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DOES PRIVATE MANAGEMENT OF WATER SUPPLY SERVICES REALLY INCREASE PRICES? AN EMPIRICAL ANALYSIS

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Does private management of water supply services really increase prices? An empirical analysis

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Abstract

In this paper we try to explain differences in the average price of domestic water supply services in Spain, paying special attention to the effects of privatisation of the service on price levels. We base our empirical analysis on the application of a `treatment effects' model on a sample of 53 major urban municipalities. This model accounts for the fact that municipalities do not randomly assign themselves between a group using strictly public ownership and management and a group where all or part of the service has been delegated to a private firm. We find that, once this endogeneity is taken into account, there seems to be a positive and significant effect of privatisation on water price levels.

JEL classification: C21, L33, L95

Keywords: Urban water services, privatization, water prices

1. Introduction

One of the basic aims of urban water supply systems is to make compatible higher levels of efficiency with a universal supply of an acceptable quality. Additionally, residential water suppliers are more often than not expected to pursue equity objectives, due to the essential character of water for several uses. Regarding these aspects, there is an unfinished debate about which kind of management (public, private, or mixed) is the best option.

The main argument proposed to justify privatization processes has been its advantages in terms of efficiency. Public management is conditioned by several constrains, due for example to the multi-objective nature of their problem, or to being more subject to restrictive labour relationships or to those imposed by the political setting. Private management might be able to attract financial resources more easily, and in theory it is characterized by more flexibility and better experience. Therefore, private firms can in principle more easily finance improvements and maintenance of infrastructure and can provide a quicker response to different social demands in a rapidly changing environment (Beecher et al., 1995; Soler, 2003).

However, we can also find arguments against private management. Hall and Lobina (2004) pointed out that the incorporation of private firms into the water sector may lead to permanent conflicts between public and private interests. In fact, after some decades of privatization, several countries now show opposition to further privatizing of public services (Hall et al., 2005). First, water suppliers operate, generally, under conditions of local monopoly or at least in highly concentrated industries. Therefore, it is difficult to achieve high levels of effective competition, which means that the privatizing of water public services should be regarded with caution (Rees, 1998). Second, privatization can be criticized on equity grounds. Sometimes, private suppliers increase prices without a corresponding enhancement in the quality of the service or capacity increases. Hall and Lobina (2004) and Lobina (2005) provide evidence of several privatization processes that have lead to price increases that were difficult to justify.

In any event, it is not possible to generalize the findings of a few specific studies, so it would be necessary to consider empirically every particular case. In this respect, Carpentier et al. (2006) and García et al. (2005) investigate the determinants of urban water prices, including the type of management (public or private). In the former (Carpentier et al., 2006) public and private operators are compared, with prices found higher under private management mainly because the operating environment is harder. Local governments are keener to privatize water supply services if there are more technical difficulties in supplying water. García et al. (2005), who analyze the effects of technical factors, competition, and strategies of private firms on water price in France, show that the local strategy of the operator has a significant impact on the water price level. Private operators can set prices below or above costs depending on the specific situation.

In Spain, local governments are expected to provide water supply and wastewater service. However, these services can be managed under alternative regimes. Municipalities can supply water services directly or through a public firm, or they can delegate the provision to a mixed or private firm. In consequence, there are currently a broad variety of management forms in the Spanish urban water sector. In 2002, (AEAS, 2004) 42% of the population was supplied by means of a public firm, 40% by private firms, 11% by mixed firms, 6% directly by the local government and the remaining 1% by other kind of management (basically, municipality associations). Regarding the degree of concentration of operators in the Spanish water sector, we clearly find an oligopolistic structure. Although the delegation of water supply services is supposed to inject competition calling for bids and limiting the length of administrative concessions, there are two large corporate groups which dominate water sector. Additionally, although there are price regulations controlling the behavior of private firms, more often than not those controls are based more on formal criteria than on economic or technical ones. The regulatory boards are usually managed by experts in financial law and formal processes, rather than by experts in water supply economics or water supply engineering. In spite of this price regulation, private firms enjoy some degrees of freedom when setting prices, so they can change the tariff structure in order to get higher revenues.

The main aim of this paper consists of testing if there exists any kind of relationship between the ownership of water supply services and urban water price levels in Spain. This issue is interesting from a socioeconomic and political point of view. When a local government declares its intention of privatizing water public services, it is usual that ecologist groups and/or left-wing parties show their opposition to the management change. They argue that the privatizing process leads to price increases that punish water users, especially those with lower income.

In addition to that main issue, we would like to analyze other relationships between environmental factors and water price levels. For example, we will include variables of input and output water quality, in order to observe trade-offs between quality and price levels. The Spanish institutional context is similar to the French case, in the sense that it is possible to find a coexistence of public and private management in the water supply sector. This fact makes it possible to investigate the relationships between ownership or management and water tariffs. To the best of our knowledge, this is the first study of the link between privatization of water supply services and water prices in Spain, and as such constitutes a relevant contribution to the improve the state of the art in this field.

