Outcomes of private sector involvement in water services: Theoretical foundations and empirical evidence from Spain

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Abstract

Water services management has became a key issue as far as urban water supply is considered a service of general interest in the European Union (EU, 2001). In this context, public-private partnerships (PPP) have emerged as a usual way of local water services provision. This paper contributes to analyze the effects and consequences of PPP, both from a theoretical and empirical point of view. First of all, we develop a theoretical framework to show the effects of water services contracting-out on water prices. Second, we test the model using a sample of Spanish municipalities recently privatized. Findings support that, in a context of limited resources, local governments are using public-private partnerships in order to get additional fundings to reduce their indebtness levels. Moreover, the fact of setting a high reservation price as a way to guarantee a minimum amount of resources has had consequences in terms of water price increases after water services privatization.

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1 Introduction

Water is a merit good that has important implications in economic, social and environmental dimensions (OECD, 2003). Moreover, urban water supply is considered a service of general interest in the European Union (EU, 2001). As a consequence, local water services management has became a key issue during the last decades. Additionally, it has been observed an increasing of private operators into the water sector. Thus, public-private partnerships (PPP) have emerged as a usual way of collaboration in the management of local water services (World Bank, 2006).

Several studies have investigated the process and consequences of PPP schemes in water sector. According to Menard (2012), PPP is primarily a contractual approach to the delivery of infrastructures, goods and services traditionally provided by the public sector or by private operators subject to tight command-and-control regulation, such as public utilities. Thus, some papers have analysed the consequences of PPP on prices (Hall and Lobina, 2004; Lobina, 2005; García et al., 2005; Chong et al., 2006; Carpentier et al., 2006; Martínez-Espiñeira et al., 2009; Ruester and Zschille, 2010; Picazo-Tadeo et al., 2012), quality (Shaoul, 1997; Lobina and Hall, 2000), or efficiency, (González-Gómez and García-Rubio, 2008; Picazo-Tadeo et al. 2009a and b) with different conclusions. Andrés et al. (2008) and Gassner et al. (2008) also address the debate of private versus public water utilities in developing and transition economies.

In this research in progress we analyse both theoretically and empirically PPPs in the water sector. Next section describes the institutional water sector framework in Spain. Section 3, we develop a theoretical model to explain PPP and auctioning in the water sector, assuming profit maximization in the case of private operator, and the presence of a vote-maximizing local government. Section 4, based on a database of Spanish municipalities recently privatized, we test the effects of PPP on several key variables. Finally, we conclude summarizing the most significant

findings and future extensions of this research.

2 Water sector in Spain: PPP schemes

The legal framework in Spain, Law 7/1985 on the Regulation of Local Government Terms and Conditions and Law 57/2003 on Local Government Modernisation Measures, establishes that local governments are responsible for guaranteeing the urban water service, but may choose how it should be managed and the legal regime for provision. The laws mentioned above and Royal Decree 2/2000 establish the legal regimes for the provision of municipal services. The local government may choose between either managing the service in-house or outsource it to an external company. In case of externalisation, management may be transferred either to a public company or privatised. In the latter case, the management of the service may be either fully privatised, contractual public-private partnership (PPP), or partially privatised to a mixed company, institutionalised PPP. It is worth highlighting that Spanish legislation only contemplates privatising the management of the service, as the infrastructure remains public property. Statistics show that there has been a progressive process of water services privatization from the 80s in Spain. In 2008 private companies supplied 46% of the Spanish population (AEAS 2010). Additionally, it should be noted that the Spanish market is highly concentrated: Aqualia and Aguas de Barcelona are the two main private operators.

Contractual public-private partnerships are the most widespread form of privatising public services in Spain. In 2008 the 33% of Spanish population was served by fully private companies (AEAS, 2010). Concessions are made official by way of contract whereby the local government entrusts an individual or corporation (legal entity) with the management, but still owns the service. They are awarded following a public tender and for a limited amount of time. In the case of water supply companies, contracts that involve building infrastructures and operating the service must be no longer than fifty years, while those that only imply

running the service have a twenty-five-year limit. At the end of the contract, local governments must again decide how they wish the service to be managed for a new period.

