator faces *inter alia* the issue of setting the concession length. Another key issue is the degree of managerial flexibility, namely whether or not the concessionaire should be allowed to set the timing of new investments.

In this paper we focus on the impact of concession length and investment flexibility on "concession value" leaving aside the problems arising from asymmetric information, and ignoring other public objectives[1]. In other words, we assume that the government wishes to maximize the value of the contract, in order to make it more appealing. Some of the benefits arising from a privately optimal contract could be extracted through concession fees or eventually transferred to consumers, in terms of a reduction in tariffs or an increase in the quality of the service.

We carry out the analysis referring to the real option literature which, starting from the seminal works by Brennan and Schwartz (1985) and McDonald and Siegel (1985, 1986) has highlighted the analogy between security options and investment flexibility. Since concessionaires must typically bear substantial capital expenditure, under uncertainty, the ability to wait and see before committing a capital outlay has an intrinsic value, since it allows the concessionaire to avoid costly errors.

The questions addressed in the paper may be summarised as follows. Does investment timing flexibility always increase the concession value? How

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[1] There is a debate in literature about the optimal length of a concession contract. Under long -term contracts the regulator may be "captured" by the concessionaire because of asymmetric information (Williamson, 1985; Posner, 1972). On the other hand, short-term contracts may lead the concessionaires to under-invest since the return period is too short (Laffont and Tirole, 1993; Armstrong et al.,1994; Littlechild, 2004).

should concession length be determined in order to maximize the concession value when the concessionaire has no obligations with regards to the investment timing?

The paper is organised as follows. In Section 2 we present a simple real option model to evaluate the concession value (the concession's extended present value). In Section 3 we apply the model by analysing an investment decision in capacity expansion (a new abstraction plant), using data drawn from the Italian water service sector. Section 4 provides a brief summary of the findings.

2 The model

We use a simplified version of the model proposed by McDonald and Siegel (1986). The following assumptions hold:

1. The investment is a large-scale project which generates, once undertaken, an instantaneous profit flow Π_t which evolves over time according to a geometric Brownian motion with instantaneous expected return $r-\delta$ and instantaneous volatility $\sigma > 0$:

   $$d\Pi_t = (r-\delta)\Pi_t dt + \sigma \Pi_t dz_t \qquad \Pi_0 = \Pi \tag{1}$$

   where dz_t is the increment of a standard Brownian process with mean zero and variance dt (i.e. $E(dz_t)=0$, $E(dz_t^2)=dt$), r the risk-free rate and δ the opportunity cost (in annuity terms) to invest at time zero in the project instead of investing in a similar traded financial security. Hereafter, we will refer to $r-\delta$ as the certainty-equivalent rate of return.[2]

2. The concession contract lasts for T_c years.

3. The investment exercise time is τ ($\tau \leq T_c$).

4. The investment entails a sunk capital cost I, while the residual value is given by:

   $$S = Ie^{-\xi(T_c-\tau)/\tau}$$

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[2] Since the investment project we are analyzing is not a traded asset, its expected rate of return is out of equilibrium. δ measures the resulting rate of return shortfall, i.e. the difference between the equilibrium expected return on a similar traded financial security and the return on the non-traded asset (McDonald and Siegel, 1984).

In order to calculate the project's value we must consider its operating life (economic life) $T_c - \tau$. In other words, whenever the concessionaire decides to defer the investment, she reduces the time over which profits can be gained by running the utility. According to assumption 4, the residual value is described as a percentage of the replacement cost. This percentage depreciates at rate ξ over the remaining years until the end of the concession. Therefore, if the firm invests at $\tau = 0$ the residual value is equal to zero, while if the firm invests close to the end of the concession, $\tau = T_c$, the residual value coincides with the replacement cost.