We proceed as follows. In Section 2, we describe the methodology used. We propose the use of a treatment effects framework in order to account for the likely endogeneity of the decision to delegate the water supply service. In Section 3 we describe the data set, the variables, and the main hypothesis to test in this paper. The results are analyzed in Section 4 and Section 5 concludes.

2. Econometric Methods

Comparing water price levels among municipalities where the service is wholly public and municipalities where it has been partly or wholly privatized is not straightforward. This is because municipalities are not likely to privatize the service in a random fashion. There are likely to be a series of characteristics of the operating environment that make it more attractive for a private firm to take over the service and/or for the municipality to try and delegate the service. In other words, some municipalities are probably more likely than others to be served by a private firm. Furthermore some of these characteristics of the municipalities that affect the likelihood of delegation also affect the level of price charged by the water supplier and cannot be observed by the researcher.

The prices that would be charged in the municipalities with delegated management if they had instead remained under public management are not observable and the prices that would be charged by a private firm in those municipalities still under public management are not observable either. In order to model this endogeneity of the delegation decision, we analyze the influence of the delegation decision using a treatment effects model.

Let p_i be a binary variable that denotes the type of management in municipality i, such that $p_i = 1$ if the supply has been partly or wholly delegated to a private firm and $p_i = 0$ if the supply is still public. Define $BILL_{0i}$ as the average *BILL* size or, equivalently, the average price per cubic meter in municipality i when $p_i = 0$ and $BILL_{1i}$ as the equivalent measure in municipality i when $p_i = 1$. Ideally, we would want to measure the effect of delegation on price as

$$\Delta_{i} = BILL_{1i} - BILL_{0i} \qquad (1)$$

However, for a given municipality i, only $BILL_{1i}$ or $BILL_{0i}$ can be observed in our cross-section, but not both[1]. That is:

$$BILL_i = p_i BILL_{1i} + (1-p_i)\, BILL_{0i} \qquad (2)$$

Therefore, it is impossible to measure directly the effect of the *treatment* (delegation of the service).

Similar problems related to the analysis of treatment effects have been considered by, among others, Ashenfelter (1978), Ashenfelter and Card (1985), and Heckman and Robb (1985 and 1986).

There are several ways to handle this type of problem and the reader is directed to Heckman (1992, 1997), Imbens and Angrist (1994), Angrist, Imbens and Rubin (1996) or Wooldridge (2002) for further details on treatment effects models.

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[1]The unobservable component in Expression 1 is known as the *counterfactual outcome*.

In this paper we deal with non-experimental data on a cross-section,[2] and we have reason to believe that the privatization effect can lead to *hidden bias* (rather than *overt bias*), so two estimators could be considered: the instrumental variables (*IV*) and the two-step Heckman selection estimators. Here we chose to follow a selection model approach (Heckman, 1979; Heckman and Robb, 1985 and 1986) based on a full information maximum-likelihood approach. This selection estimator uses two equations that are estimated simultaneously. In this case, the first equation is an explicit model of the privatization process which controls for the part of the privatization decision that is correlated with the error term of the second equation, which has the price level as the dependent variable.[3] In our case, the outcome equation models the level of *BILL* as a function of a series of explanatory variables including p:

$$BILL_i = \beta X + \alpha_i p_i + \mu_i \qquad (3)$$

Since the choice to delegate water supply services is likely to be non-random, we expect a non-zero correlation between the error term μ_i and p_i. If this correlation exists, it would not be valid to use a standard regression as Expression 3 alone. The selection model used estimates the part of the error μ_i that is correlated with p and then include it in Equation 3. By construction, what remains of the error term in Equation 3 is no longer correlated with the privatization decision.

Therefore, we use a binary choice equation that models the likelihood that a given municipality delegates the water supply service (the likelihood that $p_i = 1$). We assume that this equation can be estimated using a Probit model based on the notion that there

[2]We have a pseudo-panel in the sense that we have several observations per municipality, but they all refer to the same time period.
[3]The following presentation borrows heavily from Blundell and Costa Dias (2000).

exists a latent tendency in each municipality to end up with a delegated service:

$$I = \gamma Z + \upsilon_i \qquad (4)$$

where υ_i is an error term. This latent variable depends on a series of variables *V*, some of which, but not all, may be the same included in the set *X* in Expression 3 above. We observe, of course, only the value of the binary variable *p*, such that:

$$p_i = 1 \iff I_i > 0$$

$$p_i = 0 \iff I_i \leq 0$$

It is likely that the effect of the delegation on the price is heterogeneous among municipalities (hence the subindex in α_i). Naturally, these differentiated effects should also influence the decision to delegate and are therefore likely to be correlated with *p*.

