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Does water utilities' ownership matter in water pricing policy? An analysis of endogenous and environmental determinants of water tariffs in Italy

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Abstract

Owing to the growing importance of efficient water management, it has become crucial to understand water utilities' characteristics and the environmental factors affecting water pricing, so as to provide guidance to policy-makers. The analysis of factors influencing water tariffs is a challenging task in a context in which companies providing the service are characterized by different ownership features. Moreover, environmental factors and companies' characteristics may simultaneously influence both the decision to privatize the service and the water tariff level. Using a treatment effects model, where privatization is considered as an endogenous binary treatment variable, this paper analyzes whether and how certain relevant variables affect the tariffs levied by water utilities in Italy. The results show that higher tariffs are set in order to cover a greater amount of investments; furthermore, abundant water availability, measured by the average annual rainfall, significantly reduces prices. The data surprisingly show that tariffs are higher where the income level is lower. Significantly, after accounting for the endogeneity due to the fact that water firms are not randomly distributed between totally publicly or not totally publicly owned, our results seem to suggest that ownership does not influence the tariffs levied by water utilities.

Keywords: Italy; Ownership; Water management; Water price; Water pricing policy; Water utilities

1. Introduction

The design of a water tariff system should ideally accomplish many purposes (Dalhuisen & Nijkamp, 2002): full cost recovery, economic efficiency, equity, administrative feasibility and the efficiency of the tariff system. In developed countries water resources management (WRM) is mainly financed through a variety of modes: public subsidies provided by local authorities and states; private equity collected when

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the ownership of a water utility is thrown open to public–private (hereafter, 'mixed') or private firms; bank loans; or firm-level revenues collected through the implementation of a water pricing policy (WPP). In European Union (EU) countries, after the tightening of public and private budgets due to the current financial crisis, WRM is primarily based on the last-mentioned financial source: in recent years, revenue flows covered about 90% of planned investments in Italy, while the remaining 10% were financed through other sources (Guerrini & Romano, 2012).

Water tariffs vary in the presence of specific endogenous and location-specific (or environmental) conditions. The literature calls 'environmental variables' those that interfere, to a greater or lesser extent, in the performance of operations (of water utilities for example) and do not depend on companies' managerial practices (Carvalho & Marques, 2011). Prior studies show that prices depend on water quality, weather conditions, population characteristics and firms' policies (Martinez-Espiñera *et al*., 2009; Zetland & Gasson, 2012). Firms with different water stocks in terms of size and quality that operate in dissimilar geographical areas often apply different water prices. Likewise, some population characteristics, such as size, density, per capita water consumption and per capita income, may be correlated with tariffs. A relevant impact on prices is also exerted by some utilities' policies, and by investment and funding choices, governance and organizational features (Guerrini *et al*., 2011; Romano *et al*., 2013).

Considering the existing evidence, this paper studies the environmental factors and company characteristics that may be correlated with the water tariff level in Italy, in light of the legislative reforms that have affected this country over the last 20 years. The Italian tariff regulation system is quite similar to that of other European countries, like Portugal (Marques, 2006, 2010; Cruz *et al*., 2012), even if it has its own specificities. Italy's water regulator recently defined a new way of calculating water tariffs (Guerrini & Romano, 2014). Prior to this, the 'normalized method' for determining tariffs was introduced by the ministerial decree of 1 August 1996 (Guerrini & Romano, 2012). Revenues, given by the product of cubic meters (m^3) of water sold and tariffs, were to cover operational and maintenance costs, depreciation, amortization, and the return on invested capital; the latter was fixed at 7%. The ratio of revenues to the volume (m^3) of water delivered gave the yearly average tariff. This rule allowed utilities to cover interest and taxes and earn a profit when the interest paid for debt was less than 7% (Guerrini & Romano, 2012). Considering the constraints set by the normalized method, it is therefore worthwhile to study the role played by operational variables – such as ownership structure, diversification strategy and investments realized – and by environmental variables – such as geographical location, population served and average annual rainfall – on efficiency and, thus, on tariffs.