Another alternative for the private sector to participate in the management of the urban water service is the creation of institutionalized PPPs (Bel and Warner, 2008; González-Gómez et al., 2009), whereby capital is shared between the private and public sector. In such companies, local government participation is normally sufficiently significant to guarantee that public objectives will be accomplished successfully. In 2008, those entities served to the 13% of Spanish population (AEAS, 2010). This form of management makes it possible to combine public interests such as universal access and quality standards with the industry know-how of private management. In this sense, the private partner is mainly responsible for managing these companies, while the political decisions are made by the public partner. Nonetheless, Cruz and Marques (2012) have recently pointed out that, in spite of the theoretical advantages of institutionalised PPPs, the empirical evidence for the case of the Portuguese water service shows that the complexity involved in their management usually leads to a poor protection of the public interest. In line with those results and using a sample of big-medium size cities in Spain, García-Valiñas et al. (2012) found that mixed companies set higher prices that other kind of entities.

The literature has found several reasons that lead local governments to privatize water services (González-Gómez and García-Rubio, 2008). Political, financial and operational factors have influence on the privatization decision. Focusing on some of them, several studies have found that the fragile financial situation of several municipalities has also been a key factor in the decision to externalise urban water services (González-Gómez et al., 2011). Thus, privatisations have been a source of significant revenue for local governments. By the other side, local governments could try to get improvements in the management of water services, especially under complex operational environments.

Anyway, when local governments decide to let private initiative come into the management of water services, might do a bidding announcement with some requirements to operators in order to attend to the competition. Those specifications include, among others, a minimum entrance and/or annual fees, and a certain level of investment during the concession period. Private operators might submit a bid trying to improve those minimum requirements. Once received all the offers, local governments will take a decision based on several criteria.

In this situation, it is clear that the minimum requirements included in the initial bidding conditions could be showing the intention of local governments when they decide to privatize. Thus, they can fix a high minimum fee and or investments, in order to maximize the revenues from privatization to compensate deficits. However, if the minimum requirements are not so high, other kind of objectives could emerge. Those initial conditions could determine the final result of privatization process, in terms of price and quality. In this paper, we will analyze this hypothesis from both a theoretical and empirical point of view.

3 The model

Consider a municipality with M agents. Each agent inelastically consumes one unit of tap water. The municipality considers whether or not to privatize the supply of tap water. The privatization occurs through a first-price sealed-bid auction.

There are N firms indexed by i interested in supplying tap water. Firm i wins the auction if her bid, b_i, is higher than the other bids and if it exceeds the municipality's reservation price r. Bidder i faces cost c_i to supply tap water. The cost c_i is private information of Firm i. The cost c_i is independently drawn from an identical distribution whose c.d.f. is denoted by F. The support of F is $[0, \omega]$.

After the auction, the winning bidder must decide on how much to invest to improve the supply of water. This investment is denoted by I. The municipality, after observing I, decides on the unit price p that the water company is allowed to

charge. We assume that $p = f^s(I)$, where $s \in \{\text{maj}, \text{min}\}$ and where f^s is concave. If $s = \text{maj}$, the municipal government has a majority in the municipal council. If $s = \text{min}$, the municipal government must compromise with the opposition in the municipal council in order to increase the price of water. $f^s(0)$ is exogenous. It is also assumed that for all I, $\frac{\partial f^{min}}{\partial I} < \frac{\partial f^{maj}}{\partial I}$. This assumption ensures that the winning firm has more incentives to invest when the local government need not compromise with the local opposition parties. To avoid confusion, we consider the following sequencing of events:

1. The municipality chooses the reservation price r. Bidder i learns her cost c_i.

2. Bidder i—after observing r—participates in a first-price auction.

3. The winning bidder chooses her investment level I.

4. The municipal council observes I and sets p.

As usual this game is solved by backward induction. At time 3, the winning firm faces the following problem:

$$\max_I f^s(I)M - I - c_i.$$

As f^s is concave, there exists a unique value of I which maximizes her profits. With a slight abuse of notation, let I denote the *equilibrium* investment amount. Obviously, I depends on whether or not the local government needs to compromise with members of the opposition.[1] With a slight abuse of notation, let $p \equiv f^s(I)$ denote the *equilibrium* post-privatization price of water. Let $\pi(c)$ denote the equilibrium amount of profits (excluding her bid) made by the winning firm. Formally, $\pi(c) \equiv pM - I - c$. Observe that both p and $\pi(c)$ depend on the state s.[2] We

