Public-Private Partnerships, Network Quality and the Life Cycle of Contracts: the Case of Water Industries in France*

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Abstract

This paper empirically investigates the impact of network quality on prices through the life cycle of the contract signed between a local government and a private firm. Using a database on 1430 French public authorities over 1998, 2001 and 2004 and various econometric methods, we find an increasing negative impact of network quality on prices as the end of the contract approaches. The results show two main evidences. Firstly, operators signal their efficiency by charging lower prices when the renewal comes. Secondly, operators tend to limit their investments in network quality the end of the contract to protect themselves against the risk of expropriation in case of non-renewal. Our empirical investigation is supported by theoretical insights.

Classification JEL: D23-L51-L95
Key words: Public-private partnerships, Water industries, Local public services, Contracts.

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1 Introduction

In France, municipalities must provide local public services that have public good characteristics. As there is no national regulator for these services, local public authorities define the general principles governing those services on behalf of their citizens. They monitor prices, control entry and exit of firms into the market, organize competition and ensure uninterrupted service. The service can be managed in-house or be outsourced to a private operator through a public-private arrangement. The goal of this paper is to empirically investigate the impact of network quality on prices through the life cycle of the contract under private management.

The water industry is an expressive illustration of this problem. In France, each local public authority may choose a particular contractual form from the differentiated set of alternatives[1]. Although some municipalities manage production through a *direct public management* and undertake all operations and investments needed for the provision of the service, the dominating contractual form is the *delegated management*[2]. In this case, a private operator, independent of the local government, is hired to manage the service and operate facilities. Within this type of contracts, various kinds of arrangements can be found. The most common is the *lease* contract in which the operator manage the service, invest in the network and gets a financial compensation through consumer receipts. Under a *concession contract*, the external operator also undertakes construction risk, as it must finance a large part of investments over the duration of the contract. These contractual agreements differ from the previous ones in that operators share risk in exchange for greater decision rights and claims on revenues. Other contracts can be chosen by the local authority such as the*gerance* in which it pays an external operator a fixed fee, or an *intermediary management contract*, i.e. a gerance contract but with a small part of the operator's revenues depending on its performance. Such contracts provide few incentives to reduce costs and transfer no risks and decision rights to a private operator. In roughly 95% of the delegated management contracts, private operators have no contractual incentives to increase their cost-efficiency.

Contrary to other industrialized countries, there is no price-cap or rate-of-return regulation for water utilities in France. Such regulation has been replaced by a contract, in the case of a private operator, or a decision of the municipality board, in the case of public operation. Rules have thus been defined to ensure that standards are respected during the operation to limit the opportunistic behavior of operators. For example, administrative contracts signed between local authorities and private operators constrain the ability of private operators to renegotiate prices by more than 5% while a precise definition of more than 60 verifiable quality parameters has been set by the 1992 water act. Water quality is thus respected and is rarely below a 95% score of conformity to the standards. While water quality is observable by the municipality and the operator, network quality may be unverifiable by one of the agent and can thus lead to a moral hazard issue.

In network industries, network quality drives the level of prices[3]. One of the feature of the water industry is that water delivered to customers has no acqui-

[1] See Table [5] in the appendix for the distribution of the various types of private contracts

[2] 70% of water services are under delegated management.

[3] See the literature review

sition cost (Garcia and Thomas, [2001]). Another feature is that leakages on the network may be undesirable from the environmental point of view but also from the economic point of view when there is a risk of scarcity. In the latter case, leakages are costly and can thus impact positively the price of billed water. But high levels of leakages can also result from a cost trade-off between supporting the cost of losses and investing in the network to cut losses. In this case, leakages are less costly than the amount of investments needed to repair it. When the end of the contract approaches, incumbents can signal their quality by lowering prices or increasing network quality. As there is no regulatory incentives to invest while municipalities and customers are more sensitive to prices than leakages (provided leaks on the network are not billed as if it were in their home), a good strategy for an incumbent would be to provide a "‘best value for money"’ public water service in the end of the contract. In other words, operators should decrease prices for a given network quality instead of increasing quality in the end of the contract to signal their willingness to be renewed in the next period.

In this paper, we empirically investigate he impact of network quality on prices through the life cycle of the contract. Using a sample of variables that can explain the performance of the water network in 1,430 French municipalities for three years - 1998, 2001 and 2004 - we show using different econometric methods that a given level of network quality leads to lower prices in the end of the contract, anything else being equal. To control for dynamics of the network quality we use the distance - measured in percent - to the best practice for a given density of inhabitants. Results show that being far from the best practices leads to decreasing prices when the renewal approaches. One of the main explanation is that operator are reluctant to increase prices - especially in the prospect of a renewal - and thus tend to lower their network investments when they get closer to the end of the contract. Findings are robust to different econometric methods. This paper gives an empirical evidence of the reputational concerns of operators, especially when the renewal gets closer. This is, to the best of our knowledge, the first study that focuses on the impact of quality on prices paid by the consumers through the life cycle of the contract.

The agenda of the paper is the following. A literature review on the subject is done in section 2. We then present the database in Section 3 and the empirical strategy in section 4. Section 5 presents the results of the baseline model. A brief conclusion follows.

2 Literature review

The literature on incentives to perform better at different periods of the contract in Public-private partnerships is extensive, though much of it has a theoretical background. Because our paper focuses on the impact of network quality on prices and the trade-off between increasing network quality or decreasing prices to signal a firm's performance, it is at the intersection of two literatures: the literature on contract theory and the literature on industrial organization.