Abstracting from other regressors, *X*, the *BILL* equation becomes:

$$BILL_i = \beta + \alpha_i p_i + \mu_i$$

where α_i is the effect of delegation on *BILL* for municipality *i*. Define α^* as the population mean impact, ε_i as the deviation of $BILL_i$ from the population mean and α^*_T as the mean effect of delegation in municipalities with delegated services (the average treatment on the treated, usually labelled ATT in the literature). Thus

$$\alpha_i = \alpha^* + \varepsilon_i$$

$$\alpha^*_T = \alpha^* + E(\varepsilon_i | p_i = 1)$$

where $E(\varepsilon_i | p_i = 1)$ is the average deviation of the effect among delegated municipalities. The *BILL* regression equation may now be rewritten as:

$$BILL_i = \beta + \alpha^* p_i + [\mu_i + p_i \varepsilon_i] = \beta + \alpha^* p_i + [\mu_i + p_i(\alpha_i - \alpha^*)]$$

Additionally, another problem related to this heterogenous specification of treatment effects has to do with the form of the error term $\mu_i + p_i(\alpha_i - \alpha^*)$. This term obviously differs across municipalities depending on whether they are privatized ($p_i=1$) or not ($p_i=0$). Identifying α^* is more difficult when there is non-zero correlation with p_i. Notice that if $E(\varepsilon_i p_i) \neq 0$, then $E(\varepsilon_i|p_i) \neq 0$,[4] so:

$$E(BILL_i|p_i) = \beta + p_i\,[\alpha^* + E(\varepsilon_i|p_i)] + E(\mu_i|p_i) \qquad (5)$$

The ordinary least squares (*OLS*) estimator would identify:

$$E(\alpha') = \alpha^* + E(\varepsilon_i|p_i = 1) + E(\mu_i|p_i = 1) - E(\mu_i|p_i = 0) \qquad (6)$$

Therefore, even if μ_i is uncorrelated with p_i, so that $E(\mu_i|p_i = 1) = E(\mu_i|p_i = 0)=0$, an identification problem remains. From Expression 6 it can be seen that, without further assumptions or information, only the impact of privatisation on the privatized municipalities, $\alpha^*_T = \alpha^* + E(\varepsilon_i|p_i=1)$, is identifiable. This is because, even if the error term, μ, is uncorrelated with the decision process, the municipality-specific component of the privatisation effect, ε, is most likely not to be. We expect municipalities to choose privatisation taking into consideration their own specific operating environment. In this case $E(\varepsilon_i|p_i = 1) \neq 0$ and identifying α^* becomes more difficult.

We assume that the effect of delegation on price in each municipality is not affected by the delegation of the service in any other municipality. This means that the treatment effect Δ_i in Expression 1 for each municipality is independent of the treatment of other municipalities (Caliendo and Hujer, 2006). This is known as the *stable unit treatment value assumption* (see Holland, 1986) and guarantees that average treatment effects can

[4]See Blundell and Costa Dias (2000) for a proof.

be estimated independently of the size and composition of the treatment population. In particular, it excludes peer-effects as well as cross-effects and general equilibrium effects (Sianesi, 2004).

The selection model approach we use (Heckman, 1979, Heckman and Robb, 1985 and 1986) accounts for selection on unobservables and relies on an exclusion restriction (Blundell and Costa Dias, 2000), which in this case requires the existence of at least one variable that determines delegation of the service but does not affect *BILL*. Additionally, we assume in the full information maximum likelihood estimation that the error terms in both equations (privatisation equation and price equation) are jointly normally distributed.

If these assumptions hold then the estimates obtained[5] are consistent, efficient, and asymptotically normal. Another approach to solve this problem that does not rely on the assumption of joint normality of the error would be to use a two-step Heckman selection method. This would not assume joint normality; just normality of the error in the privatisation equation. The two-step approach would be inefficient, however, if the errors are indeed jointly normal. As explained in Section results, we compared both approaches, finding no meaningful differences in the results obtained. However, we chose to finally use the *FIML* model because it showed a slight advantage in terms of efficiency and because it would allow us to use a cluster option to account for the pseudo-panel of the data set.

All the econometric models used take into account that for each municipality each of the

[5]We use the *treatreg* routine in STATA 9.1. (StataCorp, 2005).

eight values of the dependent variable (*BILL*) may well be correlated, because they belong to the same tariff structure. This is accomplished by using a random-effects panel data model that explicitly accounts for the pseudo-panel nature of the sample, and by correcting all standard errors by using the *cluster* option.

3. Data, model specification and hypotheses

The database used in this study includes information from 53 Spanish medium-big municipalities, which either have more than 100.000 inhabitants and/or are the capital of a province. Most of these urban water suppliers usually charge non-linear and non-uniform prices. Therefore, for each of these cities, we calculated from the tariff structure a ``representative'' or ``theoretical'' average price corresponding to several levels of consumption, in order to reflect the level and structure of residential water prices in that municipality. In particular, for each city, we calculated the average price of 3 m^3, 5 m^3, 10 m^3, 15 m^3, 20 m^3, 25 m^3, and 50 m^3 per account and month. We include all those prices, alongside any fixed fee applied to the water *BILL*, in the estimations, because no information about the distribution of consumption was provided. The stacking of the eight observations on price as separate observations for each municipality lead to the availability of 424 observations (8 times 53).

We wanted to find out which factors explain the differences across municipalities in the average prices corresponding to several levels of water consumption. All the variables we considered in the estimation are shown in Table 1, together with a description of each variable and its data source.