[1]Call I^{maj}, the optimal investment level when $s = \text{maj}$. Similarly, I^{min} denotes the optimal investment level when $s = \text{min}$. As $\frac{\partial f^{min}}{\partial I} < \frac{\partial f^{maj}}{\partial I}$ $\forall I$, $I^{\text{min}} < I^{\text{maj}}$.

[2]In particular, the equilibrium price p is higher if $s = \text{maj}$ than if s were equal to min. Similarly, $\pi^{\text{min}}(c) < \pi^{\text{maj}}$. To avoid cumbersome notations, we decided to work with p and π instead of p^s and π^s.

assume that $\pi(0) > 0$. This assumption is natural: If $\pi(0)$ were negative, a bidder with zero costs who won the auction after bidding zero would still face losses. No bidder would be interested to participate in such an auction.

All bidders are assumed to bid according to a symmetric, decreasing and differentiable bidding function $\beta : [0, \omega] \to \Re^+$. Let $\bar{c} \equiv pM - I - r$. Intuitively, a bidder with cost $\bar{c}$ who pays the reservation price r gets zero profits given the price p and the investment I. Any bidder with cost $c > \bar{c}$ drops thus out of the auction. Formally, any strategy which prescribes her to bid above r is dominated. Suppose Bidder i's cost c_i is less than $\bar{c}$, i.e. that $pM - I - r - c_i > 0$. Suppose there exists an equilibrium in which she is supposed to bid less than r. In this candidate equilibrium, she never wins the auction and she therefore gets zero. She can, however, profitably deviate by bidding $r + \epsilon$: With positive probability she then wins the good and receives a payoff equal to $pM - I - r - c_i - \epsilon > 0$. Hence, in any candidate equilibrium, $\beta(\bar{c}) = r$. A unit increase in the reservation price r thus leads to a unit decrease in the types that drop out of the auction.

We assume that $p^{\text{maj}}M - I^{\text{maj}} - \omega = 0$. In words, the assumption states that if $c_i = \omega$ and if Bidder i wins her tract after bidding zero, she gets zero in state $s = \text{maj}$. It is thus without loss of generality to assume that $c_i \leq \omega$: A bidder with a cost $c_i > \omega$ would never participate in the auction, not even if $r = 0$ and if $s = \text{maj}$. Let Y_1 denote the lowest cost realization of the $N - 1$ other bidders. Formally, $Y_1 \equiv \min_{j \neq i}\{c_j\}$. Let $G(c) \equiv \Pr(Y_1 < c)$ denote the probability that the lowest cost of the $N - 1$ other bidders is less than c. As usual, this game is solved by backwards induction. The proposition below summarizes equilibrium behavior at time two.

PROPOSITION 1 *There exists a symmetric bidding function given by*

$$\beta(c) = \begin{cases} 0 & \text{if} \quad c > \bar{c}, \\ \frac{1}{1-G(c)} \left[\int_c^{\bar{c}} \pi(x) g(x) dx + [1 - G(\bar{c})] r \right] & \text{if} \quad c < \bar{c} \end{cases} \tag{1}$$

We now analyze the municipality's maximization problem. As there is a one-

to-one relationship between r and $\bar{c}$, it is without loss of generality to assume that she chooses $\bar{c}$ instead of r. We assume that she chooses $\bar{c}$ to maximize revenues. Our most important result is summarized below:

Lemma 1 *Let c^* denote the value of c such that $\pi(c) = \frac{F(c)}{f(c)}$. In equilibrium, $\bar{c} = c^*$.*

We now analyze some comparative static results of our model. Consider the following regression equation

$$p = \alpha_0 + \alpha_1 p_b + \alpha_2 r + \alpha_3 b_{max} + \alpha_4 \mathcal{I}_{\{s=\text{maj}\}} + \epsilon,$$

where p_b denotes the price of water that prevailed prior to the privatization, where b_{max} denotes the winning bid and where $\mathcal{I}_{\{s=\text{maj}\}} = 1$ if $s = \text{maj}$ and zero otherwise.