In the theoretical literature, the contract existing between a local government and a firm is usually analyzed through a principal-agent model. Career-concern theorists such as Holmstrom [1982] and Lewis [1986] show that reputational concerns lead firms to choose higher effort of investments in earlier stage of their procurement contract in order to send favorable signals to the principal regarding their productivity and avoid the project to be terminated too soon. This is in line with Baldwin and Cave [1999] who consider that long-term contracts are characterized by higher investments in the beginning of the contract and then decreasing investments as we get closer to the end of the contract; operators thus protect themselves from a 'hold-up' of their specific investments. However, the authors do not conclude to decreasing prices when contracts approach the end.

Relational contracting developed by Kim [1998] complete the previous framework. In a repeated-game model with moral hazard, effort may be induced by the presence of an implicit agreement between the principal and the agent. The choice of the agent is twofold. He can exert nonverifiable effort when the prospect of a long-term gain from contract renewal is greater than the one-shot saving on the cost of effort. Or, the principal renews the contract with a well-performing agent when the value of future cooperation is greater than the one-shot gain from reneging on the promised rent. However, relational contracting does not explain why contract renewal should make the agent work harder or use a signal of a decreasing price as the renewal date approaches. If the principal observes a deviation from the implicit agreement, she should retaliate and not renew the contract regardless of when the deviation was observed. The agent must then exert the same amount of effort in every and each period for the relational contract to be sustained. Relational contracting works only with bounded rationality and short memory of the principal. In our framework, relational contracting would not explain why the principal is keen on choosing an operator that performed well in the last periods. Iossa and Rey [2010] argue that performance in the last years of the contract is more informative about the agent's future performance prospects than its performance in the beginning of the contract.

Such results are confirmed by the empirical literature. Several studies focus on the investment or the level of effort given by the incumbent through the life cycle of the contract. For example, using a panel of 25 franchisees providing passenger services in the UK railway industry in the period 1997-2000, Affuso and Newbery [2002] found that non-verifiable investment by the contractors increased as the contract renewal date became nearer. Other empirical studies, such as Gautier and Yvrande-Billon [2008] in a sample of 124 French urban public transport networks operating between 1995 and 2002, found that costs were reduced over contract life. Performance should thus increase in the end of the contract.

However, the previous literature do not focus on the pricing of quality. Several empirical studies focus on the link between the life cycle of the contract and prices paid by consumers. Chong, Huet and Saussier [2006] studied 1102 French local public authorities and found that operators reduced customer prices as expiry date approached because of an *ex post* competition effect. Studying 5000 French water public services in 2001, Chong and Huet [2009] emphasize that private firms have less and less incentives to invest as the end of the contract approaches and thus confirm the under-investment risks at the end of the franchise bidding agreement. This results in a lower share of the profits linked to billed water for the private operator and thus to potential lower prices for the consumers in the years before the renewal.

Theoretical evidence of this phenomemon can be found in Martimort and Sand-Zantmann [2006 who consider a model of delegated management in which governments are privately informed over the quality of the facility while risk-neutral operators are subject to a moral hazard problem. They assume that high-quality networks need less investments and less management skills to provide water. On the contrary, low-quality is associated to high costs. As the principal keeps a great share of operating risk when quality is high, there is a trade-off between signaling and moral hazard. Low-quality is thus usually correlated with delegated management. Following the previous intuition, if the fear of direct management increases as the renewal approaches, the operator can be incited to keep quality at a low-level, thus reducing anticipated profits for competitors, and benefit from the 'common value', i.e. a private information of the network that gives him an advantage at the renewal.

We now turn to the industrial organization literature. In an oligopoly market such as the water provision in France[4], firms may enjoy high margins because of tacit collusion and face at the same time a strong threat from competition. Theoretically, high margins give strong incentives to sustain a reputation for high quality and thus lead to a competition between firms on product quality to steal business from rivals. According to Dana and Fong [2010], high quality can be sustained in oligopoly markets because each firm gets a fixed share of the market. In their model, consumers would punish a firm with low quality with zero sales and zero profits. If we turn it to the water industries in France, the public authority would punish operators with a degraded network quality at the end of the contract by not renewing the partnership. Operators would thus be incited to maintain quality through the life cycle of the contract.

As prices are fixed by the public authority and the operator during the bidding procedure and at different stages of the contract using renegotiations, an operator has no incentives to make investments that would induce higher costs, reduced margins and finally an increase in the price of billed water after a renegotiation. This is a mechanism close to the so-called ratchet effect: if the operator reveals that he is rather a 'good' type, here willing to take investments increasing network efficiency, the principal could take advantage of this information in future dealings with that agent, i.e. decreasing prices. Anticipating this effect, the agent is more reluctant initially to reveal this positive information since by not doing so, he can enjoy rents in the present as well as in the future.

While operators have no incentives to increase network quality as pay and performance are not linked, they may be keen on keeping performance at a given level but to decrease prices for a given quality in the end of the contract. As noticed Meyer and Vickers [1997], managers in firms can be motivated, not only by explicit contractual links between pay and performance, but also by increasing their performance alone to enhance the labor market's perception of their productivity and hence improve future earnings. This reputation effect is a type of implicit incentive encouraging higher performance for a given pay. In our case, a given performance would lead to lower pay in the end of the contract to signal an agent's willingness

[4] Three firms and their subsidiaries manage 95% of the delegated public water services in 2004.

to be renewed. This is in line with the formal signaling model developed by Spence [1973] to describe how efficient workers can signal their ability to employers by investing in education. Transposed to a dynamic principal-agent problem, Spence's analysis is that an operator keen on being renewed uses price as a signal instrument of his quality.

