The Impact of Governance Structure on Firm Performance – An Application to the German Water Distribution Sector

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- Preliminary Version -

Abstract

This paper investigates the impact of governance structure on firm performance (i.e., retail prices) using a database of 765 German water suppliers. Controlling for scale economies as well as technical and structural characteristics we find that private sector participation is accompanied with higher retail prices. Eastern states on average feature higher prices mirroring significant investments during the last two decades as well as network over-dimension. Assuming that managers make strategic decisions (e.g., governance form) not randomly but rather decide based on expectations of how their choices affect future performance we correct this "self-selection" applying in the second step a two-stage Heckman model.

JEL-Codes: L33, L95, C31

Keywords: private sector participation, performance, water supply

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1 Introduction

Retail prices vary widely in the German water sector, but not all variation can be explained by investments in the former Eastern part of the country or structural differences between the supply areas of different utilities. We observe a broad range of governance modes such as public service provision as well as varying forms of private sector participation (PSP) in the sector of water production and distribution. Researchers intensively discuss the optimal level of private involvement in the provision of traditional public services – namely natural monopolies such as the natural gas and electricity sectors where the restructuring process started in the 1980s (UK, US) and in the late 1990s in Continental Europe. Private operation should lead to higher efficiency, improved quality and higher incentives to develop innovations; hence, we would expect higher overall efficiency and lower consumer prices for operators where a private partner is involved in service provision.

Public-private partnerships (PPPs) are an alternative organizational form to full privatization. Defined as the contracting of a service along several stages of the vertical chain of production between a public authority and a private partner, different forms of PPPs differ in the allocation of risks, revenues, rights, and obligations across public and private partners. There is a huge body of theoretical literature discussing the advantages and disadvantages of this hybrid governance mode (see e.g. Hart et al., 1997; Guash et al., 2008). Empirical literature on the effect of governance choice – namely PPP – on firm performance in network industries is still rare.

Existing literature evaluating the performance of water utilities is mainly based on efficiency analysis (non-parametric Data Envelopment Analysis and parametric Stochastic Frontier Analysis) with some studies explaining in a second step efficiency scores by several exogenous variables such as the population density. See Hirschhausen et al. (2008) for a detailed literature review. Some papers directly investigate the influence of organizational structure on firm performance. Bhattacharyya et al. (1995) include the ownership type of the water supplier into the estimation model of a cost function of US water utilities. They find that private utilities tend to be more inefficient than public operators; only up to a specific firm size in measures of the total amount of water delivered, private firms are more efficient than public ones. This is in contrast to Estache and Kouassi (2002) estimating a Cobb-Douglas production function for a sample of 21 African water utilities over the time horizon from 1995 to 1997. Applying a censored Tobit regression on inefficiency levels, they suggest that privately owned water utilities are more efficient than public ones. Based on a DEA efficiency analysis García-Sánchez (2006) applies a Mann-Whitney test but finds no significant difference between efficiency scores obtained by public and private utilities. In their review of empirical literature investigating ownership and performance of water utilities Renzetti and Dupont (2003) find no compelling evidence of private firms outperforming public firms.

Only a very limited number of studies account for the self-selection of managers into the strategy where the expected performance level is the highest. Chong et al. (2006) investigate the impact of

PPPs on firm performance (measured by consumer prices) in the French water sector. To account for the endogeneity of organizational structure they estimate a switching regression model. They show that the choice of the governance form is not random and that average customer prices are significantly higher for PPPs as compared to direct public management amongst. Carpentier et al. (2006) show in a similar analysis that private participation in the provision of water supply is more likely the more challenging the environmental conditions such as water quality or network density.

Our contribution to the literature is an empirical study investigating the impact of governance choice on firm performance using a database of 765 German water suppliers. We analyze the relationship between organizational form (i.e., private sector participation in water supply versus public service provision) and retail prices controlling for scale economies as well as technical and structural characteristics of the suppliers. Amongst others, we show that private sector participation results in higher prices whereas structural parameters such as a high share of underground water or the delivery to a large city may decrease consumer prices. Eastern states on average feature higher prices mirroring significant investments during the last two decades as well as in some cases network over-dimension. Assuming that managers make strategic decisions (such as the governance form) not randomly but rather decide based on expectations of how their choices affect future performance, we correct this “self-selection” applying furthermore a two stage Heckman model.

The paper is structured as follows: Section 2 introduces the industry-specific context and derives testable hypotheses. Section 3 summarizes the dataset and introduces the applied methodology. We present and interpret the results in Section 4 before concluding in Section 5.