As pointed out by Carpentier *et al*. (2006) and Martínez-Espiñeira *et al*. (2009), the water prices fixed by private companies may be higher because local governments have a greater incentive to externalize the water service in complex environments where service costs are generally higher. In Italy at the end of 2013 most of the existing water utilities (53%) were public firms (whose shareholders are municipalities or other public bodies); 26% were totally private firms, and the remaining 21% were mixed-ownership firms with both public and private shareholders (Guerrini & Romano, 2014).

Thus, following Martínez-Espiñeira *et al*. (2009), in our model we first checked for endogeneity due to the fact that Italian water firms are not randomly distributed between public-owned and private or mixed-owned utilities. This was done using a treatment effects model (Heckman, 1978, 1979).

We aim to contribute to the existing literature on endogenous and environmental factors that can influence household water prices by analyzing whether and how some variables of relevance to the Italian water industry are related to the tariff levied by water utilities. The results of our study can provide potential guidance to policy-makers in defining a WRM framework. They are also likely to help water utilities manage operations with the aim of fulfilling the objectives of the WPP under the EU Water Framework Directive: a policy that creates incentives for the economic and efficient use of water resources, and reduces the financial burden on public authorities.

This paper is structured as follows. Section 2 offers a brief overview of the Italian water industry. Section 3 reviews the literature on the determinants of water pricing. Section 4 describes the model, the variables and model specification. Section 5 outlines the key findings of our empirical research, showing which variables affect the WPP and the resulting policy implications. Section 6 provides concluding remarks.

2. An overview of the Italian water industry

The water industry, known in Italy as the *Servizio Idrico Integrato* (SII), includes companies/water utilities that operate as monopolists in specific areas of the country. This characteristic entails specific forms of regulation and control, in order to avoid opportunistic behavior that could damage the community.

Italian water reforms began in 1994 with Law no. 36 and have progressively modified the industry's features (Danesi *et al.*, 2007; Massarutto *et al.*, 2008; Carrozza, 2011; Guerrini *et al.*, 2011).

After around 20 years since the first reforms came into effect, some progress has been made. In particular, many firms now integrate water and wastewater services (Co.N.Vi.Ri., 2009). Publicly owned companies coexist with mixed and privately owned firms, appointed by local water authorities through a public competitive tendering process. Finally, an aggregation process has led to the constitution of several large utilities, in terms of the populations and areas served, with the aim of obtaining economies of scale notwithstanding the presence of many small firms that serve only one or a few municipalities.

In 1996, following the Galli Law, a ministerial decree (DM 01/08/1996) introduced a new normalized method for setting water tariffs, the Metodo Tariffario Normalizzato (MTN). In 2006, the procedure for tariff setting in the water industry was further revised (by legislative decree no. 152/2006): water utilities were then allowed to include a capital remuneration component in water tariffs, capped at 7% (the '7% rule').

The MTN was based on the 'average real tariff', effectively a form of revenue cap regulation (Marques, 2010; Carrozza, 2011), as the tariff increase without inflation had to be lower than 5% per year. The Galli Law provided for the establishment of a tariff system based on the principle of a single tariff for each ATO ('Optimal Territorial Area') – including drinking water supply, sewerage and wastewater – to ensure full coverage of the operating costs and investment. The tariff was determined by taking into account a variety of factors, including the quality of water resources and the service provided, the investment needs and maintenance required, the extent of operating costs and the adequacy of the return on investment. According to this provision, the tariff was determined as follows:

$$Tn = (C + A + R)_{n-1} * (1 + \pi + k).$$

where

- Tn is the tariff for a cubic meter of water;
- C, A and R are the planned unit costs per cubic meter from the previous year, referring to operating costs, amortization and depreciation and return on investments, respectively;

- π is the expected inflation rate for the current year;
- k is the price cap, fixed at 5%.

Available data (Co.N.Vi.Ri., 2009) show that with the MTN, water tariffs increased at nominal rates of twice the consumer price index or more (on average by 5% from 2007 to 2008, and 6% from 2004 to 2008).