Our model predicts that α_1 is *not significantly different from zero.* This is intuitive: p_b just simply does not enter as a variable in our model. Our model predicts that α_2 should be *positive.* To understand this, recall from Lemma 1 that in equilibrium

$$\pi(\bar{c}) = \frac{F(\bar{c})}{f(\bar{c})}. \tag{2}$$

Recall also that $\pi(\bar{c}) = pM - I - \bar{c}$ and that $\bar{c} = pM - I - r$. Inserting these two equalities into Equation 2 we conclude that in equilibrium

$$r = \frac{F\left(pM - I - r\right)}{f\left(pM - I - r\right)}. \tag{3}$$

Suppose that the right-hand side is decreasing in r.[3] Observe that the right-hand side, evaluated at $r = 0$, is greater than the left-hand side. Recall also that—by definition of ω—$pM - I - \omega \leq 0$ and thus that $F(pM - I - \omega) = 0$. This implies that the right-hand side, evaluated at $r = \omega$, is less than the left-hand side. There exists thus a unique $r^* \in (0, \omega)$ which satisfies Equality 3 . Observe also that any

[3]Many distributions share this property. It would be satisfied, for example, if F is close to a normal.

increase in p represents a shift to the north-east of the right-hand side. In turn, this implies that r is increasing in p. In essence, an increase in p leads to an increase in the amount of profits (gross of bidding costs) of the winning firm. This induces the municipality to force the bidders to bid more aggressively via an increase in r. Our model predicts that α_3 is *positive*. To see this, suppose that Bidder i's cost $c < \bar{c}$. It follows from Proposition 1 that I can then rewrite her optimal bid as

$$\beta(c) = E\left(\min\left\{\pi(Y_1), r\right\} \middle| Y_1 > c \right).$$

The higher p, the higher her expected profits (excluding bidding costs). This increases her expectation of the second most efficient firm and thus also her bid. Finally, our model predicts that α_4 is *positive*. As stated above, this is entirely due to our assumption that $\forall I$, $\frac{\partial f^{min}}{\partial I} < \frac{\partial f^{maj}}{\partial I}$. If $s = \text{maj}$, the winning firm has more incentives to invest. In turn, this provides a justification for the municipal congress to allow a higher price of water.

4 Empirical evidence

In order to test some the findings showed in the previous section, we estimate a simple model using a data base of Spanish municipalities recently privatized. In particular, we analyze the influence of some auction conditions and environmental factors on water prices. Thus, we specify the next equation system:

$$p = f(pb, r, Z), \text{ and} \tag{4}$$

$$r = f(d),$$

where p is the price after the privatization, pb is the price before the privatization, r is the reservation price and Z is a vector of exogenous variables with influence on prices. At the same time, we consider that r is a function of the financial situation of the local incumbent (d). In this way, we also test if local governments are using privatization processes to get extra-funding and pay public debt

off. In Z, we include the population (pop) as a control variable, a water services infrastructure quality index (bppipeb), and two political variables (majority; difv). Unfortunatelly, it was not possible to get information of the winner's bid neither the final investment. Appendix B includes the list and definition of variables that we use in our empirical analysis.

Data on the auctioning terms and conditions are taken from several public websites which contain all the details on the privatization process. Law 30/2007 on Public Sector Contracts compels public authorities to upload to a public website all the documents linked to the public contracting processes from April 2008. Big-medium municipalities use to have a specific link in its own webpage that contains all the information. However, information on small municipalities contracting-out is centralized in a website managed by a regional public authority. Additionally, we have got information on water infrastructure quality from a survey on local infrastructures conducted periodically by the Ministry of Public Administration. Every 5 years, municipalities smaller than 50.000 inhabitants are interviewed in order to get exhaustive information on local public assets in terms of quantity and quality. The National Institute of Statistics (INE) elaborates statistics related to population, and political and public finance variables were taken from the Ministry of Economics and Public Administration webpage.

