Optimal concession of water services under common value∗

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Abstract

When an incumbent firm is in charge of a water distribution network, it accumulates through time valuable information on the state of the network. This ‘common value’ piece of information creates a winner’s curse during auctions for renewing the concession, which may explain the observed lack of competition. The municipality contracting out the provision of the service trades off the incumbent’s incentives to invest in the network, with lower costs in case an entrant is awarded the concession, and must induce effective competition despite the winner’s curse.

We show that the optimal concession contract can be designed to address this difficulty, with asymmetric auctions in which the incumbent is favored and increasing output schedules. Contrary to the results for standard auctions, the optimal auction of incentive contracts can be adjusted so as to prevent the winner’s curse at no expected cost for the regulator auctioning the concession.

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Introduction

The production and distribution of water to households and other consumers is a complex task, which requires managing a distribution network. Avoiding the duplication of networks arguably supports the idea that water services must be managed by a local monopoly. The regulation of such an operator typically balances two requirements. On the one hand, one would like the operator to invest in the network quality; since investment is only partially observable, this requires designing a regulatory contract with a long run horizon. On the other hand, to reduce the monopoly rents the contract must be re-auctioned from time to time, and this conflicts with the former objective.

An added, and important, difficulty is that the incumbent is likely to be much better informed about the quality of the network than the municipality and potential competitors. Not only does the incumbent privately invests in the maintenance of this network (an investment that can be anticipated), it also observes elements of the general environment in which it is operating, that affect future network quality. It therefore possesses a better information as to an essential component of the costs associated with the concession. This paper characterizes the optimal concession contract given the features and trade-offs just mentioned.

The French case illustrates the difficulty of balancing the benefits from efficient entry with incentives for long-term investments. Since the 19th century, the market has evolved toward a decentralized system in which local communities are free to negotiate concession contracts with private firms. These contracts specify pricing rules, as well as a sharing rule for the observable investment costs, with a typical contracting period ranging from 10 to 30 years. At the end of the period, a symmetric auction is organized in which competitors are allowed to challenge the incumbent. It turns out that these auctions seem to involve few competitors: a recent report (GEA-ENGREF, 2002) shows that in up to 30% of auctions, there is only one bidder. Moreover only 12% of auctions result in the incumbent being replaced.

Hence the competitive pressure on local monopolies seems quite low, and unable to reduce monopoly rents. Possible explanations for this unsatisfying feature include the oligopolistic nature of the industry, with a few major firms facing a small competitive fringe of small producers; collusion between firms, for which only anecdotal evidence exist, may also explain these
low participation levels; one may add the charge that local political leaders may sometimes be
corrupted by the incumbent firm in order to avoid losing the concession.

This paper examines an alternative explanation. During auctions, competition is weak be-
because the incumbent has accumulated through time a private information on the state of the
network: the incumbent knows which type of investment were performed or not, or whether
they are needed. This information matters for outside competitors, since their profitability if
they are to get the concession contract directly depends on the quality of the network. We coin
such a piece of information a “common value” information, to distinguish it from more usual
“private value” information such as the firm’s productivity or skills: the latter does not impact
an outsider’s profit if it is to manage the concession.

From a theoretical viewpoint, the distinction between private value and common value is
essential. Under private value, standard auctions such as the first-price auction remain an
optimal manner to organize competition, and get close to the competitive allocation when the
numbers of bidders is high enough. The situation is quite different under common value. Indeed
a winner’s curse is created: for an outsider, winning the auction means that the incumbent’s bid
was low, and thus that the state of the network is likely to be bad. Hence competitive pressure is
harmed by common value information. In the admittedly extreme case when only the incumbent
has private information, one can show that outsiders can only expect zero-profit on average,*
thus making participation unlikely in the first place. The case we consider is however different,
as the item auctioned off is an incentive contract, that can be adapted to take into account this
issue — contrary to a good or service whose value is exogenously given.

In this paper, we study how existing auctions must be modified in order to address the ad-
verse effects of a winner’s curse. As explained above, symmetric auctions in which the incumbent
is treated as any outside competitor are unable to stimulate competition. Our model is norm-
ative and allows for any type of auction. It studies the following trade-off: On the one-hand,
the regulator would like to bias the auction in favor of the incumbent, because this preserves

*The study of such asymmetric common value auctions has been initiated by Wilson (1967), Hausch (1987)
and Milgrom and Weber (1982). It has not given rise to much further analysis, despite more recent works, such
as Hagel and Levin (2002) on experimental evidence, or Chakraborty (2002), who proposes using price ceilings in
simple models of common value auction.
incentives for investing in the network. On the other hand, the incumbent seems to benefit from an important informational advantage, which should a priori be corrected for competition to be effective at the time of renewing the concession. More precisely, we consider a two-period setting in which a municipality delegates the management of a water concession. Potential providers benefit from a private information on their production costs. An incumbent is first offered an incentive contract specifying output levels and a probability of being renewed at the end of the first period (obviously depending on the reports made by the firms as to their costs). The incumbent privately invests in network quality, and learns this quality at the end of the first period. At this time, an entrant can participate in an auction to obtain the concession for the second period of the game. It obtains the concession according to the probability of renewal mentioned above, in which case it produces according to the incentive contract offered by the municipality.

Our main result may appear quite surprising: Common value information can be handled without costs, as if the information was not private. The optimal concession contract specifies auctions rules biased in favor of the incumbent, so as to preserve incentives to invest; the analysis is still preliminary, but we are able to show that the optimal contract can be implemented by introducing a golden parachute, to be given to the incumbent whenever it is replaced by an outsider. Our results are thus quite similar to those in Laffont-Tirole (1993, Chapter 8), who consider a similar model but only under private values. These results are however not trivial as the existence of a common value destroys the results that are applicable in the case of private values for standard auctions, as we stressed.