Following Klein and Leffler [1981] and Shapiro [1983], monopolies - such as water industries at the municipal level - have incentives to produce high-quality items only if high quality implies a rent that the producer is afraid of losing if he cuts quality. In a sector like water provision where network quality is usually unknown from the consumers and the public authority, the monopolist could be tempted to cut quality because such cuts takes long to be detected. The quality premium, i.e. higher margins for better quality, must increase to keep the monopolist from cutting quality and thus milking its reputation.

The implementation of the "‘Sapin Law"’ in 1993 which impose a two-step procedure for the selection of operating firms in delegated public management has ambiguous results: the choice of the public authority is *intuitu personae* - it does not list criteria according to which the choice of a partner has been made - but it can also incite prospective operators who lack information on the subjective selection criteria to submit bids corresponding to their true values. However, studies by Guerin-Schneider and Lorrain [2003] and Huet, Plunkett and Saussier [2006] show respectively that the number of bidders remains low while operators are geographically concentrated.

As incumbents bid for the renewal, we argue here that incumbents want to signal their efficiency by supplying a 'best-value for money' service for a given level of network quality in the end of the contract. As low-quality may not be the sign of low-efficiency but the result of low-investments in the past contractual periods, operators choose to signal their efficiency to the principal by keeping decent prices and not through an increasing network quality.

The reason is twofold. On the one hand, municipalities and users are worried about water quality more than network quality. Moreover, water quality is observable while network quality is rarely guaranteed in contracts. On the other hand, competition in the water industries are more about pricing strategy than network quality. As competition remains low[5] at the renewal, incumbents should even be incitated to end the contract with low-quality, thus reducing the anticipated profits for other competitors. However, in the late 1990s and beginning of 2000s, regulatory controls and efforts to improve water quality led indirectly to investments in network quality, through the replacement of lead pipes for example. It remains that networks have different quality and that converging to the best practices would be often costly and thus disincentive for operators, especially when the contract ends.

3 Data

The dataset used in this paper is a combination of data from the French Environment Institute (IFEN), the French Health Ministry (DGS) and the National Statistics Institute (INSEE) on 5000 local public authorities in 1998, 2001 and

[5] Guérin-Schneider and Lorrain [2003] find that 90% of the incumbents are renewed

2004. This sample is representative of the total French population and the local public authorities where they are living: all sizes of local authorities are proportionally represented and the larger local authorities - those with more than 5000 inhabitants - are all represented. As we take into account the life cycle of contracts as a variable of interest, we can only consider local public authorities under private management. Because of missing data, the sample goes down to 4290 observations. The unit of observation is a municipality.

3.1 Prices of water

The dependent variable is the price of water in a local public authority for a yearly consumption of 120 cubic meters. The price measure is the amount paid by the consumer, including national subscription fee but net of local and national taxes. As the IFEN database just gives us gross prices, we deflated prices between 1998, 2001 and 2004 using the Eurostat inflation figures for France to smooth the evolutions of nominal prices. In some regressions, we also use the log-value of the price to assess the semi-elasticity of prices to our quality proxies.

3.2 Network quality and distance to the best practices

Network quality is difficult to measure. Empirical studies such as Reynaud Thomas [2005] use the ratio of the billed water to the production while Chong, Huet, Saussier and Steiner [2006] and Erbetta and Cave [2007] use water losses as a proxy for the infrastructure quality. Other studies such as Coelli, Estache, Perelman and Trujillo [2003] regard water losses as an indicator of technical quality of the producer. Corton and Berg [2009] condider that water losses reflect a cost trade-off between increasing water production and repairing network leaks to keep up with water demand. We can consider greater leakages as a property of a low-quality network.

However, the volume of leakage itself or the ratio of unbilled water to produced water may not be representative of the characteristics of the network. As a performance indicator, public agencies and private operators must provide every year the *linear leakage index* which is the ratio of the average daily volume of leakages to the length of the network. As networks differ in their size and the density of population they serve, the linear leakage index is the best proxy for network quality as it takes into account the facts that networks may be over-sized compare to the population. This is the case in France where rural areas are highly represented on the territory. Rural municipalities can thus have a high leak ratio but a low linear leakage index as the produced water is small compare to the length of the network. In this case, while most rural networks may be considered as low-efficient using the leak ratio, they become less-efficient using the linear leakage index. We consider that the latter is the best proxy for quality as it is the reglementary indicator to be reported every year in a public document to the municipality.

However, in order to take into account the fact that networks differ in the size of the market, we decided to consider four groups of water production units. We calculated the density of the population as the ratio between the size of the area and the population of the municipality. We identified four groups[6] corresponding to the

[6] See Table [4] in appendix

four quartiles of the density distribution. We calculated the distance to the quality frontier as the ratio between the linear leakage index for a given municipality i at time j and the highest linear leakage index in the same group at the same time. For the highest linear leakage index, the distance to the quality frontier is 1, i.e. the worst practice, while for the lowest linear leakage index, the distance to the quality frontier is close to 0, i.e. the best practice for a given density group a given year. We expect the distance to the quality frontier, as the linear leakage index, to have a negative impact on prices. Low-quality network have lower prices because they suffer from under-investments.