MTN planned operating costs starting from a firm's most recent income statement and applying an efficiency rate to every year of the plan period. The procedure to follow was set out in ministerial decree DM 01/08/1996. First, a modeled cost curve for water and wastewater services had to be estimated by utilities, using three parametric functions referring to drinking water, sewage transportation and treatment. These functions were designed using technical and cost data from Italian water utilities (such as cubic meters of water sold, kilometers of mains and wastewater network, energy costs, number of inhabitants served, organic impact of sewage). The modeled cost curve was compared to the planned cost curve and provided a standard cost to use as a benchmark. The planned cost curve was not to exceed the modeled cost curve, plus a 30% markup. If the planned costs were higher than the modeled costs plus a 20% markup, a mandatory cost reduction rate of 2% became applicable annually to the planned costs; if the planned costs were lower than the modeled costs plus a 20% markup, a 1% efficiency rate was applicable. Finally, if the planned costs were lower than the modeled costs, the efficiency rate applicable was 0.5%. This mechanism was stated in order to ensure effective cost reduction. Moreover, the MTN established that borrowing costs, income taxes and provisions for bad credit could be covered with a 7% return on net fixed assets (the 7% rule).

It is relevant to mention that in 2011 the new authority for water, Autorità per l'Energia Elettrica, il Gas e i Servizi Idrici (AEEGSI), introduced a different method, the Metodo Tariffario Transitorio (MTT), for the regulatory period 2012 and 2013, then replaced it with the new Metodo Tariffario Idrico (MTI) for 2014 and 2015. Further reforms are expected in the next regulatory period (2016 onward). The privatization of the water industry in Italy is still a key and much-debated issue. As a matter of fact, the compulsory privatization of water services was introduced by Law 133/2008; however, its enactment was delayed by a controversial referendum in 2011. Nevertheless, the privatization of water services in Italy remains a possibility, since the management of water and wastewater systems can be entrusted to wholly public, mixed or wholly private firms. Moreover, some municipalities or provinces are still allowed to manage the service in-house.

Recent studies have shown a general potential for the improvement of efficiency in Italy (Romano & Guerrini, 2011; Cruz *et al*., 2012). Italian tariffs still remain among the lowest in Europe (Organisation for Economic Co-operation and Development (OECD), 2010), while investments in this industry have progressively decreased since the 1980s (Ermano, 2012). In 2008, only half the investments scheduled in the previous 3 years actually came to fruition, with substantial variations in investment levels between regions (Co.N.Vi.Ri., 2009). As a result of inadequate investments, leakages accounted for around 37.3% of the water fed into the water grid in 2007 (Co.N.Vi.Ri., 2009).

A study on the determinants of tariffs is useful to explain the origins of the above-mentioned features of the Italian water industry and to find effective strategies for investment improvements. Moreover, following Martínez-Espiñeira *et al*. (2009), this paper aims to contribute to the empirical literature on the relationship between the ownership of water utilities and tariff levels in Italy. Since there is still intense debate in Italy on private participation in the management of water services (Guerrini & Romano, 2014), our empirical results will contribute to the political and socio-economic discussion on this issue.

3. Literature review

Most of the existing publications have focused on the WPP in terms of how tariffs affect water consumption under different exogenous conditions (see for references Arbués *et al*. (2003) and Worthington & Hoffmann (2008)). This topic has become increasingly important with the increasing scarcity of water in some densely populated areas of the world. The issue of public service tariffs has also been studied with reference to other sectors, such as waste management, energy and gas. Nevertheless, most articles on waste collection and treatment focus on the determinants of efficiency and only indirectly provide insights on pricing (i.e. Koushki *et al*., 2004; Lopez *et al*., 2011). This also occurs when the electricity and gas sectors are studied (Kumbhakar & Hjalmarsson (1998) and Hjalmarsson & Veiderpass (1992) for electricity retailing services; Hollas & Stansell (1994) and Hollas *et al*. (2002) for gas distribution). In contrast, some interesting evidence has been put forward concerning water pricing determinants. Table 1 provides an overview of the literature on factors related to water pricing. The different variables correlated with WPPs are grouped under four main items: water characteristics, weather conditions, population characteristics, and the growth and diversification strategies adopted by water utilities. The results obtained are consistent among themselves, with the exception of income (a population characteristic), for which there are two conflicting pieces of evidence. Thorsten *et al*. (2009) demonstrated that a high per capita gross domestic product increases prices, while Martinez-Espiñeira *et al*. (2009) associated low prices with high income. The first result is quite easy to explain, considering that wealthier clients can pay higher prices, while Martinez-Espiñeira *et al*. (2009) explained their finding by claiming that the higher incomes in the city make it possible to achieve economies of scale and density, and therefore lead to lower prices.