The remainder of the paper is organized as follows. Section 1 describes the model and Section 2 provides the benchmarks of complete information on all variables, and on investment levels and the state of the world. Section 3 characterizes the optimal incentive concession contracts. Implementation is discussed in Section 4. Section 5 offers concluding comments.

1 The model

We consider a two-period model in which an incumbent produces and invests in the first period, and may be replaced by an entrant at the beginning of the second-period.
**Intrinsic cost parameters**  We assume that in the first period, production can only be undertaken by one firm, the ‘incumbent’. This firm has private knowledge on some intrinsic cost parameter, $\beta \in [\underline{\beta}, \overline{\beta}]$. The potential entrant, that can bid for the contract at the end of the first period, also has private knowledge on its cost parameter, $\beta^E$. Both $\beta$ and $\beta^E$ are independently identically distributed. They are drawn according to the same† cumulative distribution function $F(.)$, with density $f(.)$, over the full interval $[\underline{\beta}, \overline{\beta}]$. These functions satisfy the monotone likelihood ration property: $\frac{F(\beta)}{f(\beta)}$ is increasing in $\beta$.

**Common characteristics**  The costs of the incumbent also depend on characteristics of the activity to be undertaken, for instance on network quality. This quality is denoted $K_i$ for period $i$, $i = 1, 2$, and will evolve over time as a function of first-period investments and of exogenous shocks. While the initial network ‘stock’, $K_1$, is known by all economic agents, the second-period value will be private information to the incumbent. Network quality is a common value in the sense that it affects both the incumbent and the entrant if it obtains the contract.

In the first period, the incumbent chooses the amount $I$ it will spend in cost-reduction activities. This decision constitutes a long term investment that will improve the second-period network quality, $K_2$, and reduce future marginal costs. It is assumed to be fully transferable to the entrant and it is private information to the incumbent. Another version of this paper assumed that investment expenses were observable, but that a part of them could be (privately) diverted towards actions reducing costs only in the short run (like temporary repairs), instead of long-term investment. The mathematical expressions were more complex, but the qualitative results were identical‡.

Network quality in the second period, $K_2$, depends on the long term investment $I$, but also on some shock, $\theta$. Being in charge of the activity allows the incumbent to observe this shock, contrary to the principal and the potential entrant. It is common knowledge that $\theta$ is drawn

†The entrant might benefit from a newer and better technology, in which case $\beta$ and $\beta^E$ would be drawn according to different distributions. We abstract from this possibility here as it would introduce an exogenous bias in favor of the entrant.

‡The only qualitative difference was that the first period quantity for the incumbent had to be further distorted downward, so as to make short-term patch up work less attractive.
according to a cumulative distribution function $H(\cdot)$, with density $h(\cdot)$, on a given interval $\Theta$. The evolution of the characteristics of the activity is given by a function $\Phi(\cdot, \cdot)$, increasing in both its arguments:

$$K_2 = \Phi(K_1 + I, \theta).$$

The incumbent is privately informed on $I$, but also on $\theta$. Thus, even if the other players can anticipate the rational choice of investment made by the incumbent in the first period, the incumbent still possesses an informational advantage thanks to its private information on characteristics that constitute a common value of the contract in the second period.

We assume that the exact value of $K_2$ will become observable, but not verifiable, to the entrant if it is selected, and to the principal. Despite this ex post knowledge, we rule out ‘punishments’ on the incumbent if it has not reported the true value $\theta$ of the state of nature. If such penalties were used, it would have to be based on the ex post knowledge of $\theta$ obtained by the entrant and the principal. The latter would then have incentives to collude so as to impose penalties on the incumbent.

The cost functions are the same for the incumbent and the entrant, except for their intrinsic cost parameter. The cost function of the incumbent in the first period is $C(\beta, K_1, q)$, convex in $q$, with $C_1(\cdot) > 0$, $C_2(\cdot) < 0$, $C_3(\cdot) > 0$, $C_{12}(\cdot) > 0$, $C_{13}(\cdot) > 0$, and $C_{23}(\cdot) < 0$. The second-period cost function is $D(b, K_2, q)$, with $b = \beta$ for the incumbent and $b = \beta^E$ for the entrant. Moreover, $D_1(\cdot) > 0$, $D_2(\cdot) < 0$, $D_3(\cdot) > 0$, $D_{12}(\cdot) > 0$, $D_{13}(\cdot) > 0$, and $D_{23}(\cdot) < 0$.

The contracts offered by the principal We have assumed that the principal can perfectly commit to a long term contract, so that renegotiation and ex post opportunism are not possible. The incumbent can on the other hand leave at the end of the first period if the contract specifications for the second period do provide it with positive profits, at a time at which it is informed on the state of the world (ex post participation constraints). We will show that considering ex ante or ex post constraints for the entrant makes no qualitative difference to our results.

From a theoretical point of view, if it was possible to reward or punish the incumbent even when it has been replaced, one could design a set of contingent ex post transfers so as to ensure that the incumbent prefers to truthfully reveal its information ex ante, at no informational cost (Crémé and McLean, 1988, Riordan and Sappington, 1989).
We will consider only direct and truthful contracts, that depend only on the reports made by the firms on their parameters of private information, under incentive and participation constraints. The implementation of these contracts is discussed in Section 4. The incumbent has a piece of information on its intrinsic cost parameter \( \beta \) and on its choice of long-term investment \( I \) in the first period, and on the state of nature, as represented by shock \( \theta \) at the end of this period. The potential entrant has private information on its intrinsic cost parameter \( \beta^E \).