[INSERT TABLE 1 about here]

The dependent variable in the main price regression is the average price in the water *BILL*. This variable is denoted *BILL*. It is calculated as:

$$BILL = (Water\ bill\ corresponding\ to\ N\ m^3/N)$$

$$\Leftrightarrow BILL_N = 1 \ \ for\ N = 3, 5, 10, 15, 20, 25, 50 \qquad (7)$$

and

$$BILL = Fixed\ Quota \Leftrightarrow FIXED = 1$$

Note that, for a given municipality, *BILL* would always take the same value, if all the tariffs were linear. This is the exception (it applies to less than 8% of observations) rather than the rule. With a majority of increasing block tariffs, we should expect *BILL* to rise with *N*.

As explanatory variables, we first incorporated several socio-economic characteristics of the municipality, such as the size in terms of population and surface (*POP*, *AREA*), the population density (*DENS*), the economic level (*ECON*) and several features of the housing stock (*SECDWEL*, PM_1, PM_3, PM_7, $PSEC_1$, $PSEC_6$, $PSEC_9$, *PSECTOT*). The next set of factors includes two climate variables (*TEMPER*, *HUMID*) which can have an influence on price differences. An additional set of variables is related to water quality and other technical characteristics, such as an index of global water quality (*QGLOBAL*), the kind of treatment applied to water in order to make it drinkable ($TREAT_1$, $TREAT_2$), or whether underground water sources are used (*SUNDER*). Moreover, several indicators related to the water tariff have been included, such as whether the observation corresponds to the fixed charge (*FIXED*) or, instead to one of three ($BILL_5$, $BILL_{20}$,

$BILL_{50}$) among the seven different consumption levels.[6] Since normally the tariffs are based on an increasing-block structure, we expect the coefficients of $BILL_{20}$ and $BILL_{50}$ to be positive and the coefficient of $BILL_5$ to be negative. Finally, with the double role of dependent variable in the regime equation and independent variable in the price one, a dummy variable was included to identify if urban water services are supplied under a private or mixed management[7] regime is present (*P*). This variable takes the value of zero if the water supply is totally public and one otherwise.

As we explain in Section Methods, in a first step (1) we estimate a Probit model to investigate the probability of there being a private or mixed water supplier. Next, we try to find factors which affect water prices level and structure (2). Thus, in Table 1 we point out which variables were considered in each estimation. Some of those variables were included only in the first step estimation (1), some only in the second one (2), and some in both equations (1, 2).

In the regime equation, we included the four variables related to water quality, sources, and treatments (*QGLOBAL*, $TREAT_1$, $TREAT_2$ and *SUNDER*). In this sense, the expectation is not clear. On the one hand, private firms may look to take over water supply in those municipalities with good technical conditions. On the other hand, it is logical to think that municipal government will favour privatization when there are some

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[6]Obviously, including all the eight dummies in the regression would lead to perfect multicollinearity, so we chose to include in the final regression an indicator of the fixed quota (FIXED), which is obviously rather different form any of the average prices, and three indicators of bill size: one associated with a low ($BILL_5$), one with a medium-large ($BILL_{20}$), and one with a very large ($BILL_{50}$) bill size.

[7]Usually, mixed management is carried out by a firm which has public and private participation.

economic[8] or technical problems (Carpentier et al. 2006). At the same time, it is possible that private firms try to increase profits by reducing the quality of the service (Lobina and Hall, 2000; Hall and Lobina, 2005).

Several socioeconomic factors (*POP, AREA, ECON*) were included in the regime equation. In particular, we wanted to test the influence of potential economies of scale, such as population and area (Antonioli and Filippini, 2001; Estache and Rossi, 2002; Tupper and Ressende, 2004; Carpentier et al. 2006). Moreover, we are interested in observing if the economic level affects the probability of finding private management. We would expect that private firms seek revenue opportunities, so they would favour high-income municipalities.

All the variables about features of the housing stock (*SECDWEL*, PM_1, PM_3, PM_7, $PSEC_1$, $PSEC_6$, $PSEC_9$, *PSECTOT*) were included in the regime estimation (Probit). We think than the absolute number of secondary dwellings could exhibit a positive impact on the probability of being privatized, since this may be linked to increased possibilities of collecting extra revenues. At the same time, the proportion of secondary dwellings within the total of housing units was included in order to test if private water suppliers are more likely to be located in tourist municipalities, where this variable would take higher values. Finally, we chose some representative variables associated with the percentage of housing units with different height used as main or secondary dwelling. It is well-known that buildings' height is an important factor behind water supply costs, but

[8]Miralles (2006) included an index of local government deficit in order to test that hypothesis. He did not find a clear and strong relationship. There was a low significance only during the 1992-1995 period, showing that, in that period, financial difficulties lead to increase the probability of privatization.

also in revenues. Obviously, if the building is very tall, it is more expensive to pump up water to the highest floors. Moreover, one-floor height dwellings are usually owned by customers who enjoy a higher consumption purchasing power, because of their bigger size and the higher probability of including a garden.

The last variable considered is the ideological orientation of the ruling local government. Miralles (2006) found a higher probability of privatization under right-wing or moderate local governments. We also think that the probability of being privatized is lower in those Spanish municipalities ruled by left-wing governments, because those governments are less fond of privatizing public services, unless there are some guaranties of improving the supply conditions. Therefore, the expectation is towards finding a negative relationship between the variable *LEFT* and the variable *P*.