The market value of the project can be evaluated as the expected present value of discounted cash flows:

$$\begin{aligned} V(\Pi) &= E\left\{\int_0^{T_c-\tau} e^{-rt}\Pi_t dt + e^{-r(T_c-\tau)}S\right\} \\ &\equiv \frac{\Pi}{\delta}(1-e^{-\delta(T_c-\tau)}) + Ie^{-(r+\frac{\xi}{\tau})(T_c-\tau)} \end{aligned} \tag{2}$$

where E denotes the expectation operator under the risk neutral probability measure (Cox and Ross, 1976; Harrison and Kreps, 1979).

Given the above assumptions, the value of the opportunity to invest, i.e. the project's Extended Net Present Value, is analogous to a European call option on a constant dividend-paying asset:

$$F(\Pi_t, t) = E_t\left\{e^{-r(\tau-t)}\max\left(\hat{V}(\Pi_\tau) - \hat{I}, 0\right)\right\} \tag{3}$$

where $\hat{V}(\Pi) \equiv \frac{\Pi}{\delta}(1-e^{-\delta(T_c-\tau)})$, $\hat{I} = I(1-e^{-(r+\frac{\xi}{\tau})(T_c-\tau)})$, τ is the expiration date and Π_τ the project cash flow at time τ. The solution of (3) is given by the well-known formula derived by Black and Scholes (1973):

$$F(\Pi_t, t) = e^{-\delta(\tau-t)}\Phi(d_1)\hat{V}(\Pi_t) - e^{-r(\tau-t)}\Phi(d_2)\hat{I} \tag{4}$$

where:

$$d_1(\Pi_t) = \frac{\ln(\hat{V}(\Pi_t)/\hat{I}) + (r-\delta+\sigma^2/2)(\tau-t)}{\sigma\sqrt{\tau-t}}, \quad d_2(\Pi_t) = d_1(\Pi_t) - \sigma\sqrt{\tau-t}$$

and $\Phi(\cdot)$ is the cumulative standard normal distribution function. While the terminal condition becomes (D'Alpaos and Moretto, 2004):[3]

$$\lim_{\tau\to T_c} F(\Pi_\tau, \tau) = \lim_{\tau\to T_c} \max[(\hat{V}(\Pi_\tau) - \hat{I})^+, 0] = 0 \tag{5}$$

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[3] Brennan and Schwartz (1985) introduce a similar terminal condition. In their analysis, though, the contract lease does not provide for any limitation on the number of years over which the resource can be exploited.

3 The case of a water abstraction plant

The Italian water sector represents an interesting case study to apply the above model. First of all, Italy has undergone a reform over the past decade which has established a separation between water resource planning and the operation of water utilities. Under Law n° 36/94, resource planning is assigned to the local water authority, called ATO,[4] which assigns the operation of water services to a concessionaire and fixes the tariff.[5][6] Besides ensuring the maintenance of existing infrastructures, the concessionaire must typically undertake new investments in order to fulfill the standards set by the ATO and to expand service capacity.[7]

Secondly, the water sector is characterized by a wide range of feasible alternative technical solutions planners can choose from as far as the operation and management of the water utilities are concerned. Technological innovations have led to the construction of complex systems allow for high operational flexibility. It is quite common today to design vertical integrated systems with several interconnections between the network infrastructures, which can be expanded by sequential or modularized investments. Such systems can easily be modified over time in order to face and adapt to changes in the state variables (e.g. average day demand, number of users, input costs, etc.). This flexibility, which arises from technical aspects, has an economic value that is related to the concessionaire's "ability" to decide whether and when it is optimal to invest in capacity expansion.

By referring to the case of a new water abstraction plant, this section investigates the relationship between concession length and investment timing as well as the effect of concession length on concession value (Extended Net Present Value).

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[4] The ATOs are taking over control functions which were previously state-run (decentralization). Generally speaking the word ATO refers to both the water authority and the area where the authority operates.

[5] The Law compells the ATO to entrust a single operator for the full vertical water cycle and charge the same tariff within the area where the ATO itself operates.