3.3 The life cycle of contracts

The life cycle of the contract is taken into account by two different variables. The first one is the *Time to the end* of the contract in years. Time to the end of the contract is simply the difference between the year at which contract ends and the year we consider. It helps us to understand whether prices are more sensitive to a given level of quality in the last years. An interacted variable between the time to the renewal and network quality is introduced to measure the impact of the quality on prices through the life cycle of the contract. We expect the interaction term to be positive but close to zero. Indeed, as operators have to report every year the linear leakages index to the municipality, they try to reduce it or to maintain it through the time. The overall effect of the time to the end on prices is expected to be positive as we supposed that operators want to signal their management skills by lowering prices in PPP. However, the time to the end alone can have a negative coefficient as it will be interacted with network quality that can increase through the life cycle of the contract.

3.4 Controls

We also include a set of variables that might shift the costs, and therefore the price, of water distribution. A first set of controls accounts for the complexity of the water treatment performed by the operator before the water is distributed. *Treatment type* and *Origin of the water* are proxies not only for the complexity of service provision, but also the level of specific investments needed to operate the service, an important variable from a transaction cost perspective (Williamson, [1999]). Origin of the water should determine the type of treatment as the quality of underground water is generally more stable over time, reducing uncertainty about the evolution of the kind of treatment over the life of the contracts.

Secondly, we include a set of variables to control for the structure of the network. The *Population* in thousands is included to control for the size of the market. A large population can impact the price of water as it often means economies of scale and a stronger negotiating ability of the local public authority regarding the private operators. Small towns have fewer internal resources either to produce water themselves or to pay external experts and to monitor and control private operators. At the same time, private operators have little incentive to set up shop in small towns. This may explain the tendency of small towns to create pools, which then either provide water directly through a joint bureau of outsource. Conversely, when the population is large, local authorities have greater resources to hire technical experts and simultaneously their market is more attractive to private operators. Furthermore, some municipalities can be subject to a high volatility of demand due to seasonal variation in the population that might necessitate overcapacity in order to satisfy peak-load demand. A dummy variable *Touristic area* takes the value 1 if the municipality is considered to be touristic according to the INSEE classification.

Other controls are included. To take into account the ability of a set of municipalities to provide water and to negotiate with operators, we included a dummy *Inter-authority* equal to 1 and 0 otherwise if the municipality provides water jointly with other local authorities. As there are some geographical asymmetries in the production of water in France, mainly depending on the characteristics and the climate of the territories, or to unexpected natural events, we include dummies for the 26 French *Régions*. We also control for shocks by including *Year dummies* for 1998, 2001 and 2004 to take into account yearly effects such as high leaks due to an accident.

As PPP in the water networks are characterized by different types of contracts, we also include *Management dummies* to check whether different types of management lead to different prices. Indeed, according to the type of organizational choice chosen by the municipality, the repartition of investments between the municipality and the operator is different, which may explain a different impact of quality on prices.

Finally, we consider four density-groups as controls. We indeed consider that operators in rural and urban areas have different strategies. As there are scale economies, network quality is a more sensible question in areas that cover a large number of inhabitants because low-efficiency can lead to consequent monetary losses. This control is particularly important when one considers the linear leakage index as the distance to the quality frontier is already calculated respectively to the different density-groups. All these controls help us to explain the difference in prices and to thus to focus on the single impact of quality on prices during the contract life.

4 Empirical strategy

4.1 Econometric issues

Our empirical approach follows the literature on PPP and contracts which emphasizes the importance of several variables to explain prices. We first run ordinary least squares (OLS) estimations as it is the most widely used regression method (Greene, [2003]; Stock and Watson, [2003]). If the least squares assumptions hold and if errors are homoscedastic (i.e. the variance of the error term conditional on the regressor is constant), then OLS is the best linear unbiased estimator. However, endogeneity may arise when a regressor is correlated with the error term, thereby violating the exogeneity condition of the OLS. In our case, one may argue that there is a simultaneous causality between network quality and prices: low-quality network can result in lower prices but low prices can downward incentives of the operators to improve network quality.

To correct for the possible endogeneity of our OLS model, we then run a generalized method of moments (GMM) estimation (Hansen, [1982]) that contains the Instrument-Variable estimator as a special case. This helps us to minimize the GMM criterion function which depends on the sample size (more than 700 observations are required; Ferson and Foerster, [1994]) , the exogeneity condition and a weighting matrix. As the GMM estimation uses these three functions, it produces more efficient estimators than two-stage least squares (2SLS) estimation. The GMM estimation gives us results robust to heteroscedasticity and autocorrelation. This is important as heteroscedasticity and autocorrelation may invalid the standard errors and test statistics.

4.2 The baseline model

Our OLS regressions focus on the impact of network quality and the time to the end of the contract. Our main OLS model can be approached by the following model:

$$Price_{ij} = \beta_1 Quality_{ij} + \gamma_1 Timetotheend_{ij} + \gamma_2 Quality_{ij} * Timetotheend_{ij} + \gamma_4 Z_{ij} + \mu_{ij} \quad (1)$$

Where i indexes the municipality, j the year and $Quality_{ij}$ is the linear leakage index or the distance to the best practices for a municipality i at the time j and Z_{ij} is a vector of variables. In some regressions, we run the same model than equation (1) but using the log-value of price as a dependent variable to compute semi-elasticities.

Moreover, we want to show that the linear leakage index has a negative increasing marginal impact on prices when the time to the end of the contract decreases. The interacted variable helps us to analyse the effect of quality on prices through the life cycle of the contract. We argue indeed that the impact of network quality on prices is conditional to the proximity to the renewal of the contract.