In the price estimation, we included factors which have a influence on price differences. First of all, some binary indicators of what level of use *BILL* refers to (FIXED, $BILL_5$, $BILL_{20}$, $BILL_{50}$) are considered, to reflect differences in the average price of water generated by the nonlinear structure of the tariffs. Next, some of the technical drivers were included (*QGLOBAL*, $TREAT_2$). In principle, we would expect (for a given level of raw water quality[9]) a positive relationship between the global water quality at the customers' tap and water prices, since these reflect some of the costs of supplying water services. Additionally, we included $TREAT_2$ in order to control for the standard of water treatment.

Regarding socio-economic features, we include *ECON* to test whether water prices are

[9]Unfortunately we do not have consistent information on the level of raw water quality.

higher in richer municipalities, which could be explained by the ability of water suppliers to price discriminate as local monopolies or by the progressive character of water prices. We are interested in observing if water prices increase or decrease with municipality income. Additionally, the variables *DENS* and *ISLAND* are considered, since we expect higher prices when population density is higher and in the insular provinces because the costs of water services are higher too. With respect of climate factors, such as *TEMP* or *HUMID* , the relationship is not clear, but maybe higher temperatures lead to higher consumption levels and water sources of lower quality and/or less quantity, and therefore higher costs and prices (Bjornlund, 2003; Bjornlund and Rossini, 2005).

Finally, a dummy variable representative of the type of management regime (*P*) is included. We want to observe the impact of ownership regime on prices. By isolating the effect of private management from the remaining factors, the two-step procedure used, allows a proper estimation of this coefficient even when there is a correlation between the likelihood of privatization and the error term in the price equation. The expectation is not clear, and we would like to test an important issue, which is whether private suppliers set higher prices than public ones, everything else the same.

On the one hand, water prices may be higher after privatizing the service. After all, the main goal of the private firm is to maximize profits, so if there were no economic returns, it would not be worthwhile to supply water. We mentioned in the introduction the oligopolistic structure of the water sector, which could explain a higher probability of finding prices above average costs. Additionally, some municipalities privatize water services when they have economic or technical difficulties in supplying water. In those cases, it is usual that the private operator will raise water prices in order to compensate for the increasing expenditures. On the other hand, if private management is more efficient, costs will be lower and prices could decrease. However, regarding efficiency issues in water sector, the empirical evidence is not clear at all.[10]

Descriptive statistics for the previous variables are shown in Table 2. This shows that our sample includes approximately the same number of municipalities with private or mixed water management as with a public one.

[INSERT TABLE 2 about here]

4. Results

As shown in Table 3, the global tests show the consistency of the econometric procedure and results. If we compare a simple *Probit* estimation with our treatment effects model (*FIML*), we can see that some coefficients increase its significance. In fact, the majority of coefficients are significant and according to our expectations. A Wald test of independence of the equations (H_0*: ρ = 0*) yields an estimate of $\chi^2(1) = 6.67$ (with Prob > χ^2 = 0.0098), suggesting that modelling the effect of privatization without accounting for

[10]It is possible to find some studies which show that public management is more efficient (Mann and Mikesell, 1976; Bruggink, 1982; Lamber et al., 1993; Bhattacharyya et al., 1994, 1995a), other which defend the higher efficiency levels of private management (Morgan, 1977; Crain and Zardkoohi, 1978; Bhattacharyya et al., 1995b; Estache and Kouassi, 2002) and finally, several studies which do not find significant differences between both kind of management from an efficiency point of view (Feigenbaum and Teeples, 1983; Byrnes et al., 1986; Fox and Hofler, 1986; Joner and Mygind, 2000; Ménard and Saussier, 2000; Estache and Rossi, 2002; Kirkpatrick et al., 2004; García-Sánchez, 2006). In this respect, an exhaustive review can be seen in Renzetti and Dupont (2004) and González-Gómez (2006).

the possibility of endogeneity would not be appropriate. The treatment effects model (*FIML*) estimates the correlation between the error terms of the two equations as $\rho=-0.351$. Since this is less than zero, the estimated effect of privatization from a single-equation estimation approach would generally be biased towards zero. That is, ignoring the endogeneity of the variable *P* in the price equation would underestimate the effect of privatization on prices. This is confirmed by the non-significance of the coefficient of this variable in the more naive models *OLS* and *RE* in Table 3. That is, ignoring the correlation between the errors in both equations would lead us to wrongly estimate that prices under privatized management are not significantly higher than under public management.

Model *FIML* is a Heckman selection model based on full information maximum likelihood (FIML) and it assumes joint normality of the errors in both equations (as explained in Section 2). If this assumption is valid, the estimates obtained are consistent, efficient, and asymptotically normal. An alternative approach that does not rely on the assumption of joint normality of the errors would be a two-step Heckman selection method.[11] This would not assume joint normality; just normality of the error in the privatization equation, but would be inefficient if the errors are indeed jointly normal. We compared both approaches (leaving out the *cluster* option) and found no substantial differences in the results obtained. However, we chose to finally use the *FIML* model because it showed a slight advantage in terms of efficiency (the size of the coefficients would be larger and their t-ratios slightly larger too) and because it would allow us to use a *cluster* option to account for the pseudo-panel of the data set. The results of this

[11]This would be the *treatreg* routine with the option *twostep* in STATA 9.1 (StataCorp,

comparison are not reported but available upon request.

