Concession length and investment timing flexibility

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[1] When assigning a concession contract, the regulator faces the issue of setting the concession length. Another key issue is whether or not the concessionaire 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 its 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; that is, investment flexibility and long-term contracts do not necessarily increase the concession value.

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1. Introduction

[2] In recent years, there has been a significant increase in 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].

[3] 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 [*Braeutigam*, 1989]. Under concession contracts the government retains ownership of the infrastructure but transfers all risk and responsibility for running the utility, including responsibility for financing investments [*Marin*, 2002].

[4] When assigning a contract, the regulator faces the issue of setting the concession length. For instance, under long-term contracts the regulator may be captured because of asymmetric information [*Williamson*, 1985; *Posner*, 1972]. On the other hand, short-term contracts may lead the concessionaires to underinvest since the return period is too short [*Laffont and Tirole*, 1993; *Armstrong et al.*, 1994; *Littlechild*, 2004].

[5] Another key issue is the degree of managerial flexibility, namely, whether or not the concessionaire should be allowed to decide whether and when to undertake new investments. Although concessions often entail mandatory investment plans, the regulator may simply require the concessionaire to fulfill service obligations (e.g., drinkable water supply) without imposing specific investments at some point in time.

[6] 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, 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.

[7] The questions addressed in the paper can be summarized as follows. Does investment timing flexibility always increase the concession value? How should concession length be determined in order to maximize the concession value when the concessionaire has no obligations with regard to the investment timing?

[8] 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 as it allows the concessionaire to avoid costly errors.

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

2. Model

[10] 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

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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 $dt[E(dz_t) = 0, E(dz_t^2) = dt]$, r is the risk-free discount rate, and δ is the opportunity cost (in annuity terms) to invest at time zero in the project instead of investing in a similar traded financial security [*McDonald and Siegel*, 1984]. Hereinafter we will refer to $r - \delta$ as the certainty equivalent rate of return. (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

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

[11] In order to calculate the project's value we must consider its economic life $T_c - \tau$. In other words, whenever the concessionaire decides to defer the investment, it 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 capital cost. This percentage depreciates at rate ξ over the remaining years until the end of the concession. Therefore, if the firm invests close to the end of the concession, $\tau = T_c$, the residual value coincides with the capital cost, while if the firm invests at $\tau = 0$, the residual value depends on any given depreciation rate on the concession length.

[12] The market value of the project can be evaluated as the expected present value of discounted cash flows,

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

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

[13] 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,

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

where $\hat{V}(\Pi_\tau) \equiv \frac{\Pi}{\delta}(1 - e^{-\delta(Tc - \tau)})$, $\hat{I} = I(1 - e^{-(r+\xi)(Tc - \tau)})$, τ is the expiration date, and Π_τ is 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

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

and Φ ( ) is the cumulative standard normal distribution function, while the terminal condition becomes [*D'Alpaos and Moretto*, 2004]

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

3. Case of a Water Abstraction Plant

[14] In order to apply the model so as to investigate the relationship between concession length and investment timing as well as the effect of concession length on the extended net present value, we consider an investment in capacity expansion, namely, a new water abstraction plant, by using data drawn from the Italian water service sector.

[15] 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 the national law number 36/94, resource planning is assigned to local water authorities (Autorità d'Ambito Territoriale Ottimale (AATO)), who assign the operation of water services to a concessionaire and fix the tariff according to a new pricing mechanism (Metodo Tariffario Normalizzato), which combines the idea of price cap regulation with full recovery of the service costs [*Bardelli and Muraro*, 2003]. Furthermore, the AATO draws up a multiyear plan (Piano d'Ambito), which sets both the minimum level of services and the quality standards.

[16] In order to meet the service requirements the Italian concessionaires have two alternatives. One option is to invest in capacity expansion. Alternatively, the concessionaire may decide to satisfy water demand by buying water via another firm. Since the price of traded water is established by the AATOs according to "solidarity and fairness criteria," we assume the net present value (NPV) of the latter alternative is equal to zero. This allows us to focus exclusively on the decision to invest in a new water abstraction plant.

3.1. Data

[17] Let us define the profit function as

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

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

[18] For the sake of simplicity we make the following assumptions: (1) R_t are nonstochastic since the tariffs are set by the regulator over the entire concession period. (2) C_t are stochastic and follow a geometric Brownian motion with a growth rate ($r - \delta$) and volatility σ,

$$dC_t = (r - \delta)C_t dt + \sigma C_t dz_t.$$

(3) The risk-free discount rate r is constant over time. (4) The plant's residual value at the end of the concession period is zero.

[19] Generally speaking, the last assumption seems nonrestrictive as capital depreciation functions are of hyperbolic type with a substantially high estimated rate of depreciation ξ [*Mauer and Ott*, 1995]. Moreover, the assumption appears

Table 1. Summary of Information for the Water Abstraction Plant

Parameter	Value
X	0.300 m^3/s
I	3,500,000 Euros
T_c	10–40 yrs
C^a	0.13 Euro/m^3
R^b	0.30 Euro/m^3
i	20%
δ	2%
r^c	5%
σ^d	30%

[a]Designers and industry experts interviewed agree on estimating the average operational costs of this type of plant at around 0.13 Euro/m^3.

[b]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.

[c]Risk-free rate is assumed to be equal to the rate of return of state-owned bonds.