The contract offered in the first period by the principal to the incumbent specifies

- the quantity produced in the first period, \( q_1 \) and a first-period transfer, \( t_1 \),
- the probability that the incumbent be renewed for the second period, as a function of the reports made by the incumbent on its intrinsic cost parameter, \( \beta \), and on the shock \( \theta \), as well as of the report made by the contender on its own intrinsic cost parameter \( \beta^E \) : \( p(\theta, \beta, \beta^E) \),
- the quantity produced in the second period, \( q_2 \), and a second-period transfer, \( t_{2s} \), if the incumbent is renewed, and a transfer \( t_{2ns} \) in case it is not.

Although the incumbent only cares for the expected transfer it receives, the principal has the ability to use separate transfers for periods 1 and 2, and depending on whether the incumbent is renewed, if needed for incentive purposes. When using different transfers is not needed, we will use the expected transfer, \( t = t_1 + \mathbb{E}_{\beta \theta \theta}[p t_{2s} + (1 - p) t_{2ns}] \).

The contract offered to the potential entrant specifies a second-period quantity, \( q^E \), and a transfer, \( t^E_s \), when it is selected, with a transfer \( t^E_{ns} \) when it is not. When it is not necessary to use different transfers according to whether the entrant is selected, we will use the expected transfer, \( t^E = \mathbb{E}_\theta[(1 - p) t^E_s + p t^E_{ns}] \).

We assume that the principal can commit to a contract that depends on the reports made by the incumbent – Section 4 offers a discussion of how to implement this contract. The first-period contract, as well as its outcome (quantities and transfers), are observable to all economic agents, including the potential entrant.

The timing of the game is as follows.
1. All agents observe $K_1$. The principal offers a menu of contracts $(q_1, t_1, p, q_2, t_{2s}, t_{2ns})$ to the incumbent.

2. If the incumbent refuses, the game ends. It otherwise chooses within the menu of contract and produces the corresponding first-period quantity $q_1$ in exchange for a payment $t_1$. It simultaneously decides how much to invest in long term investment $I$. The specifications of the contract are observed by all economic agents.

3. The incumbent learns the value of $\theta$.

4. The principal offers a menu of incentive contracts $(q^E, t^E_s)$ to the potential entrant, to apply if it is selected. If the entrant is not selected, the principal has still the possibility to make a transfer $t^{E}_{ns}$ to the entrant.

5. The incumbent and the potential entrant simultaneously report to the principal a value for respectively $\theta$ and $\beta^E$.

6. The selection rule is used. If the incumbent is renewed, it produces $q_2$ in exchange for a transfer $t_{2s}$, as mentioned in the initial contract. Otherwise, the competitor replaces it and produces $q^E$ in exchange for a transfer $t^E_s$, as specified in the menu of contract offered by the principal, given the entrant’s report made on $\beta^E$ in the previous stage. When it is replaced, the incumbent receives a transfer $t^E_{ns}$.

2 Benchmark situation

In this section, we present results concerning the optimal regulatory policy when there is asymmetric information on characteristics but when investment and network quality are verifiable. In a second step, we deduce the optimal policy under full information, that is when individual characteristics are perfectly observed by the regulator.

Assume that the principal is perfectly informed on the investment level $I$ undertaken and on the state of nature $\theta$, and can contract on them, but that she operates under asymmetric information on firms’ intrinsic characteristics $\beta$ and $\beta^E$. Thanks to private information, firms will obtain an information rent that we denote $V$ for the incumbent and $V^E$ for the entrant.
The Revelation Principle applies, and there is no loss of generality in considering only direct and truthful mechanisms.

We first define the incumbent’s rent:

\[ V(\beta) = t_1(\beta) - C(\beta, K_1, q_1(\beta)) + \mathbb{E}_{\theta, \beta^E} p(\theta, \beta, \beta^E)[t_2(\theta, \beta, \beta^E) - D(\beta, \Phi(K_1 + I(\beta), \theta), q_2(\theta, \beta, \beta^E))] \]

\[ + \mathbb{E}_{\theta, \beta^E} (1 - p(\theta, \beta, \beta^E))t_3(\beta, \beta^E). \]

Similarly, we define the entrant’s rent ex-post to the revelation of the incumbent’s type:

\[ V^E(\beta^E) = \mathbb{E}_{\theta^E}(1 - p(\theta, \beta, \beta^E))[t_2^E(\theta, \beta, \beta^E) - D(\beta, \Phi(K_1 + I(\beta), \theta), q_2(\theta, \beta, \beta^E))] \]

\[ + \mathbb{E}_{\theta^E} p(\theta, \beta, \beta^E)t_3^E(\beta, \beta^E). \]

For simplicity, we omit to condition \( V^E(\beta^E) \) on \( \beta \) although it clearly depends on the value of \( \beta \) revealed by the incumbent.

The principal’s program is then

\[ \max_{q_1(.), q_2(.), I(.), q^E(.), p(.)} \mathbb{E}_\beta \{ S_1(q_1(\beta)) - C(\beta, K_1, q_1(\beta)) - I(\beta) - V(\beta) \]

\[ + \mathbb{E}_{\theta, \beta^E} p(\theta, \beta, \beta^E)[S_2(q_2(\theta, \beta, \beta^E)) - D(\beta, \Phi(K_1 + I(\beta), \theta), q_2(\theta, \beta, \beta^E))] \]

\[ + (1 - p(\theta, \beta, \beta^E))[S_2(q^E(\theta, \beta, \beta^E)) - D(\beta, \Phi(K_1 + I(\beta), \theta), q^E(\theta, \beta, \beta^E)) - V^E(\beta^E))] \}, \]

subject to

\[ V(\beta) \geq 0, V^E(\beta^E) \geq 0, \]

\[ \dot{V}(\beta) = -C(\beta, K_1, q_1(\beta)) - \mathbb{E}_{\theta, \beta^E} p(\theta, \beta, \beta^E) D(\beta, \Phi(K_1 + I(\beta), \theta), q_2(\theta, \beta, \beta^E))), \]

\[ \dot{V}^E(\beta^E) = -\mathbb{E}_{\theta^E}(1 - p(\theta, \beta, \beta^E)) D(\beta, \Phi(K_1 + I(\beta), \theta), q^E(\theta, \beta, \beta^E))]. \]