The treatment selection equation shows that the probability of finding private management of water services is higher if some technical and productive conditions affecting the operational environment are harder. Therefore, we find some supporting evidence for the argument that privatization may be more likely in municipalities where municipal governments face more difficulties to supply water by itself. For example, we observed a positive effect of having at least part of the water resources extracted from underground sources (*SUNDER*). Production costs are expected to be higher when some of the water comes from underground sources. However, our results suggest that private suppliers carry out less intensive or standard treatments, as the positive coefficients of the dummy variables $TREAT_1$ and $TREAT_1$ show.[12] This fact, jointly with the negative sign of *QGLOBAL*, would support the notion that a private or mixed firm supplies water of a lower quality.

Additionally, we found a negative relationship between the probability of there being a privatized water supply service and the size of the municipality, in terms of population (*POP*) and area (*AREA*). In other words, private or mixed management is more frequently present in small or medium cities, where it is possible that the economies of scale have not been fully exploited and the firm was not supplying the optimum amount of water. This adds further support to the idea that private management operates more often under not the best productive conditions. The negative sign in the case of population is in line

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2005).

[12]The baseline type of treatment (omitted dummy) would be $TREAT_3$, associated to a more comprehensive level of treatment.

with the finds of Miralles (2006), who found a negative relationship between the probability of being privatized and the number of inhabitants of the municipality during the period 1996-2002.

The less advantageous costs conditions may be compensated by a higher probability of getting higher revenues. The positive sign found for some variables (*ECON* and *SECDWEL*) is representative of that idea. Private firms apparently prefer to supply water services in higher income municipalities, or in those places where there are more secondary dwellings in absolute terms, complementing in this way the revenues from main dwellings. However, private firms prefer more secure and non-seasonal revenues, as the negative coefficient of *PSECTOT* is showing. Regarding the remaining features of the housing stock, there is a higher probability of finding a private or mixed firm supplying water in those municipalities with a higher percentage of one-floor main dwellings. Additionally, we observe that the coefficient decreases with height in the case of main residences, and increases in the case of secondary dwellings. Finally, and as expected, left-wing local governments are less prone to privatize water services, as the coefficient of *LEFT* shows. Due to the low level of competition in the water sector, left-wing governments are suspicious about whether privatization leads to efficiency gains, so they tend to decided against it.

[INSERT TABLE 3 about here]

Regarding the price equation, we obtained some interesting findings. A lower input water quality (*QGLOBAL*) leads to higher costs, so average water prices are higher too. In municipalities where only a standard water treatment is applied prices are lower.

Additionally, we observe that, somewhat surprisingly, average water prices are negatively related to the economic level of the municipality (*ECON*), suggesting that in a way water prices as a fee are regressive. On the other hand, we found a positive relationship between water prices and population density (*DENS*) in the municipality. This can be explained by recognizing that when the spatial concentration of population is high production costs can be higher (there is more pressure over water resources and system, it is more costly to undertake repairs, etc.).

Desalinization is usually used in some islands, which may explain the higher price levels observed in municipalities located in Canarias and Baleares ($ISLAND$). With respect to climate variables, only temperature (TEMP) is significant. This variable is strongly correlated with the demand, in the sense that higher temperatures lead to higher consumption levels. The pressure over water resources increases, so supply costs are higher. According to peak-load demand theory, higher prices must be set on periods with an intense consumption.

Finally, we have found a positive and significant coefficient for the P variable. That means that, ceteris paribus, private or mixed firms set higher average price levels that public ones. This fact suggests that private firms, searching to maximize profits, set higher prices in order to achieve that objective. We found significant differences in prices in the case of private or mixed management which are not exclusively explained by costs differences (we control in the price equation for some cost features).

[INSERT TABLE 4 about here]

Table 4 shows the marginal effects of a one-unit change in each variable on the average price. We have calculated the changes of the expected value of *BILL* conditional on *P=1* (being privatized) in the first column and conditional on *P=0* in the second column. Additionally, we show the marginal effects for the probability of being privatized (third column). Comparing the first and second columns, we can observe that price differences are explained more by `revenue' factors when we condition on being privatized. Some marginal effects, such as those related to the economic level or the number of secondary dwellings, are higher in the first column, and other more related to costs, such as the related to global quality or treatments are lower in absolute terms.

5. Conclusions and suggestions for further research

The debate between private and public management has a long tradition in the economic literature. When it comes to the privatization of services such as water supply, subject to local monopoly conditions which leave little room for competition, there are opposing views surround the debate. One of the main arguments against privatisation is that water prices are higher under private management, since the private profit-maximising firms exploit their dominant position. However, given the dearth of conclusive empirical evidence about this issue, we have investigated whether water prices were indeed higher under private management. We show the results of testing, on a dataset comprising the main urban centres in Spain, whether private utilities charge higher prices than public ones without apparent justification.