[d]Variance has been estimated considering analogous investment projects carried out in the past whose operating costs were known throughout the project life.

to be consistent with Italian legislation, which provides for infrastructures to become publicly owned at the end of the concession period.

[20] Given the above assumptions, the present value of the project is

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

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 (1) a well field (three wells), (2) a pumping station, (3) a treatment plant, (4) a storage system (10,000 m^3), and (5) an electrical system for the equipment installed. The treatment plant includes a filtration process on granular activated carbon, and the storage system includes disinfection and chlorination procedures [*Twort et al.*, 2000]. The system guarantees a water provision of about 300 L/s (equivalent to 9,460,800 m^3/yr), but it is subject to water losses in the network (i = 20%). Finally, the plant's construction and installment costs amount to 3,500,000 Euros. Table 1 summarizes the project's technical and financial parameters.

3.2. Results

[21] 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. According to assumption 4 in section 3.1, when τ is equal to T_c, we get $F = 0$.

[22] The concession value is concave in exercise time. 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.

[23] 1. Let us first consider the case where the regulator arbitrarily sets T_c and allows the concessionaire to choose the investment time τ. The optimal exercise time (τ^*) varies depending on T_c. For example, assuming T_c = 40 years, F has a maximum for τ^* = 17 years. All else being equal, if T_c is reduced to 25 years, τ^* becomes 5 years. Finally, if T_c = 15 years, F consistently decreases in τ so that it is optimal to invest immediately (τ^* = 0). In this case the investment timing flexibility allowed by the regulator does not increase the concession value ($F \equiv$ NPV).

[24] 2. 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 $b' = -8.93$ (OLS). When $T_c \leq 20$ years, the concessionaire is neutral to signing contracts that allow or rule out investment flexibility.

[25] 3. Let us 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 maximum NPV corresponds to T_c^* = 20 years. On the contrary, if $\tau > 0$, the optimal concession length should be chosen by ranking the F. For example, if the concessionaire is allowed to defer the investment for 5 years (i.e., τ = 5), the optimal length is T_c^* = 25 years, while if τ = 10 years, the maximum F corresponds to T_c^* = 30 years.

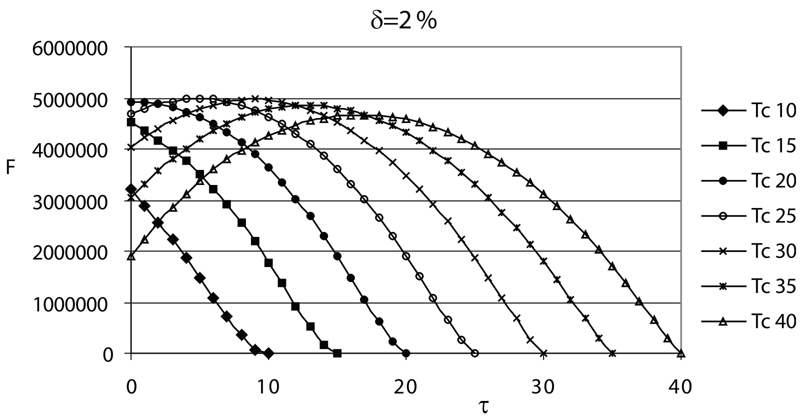

Figure 1. Extended net present value for different concession lengths and exercise times.

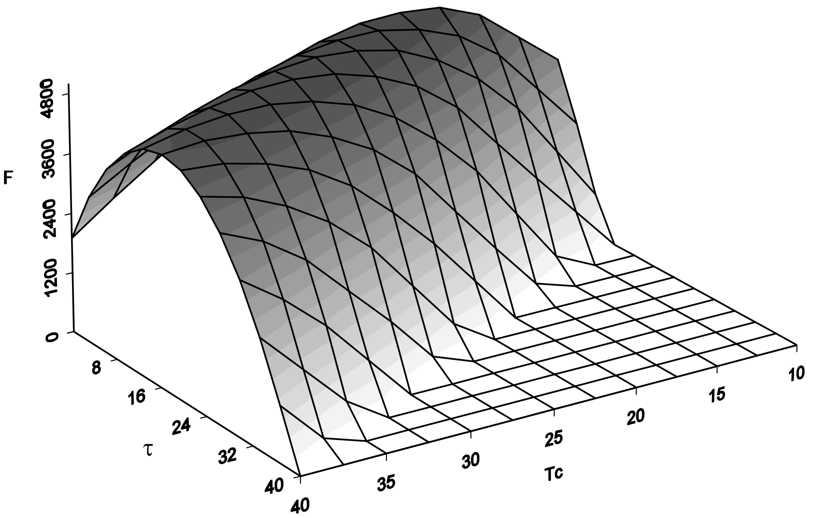

Figure 2. Concession value for different concession lengths and exercise times.

[26] If we put the above results together, we find that in order to maximize the concession value the regulator should identify 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.

4. Concluding Remarks

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

[28] Our results suggest that this is not always the case since there is not a monotonic relationship between the extended net present value and the concession length.

[29] First, investment timing 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 extended net present value coincides with the conventional net present value).

[30] Second, long-term contracts do not necessarily increase the concession value. Since the duration of the contract affects the optimal investment timing, if a concession is too long, the concessionaire may find it profitable 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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