However, one may argue that network quality or distance to the best practice depend themselves on other several factors such as the price of billed water in the last period, the contractualization of an investment program or whether the water production and distribution service are bundled with the sewerage service or not, i.e. whether scale economies can lead to increase potential investments to lower leakages. We thus run an instrumental variables regression to endogenize network quality using these variables.

The two equations given in (2), describe the general relationship between network quality and prices:

$$Quality_{ij} = f(X_{ij}) \quad (2)$$

$$Price_{ij} = g(Quality_{ij}, Z_{ij}) \quad (3)$$

where X_{ij} and Z_{ij} are vectors of factors influencing these relationships. We begin by examining the relationship between the linear leak ratio and whether the operator and the municipality contracted for an investment program, the price paid by the consumer in *j-1* and a dummy that captures whether the same operator runs the sanitation services for a given municipality given by:

$$Quality_{ij} = \alpha_1 Program_{ij} + \alpha_2 Price_{ij-1} + \alpha_3 Bundling_{ij} + \epsilon_{ij} \quad (4)$$

where *Program* is a dummy equal to 1 when an investment program has been contractualized, $Price_{ij-1}$ is the lagged price and *Bundling* is a dummy equals to one if the same operator runs the sanitation and the water production and distribution services. These three factors tend to explain the level of investments in quality as they refer to the global profit of the firm. Low prices can have a negative impact on the incentives of the firm to invest in the quality of the network. Furthermore, bundling services of water production and sanitation can increase incentives to launch investments on networks or to decrease leaks because of scale economies.

Equation (3) is used as the first-stage reduced-form in an instrumental variables estimation of the second-stage equation which characterizes the relationship between prices of water, network quality and the life cycle of the contract. To correct for heteroskedasticity and auto-correlation, our instrumental variables estimation will take the form of a GMM model using a robust weighted matrix and a bandwidth of two for the Bartlett kernel function. We then run alternative models including other controls, such as the group density in order to compare trends in services of the same size.

4.3 The marginal impact of network quality on prices

We want to measure the impact of network quality on prices through the life cycle of the contract. Our tables of regression are thus followed for all regressions on prices of a computed marginal effect of quality on prices and its significance at the mean values of quality and at different point of the life cycle of the contract. One may argue that contracts differ in their duration and that we do not observe contract during their whole life cycle. However, we argue that the last years in the contract are the most important for the renewal. Indeed, municipalities are subject to the political life cycle. In France, municipal elections are organized every six years while the average duration of contracts in our database is twelve years. The marginal effect of quality at different moments of the contract gives us a good overview of how operators impact network quality on prices. From equation (1), we know that the marginal effect of network quality on prices is:

$$\delta E(Price_{ij})/\delta Quality_{ij} = \beta_1 Quality_{ij} + \gamma_2 Timetotheend_{ij} \quad (5)$$

For each model, the marginal impact of network quality on prices is reported at different values of the time remaining before the end of the contract. It is easy to see that the main effect of network quality on prices is computed at the end of the contracts, we thus expect time to the end to have a negative coefficient. In the OLS regression, the marginal impact is the derivative of the estimate of the dependent variable considering other variables by the proxy for network quality. As the GMM estimation includes network quality as an instrumented variable, one may argue that the interaction term between network quality and the time to the end of the contract should be instrumented too. In order to be enable to report the marginal impact of network quality on prices through the life cycle of the contract, we decided to consider the interaction term as being independent from the instrumented variable. We alternatively run the same model using the log-value of water prices as a dependent variable to measure the semi-elasticity of network quality on prices. Standard errors and significance are also reported.

4.4 Tests for relevance, overidentification and exogeneity

We run several tests to assess the robustness of our model. We first test the relevance of the model. The First-stage F-statistic (Staiger and Stock, [1997]; Stock and al., [2002]; Stock and Yogo, [2004]) is reported for all GMM regressions. The threshold of 10% maximal relative bias provided by Stock and Yogo [2004] is always exceeded by the First-stage F-statistic and thus satisfies the relevance condition.

For all our estimations, we reported Hansen's J-Statistic (Hansen, [1982]) for overidentifying restrictions to check that the instruments are not correlated with μ_{ij}, the error term of the structural equation. A telltale is that the Hansen's J-Statistic must be larger than 0.10 to satisfy the overidentification conditions. This is the case for our GMM models.

We also verified that all instruments were exogenous by running for each of them the difference-in-Sargan statistic (Hayashi, [2000]), i.e. the difference between two Hansen J-Statistics to test the exogeneity of one or more instruments by relying on one other or several other instruments assumed to be exogenous (Baum, Schaffer and Stillman, [2003]). This test must be run for all instruments.

To conclude on the robustness of the GMM method, we finally run Moreira's conditional likelihood ratio (Moreira, [2003]). Moreira's CLR gives critical value functions for the Wald and likelihood ratio tests, which leads to correct rejection probabilities independent of how weak the instruments are. These Wald and likelihood ratio tests give confidence regions that are reliable regardless of the strength of the instruments (Andrews, Moreira and Stock, [2006], [2007], [2008]). Confidence regions and their p-values are reported in the tables.

5 Empirical results

We now turn to our empirical results. We first discuss the impact of network quality on prices through the life cycle of the contract in the OLS and GMM regressions. Then, in sub-section 5.3., we discuss the robustness of our model.

5.1 OLS estimations

Table [1] and [2] report our results for the OLS regressions for the four models tested and the two proxies for network quality. Model (1) is our basic set-up model while model (2) includes a density-group control. Model (3) and (4) measure the impact of network quality on the log-value of prices respectively without and with density-group controls.