These results have policy implications in countries such as Spain and France, where local governments can pass on to private firms the management of water supply services.

These implications are the more relevant once we consider that the private sphere of this industry is dominated by a few large corporations, that there is usually little competition when the public manager calls for bids from he private sector (sometimes only one firm bids when the local government decides to relinquish management), and that the decisions made at the local level are not supervised by watchdog bodies such as OFWAT in England and Wales. On the other hand, in countries where water supply is expected by law to remain under public management, the conclusions of analyses like this one could help to inform foreseen regulatory changes.

First we analysed whether factors describing the operational environment had been key to the decision of privatising the water supply service. Our results match our hypotheses: local governments appear more likely to relinquish the management when they operate under more complex environments, while private firms seek to take over the service in those areas where it is easier to obtain higher profits. A second phase of the analysis shows that, once the factors describing the operational environment have been accounted for, it can be seen that private firms set on average higher prices than the public ones. This result lends support to the idea that private firms do exploit their dominant position, which suggests that the regulatory framework might be somewhat lax. It may be wise for local governments to, before privatising the services, have studies conducted by qualified specialists to make sure that the water service is managed ensuring maximum customer welfare and to make sure that the control of the price review process does not rely exclusively on mere administration officials.

Finally, as a future research, it would be useful to consider whether the regulatory constraints are being met. It would be interesting to check, first, whether price setting respects the principle of costs recovery and second, whether the legal framework promotes prices leading to an efficient use of the water resources. This is especially relevant as the effects of climate change emerge (with higher temperatures and less and more irregular precipitation), there is increased demand pressure due to low relative water prices, and there are evident environmental and economic limits to the development of new infrastructure. Finally, it is noteworthy that water prices are negatively related to the income level of the municipality. It would be interesting to analyse whether the regulatory framework in Spain is leading to inequitable water prices.

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VARIABLE	TYPE	DESCRIPTION (UNITS)	SOURCE
FIXED(2)	C	=1 if BILL is the fixed quota, =0 otherwise	Water supplier
$BILL_5$ (2)	D	=1 if BILL is the AVP corresponding to 5 m^3 , =0 otherwise	Water supplier
$BILL_{20}$ (2)	D	=1 if BILL is the AVP corresponding to 20 m^3 , =0 otherwise	Water supplier
$BILL_{50}$ (2)	D	=1 if BILL is the AVP corresponding to 50 m^3 , =0 otherwise	Water supplier
ECON(1, 2)	S	Index of economic level in the municipality	La Caixa (2006)
TEMPER(2)	C	Average annual temperature (ºC)	Meteorological National Institute
HUMID(2)	C	Average annual relative humid (%)	Meteorological National Institute
QGLOBAL(1)	S	Index of global water quality	OCU (2006)
SUNDER(1, 2)	D	=1 if water partly extracted from underground sources, =0 otherwise	SINAC (2006)
$TREAT_1$ (1)	D	Water treatment 1: filtration and disinfection or less	SINAC (2006)
$TREAT_2$ (1, 2)	D	Water treatment 2: normal physical and chemical treatment and disinfection	SINAC (2006)
POP(1)	C	Population (inhabitants)	INE (2005)
AREA(1)	C	Area (km2)	INE (2005)
DENS(2)	C	Population density (inhabitants/km2)	INE (2005)
ISLAND(2)	D	=1 if it is a municipality located in an island, =0 otherwise	Own construction
SECDWEL(1)	C	Total number of secondary dwellings	INE (2005)
PM_1(1)	C	% of 1-floor main dwellings	INE (2005)
PM_3 (1)	C	% of 3-floor main dwellings	INE (2005)
PM_7 (1)	C	% 7-floor main dwellings	INE (2005)
$PSEC_1$ (1)	C	% 1-floor secondary dwellings	INE (2005)
$PSEC_6$ (1)	C	% of 6-floor secondary dwellings	INE (2005)
$PSEC_9$ (1)	C	% of 9-floor secondary dwellings	INE (2005)
PSECTOT(1)	C	% of secondary dwellings on total housing	INE (2005)
LEFT(1)	D	=1 if municipal government is left-wing 0= otherwise	INE (2005)
P(1, 2)	D	=1 if water supplier is a private or a mixed-ownership firm	Water supplier