Water characteristics are also strongly correlated with the WPP. First, the use of high-quality sources, like groundwater, avoids the cost for treatment, thereby leading to reduced water prices (Chong *et al*., 2006; Thorsten *et al*., 2009; Ruester & Zschille, 2010). This relationship is also confirmed by Martinez-Espiñeira *et al*. (2009): high-quality water allows for efficiency improvements and leads to lower prices. Similarly, a greater availability of water, which is a characteristic of areas with access to freshwater or depends on the seasons, is also associated with lower prices (Martinez-Espiñeira *et al*., 2009; Thorsten *et al*., 2009; Zetland & Gasson, 2012). Thus, in an area with a natural water shortage, such as an island (Martinez-Espiñeira *et al*., 2009), or in a season characterized by high consumption and low availability, like summer in coastal regions (Martinez-Espiñeira *et al*., 2009; Thorsten *et al*., 2009), a cubic meter of water costs more.

The quality of the service provided by water utilities also requires consideration. The higher the quality of the service, the higher is the price charged. Zetland & Gasson (2012) demonstrated that high (low) water tariffs are correlated with low (high) risk of shortage: the additional revenues obtained should be used to pay back the investments made on plants and water mains.

Further interesting observations can be made by considering the relationship between population characteristics and prices. Despite the contrasting results for the variables 'income' and 'poverty,' these items provide quite robust findings. Zetland & Gasson (2012) found that larger populations are associated with lower water prices. As many other researchers have also argued (Knapp, 1978; Fox & Hofler, 1985; Kim, 1987; Kim & Clark, 1988; Bhattacharyya *et al*., 1994; Kim & Lee, 1998), this proves that the water sector is characterized by economies of scale, although contrasting results have also been reported (Fraquelli & Giandrone, 2003; Sauer, 2005; Tynan & Kingdom, 2005; Martins *et al*., 2006; Torres & Morrison Paul, 2006).

Table 1. Overview of the literature on water price determinants.

Items	Variables	Reference	Relationship
Characteristics of the water	Water sources	Ruester & Zschille (2010)	Use of groundwater negatively correlated with prices
		Thorsten *et al*. (2009)	Use of surface water positively correlated with prices
		Chong *et al*. (2006)	Use of groundwater negatively correlated with prices
	Water quality	Martinez-Espiñeira *et al*. (2009)	High-quality negatively correlated with prices
		Chong *et al*. (2006)	Use of water requiring treatment positively correlated with prices
	Water availability	Zetland & Gasson (2012)	High availability negatively correlated with prices
	Risk of water shortage	Zetland & Gasson (2012)	High risk of shortages negatively correlated with prices
Weather conditions	Temperature	Thorsten *et al*. (2009)	High temperature positively correlated with prices
		Martinez-Espiñeira *et al*. (2009)	High temperature positively correlated with prices
	Localization (island)	Martinez-Espiñeira *et al*. (2009)	Water prices are higher on islands
Population characteristics	Population	Zetland & Gasson (2012)	High population negatively correlated with prices
	Population density	Ruester & Zschille (2010)	High density negatively correlated with prices
		Martinez-Espiñeira *et al*. (2009)	High density negatively correlated with prices
		Chong *et al*. (2006)	High density negatively correlated with prices
	Income	Thorsten *et al*. (2009)	High income positively correlated with prices
		Martinez-Espiñeira *et al*. (2009)	High income negatively correlated with prices
	Poverty	Thorsten *et al*. (2009)	High poverty rates positively correlated with prices
	Consumption per capita	Zetland & Gasson (2012)	High consumption negatively correlated with prices
Utility-based policies	Investments	Ruester & Zschille (2010)	High investments positively correlated with prices
		Marin (2009)	High investments positively correlated with prices
	Size	Thorsten *et al*. (2009)	Large firms levy lower prices
	Debts	Thorsten *et al*. (2009)	High debts positively correlated with prices
	Ownership structure	Guerrini *et al*. (2011)	Private ownership positively correlated with prices
		Ruester & Zschille (2010)	Private ownership positively correlated with prices
		De Witte & Saal (2010)	Private ownership positively correlated with prices
		Martinez-Espiñeira *et al*. (2009)	Private ownership positively correlated with prices
		Zaki & Amin (2009)	Private ownership positively correlated with prices
		Marin (2009)	Private ownership positively correlated with prices
		Oliveira (2008)	Private ownership positively correlated with prices
		Kouanda & Moudassir (2007)	Private ownership positively correlated with prices
		Chong *et al*. (2006)	Private ownership positively correlated with prices
		Carpentier *et al*. (2006)	Private ownership positively correlated with prices
		Bitràn & Velenzuela (2003)	Private ownership positively correlated with prices
		Saal & Parker (2001)	Private ownership positively correlated with prices