[6] The Law n° 36/94 also defines a new pricing mechanism (Metodo Tariffario Normalizzato) which combines the idea of price cap regulation with the full recovery of the service costs (Bardelli and Muraro, 2003).

[7] The physical assets needed to provide the service (e.g. pipelines, reservoirs, treatment plants) are publicly owned.

3.1 The data

In order to meet the contract requirements, the Italian concessionaires have two alternatives. One option is to provide the service by buying water via another firm. In this case we assume the NPV is equal to zero since the price of traded water is established by the ATOs according to “solidarity and fairness criteria”. Alternatively, the concessionaire may invest in capacity expansion. This can be done by constructing a new water abstraction plant of dimension X.

Assuming a profit function linear in X, we obtain:

$$\Pi_t = R_t(1-i)X - C_tX \tag{6}$$

where R_t are the revenues per cubic meter, C_t the operating costs per cubic meter, X the plant's capacity (m^3) and i the volume losses in the network. We also make the following assumptions:

1. Revenues are non stochastic since the tariffs are set by the regulator over the entire concession period.
2. Operating costs are stochastic and follow a geometric Brownian motion with a growth rate $(r-\delta)$ and volatility σ:

   $$dC_t = (r-\delta)C_tdt + \sigma C_tdz_t$$

3. The risk-free discount rate r is constant over time.
4. The project's residual value at the end of its lifetime is zero.[8]

Given the above assumptions, the present value of the project is:

$$\begin{aligned}\hat{V} &= E\left[\int_0^{T_c-\tau} e^{-rt}[(1-i)R_t - C_t]Xdt\right] = \\ &= \left[\frac{(1-i)R}{r}\left(1-e^{r(T_c-\tau)}\right) - \frac{C}{\delta}(1-e^{-\delta(T_c-\tau)})\right]X\end{aligned} \tag{7}$$

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[8] This assumption seems non-restrictive as capital depreciation functions are generally of hyperbolic type (Mauer and Ott, 1995) with a substantially high estimated rate of depreciation ξ. Nevertheless, introducing a residual value in the evaluation model would not substantially modify our results. Under this hypothesis we obtain a cautious estimate of the project's Extended Net Present Value.

while the Extended Net Present Value is given by:

$$F(\Pi_t, t) = e^{-\delta(\tau-t)}\Phi(d_1)\hat{V}(\Pi_t) - e^{-r(\tau-t)}\Phi(d_2)I$$

In detail, the water abstraction plant is made up of: a) a well field (3 wells); b) a pumping station; c) a treatment plant; d) a storage system (capacity equal to 10,000 m^3); e) a treatment plant; f) an electrical system for the equipment installed. The treatment plant includes a filtration process on Granular Activated Carbon (GAC) and the storage system includes disinfection and chlorination procedures.[9] The system guarantees a water provision of about 300 l/s (equivalent to 9,460,800 $m^3/year$) but it is subject to water losses in the network ($i = 20\%$). We assume that the plant's construction and installment costs are not time-dependent and amount to about 3,500,000 Euros. Table 1 summarizes estimates of the project's technical and economic parameters.

$X\ (m^3/s)$	0.300
$I\ (Euro)$	$3,500,000$
$T_c\ (years)$	$10 - 40$
$C\ (Euro/m^3)^*$	0.13
$R\ (Euro/m^3)^{**}$	0.30
i	20%
δ	2%
r^{***}	5%
σ^{****}	30%

Table 1: Summary of information for the water abstraction plant.

*Designers and industry experts interviewed agree on estimating the average operational costs of this type of plant at around 0.13 Euro/m^3. **Revenues per cubic meter have been determined by a statistical analysis performed over a distribution whose parameters have been estimated on the basis of the average tariff paid by users for the provision of drinking water. ***The risk-free rate is assumed to be equal to the rate of return of *on?* stated-owned bonds. ****The variance has been estimated considering analogous investment projects carried out in the past, whose operating costs were known throughout the project life.

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[9] See Twort *et al.* (2000).