Table 1: Variables description

VARIABLE	OBS	MEAN	STD. DEV.	MIN	MAX
BILL	408	0.6169811	0.7521102	0.0182815	6.364486
FIXED	408	0.125	0.331125	0	1
$BILL_5$	408	0.125	0.331125	0	1
$BILL_{20}$	408	0.125	0.331125	0	1
$BILL_{50}$	408	0.125	0.331125	0	1
ECON	408	6.156863	2.073562	3	10
QGLOBAL	408	2.843137	1.056117	1	4
TEMPER	408	15.10784	2.897688	10.5	22.3
HUMID	408	0.6564706	0.059476	0.56	0.79
DENS	408	0.2505667	0.3214697	0.005086	1.622111
ISLAND	408	0.0392157	0.1943461	0	1
P	408	0.5098039	0.5005176	0	1
AREA	408	0.3183804	0.394621	0.0123	1.75033
POP	408	34.54625	62.29078	3.3238	315.5359
SUNDER	408	0.1764706	0.3816881	0	1
$TREAT_1$	408	0.0392157	0.1943461	0	1
$TREAT_2$	408	0.3333333	0.4719833	0	1
SECDWEL	408	1.245812	2.110052	0.2161	10.6192
PM_1	408	0.0561106	0.0498017	0.0048884	0.2391663
PM_3	408	0.0613748	0.0340216	0.0105117	0.1594924
PM_7	408	0.096517	0.0351168	0.0227966	0.1781258
$PSEC_1$	408	0.0933152	0.0986654	0.0054395	0.3830434
$PSEC_6$	408	0.1271567	0.0468151	0.0333463	0.2213394
$PSEC_9$	408	0.0235526	0.0196195	0	0.0783293
PSECTOT	408	0.1130246	0.0444417	0.0263071	0.2507916
LEFT	408	0.3137255	0.4645759	0	1

Table 2: Summary descriptives of variables

	VARIABLE	*PROBIT*	*OLS*	*GLS*	*FIML*
BILL equation	*FIXED*		1.713***	1.713***	1.711***
	$BILL_5$		-0.074***	-0.074***	-0.073***
	$BILL_{20}$		0.049***	0.049***	0.048***
	$BILL_{50}$		0.232***	0.232***	0.232***
	QGLOBAL		-0.045**	-0.045**	-0.045**
	$TREAT_2$		-0.098	-0.098*	-0.106*
	ECON		-0.039***	-0.039***	-0.041***
	DENS		0.140*	0.14*	0.157**
	ISLAND		0.771***	0.771***	0.756***
	TEMP		0.032***	0.032***	0.027**
	HUMID		0.857*	0.857*	0.598
	P		0.074	0.074	0.116**
	cons		-0.366	-0.366	-0.13
P equation	*QGLOBAL*	-0.869*			-0.977**
	SUNDER	34.414***			34.813***
	$TREAT_1$	5.345***			5.453***
	$TREAT_2$	12.836***			12.875***
	POP	-1.573***			-1.600***
	AREA	-2.316*			-2.401*
	ECON	5.439***			5.526***
	SECDWEL	44.929***			45.825***
	PM_1	339.226***			338.164***
	PM_3	106.744***			107.931***
	PM_7	42.986			44,365
	$PSEC_1$	68.224***			72.322***
	$PSEC_6$	75.020**			77.574***
	$PSEC_9$	307.073***			307.712***
	PSECTOT	-70.950***			-72.071***
	LEFT	-8.331***			-8.586***
	cons	-85.237***			-86.345***
	ath(ρ)				-0.366***
	$\ln \sigma$				844***
	Wald chi2(12)			1193.40***	504.05***
	N	408	408	408	408
	R^2	0.8216	0.6734	0.6734	
	ll	-282.726	-233.913		-281.941

Legend: * p<0.1; ** p<0.05; *** p<0.01

Table 3: Probit, Ordinary Least Squares, Random-Effects, and Treatment Effects regression results

	$(\hat{B}ILL \mid C=1)=0.503$	$(\hat{B}ILL \mid C=1)=0.636$	PROBIT	
	$E(bill \mid C)=1$	$E(bill \mid C)=0$	$\hat{P}r\,ob(P)=0.314$	Evaluated at X =
$FIXED^*$	1.711	1.711		0.125
$BILL_5{}^*$	-0.073	-0.073		0.125
$BILL_{20}{}^*$	0.048	0.048		0.125
$BILL_{50}{}^*$	0.232	0.232		0.125
$QGLOBAL$	-0.152	-0.152		2.843
$TREAT_2{}^*$	0.644	0.644		0.333
$ECON$	0.567	0.567		6.157
$DENS$	0.157	0.157		0.251
$ISLAND^*$	0.756	0.756		0.039
$TEMP$	0.027	0.027		15.108
$HUMID$	0.598	0.598		0.656
P^*	0.000	0.000		0.510
$SUNDER^*$	1.022	4.257	0.758	0.176
$TREAT_1{}^*$	0.195	0.684	-0.567	0.039
POP	-0.176	-0.125	-0.851	34.546
$AREA$	-0.264	-0.188	16.249	0.318
$SECDWEL$	5.041	3.579	119.907	1.246
PM_1	37.199	26.413	38.270	0.056
PM_3	11.873	8.430	15.731	0.061
PM_7	4.880	3.465	25.644	0.097
$PSEC_1$	7.956	5.649	27.507	0.093
$PSEC_6$	8.534	6.059	109.109	0.127
$PSEC_9$	33.850	24.035	-25.555	0.024
$PSECTOT$	-7.928	-5.629	-0.986	0.113
$LEFT^*$	-0.979	-0.386		0.314

For variables marked with *, the marginal effect correspond to the change of those binary variables from zero to one

Table 4: Marginal effects