The above-mentioned result is confirmed if the size of the utility is considered (Thorsten *et al*., 2009): bigger water firms charge lower prices than do medium and small firms. Similarly, firms that serve densely populated areas can achieve superior performance through economies of density (Chong *et al*., 2006; Martinez-Espiñeira *et al*., 2009; Ruester & Zschille, 2010). Then, firms serving a population with a high level of consumption per capita apply lower tariffs (Arbués & Villanua, 2006; Mazzanti & Montini, 2006; Zetland & Gasson, 2012).

Besides their size, other water utility characteristics and strategies may be correlated with prices. Substantial investments (Marin, 2009; Ruester & Zschille, 2010), especially if covered by debts (Thorsten *et al*., 2009), are associated with a price increase. Moreover, another result from the literature refers to the ownership structure (Pèrard, 2009): the great majority of existing studies agree that privately owned firms levy higher prices for two different reasons, namely, to improve profitability (Saal & Parker, 2001; Marin, 2009; De Witte & Saal, 2010) or to maximize investments (Bitràn & Valenzuela, 2003; Marin, 2009). The only study to deny this evidence examined the privatization process in a developing country (Thailand): Zaki & Amin (2009) observed that private ownership seems to be correlated with a price decrease, while improving water access and quality. These results could be attributed to the regulatory process implemented by the Thai government. In France, direct public management provides water services at lower prices than those of private firms (Chong *et al*., 2006): this occurs since municipalities entrust water management to private firms only when they face adverse operational and environmental conditions (Carpentier *et al*., 2006).

4. Methods and data

4.1. Model

Analyzing the factors related to water tariffs is a very challenging task in a context in which companies providing the service have public, private or mixed ownership. As a matter of fact, environmental factors and company characteristics may simultaneously influence both the decision to privatize the service and the water tariff level. As a consequence, the decision to privatize cannot be considered an exogenous variable, as in randomized studies, and the parameter estimates of the factors affecting the water tariff derived from a naïve ordinary least squares (OLS) regression model are inconsistent and biased. Under these conditions, Heckman (1978, 1979) emphasized the importance of modeling structures of selection bias, treating the unobserved selection factors as a problem of specification error or a problem of omitted variables (Guo & Fraser, 2010). In this paper, endogeneity due to the decision to privatize the water supply service is addressed by using a treatment effects model, where privatization is considered as an endogenous binary treatment variable. The treatment effect model involves two equations: (1) the regression equation to define the outcome variable, i.e. the water tariff; and (2) the selection equation to model the selection process, i.e. the probability of privatizing the water supply service. The regression equation for the outcome variable y_i (water tariff) is a function of the vector of covariates $\mathbf{x}$ (with the corresponding vector of regression coefficients $\boldsymbol{\beta}$) and a binary endogenous variable, denoted by w_i, indicating the treatment condition, where $w_i = 1$ stands for public companies and $w_i = 0$ for private companies:

$$y_i = \boldsymbol{\beta}\mathbf{x} + w_i\delta + \varepsilon_i$$

Here, w_i is assumed to stem from an unobservable endogenous variable and represents the response variable of the selection equation

$$w_i^* = \boldsymbol{\gamma}\mathbf{z}_i + u_i,$$

where $w_i = 1$ if $w_i^* > 0$ and $w_i = 0$ otherwise; moreover, z_i is a vector of the exogenous variables determining the selection process (with the corresponding vector of regression coefficients $\boldsymbol{\gamma}$), some (but not all) of which may be the same as included in the vector **x**. The selection equation formulates a model for the probability of privatizing the water supply service via a probit model