3.2 The results

The main results are illustrated in Figure 1, which describes the Extended Net Present Value (F) for different concession lengths $T_c = \{10, 15, 20, 25, 30, 35, 40\}$, and different exercise times τ.[10]

Figure 1 about here

The concession value is concave in exercise time τ. This implies that for given T_c we may find an interior investment time (τ^*) which maximizes the concession value F.

By observing Figure 1 several conclusions can be drawn:

1. Let's first consider the case where the regulator arbitrarily sets T_c and allows the concessionaire to choose the investment time (τ). The optimal investment time (τ^*), which maximizes the Extended Net Present Value, varies depending on T_c. For example, assuming $T_c = 40$ years, F has a maximum for $\tau^* = 17$ years. Everything else being equal, if T_c is reduced to 30 years, τ^* becomes 9 years. Finally, if $T_c = 15$ years concession value F consistently decreases in τ so that it is optimal to invest immediately (i.e. $\tau^* = 0$). In this case, the investment timing flexibility allowed by the regulator does not increase the project's value ($F \equiv NPV$).[11]

2. Let's now consider how the optimal concession length (T_c^*) is affected by τ. The optimal T_c^* is the one maximizing F. If τ is equal to zero (i.e. no flexibility is allowed by the regulator), the concession value collapses to the conventional NPV. In this case, T_c^* can be chosen by ranking the $NPVs$: more specifically, the maximun NPV correponds to $T_c^* =$ 20 years. On the contrary, if $\tau > 0$, the optimal concession length should be chosen by ranking the Fs. For example, if the concessionaire is allowed to defer the investment for 5 years (i.e. $\tau = 5$), the optimal concession length is $T_c^* = 25$ years, while if $\tau = 10$ years, the maximun F correponds to $T_c^* = 30$ years.

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[10] According to assumption 4, when τ is equal to T_c (i.e. when the concession contract ceases), we get $F = 0$.

[11] The relationship between τ^* and T_c can be described by a linear function:

$$\tau^* = \begin{cases} 0 & \text{if} \quad T_c \leq 20 \text{ years} \\ \\ bT_c + b' & \text{if} \quad T_c > 20 \text{ years} \end{cases}$$

where $b = 0,81$ and $b\prime = -8,93$ (OLS). When $T_c \leq 20$ years, the concessionaire is neutral to signing concession contracts that allow or rule out managerial flexibility.

If we put the above results together, we find that in order to maximize the concession value, the regulator should determine the couple (T_c^*, τ^*) that maximizes F (Figure 2). In our example, the maximum F is obtained, approximately, when $T_c^* = 25$ years and $\tau^* = 5$ years.

Figure 2 about here

3.3 Concluding Remarks

In this paper we investigated how the concession length and investment timing flexibility affect the concession value. It is generally argued that long-term contracts are privately valuable as they allow a concessionaire to increase her overall discounted returns. Moreover, the real option theory suggests that investment flexibility has a value, as it makes it possible to avoid costly errors. By combining these two conventional wisdoms, one may argue that long-term contracts, embedding investment timing flexibility, should always result in higher concession values.

Our results suggest that this is not always the case, since there is not a monotone relationship between the Extended Net Present Value and concession length. Firstly, investment flexibility does not always increase the concession value. For example, under a short-term contract, the concessionaire's ability to defer irreversible investments may not provide additional value, since it becomes optimal to invest immediately (the concession's Extended Net Present Value coincides with to the conventional Net Present Value).

Secondly, long-term contracts do not necessarily increase the concession value. Since the duration of the concession contract affects the optimal investment timing, if a concession contract is "too long", the concessionaire may be forced to postpone investments in order to reduce the uncertainty over future returns. Again, this may result in a lower Extended Net Present Value.