The slopes of the information rents obtained by the firms can be integrated using the distribution of the intrinsic cost parameter, and the second-best quantities are obtained by maximizing
the resulting program:

\[ S_1'(q_1(\beta)) = C_q(\beta, K_1, q_1(\beta)) + C_{3q}(\beta, K_1, q_1(\beta)) \frac{F(\beta)}{f(\beta)} \]

\[ S_2'(q_2(\theta, \beta, \beta^E)) = D_q(\beta, \Phi(K_1 + I(\beta), \theta), q_2(\theta, \beta, \beta^E)) \]

\[ + D_{3q}(\beta, \Phi(K_1 + I(\beta), \theta), q_2(\theta, \beta, \beta^E)) \frac{F(\beta)}{f(\beta)} \]

\[ S_2'(q^E(\theta, \beta, \beta^E)) = D_q(\beta^E, \Phi(K_1 + I(\beta), \theta), q^E(\theta, \beta, \beta^E)) \]

\[ + D_{3q}(\beta^E, \Phi(K_1 + I(\beta), \theta), q^E(\theta, \beta, \beta^E)) \frac{F(\beta^E)}{f(\beta^E)}. \]

The second best investment level required \( I(\beta) \) differs from the first-best one first because all quantities \( q_1, q_2 \) and \( q^E \) are downward distorted compared to the first-best ones, but also because investment affects the information rent obtained by the firms, through the network quality level.

It is implicitly given by

\[ 1 = -E_{\theta, \beta, E} \{ \Phi(K_1 + I(\beta, \theta)[p(\theta, \beta, \beta^E)(D_K(\beta, \Phi(K_1 + I(\beta, \theta), q_2(\theta, \beta, \beta^E)) \]

\[ + D_{3K}(\beta, \Phi(K_1 + I(\beta, \theta), q_2(\theta, \beta, \beta^E)) \frac{F(\beta)}{f(\beta)} \]

\[ +(1 - p(\theta, \beta, \beta^E))(D_K(\beta^E, \Phi(K_1 + I(\beta, \theta), q^E(\theta, \beta, \beta^E)) \]

\[ + D_{3K}(\beta^E, \Phi(K_1 + I(\beta, \theta), q^E(\theta, \beta, \beta^E)) \frac{F(\beta^E)}{f(\beta^E)}) \} \].

The renewal rule will now be based on the comparison between the ‘virtual surpluses’ (Myerson, 1979) associated with production by the two firms, that is:

- the cost of the incumbent in the second period, including its information rent, \( D(\beta, \Phi(K_1 + I(\beta, \theta), q_2(\theta, \beta, \beta^E)) + D_{3\beta}(\beta, \Phi(K_1 + I(\beta, \theta), q_2(\theta, \beta, \beta^E)) \frac{F(\beta)}{f(\beta)} \),

- and the cost, taken at date 2, of the entrant, including its information rent, \( D(\beta^E, \Phi(K_1 + I(\beta, \theta), q^E(\theta, \beta, \beta^E)) + D_{3\beta}(\beta^E, \Phi(K_1 + I(\beta, \theta), q^E(\theta, \beta, \beta^E)) \frac{F(\beta^E)}{f(\beta^E)} \).

With asymmetric information on cost parameters, the renewal rule is such that \( p(\theta, \beta, \beta^E) = 1 \) whenever

\[ D(\beta, \Phi(K_1 + I(\beta, \theta), q_2(\theta, \beta, \beta^E)) + D_{3\beta}(\beta, \Phi(K_1 + I(\beta, \theta), q_2(\theta, \beta, \beta^E)) \frac{F(\beta)}{f(\beta)} \]

\[ < D(\beta^E, \Phi(K_1 + I(\beta, \theta), q^E(\theta, \beta, \beta^E)) + D_{3\beta}(\beta^E, \Phi(K_1 + I(\beta, \theta), q^E(\theta, \beta, \beta^E)) \frac{F(\beta^E)}{f(\beta^E)} \).]
and \( p(\theta, \beta, \beta^E) = 0 \) for the reverse inequality. In addition, any \( p(\theta, \beta, \beta^E) \in [0, 1] \) can be chosen in case of perfect equality. Hence, the bidding parity rule applies. Indeed, there is no reason to distort the probability of renewing the incumbent. For given values of \( \theta, \beta \) and \( \beta^E \), the principal should renew the incumbent if and only if \( \beta \leq \beta^E \).

Under imperfect information w.r.t. \( \beta \) and \( \beta^E \), the optimal renewal rule entails bidding parity*:  

\[
\begin{align*}
  p(\theta, \beta, \beta^E) = 1 & \iff \beta < \beta^E \\
p(\theta, \beta, \beta^E) = 0 & \iff \beta > \beta^E \\
p(\theta, \beta, \beta^E) \in [0, 1] & \iff \beta = \beta^E.
\end{align*}
\]

From these results, it is easy to derive the first best regulatory policy which is obtained when \( \beta \) and \( \beta^E \) are perfectly observed by the regulator (full information situation) in addition to \( I \) and \( \theta \). In that case, the principal then exactly compensates the firms for their costs when they are active: \( t_1 = C(\beta, K_1, q_1) + I \), \( t_2 = D(\beta, \Phi(K_1 + I, \theta), q_2) \) and \( t_3^E = D(\beta^E, \Phi(K_1 + I, \theta), q^E) \). Moreover, there is no need to offer transfer when either firm is not active in the second period: \( t_3 = t_3^E = 0 \).