The representative municipality is a small entity close to 20.000 inhabitants, with financial problems and a 25% of its pipes in bad conditions. In average, the difference between price after and before the privatization amonts by 0.18 Euros per cubic meter. Regarding political variables, we observe that majority governments during the privatization, that loose votes in the elections celebrated after privatization. Additionally, in the majority of municipalities, there are not minimum investment requirements included in the bid tems and conditions. That evidence makes easier to assume that the municipality has focused basicly on the price offered by the bidders. Table 2 presents equation system (4) estimates using 3SLS. Compared with OLS, this method allows correcting endogeneity and

Table 1: Summary statistics

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**N**
p	0.699	0.33	0.286	1.976	54
pb	0.519	0.186	0.231	0.966	54
r	3675.692	7227.417	0	37000	54
pop	18.509	29.848	0.439	148.918	54
bpipeb	24.88	33.736	0	98.040	45
majority	0.704	0.461	0	1	54
difv	-2.895	10.278	-27.24	22.91	54
debtb	7598.021	16420.224	0	94160	48

improves efficiency.

Those preliminary results are according to our expectations. The empirical analysis shows a positive and strongly significant relationship between the reservation price and the price after the privatization. Moreover, there is not significant relationship between the water price before and after the privatization, as the theoretical model has predicted. Additionally, local governments with higher financial problems set higher reservation prices in the auction. Thus, local public debt is emerging as a determinant of the reservation price, assuring higher revenues to improve municipal financial situation. Water infrastructures in bad conditions require higher investments, so the price after the privatization is higher. In bigger municipalities, water price after privatization is lower. This finding makes sense, since municipality size is directly linked to the costs of water services (Garcia-Valiñas et al. 2012). Regarding political variables, we have found higher prices linked to majority governments, but it is also true that it is possible to observe a negative relationship between the price after privatization and the proportion of votes that the party gains after the privatization. However, in this case, the causality is not totally clear.

Table 2: Estimation results

Variable	**Coefficient**	**(Std. Err.)**
Equation 1 : p		
pb	-0.094	(0.553)
r	0.002**	(0.000)
pop	-0.298**	(0.096)
bpipeb	0.004*	(0.002)
majority	0.455*	(0.209)
difv	-0.029*	(0.012)
Intercept	0.010	(0.213)
Equation 2 : r		
debtb	0.289**	(0.056)
Intercept	714.696*	(277.664)

5 Concluding remarks

This paper is a first approach to the consequences of contracting-out and privatizations in the water sector. It is part of a more ambitious research project on the economic implications of PPP in residential water services. So, outcomes showed in this paper might be considered as very preliminary findings. However, those results are very intuitive, showing some interesting effects linked to the auctioning of water services.

A significant contribution of this paper is related to the current public sector financial situation. Thus, it has been shown that local governments are using public-private partnerships in order to get additional fundings to reduce their indebtness levels. Moreover, the fact of setting a high reservation price as a way to guarantee a minimum amount of resources has had consequences in terms of water price increases after the privatization processes. Political issues are also significant, in the sense that majority governments allow private operators to set higher water

prices after the privatization.

At present we are working on improving the data base by extending the sample. We are including additional municipalities, and it is also expected to consider extra variables to enrich the model. As a short-run objective, we are looking for the information related to the winner bid. Moreover, we are searching for data about other relevant variables related to quality and efficiency issues. Definitively, we are trying to improve the essential information about the processes of externalization occurred in Spain along the last years in order to be able to estimate the theoretical model proposed. We hope to contribute to enhance the knowledge on the management of this significant merit good.

Appendix A

Proof of Proposition 1.