For each regression, we reported in a sub-table the marginal effect of quality on prices at different periods of the contract life. The first line of the sub-table presents the marginal effect of quality at the end of the contract. The second line and the fourth line report the marginal effect respectively for the first quartile and the third quartile value of the time to expiry. The third line shows the marginal effect at the median value of the time to the end of the contract. Finally, the last line gives the marginal effect of quality on prices in the contract the further from the renewal. One can thus read how marginal effects of quality evolve when we get closer to the end of the contract.

The linear leakage index has a significant negative impact on prices as shown on table [1]. Anything else being equal, a linear leakage index increased by one cubic meter will decrease price by 1.648 euros in model (1) and by 1.114 euros in model (2). Using the semi-elasticity model, we find that increasing the linear leakage index by one cubic meter decreases price by grossly 1%. OLS regressors in table [2] show the impact of the distance to the best practice per density group on price. The farthest is the linear leakages index from the best practice, the lower is the price. Being 10 points above the mean distance can lead to a decrease by 7.63 euros in prices in model (1) and by 6.33 euros in model (2). Taking a glance at model (3) and (4) in table [2] shows that decreasing distance by 10 points increases price by 5% in (3) and by 4% in (4). This is consistent with previous results.

The time to the renewal has always a negative impact on prices but remains significant only in model (1) and (3) for both quality proxy. While other studies (Chong, Huet and Saussier, [2006]) found a positive sign for the time to the end, we here argue that getting closer to the end of the contract leads to higher prices as quality tends to increase through the contract. This is because our regression takes into account the network quality effect by interacting the time remaining and the quality of the network that time to the end has a negative impact on prices. Precisely, the interaction term is always positive showing that network quality and the time to the renewal are positively correlated, i.e. getting closer to the end of the contract goes with a decreasing linear leakages index. The slope is however close to zero in the OLS regressor revealing a probable multicollinearity effect due to the interaction term.

As our interaction term is not significant in table [1] and not always significant in table [2], we can focus on the marginal impact of quality on prices through the life cycle of the contract reported behind each tables. A given level of quality tends to have a significant negative increasing impact on prices at the end of the contract *ceteris paribus*. This effect remains the same when we take into account the distance to the best practice in table [2] and has *grosso modo* the same amplitude. The reason for this growing impact of network quality on prices is twofold. Firstly, operators may use a signal strategy as in the case of a repeated game, charging low prices in the end to get the renewal. Secondly, operators may limit their investments in the end of the contract to protect themselves against the risk of expropriation of the increased network quality (Williamson, [1975]).

5.2 GMM regressions

As argued in the previous section, OLS estimators may not be appropriate for the problem considered here. The use of GMM will allow us to deal with the potential endogeneity of our network quality proxy. For example, a given level of network quality can reflect the pricing policy of the previous period or scale economies. For these reasons, the network quality indicators are considered endogenous in the GMM estimations.

Table 1: OLS regressors with the Linear Leakages Index as a proxy for quality

	(1)	(2)	(3)	(4)
VARIABLES	OLS	OLS	OLS	OLS
Dependent Variable	Price	Price	Price(log)	Price(log)
Leakages	-1.648***	-1.114***	-0.012***	-0.008***
	(0.300)	(0.232)	(0.002)	(0.002)
Time to the end×*Leakages*	0.035	0.024	0.000	0.000
	(0.023)	(0.020)	(0.000)	(0.000)
Time to the end	-0.497***	-0.138	-0.003**	-0.001
	(0.185)	(0.176)	(0.001)	(0.001)
Population (in thousands)	0.016	0.061*	0.000	0.000**
	(0.041)	(0.034)	(0.000)	(0.000)
Interauthority	23.634***	21.276***	0.170***	0.156***
	(1.691)	(1.692)	(0.013)	(0.013)
Touristic Area	1.172	3.921**	0.011	0.028**
	(1.847)	(1.867)	(0.012)	(0.013)
Contract Dummies	Yes	Yes	Yes	Yes
Regional Dummies	Yes	Yes	Yes	Yes
Origin Dummies	Yes	Yes	Yes	Yes
Treatment Dummies	Yes	Yes	Yes	Yes
Time Dummies	Yes	Yes	Yes	Yes
Group Dummies	No	Yes	No	Yes
Constant	156.470***	138.451***	4.962***	4.849***
	(15.724)	(17.985)	(0.141)	(0.156)
Observations	4,290	4,289	4,289	4,288
Adjusted R-squared	0.361	0.403	0.333	0.370
Marginal impact of quality on prices				
End of the contract	-1.648***	-1.114***	-0.012***	-0.008***
	(0.300)	(0.232)	(0.002)	(0.002)
5 years to the renewal	-1.472***	-0.995***	-0.010***	-0.007***
	(0.208)	(0.158)	(0.002)	(0.001)
8 years to the renewal	-1.366***	-0.924***	-0.010***	-0.007***
	(0.167)	(0.130)	(0.001)	(0.001)
11 years to the renewal	-1.261***	-0.854***	-0.009***	-0.006***
	(0.149)	(0.126)	(0.001)	(0.001)
27 years to the renewal	-0.697*	-0.475	-0.005	-0.003
	(0.391)	(0.357)	(0.003)	(0.003)

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 2: OLS regressors with the Distance to the best practice as a proxy for quality