Under full information, the regulator’s program simply reduces to

\[
\max_{q_1(.), q_2(.), I(.), q^E(.), p(\cdot)} S_1(q_1(\beta)) - C(\beta, K_1, q_1(\beta)) - I(\beta)
+ \mathbb{E}_{\theta, \beta^E} \left( p(\theta, \beta, \beta^E) [S_2(q_2(\theta, \beta, \beta^E)) - D(\beta, \Phi(K_1 + I(\beta), \theta), q_2(\theta, \beta, \beta^E))] \right)
+ (1 - p(\theta, \beta, \beta^E)) [S_2(q^E(\theta, \beta, \beta^E)) - D(\beta^E, \Phi(K_1 + I(\beta), \theta), q^E(\theta, \beta, \beta^E))] .
\]

*One should note that ‘bidding parity’ could also be understood as the following rule: choose the firm who produces a given quantity \( q \) in exchange for the lowest transfer \( t \). In practice however, contenders offer different levels of service and investment together with different prices, so that the comparison between them is not so simple. Our ‘contracts theory’ approach makes it more justified to interpret bidding parity as done in the main text.
This yields the following quantities:

\[ S'_1(q_1^*(\beta)) = C_q(\beta, K_1, q_1^*(\beta)) \]

\[ S'_2(q_2^*(\theta, \beta, \beta^E)) = D_q(\beta, \Phi(K_1 + I^*(\beta), \theta), q_2^*(\theta, \beta, \beta^E)) \]

\[ S'_2(q^{E*}(\theta, \beta, \beta^E)) = D_q(\beta^E, \Phi(K_1 + I^*(\beta), \theta), q^{E*}(\theta, \beta, \beta^E)) \]

\[ 1 = -E_{\theta, \beta^E} \left( \Phi_K(K_1 + I^*(\beta), \theta)[p(\theta, \beta, \beta^E)D_K(\beta, \Phi(K_1 + I^*(\beta), \theta), q_2^*(\theta, \beta, \beta^E)) \right. \]
\[ + \left. (1 - p(\theta, \beta, \beta^E))D_K(\beta^E, \Phi(K_1 + I^*(\beta), \theta), q^{E*}(\theta, \beta, \beta^E)) \right] \]

Once again, there is no reason to distort the probability of renewing the incumbent. For given values of \( \theta, \beta \) and \( \beta^E \), the principal should renew the incumbent if and only if

\[ D(\beta, \Phi(K_1 + I^*(\beta), \theta), q_2^*(\theta, \beta, \beta^E)) \leq D(\beta^E, \Phi(K_1 + I^*(\beta), \theta), q^{E*}(\theta, \beta, \beta^E)), \]

that is if and only if \( \beta \leq \beta^E \).

### 3 The optimal contract

#### 3.1 The contract offered to the entrant

Let us first consider the contract offered to the competitor within the bidding process. The Revelation Principle applies with respect to this competitor. Quantity \( q^E \) and transfer \( t^E \) must be chosen so as to maximize the expected utility of the principal under ex post participation (\( P^E \)) and incentive compatibility (\( IC^E \)) constraints. One must also remember that the competitor obtains the contract only with probability \( 1 - p(\beta, \beta^E, \theta) \). With the complementary probability, the incumbent is renewed, and the initial contract applies. At this stage, \( \beta \) and \( I \) are given (known or perfectly anticipated) parameters, assuming that the initial contract was separating.

The program of the principal restricted to the goal of designing the entrant’s contract can be written as follows:

\[ \max_{q^E(\cdot), t^E(\cdot)} E_{\theta} \left\{ \int_{\beta}^7 [(1 - p(\beta, \beta^E, \theta))S_2(q^E(\beta, \beta^E, \theta)) - t^E(\beta, \beta^E, \theta)]f(\beta^E)d\beta^E \right\} \]
subject to

\[ t^E(\beta^E, \theta) - (1 - p(\theta, \beta, \beta^E))D(\beta^E, \Phi(K_1 + I(\beta), \theta), q^E(\beta, \beta^E, \theta)) \geq 0 \] \quad (PE)

\[ \beta^E \in \arg \max_b \{ E_\theta[1 - p(\theta, \beta, \beta^E)](t^E(\beta, b, \theta) - D(\beta^E, \Phi(K_1 + I(\beta), \theta), q^E(\beta, b, \theta))) \}. \quad (IC^E) \]

As previously, we denote the expected rent obtained by the entrant, omitting to condition it on \( \beta \), as,

\[ V^E(\beta^E) = E_\theta[1 - p(\theta, \beta, \beta^E)(t^E(\beta, \beta^E, \theta) - D(\beta^E, \Phi(K_1 + I(\beta), \theta), q^E(\beta, \beta^E, \theta))]). \]

Using the first-order approach, the incentive compatibility constraint implies that the slope of this expected rent must be given by

\[ \dot{V}^E(\beta^E) = -E_\theta[(1 - p(\theta, \beta, \beta^E))D_\beta(\beta^E, \Phi(K_1 + I(\beta), \theta), q^E)]. \]

This expected rent can be integrated into the program of the principal and one obtains the quantity required from the entrant:

\[ S_2'(q^E) = D_q(\beta^E, \Phi(K_1 + I(\beta), \theta), q^E) + D_{q_2}(\beta^E, \Phi(K_1 + I(\beta), \theta), q^E) F(\beta^E). \]

The quantity produced by the entrant entails the standard downward distortion (except for the most efficient type \( \beta \)) due to asymmetric information on the cost parameter \( \beta^E \). Note that since network quality in the second period, \( K_2 = \Phi(K_1 + I(\beta), \theta) \), depends on the efficiency parameter of the incumbent, the quantity produced by the entrant is indirectly a function of \( \beta \) as well.

### 3.2 The contract offered to the incumbent

We assume here that the Revelation Principle applies in the first period.