Denote bidder i's cost by c. Fix s. Suppose $c < \bar{c}$. She faces the following problem

$$\max_b \left[1 - G\left(\beta^{-1}(b)\right)\right](pM - c - I - b).$$

The first-order condition is

$$-\frac{g\left(\beta^{-1}(b)\right)}{\beta'\left(\beta^{-1}(b)\right)}(pM - c - I - b) = 1 - G\left(\beta^{-1}(b)\right).$$

In a symmetric equilibrium, $b = \beta(c)$ and $\beta^{-1}(b) = c$. The first-order condition can therefore be rewritten as

$$-\frac{g(c)}{\beta'(c)}(pM - c - I - \beta(c)) = 1 - G(c),$$

which is equivalent to

$$\begin{aligned} \beta'(c)\left[1 - G(c)\right] - \beta(c)g(c) &= -g(c)\pi(c) \\ \Leftrightarrow \frac{d}{dc}\left[\beta(c)\left[1 - G(c)\right]\right] &= -g(c)\pi(c). \end{aligned}$$

Using the second fundamental theorem of calculus one has:

$$[1 - G(c)]\,\beta(c) = [1 - G(\bar{c})]\,\beta(\bar{c}) + \int_c^{\bar{c}} \pi(x)g(x)dx.$$

Observe that $\beta(\bar{c}) = r$. This insight, combined with our earlier equation yields (1).

Proof of Lemma 1.

We first obtain a different expression for the expected revenues R. Let $m(c)$ denote the expected payment of a bidder with cost c in state s, i.e. $m(c) = [1-G(c)]\beta(c)$. Observe that $R = N\int_0^{\omega} m(c)f(c)dc = \int_0^{\bar{c}} m(c)f(c)dc$. Observe also that

$$\int_0^{\bar{c}} m(x)f(x)dx = \int_0^{\bar{c}}\int_{\bar{c}}^{\omega} \pi(\bar{c})g(x)dxf(c)dc + \int_0^{\bar{c}}\int_c^{\bar{c}} \pi(x)g(x)dxf(c)dc. \quad (5)$$

Observe that

$$\int_0^{\bar{c}}\int_{\bar{c}}^{\omega} \pi(\bar{c})g(x)dxf(c)dc = [1 - G(\bar{c})]\pi(\bar{c})\,F(\bar{c}). \quad (6)$$

Inverting the order of integration of the second integral of Equation 5, one has:

$$\begin{aligned}\int_0^{\bar{c}}\int_c^{\bar{c}} \pi(x)g(x)f(c)dxdc &= \int_0^{\bar{c}}\int_0^{x} \pi(x)g(x)f(c)dcdx \\ &= \int_0^{\bar{c}} \pi(x)g(x)F(x)dx. \quad (7)\end{aligned}$$

Inserting (6) and (7) into (5), we conclude that

$$R = N\left[[1 - G(\bar{c})]\pi(\bar{c})\,F(\bar{c}) + \int_0^{\bar{c}} \pi(x)g(x)F(x)dx\right]. \quad (8)$$

The local municipality chooses $\bar{c}$ to maximize R. Using (8), the first-order condition is

$$\frac{\partial R}{\partial \bar{c}} = N[1 - G(\bar{c})]\left\{\pi(\bar{c})f(\bar{c}) - F(\bar{c})\right\}.$$

Hence, $\frac{\partial R}{\partial \bar{c}} = 0 \Leftrightarrow \pi(\bar{c}) = \frac{1}{\sigma(\bar{c})}$, where $\sigma(c) \equiv \frac{f(c)}{F(c)}$ denotes the reverse hazard rate of F. Suppose that $\sigma(c)$ is decreasing in c. Many distributions share this property. For example, if F were close to a normal, $\sigma(c)$ would be decreasing in c. Under this assumption it is straightforward to check that there exists a unique c^* such that $\pi(c^*) = pM - I - c^* = \frac{1}{\sigma(c^*)}$.

Appendix B: Variables definition

p: average price after privatization, corresponding to an average consumption of 15 cubic meter per month (in Euros per cubic meter).
pb: average price before privatization, corresponding to an average consumption of 15 cubic meter per month (in Euros per cubic meter).
r: reservation price (in thousands of Euros).
pop: Population of the municipality in 2011 (in thousands of people).
bpipeb: Percentage of pipes in bad conditions in 2005 (in percentages).
majority: Dummy which takes value 1 if there was a majority government the year of privatization.
difv: Difference between the percentage of votes gets by the party governing in the moment of privatization, after and before the privatization (in percentages).
debtb: Local debt the year before privatization (in thousands of Euros).

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