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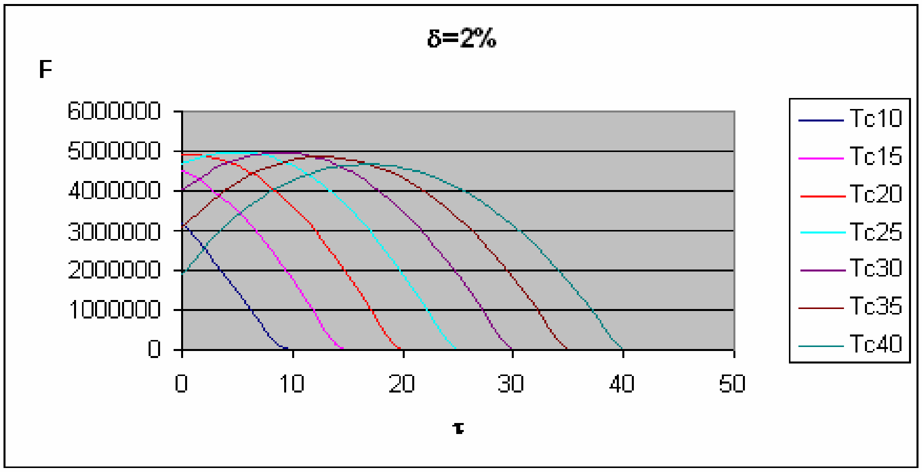
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Figure 1

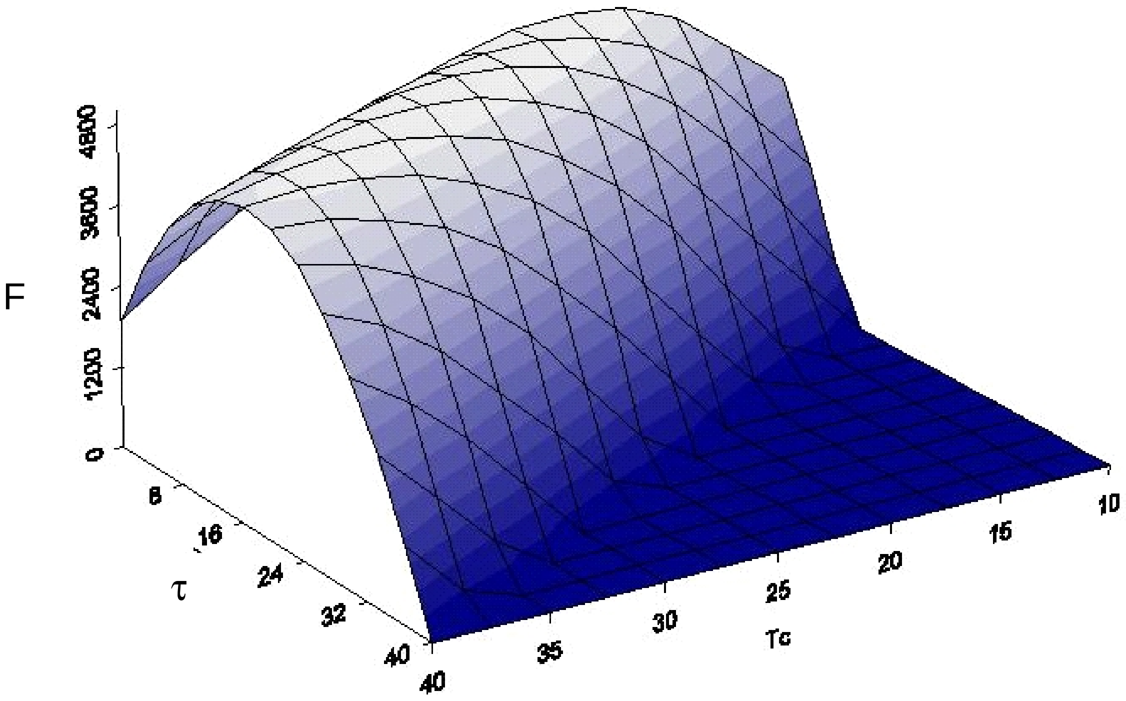

Figure 2

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