$$\Pr(w_i = 1|\mathbf{z}_i) = \boldsymbol{\Phi}(\boldsymbol{\gamma}\mathbf{z}_i),$$

where $\Phi(\cdot)$ is the standard normal cumulative distribution function. Thus, the treatment effect model uses the variables observed to estimate the regression coefficients for the factors affecting the water tariff, while controlling for the selection bias induced by the non-ignorable treatment assignment (the decision to privatize the water service). This model is particularly useful in producing improved estimates of the treatment effect, especially when the possible causes of the selection process are known and correctly specified in the selection equation. The model can be estimated by either the maximum likelihood (ML) method or the least squares method (two-step estimator). The ML method assumes a bivariate normal distribution with mean zero for the error terms of the two regression equations, that is $u_i\tilde{N}(0, \sigma^2)$, $u_i\tilde{N}(0, \sigma^2)$, with the correlation $\mathrm{corr}(u_i, \varepsilon_i) = \rho$. Under the assumption of the joint normality of errors, the estimates obtained are consistent, efficient and asymptotically normal. The two-step estimator assumes normality only for the error term of the selection equation, that is $u_i\tilde{N}(0, 1)$ (Wooldridge, 2002). The results obtained from both estimation methods are compared in order to identify possible differences.

4.2. Variables and model specification

The response variable in the regression equation that defines the outcome variable is the water tariff, which describes the expenditure (in euros) for the consumption of 100 m^3 of water. The Italian National Institute of Statistics (ISTAT, http://www.istat.it/en) reports that in the period 1996–2007 the average annual per capita consumption in Italy was around 92 m^3 of water. We collected this utility-specific information from the Co.N.Vi.Ri. (2011) report. The expenditure includes the price of the water supply, wastewater treatment and sewerage, the fixed amount paid by each domestic user, and taxes.

Since we are also interested in investigating the possible relationship between ownership and water prices, by using the corporate websites of the utilities and their annual reports, a binary treatment variable (public) indicating companies with private or totally public ownership was recorded. Moreover, among the possible explanatory variables, a variety of factors were selected and collected from the Co.N.Vi.Ri. (2011) report, the corporate websites of the utilities, the ISTAT database and other available documents (such as annual reports). These factors included environmental features (geographic area in which the company operates, presence of islands in the area served, network density, i.e. the population served divided by the length of the water supply), company characteristics (multi-utility or mono-utility company, length of the water network), climate conditions (annual precipitation and average temperature in the province served), and one socio-economic factor (average taxable per capita income in the province served). These factors were selected because they may affect the costs of providing the service and, accordingly, the water tariff.

Therefore, this study considers both utilities' endogenous factors (such as ownership, investments and diversification) and exogenous or environmental elements (such as geographical location, temperature and annual rainfall). Considering the latter is particularly vital as environmental factors influence the operational scenario in which water utilities operate (De Witte & Marques, 2009; Carvalho & Marques, 2011). Moreover, even though these factors cannot be controlled by the management, they do have an effect on the utility's WPP.

The final sample is composed of 58 companies and includes information about all the variables analyzed. These 58 companies serve about 30 million people – around half the Italian population – and their characteristics also reflect those of the companies/water utilities not included in the sample (Guerrini & Romano, 2014). The number of observations is in line with many other studies on the European water industry (e.g. Martinez-Espiñera *et al.*, 2009; Romano & Guerrini, 2011; Romano *et al.*, 2013).

Tables 2 and 3 show the descriptive statistics. With reference to the ownership structure, half of the data set is composed of totally publicly owned firms and half of privately (totally or partially) owned companies.

The variables analyzed diverged widely within the sample, with large differences between the maximum and minimum values. In 2009, the expenditure for the consumption of 100 m^3 of water varied significantly among the Italian utilities observed, ranging from 55 to 197 euros, with a mean of 132 euros.

The majority of the data set is composed of utilities located in the north of Italy (60%). Mono-utilities hold a slight majority (56.9%) and only five utilities serve islands.

Table 2. Descriptive statistics.