The program of the principal consists in maximizing her expected welfare under a participation constraint for the incumbent, \((P)\), and incentive compatibility constraints relating to the two parameters of adverse selection, \( \beta \) and \( \theta \), and to the moral hazard variable, the investment level \( I \). This program writes as follows:

\[
\max_{q_1(\cdot), t_1(\cdot), q_2(\cdot), t_2(\cdot), p(\cdot)} \mathbf{E}_\beta \left\{ S_1(q_1(\beta)) + E_{\beta^E, \beta} \left[ p(\theta, \beta, \beta^E) \left( S_2(q_2(\beta, \beta^E, \theta)) + (1 - p(\theta, \beta, \beta^E))(S_2(q^E(\beta^E, \theta)) - t(\beta, \beta^E, \theta)) - t^E(\beta, \beta^E, \theta) \right) \right] \right\}
\]
subject to participation and incentive constraints that we derive below.

The incumbent’s incentives  Assume that the incumbent has announced a cost parameter \( \tilde{\beta} \) and chosen an investment level \( I \) in the first period. At the end of the first period, it will choose which state of nature to announce, \( \tilde{\theta} \), so as to maximize its expected utility in the second period, \( V^2(\cdot) \). The optimal report from the point of view of the incumbent at this stage is thus

\[
\tilde{\theta}(\theta, \beta, \tilde{\beta}, I),
\]

solution to

\[
\max_{\tilde{\theta}} V^2(\beta, \theta, \tilde{\beta}, \tilde{\theta}) \equiv \mathbb{E}_{\beta}\left[p(\tilde{\theta}(\tilde{\beta}, \beta, \tilde{\beta}, \tilde{\theta}) - D(\beta, K_2(I, \theta), q_2(\tilde{\beta}, \beta, \tilde{\theta}))\right] + (1 - p(\tilde{\theta}(\tilde{\beta}, \beta, \tilde{\theta}, I), \tilde{\beta}, \tilde{\beta})) \mathbb{E}_{\theta, \beta}\left[p(\tilde{\theta}(\tilde{\beta}, \beta, \tilde{\theta}, I), \tilde{\beta}, \tilde{\beta})\right]
\]

The expected rent of the incumbent in the first period when its cost parameter is \( \beta \) and it reports \( \tilde{\beta} \) is therefore

\[
V^1(\beta, \tilde{\beta}) \equiv t(\tilde{\beta}, \beta, \tilde{\beta}) - \left[C(\beta, K_1, q_1(\tilde{\beta})) + \max_{\tilde{\beta}} E_{\theta, \beta}\left[p(\tilde{\theta}(\tilde{\beta}, \beta, \tilde{\beta}, I), \tilde{\beta}, \tilde{\beta})D(\beta, K_2(I, \theta), q_2(\tilde{\theta}(\tilde{\beta}, \beta, \tilde{\beta}, I), \tilde{\beta}, \tilde{\beta}))\right]\right]
\]

To obtain the revelation of the cost parameter \( \beta \) and subsequently of the state of nature \( \theta \), the principal must offer a contract such that

\[
\theta = \tilde{\theta}(\theta, \beta, \tilde{\beta}, I),
\]

\[
\beta \in \arg \max_{\tilde{\beta}} V^1(\beta, \tilde{\beta}),
\]

\[
I \in \arg \max_{\tilde{\beta}} -1 - E_{\theta, \beta}\left[p(\tilde{\theta}(\tilde{\beta}, \beta, \tilde{\beta}, I), \tilde{\beta}, \tilde{\beta})D(\beta, K_2(I, \theta), q_2(\tilde{\theta}(\tilde{\beta}, \beta, \tilde{\beta}, I), \tilde{\beta}, \tilde{\beta}))\right].
\]

This yields two incentive compatibility constraints with respect to asymmetric information on \( \beta \) and \( \theta \), plus a characterization of the choice of investment \( I \).

The participation constraint for the incumbent is

\[
t(\beta) - C(\beta, K_1, q_1(\beta)) - E_{\beta, \theta}\left[p(\theta, \beta, \tilde{\beta})D(\beta, K_2(I, \theta), q_2(\beta, \theta))\right] \geq 0 \quad (P).
\]

A second participation constraint must be satisfied for period 2, since the incumbent must be willing to participate to the renewed contract, at a time at which it knows the value of the common shock \( \theta \):

\[
E_{\beta, \theta}\left[p(\theta, \beta, \tilde{\beta})\left(t_{2s}(\beta, \beta, \theta) - D(\beta, K_2(I, \theta), q_2(\beta, \beta, \theta))\right)\right] + (1 - p(\theta, \beta, \tilde{\beta})) \mathbb{E}_{\beta, \theta}\left[p(\theta, \beta, \tilde{\beta})\right] \geq 0 \quad (P).
\]
**Information rents**  The probability that the incumbent’s contract be renewed affects information rents for both the incumbent and the potential entrant. These rents can be computed from the incentive compatibility constraints faced by the principal. The slope of the rent for the incumbent in the first period, the incumbent in the second-period, and an entrant are respectively given by:

\[
\dot{V}_1(\beta) = -C_\beta(\beta, K_1, q_1) - E_{(\theta_0, \beta^E)}p(\theta, \beta, \beta^E)D_\beta(\beta, K_2, q_2)
\]

\[
\dot{V}_2(\theta) = -E_{\beta^E}p(\theta, \beta, \beta^E)\Phi(\theta, K_1 + I, \theta)D_K(\beta, K_2, q_2)
\]

\[
\dot{V}_E(\beta^E) = -E_\theta(1 - p(\theta, \beta, \beta^E))D_\beta(\beta^E, K_2, q_2).
\]