	(1)	(2)	(3)	(4)
VARIABLES	OLS	OLS	OLS	OLS
Dependent Variable	Price	Price	Price(log)	Price(log)
Distance	-0.763***	-0.633***	-0.005***	-0.004***
	(0.119)	(0.119)	(0.001)	(0.001)
Time to the end $\times Distance$	0.020*	0.020*	0.000	0.000
	(0.011)	(0.011)	(0.000)	(0.000)
Time to the end	-0.613***	-0.193	-0.004***	-0.001
	(0.181)	(0.179)	(0.001)	(0.001)
Population (in thousands)	-0.005	0.065**	-0.000	0.000***
	(0.043)	(0.033)	(0.000)	(0.000)
Interauthority	24.435***	21.991***	0.175***	0.160***
	(1.704)	(1.705)	(0.013)	(0.013)
Touristic Area	2.017	4.550**	0.014	0.031**
	(1.891)	(1.886)	(0.013)	(0.013)
Contract Dummies	Yes	Yes	Yes	Yes
Regional Dummies	Yes	Yes	Yes	Yes
Origin Dummies	Yes	Yes	Yes	Yes
Treatment Dummies	Yes	Yes	Yes	Yes
Time Dummies	Yes	Yes	Yes	Yes
Group Dummies	No	Yes	No	Yes
Constant	137.344***	121.725***	4.870***	4.770***
	(15.776)	(17.800)	(0.141)	(0.154)
Observations	4,289	4,289	4,288	4,288
Adjusted R-squared	0.343	0.394	0.315	0.360
Marginal impact of quality on prices				
End of the contract	-0.763***	-0.633***	-0.005***	-0.004***
	(0.119)	(0.119)	(0.001)	(0.001)
5 years to the renewal	-0.661***	-0.531***	-0.004***	-0.004***
	(0.075)	(0.074)	(0.001)	(0.001)
8 years to the renewal	-0.600***	-0.470***	-0.004***	-0.003***
	(0.596)	(0.057)	(0.000)	(0.000)
11 years to the renewal	-0.539***	-0.408***	-0.004***	-0.003***
	(0.062)	(0.058)	(0.001)	(0.000)
27 years to the renewal	-0.213	-0.081	-0.002	-0.001
	(0.213)	(0.206)	(0.002)	(0.002)

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Tables [3] report our results for GMM regressions for the model including the impact of the linear leakages index and the impact of distance to the best practices on log-prices. To assess the relationship between quality and prices, we instrumented our quality proxies by the lagged price, a dummy to capture whether an investment program has been contracted and whether contracts for water and sewerage are bundled. As in the OLS estimations, we find that low quality has always a significant and robust negative impact on prices. Increasing the linear leakage index by one cubic meter decrease prices by 18% while increasing distance to the best practice by 1 point could decrease prices by 7%. The interaction between the time to the end of the contract and network quality is positive and significant and thus confirms that the closer we get the renewal, the better is network quality. However, it is largely steeper than in the OLS regressions, especially for the distance to the best practice. It thus increases the sensitivity of prices to network quality. The time to the end of the contract in years has always a negative significant coefficients, thus confirming the preceding effect of joint evolution of the time to the end and network quality.

If we look at the marginal impact of quality on prices, we can see that quality tends to have a significant negative increasing impact on prices at the end of the contract. However, for long-term contracts, time to the end tends to have a positive marginal effect on prices. One may argue that long-term contracts are used when investments are needed (Laffont and Tirole, [1993]). In long-term contracts far from the renewal, an operator could chose to impact positively low-quality network on prices because it needs profits to invest further or to decrease prices when it will get closer to the renewal. Overall, we find that decreasing prices relatively to quality can be a positive signal sent by the operator to the municipality when reputational concerns are important.

In the rest of the contract, higher quality measured as a drop in the linear leakage index or in the distance to the quality frontier, would lead to higher prices. Operators thus tend to increase network quality only if they expect higher prices from the renegotiation process. This is in line with Klein and Leffler [1981] quality premium.

5.3 Robustness checks

A first test for robustness is to check the signs and the coefficients our variables. The quality of our model remains relatively unchanged especially when comparing the signs and the coefficients of our variables in the columns (1) and (2) on the one hand and (3) and (4) on the other hand for the OLS estimations. The signs of the coefficients for our interest variables remain the same when we switch from the linear leakage index to the distance to the best practice and from the OLS to the GMM regressors. The marginal effects have also the same signs, except for contracts at 27 years from the renewal in the GMM regressions. We can thus conclude to the robustness of our model.

Specific robustness tests are reported in the GMM regression tables. We can consider our model to be relevant. Firstly, the First-stage F-statistic satisfies the relevance condition at the threshold of 10% maximal relative bias provided by Stock and Yogo [2004]. Secondly, the p-value of the Hansen J-statistic does not reject the