	Expenditure for the consumption of 100 m^3 of water (2009, euros)	Annual investment realized per inhabitant (euros)	Mean annual rainfall (2000–2009, mm)	Average annual mean temperature in the province (degrees Celsius)	Average taxable income per capita (euro per person)	Length of water network (km)	Density of water network (inhabitants/km)	Annual sales (2009, millions euros)
Mean	132	14	789	13	14,705	3,513	146	641
Median	129	13	791	14	14,881	2,799	106	45
Minimum	55	0	580	7	10,166	37	19	3
Maximum	197	40	1,098	17	20,922	21,000	591	5,762
Standard deviation	32.61	9.79	81.30	2.23	2,006.47	3,372.27	115.78	1,454

Table 3. Descriptive statistics.

Geographical location	No.	%	Ownership structure	No.	%	Diversification strategies	No.	%
North	35	60.3	Public	29	50.0	Mono	33	56.9
Center	15	25.9	Mixed	27	46.6	Multi	25	43.1
South	8	13.8	Private	2	3.4	Total	58	100.0
Total	58	100.0	Total	58	100.0			

The selection equation has the binary treatment variable as the response variable, whereas the explanatory variables are only in part the same. More specifically, the privatization decision is modeled considering environmental features (geographical area in which the company operates, presence of islands in the area served) and company characteristics (multi-utility or mono-utility company, length of the water network, density of the water network, annual sales, investments).

5. Results and discussion

The results are shown in Table 4, where the treatment effects regression coefficients for the water tariff, obtained using the ML method with robust standard errors (White, 1980), are compared with the naïve OLS model estimates. The least squares method for the treatment effect model (two-step estimator) is not shown because no significant difference was observed from the results obtained with the ML method. Because of this, the assumption of the joint normality of the error terms of the regression equation for the definition of the water tariff and those of the selection equation is verified, justifying the

Table 4. Regression coefficients estimated with the naïve OLS model and treatment effects regression coefficients estimated with ML method.

Variable	OLS	ML
Water tariff equation		
Constant	270.564 (66.023)	258.713
Multi-utility vs mono-utility	6.906 (7.679)	12.573 (8.687)
Precipitation (mm)	−0.117** (0.045)	−0.125* (0.039)
Investments (euros)	1.083** (0.450)	0.968* (0.377)
Temperature (degrees Celsius)	2.599 (1.674)	2.583 (1.423)
Island	−3.652 (14.667)	2.747 (16.441)
Income per capita (× 1,000 euros)	−0.004 (0.002)	−0.004* (0.001)
North vs South	6.719 (12.414)	7.484 (10.461)
Center vs South	12.900 (11.899)	19.381 (10.982)
Length of the water network (km)	0.103 (0.835)	−0.017 (0.926)
Public vs mixed or private company	−16.535**(7.379)	3.332 (14.254)
Selection equation (probit)		
Multi-utility vs mono-utility		−0.189 (0.483)
Length of the water network (km)		0.000 (0.098)
Investments		0.007 (0.019)
Revenues (× 100,000 euros)		−0.005** (0.003)
North vs South		0.382 (0.568)
Center vs South		−0.926 (0.567)
Island		−0.909 (0.827)
Density of the water network (inh/km)		−0.002 (0.002)
Rho		−0.635 (0.279)
Sigma		23.461 (2.826)
Lambda		−14.896 (7.962)
Log-likelihood		−286.1692
R^2	0.474	0.468

Wald test of independence equations. (rho = 0): $\chi^2(1) = 4.30$; $p = 0.0381$.

use of the ML estimation method. Standard errors are in parentheses, while regression coefficients significant at $p < 0.05$ or $p < 0.01$ are indicated with * and **, respectively.

Because the treatment effect model assumes a non-zero correlation between the error term of the regression equation and the error term of the selection equation, and because the violation of that assumption can lead to biased estimates, a Wald test of independence of the two equations (H_0: $\rho = 0$) is first performed. This correlation coefficient compares the joint likelihood of an independent probit model for the selection equation and a regression model of the data observed against the treatment effect model. Given that the $\chi^2(1) = 4.30$ ($p = 0.0381$), the null hypothesis is rejected, suggesting that the treatment effect model is appropriate. The estimated ML rho is negative ($\hat{\rho} = -0.657$) and indicates that ignoring the endogeneity of the treatment variable in the regression equation for the definition of the water tariff, the coefficients estimates would be biased. This is also confirmed by the significant coefficient of the treatment variable in the naïve OLS coefficient estimates, whose values would lead to the erroneous conclusion that public companies apply a lower water tariff.