Information rents are obtained by integrating the above expressions with respect to cost parameters. The program of the principal can then be rewritten as function of quantities and of the probability of renewing the contract:

\[
\max_{q_1, q_2, p, q^E} \mathbf{E}_\beta \left\{ S_1(q_1(\beta)) - C(\beta, K_1, q_1(\beta)) - I \\
- \left[ C_\beta(\beta, K_1, q_1(\beta)) - E_{(\theta_0, \beta^E)}p(\theta, \beta, \beta^E)D_\beta(\beta, K_2(\beta, \theta), q_2(\beta, \beta^E, \theta)) \right] \frac{F(\beta)}{f(\beta)} \right\} + E_{(\beta, \beta^E, \theta)} \left\{ p(\theta, \beta, \beta^E) \left[ S_2(q_2(\beta, \beta^E, \theta)) - D(\beta, K_2(\beta, \theta), q_2(\beta, \beta^E, \theta)) \right] \\
- D_\beta(\beta, K_2(\beta, \theta), q_2(\beta, \beta^E, \theta)) \frac{F(\beta)}{f(\beta)} \right\} + (1 - p(\theta, \beta, \beta^E)) \left[ S_2(q^E(\beta, \beta^E, \theta)) - D(\beta^E, K_2(\beta, \theta), q^E(\beta, \beta^E, \theta)) \right] \\
- D_\beta(\beta^E, K_2(\beta, \theta), q^E(\beta, \beta^E, \theta)) \frac{F(\beta^E)}{f(\beta^E)} \right\}\}
\]

subject to

\[-1 - E_{\theta, \beta^E} \left\{ p(\theta, \beta, \beta^E)\Phi(K_1 + I(\beta, \theta)D_K(\beta, K_2(\beta, \theta), q_2(\beta, \beta^E, \theta)) \right\} \geq 0.\]

We associate multiplier \(\mu\) to this constraint. This investment constraint arises from the moral hazard problem faced by the principal, who cannot directly control the long-term investment level \(I\). The only tools available to the principal to induce a particular level are the choice of the second-period quantity, \(q_2(\beta, \theta)\), and of the probability of contract renewal, \(p(\theta, \beta, \beta^E)\). These indeed affect the equilibrium choice of investment level by the incumbent.
3.3 The optimal quantities and investment levels

From the first-order conditions of the above program, quantities $q_1$ and $q_2$ are characterized as follows:

\[ S_1'(q_1) = C_q(\beta, K_1, q_1) + C_{\beta q}(\beta, K_1, q_1) \frac{F(\beta)}{f(\beta)} \]

\[ S_2'(q_2) = D_q(\beta, K_2, q_2) + D_{\beta q}(\beta, K_2, q_2) \frac{F(\beta)}{f(\beta)} + \mu \Phi_K(K_1 + I, \theta)D_{Kq}(\beta, K_2, q_2), \]

and we have seen that the quantity if the entrant is selected is given by:

\[ S_2'(q_E) = D_q(\beta^E, K_2, q^E) + D_{\beta q}(\beta^E, K_2, q^E) \frac{F(\beta^E)}{f(\beta^E)} + \mu \Phi_K(K_1 + I, \theta)D_{Kq}(\beta^E, K_2, q^E). \]

The quantity produced by the entrant entails the standard downward distortion due to asymmetric information on the cost parameter $\beta^E$. Such a distortion also exist for the quantities produced by the incumbent. The investment constraint — with positive shadow cost $\mu$ — induces an upward distortion of the second-period quantity produced by the incumbent, which counters the effect of adverse selection. Requiring higher second-period quantities from the incumbent is a indeed a way of inducing a higher long term investment $I$, by making this investment more beneficial for the incumbent.

Quite understandably, $\mu$ does not affect the quantity produced by the entrant when it obtains the contract, since this would have no incentive effect on first-period investment. The entrant thus produces a lower quantity than the one that the incumbent would have been asked to produce in the second-period if it had had the same intrinsic cost parameter: $q_2(\beta, x, z) \geq q^E(x, \beta, z)$ for all $\beta, x, z$. It can therefore happen that the entrant produces a lower quantity than the incumbent would have produced, even though the entrant is more efficient.

The first order condition with respect to $I$ simplify into:

\[ 1 = E_{(\beta^E, \theta)} \left\{ p(\theta, \beta, \beta^E)\Phi_K(K_1 + I, \theta) \left[ D_K(\beta, K_2, q_2) + D_{\beta K}(\beta, K_2, q_2) \frac{F(\beta)}{f(\beta)} \right] \right. \]

\[ + (1 - p(\theta, \beta, \beta^E))\Phi_K(K_1 + I, \theta) \left[ D_K(\beta^E, K_2, q^E) + D_{\beta K}(\beta^E, K_2, q^E) \frac{F(\beta^E)}{f(\beta)} \right] \]

\[ + \mu p(\theta, \beta, \beta^E) \left\{ \Phi_{KK}(K_1 + I, \theta)D_K(\beta, K_2, q_2) + (\Phi_K(K_1 + I, \theta))^2 D_{KK}(\beta, K_2, q_2) \right\}. \]
3.4 The optimal renewal rule

The optimal rule results from a comparison between the ‘virtual surpluses’ associated with production by the two firms. To the physical cost of production, must be added the information rent obtained by the firm, plus the cost of inducing an adequate level of investment, in the case of the incumbent firm. The renewal rule is thus given by:

\[ p(\theta, \beta, \beta^E) = 1 \iff A > B \]
\[ p(\theta, \beta, \beta^E) = 0 \iff A < B \]
\[ p(\theta, \beta, \beta^E) \in [0, 1] \iff A = B, \]

where \( A \) and \( B \) are defined as:

\[ A = S_2(q_2) - D(\beta, K_2, q_2) - D_\beta(\beta, K_2, q_2) \frac{F(\beta)}{f(\beta)} - \mu \Phi_K(K_1 + I, \theta)D_K(\beta, K_2, q_2), \]
\[ B = S_2(q^E) - D(\beta^E, K_2, q^E) - D_\beta(\beta^E, K_2, q^E) \frac{F(\beta^E)}{f(\beta^E)}. \]

The term denoted \( A \) represents the virtual surplus associated with second-period production by the incumbent, minus the cost of the investment constraint, given that it modifies second-period characteristics, and hence cost (recall that \( \mu \) is the Lagrange multiplier of the constraint ensuring that the adequate long-term investment \( I \) is chosen in the first period). The term to which \( A \) is compared, \( B \), is the virtual surplus generated by second-period production by the entrant if it obtains the contract.