Table 3: Results for GMM estimators

VARIABLES	(1) GMM	(2) GMM	(3) GMM	(4) GMM
Dependent Variable	Price	Price(log)	Price	Price(log)
Leakages	-76.427***	-0.497***		
	(14.391)	(0.095)		
Time to the end×*Leakages*	6.056***	0.039***		
	(1.276)	(0.008)		
Distance			-36.373***	-0.236***
			(6.513)	(0.043)
Time to the end ×*Distance*			3.115***	0.020***
			(0.612)	(0.004)
Time to the end	-36.347***	-0.236***	-37.141***	-0.241***
	(7.365)	(0.048)	(6.949)	(0.046)
Population (in thousands)	0.162	0.001	0.002	-0.000
	(0.141)	(0.001)	(0.116)	(0.001)
Interauthority	-0.684	0.005	-20.470	-0.123
	(17.730)	(0.115)	(17.674)	(0.114)
Touristic Area	19.546	0.127	45.962**	0.300**
	(13.875)	(0.091)	(19.811)	(0.130)
Contract Dummies	Yes	Yes	Yes	Yes
Regional Dummies	Yes	Yes	Yes	Yes
Origin Dummies	Yes	Yes	Yes	Yes
Treatment Dummies	Yes	Yes	Yes	Yes
Time Dummies	Yes	Yes	Yes	Yes
Group Dummies	Yes	Yes	No	No
Constant	797.320***	9.193***	601.262***	7.915***
	(142.404)	(0.930)	(103.045)	(0.668)
Observations	3,111	3,111	3,111	3,111
Adjusted R-squared	-24.161	-23.133	-22.256	-21.334
First-stage F-Stat	9.27	9.27	10.24	10.24
p-value of Hansen J-test	0.668	0.685	0.511	0.560
Difference-in-Sargan Statistic	Yes	Yes	Yes	Yes
Moreira's CLR (p-values)	[-126.024;-28.318]	[-0.819;-0.185]	[-57.498;-16.016]	[-0.374;-0.104]
	(0.000)	(0.000)	(0.000)	(0.000)
Marginal impact of quality on prices				
End of the contract	-76.427***	-0.497***	-36.373***	-0.236***
	(14.391)	(0.095)	(6.513)	(0.043)
5 years to the renewal	-46.146***	-0.300***	-20.800***	-0.135***
	(8.352)	(0.055)	(3.592)	(0.024)
8 years to the renewal	-27.977***	-0.182***	-11.457***	-0.074***
	(5.140)	(0.034)	(2.042)	(0.013)
11 years to the renewal	-9.808***	-0.063***	-2.113	-0.014
	(3.521)	(0.022)	(1.473)	(0.010)
27 years to the renewal	87.094***	0.568***	0.067	0.310
	(20.798)	(0.136)	(10.258)	(0.279)

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

overidentifying restrictions, i.e. the p-value is higher than the threshold of 0.10. Thirdly, the orthogonality condition is satisfied for each instrumented variables. Finally, Moreira's CLR gives reliable confidence regions that include the value of the coefficients for quality in the various GMM models with strong p-values. We thus conclude that our model is consistent and reliable.

6 Discussion and policy implications

In this paper, we presented evidence that the life cycle of the contracts do matter to explain prices' evolution. The marginal effect of quality on prices is negatively increasing when the contract gets closer to the end. As operators do care about their reputation, a given level of quality has a higher impact on prices when they get closer to the renewal of the contract. This is in line with results of previous studies.

Our results have a bearing on the expected effects of possible future negotiations on the water contracts. Shorter duration and being closer to the end of the contract can partly explain the decrease in prices for the consumer in the coming years. A French consultancy - BIPE - evaluated a decrease by 5 to 9% in tap water prices in France for 2009. We should notice, however, that we do not have data for costs, investments and margins that greatly explain and influence trends in prices. Further research will have to focus on these points.

We finally turn to the policy implications. As there is no regulator in France, controls such as public 'naming and shaming' on network quality through the Public Agencies could be implemented. Several countries like the Netherlands have recently implemented a sunshine regulation (De Witte and Saal, [2010]), i.e. by pointing low-quality networks who lack from under-investments with a benchmarking exercise made publicly available so as to embarrass the least performing entities and to put the best performing entities into the limelight. In the French case, the benchmarking should only concern indicators for network quality because they would give an idea of the evolution of prices in the coming years. The sanction for an operator that has underinvested in network quality could thus be the non-renewal or a penalty at the end of the contract.

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7 Appendix

7.1 Groups by density

Table 4: **Groups according to the density**

Group number	Mean Density	St. Deviation	Min, Max
Group 1	0.058	0.042	[0.004, 0.148]
Group 2	0.316	0.119	[0.148, 0.571]
Group 3	1.065	0.346	[0.571, 1.778]
Group 4	8.54	69.567	[1.779, 1585.621]

7.2 Management types of the production of water

Table 5: **Distribution of the Management Types**

Type	Share of the sample
Lease	83.46%
Concessions	5.27%
Intermediary management	4.78%
Gerance	6.49%

7.3 Summary statistics

Table 6: **Summary Statistics**

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
Price	4290	156.2264	45.690	9.805	365.631
Leakages	4290	5.777	6.922	0.001	121.3151
Distance	4290	0.071	0.088	0.000	1
Time to the end	4290	8.287	5.080	0	27
Population (in thousands)	4290	10.535	31.121	0.029	826.955
Interauthority	4290	0.812	0.390	0	1
Touristic area	4290	0.144	0.352	0	1
Investment Program	3111	0.683	0.465	0	1
Bundling	3111	0.527	0.499	0	1

7.4 Pair-Wise Correlation Matrix

Table 7: **Cross-Correlation Table**

Variables	**Price**	**Leakages**	**Distance**	**Time to the end**	**Population**	**Interauthority**	**Touristic**
Price	1.000						
Leakages	-0.252	1.000					
Distance	-0.241	0.810	1.000				
Time to the end	-0.118	0.135	0.068	1.000			
Population	-0.028	0.261	0.149	0.152	1.000		
Interauthority	0.274	-0.090	-0.151	-0.009	-0.019	1.000	
Touristic	0.049	0.036	0.081	-0.007	-0.015	-0.098	1.000