The treatment effect selection equation shows that the probability of having public companies in the water service sector is higher among the companies with lower revenue levels. Among the other factors considered, neither the level of investments nor the location of the companies has a significant effect on this probability.

The regression equation for the outcome variable shows that the water tariff is explained by some factors, as reported by the model $\chi^2(1) = 78.93$ ($p < 0.0001$) resulting from the Wald test. Among the climate factors, only precipitation has a negative and significant effect on the water tariff, showing that where precipitation is higher than average the water availability presumably increases and its price falls. On the contrary, utilities that operate in drier areas usually apply higher tariffs to cope with the higher costs of providing water. This result is consistent with expectations and the existing literature. For example, Zetland & Gasson (2012) linked low rainfall (and consequently, scarcer water reserves) with higher prices. However, lower precipitation can also require lower demand for piped water in hot places, since outdoor water use could be less necessary. Similarly, in some cases prices may not be higher in areas with limited water, if they reflect delivery costs alone.

Moreover, the tariff level is significantly higher for companies with a higher level of investment, as expected. The literature shows that water utilities increase the tariff levied on their customers in order to realize more investments (Marin, 2009; Ruester & Zschille, 2010) and, after their realization, to cover the expenditure (Romano *et al*., 2014). In this sense, our research data confirm that Italian citizens usually pay higher tariffs for additional and better services (i.e. more modern infrastructures). This result confirms our expectations, since the Italian water reform and the EU Water Framework Directive require that tariffs should be able to cover both current costs and investments.

Furthermore, the water tariff is negatively related to the economic level of the area served (i.e. the average annual per capita income in the area served). This is an unexpected result, which does not confirm the existing literature (Martinez-Espiñeira *et al*., 2009; Thorsten *et al*., 2009) and seems to suggest that the water tariff does not have a redistributive effect in Italy.

In contrast to the results of Martinez-Espiñeira *et al*. (2009) in Spain, after the treatment effect model is applied, our results seem to suggest that the ownership of Italian water utilities does not influence the tariff level levied on customers.

Finally, neither the length of the water network (i.e. firm size) nor diversification strategies showed significant relationships with the tariff level. The literature reviews show that there is still no consensus regarding the optimal size of water utilities or the extent of economies of scope in the water industry worldwide (Abbott & Cohen, 2009; Carvalho *et al*., 2012). The majority of existing studies on Italian water utilities have demonstrated the presence of economies of scale and scope (Guerrini *et al*., 2011; Romano & Guerrini, 2011) although, as highlighted by Cruz *et al*. (2012), it is unclear whether the reforms implemented in this country have allowed for the effective exploitation of economies of scale and scope in a universal sense.

6. Concluding remarks

This paper studies the WPP in Italy and seeks to contribute to the existing literature on endogenous and environmental factors affecting household water prices, by analyzing whether and how some variables of relevance to the Italian water industry affect the tariff levied by water utilities. In particular, it aims to contribute to the current debate about the privatization of water services in Italy, within which a referendum has recently revealed citizens' preference for totally publicly owned water utilities. As highlighted by Martinez-Espiñeira *et al*. (2009), one of the main arguments against privatization is that water prices are expected to rise under private management.

Our model shows that private partners are more likely to be involved in the water sector if the annual sales achieved are higher. At the same time, local governments may be more likely to relinquish the management of water services, assigning it to mixed or private firms, when the business is more complex (i.e. it requires a higher scale of operations), needing more resources and competences and more capital investments.

A second phase of the analysis shows that investments and annual precipitation influence water prices in Italy. Moreover, where the average annual income per capita is higher, lower tariffs are observed.

In addition, once the endogeneity due to the ownership factor is taken into account, the paper shows that, on average, private firms do not levy higher prices than do public ones. Finally, the data show that an increase in firm size (measured by the length of water network) and the implementation of diversification strategies do not contribute to reducing tariff levels.

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