The optimal rule differs from bidding parity. It indeed trades off productive efficiency, information rents, and incentives to invest in long-term improvements. The principal must compare the change in the virtual surplus in case of replacement of the incumbent, with the cost of giving the incumbent incentives to invest in the first period. Bidding parity is generally not optimal, contrary to our benchmark case with observable \( I \) and \( \theta \). The increased difficulty in inducing long-term investment when the renewal probability decreases gives rise to a preference for the incumbent. To induce the adequate long-term investment level, the principal must ask the incumbent to produce a quite large second-period quantity and/or increase the renewal probability. A higher renewal probability allows reducing the upward distortion in the second-period quantity.
To the contrary, the fact that $\theta$ constitutes a private information of the incumbent (instead of being simply a common risk, as in our benchmark case) surprisingly does not require distorting the selection rule. The revelation of $\theta$ indeed entails no expected cost, as the information rents that have to be left in the second period are being paid for by the incumbent in the first period. Ex post participation constraints do not give rise to additional costs either, since the same effect applies: the incumbent is willing to bear losses in the first period, since it anticipates obtaining rents in the second period.

The ex post participation constraints for the entrant do not play a role either. Since the entrant must obtain an information rent (and hence a weakly positive profit for any value of $\beta^E$), one can always design transfers so as to also provide the entrant with a positive profit in all states of nature $\theta$. A simple solution consists in giving the entrant the same information rent $V^E(\beta^E)$ in all states of nature, i.e., an information rent that depends on its report $\tilde{\beta}^E$ but is independent from $\theta$, together with cost reimbursement (that depends on $\theta$). The entrant is then insured against variations in $\theta$ and obtains a positive profit in all states of nature, at no additional cost for the principal.

The optimal contract thus solves for the problems associated with a common value in such a way that

- the entrant does not face the risk of a winner’s curse,
- and the principal suffers no additional cost from the incumbent’s insider knowledge on a common value, even with ex post participation constraints.

4 Implementation

We have seen that the optimal contract consists in

- an auction procedure that is biased in favor of the incumbent,
- and a larger second-period quantity required from the incumbent than from the entrant.

Such a contract can be implemented in practice with rather simple modifications of standard concession contracts.
First, the optimal contract is written as a function of the report made by the incumbent on its cost characteristics in the first period, $\beta$, and on the state of nature, $\theta$, in the second period. We have obtained $(q_1(\beta), t_1(\beta))$, and $(q_2(\beta, \beta^E, \theta), t_2(\beta, \beta^E, \theta))$, together with $(q^E(\beta, \beta^E, \theta), t^E(\beta, \beta^E, \theta))$ and the renewal rule. These couples of quantity and transfer could rather be implemented with:

- a transfer (possibly below actual costs) $\tau_1(q_1)$ in the first period, letting the incumbent choose $q_1$ and $I$;
- a transfer $\tau_2(q_2, q_1, q^E)$ in case the incumbent is selected, and another one, $T(q_1, q_2, q^E)$ in case it it not (a ‘golden parachute’); the incumbent’s bid is which quantity $q_2$ to provide;
- a transfer $\tau^E(q_1, q_2, q^E)$ for the entrant if it is selected, the entrant’s bid being quantity $q^E$.

To create a credible commitment to bias the selection rule in favor of the incumbent, the principal should indeed include in the first-period contract offered to the incumbent, a ‘golden parachute’, that is, a monetary compensation $T(q_1, q_2, q^E)$ for the incumbent if it is not renewed. This compensation should depend on both the first period and the second period quantities selected by the incumbent, since these quantities contain information on the firm’ costs and on the quality of the network. The principal would then trade off the benefit of selecting the entrant with the added cost of compensating the incumbent for not being renewed. Hence a bias in favor of the incumbent. The optimal selection rule can be implemented with the adequate choice of $T(\cdot)$.

A golden parachute increasing in $q_2$ allows to also induce the incumbent to choose a larger quantity $q_2$ than the entrant, who cannot benefit from this transfer. The upward distortion of $q^2$ compared to $q^E$ can thus be implemented even if we impose that both firms receive the same type of contract, that is: if we impose $\tau_2(q_1, x, y) = \tau^E(q_1, y, x)$, for any $q_1, x, y$.

Complete characterization: To be completed
5 Conclusion

In this paper we have explored the consequences of introducing an informational advantage for the incumbent, which better knows the quality of the network he has managed so far. Such a feature makes standard symmetric auctions inefficient. Instead we have shown that asymmetric auctions must be used, and that the auction is biased in favor of the incumbent. Still the non-observability of the network’s quality does not create any additional distortions, compared to the case when this information would be public. Technically this result relies on the fact that the initial contract is signed at a date when the operator has no private information on the network; the operator only gathers information through time. The initial contract can then be designed ex-ante so as to make free the information revelation at the interim date. Hence two features are important: the horizon of the contract must be long enough so as to make any initial information irrelevant, and the regulator must be able to commit on this horizon. Concerning the latter point, we are able to show that the regulator only needs to commit to transferring a golden parachute in case the incumbent loses the interim auction. The former point about the horizon of the contract fits well to the case of water networks. The analysis could in fact be extended to any sector in which the operator manages a network whose quality is difficult to observe, and which remains property of the local community.

References