2 Industry Context

2.1 The industry

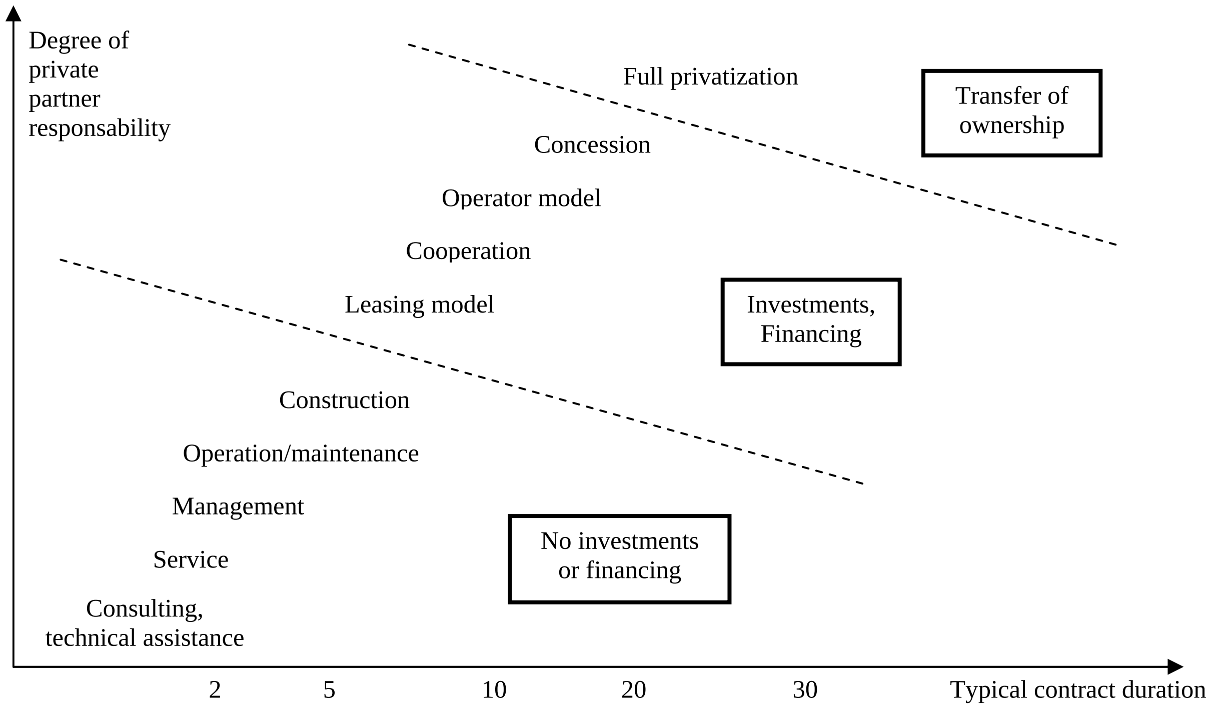
Local public authorities are traditionally responsible for water supply to the German residential and industrial sectors (i.e., public service obligation); they have to provide all infrastructures necessary for the supply of water. Water supply is regulated within the federal laws of the German states. This decentralized decision making has been conducive to the establishment of a large variety of governance forms under which water supply is provided. We observe public service provision as well as the participation of private companies (i.e., private operators or mixed public-private operators).[2] Based on the number of end consumers, 26% of the water utilities are companies with private sector participation while 74% are characterized by public service provision (BMWA, 2005).

Between the two poles of pure public service provision and total privatization we distinguish the following models of privatization differing in the degree of private responsibility as well as on how private partners are compensated for their services and investments: i) public service provision with

[2] One distinguishes between firms having legal capacity (Anstalt öffentlichen Rechts, GmbH, AG), firms having no legal capacity (Regiebetrieb, Eigenbetrieb), and cooperations between municipalities (e.g. Zweckverband).

the private sector contracting for a part of operation and maintenance, consulting, or management; ii) leasing model with the infrastructures remaining under public property but the private party operating the system (e.g., Zweckverband Wasser/Abwasser Mittleres Elstertal as public owner of infrastructure and the OTWA GmbH as private operator); iii) cooperation model where a joint company is founded between the local authority (typically majority share) and a private partner (e.g., Kommunale Wasserwerke Grimma-Geithain GmbH); iv) operator model where we have an ex-ante competition for the contract of planning, financing, constructing and operation of new facilities; cost and operational risk are borne by the private operator (e.g., Eurawasser Nord GmbH as private operator on behalf of the Wasserversorgungs- und Abwasserzweckverband Güstrow-Bützow-Sternberg); and v) the concession model (e.g., Stadtwerke Düsseldorf AG). See Figure 1 for a graphical illustration. Germany does not have the pre-conditions for a full privatization of the supply of water (i.e., uniformly organized utilities, central regulator monitoring prices etc.). Hence, public-private partnerships are the recent way of private sector participation.

Figure 1: Models of privatization



Source: Own depiction following BMWA (2005, 71)

If the municipality decides to cooperate with a private firm (via contracting out or public-private partnership), it has to launch an official invitation to tender that is open to all interested operators in order to ensure ex-ante competition for the market and to select the most efficient firm for the service provision. A step-wise reduction of the community of bidders and negotiation procedures are common. There are potential hazards faced by the local public authority which are intensively discussed in theoretical and empirical literature: Bidders may strategically underestimate production costs or overestimate revenues in order to obtain the contract for service provision; ex-post renegotiations resulting in increased customer prices and a redistribution of rents might occur. Furthermore, complex long-term contracts are unavoidably incomplete; changes in the institutional environment may require efficient adaptation mechanisms.

In total, around 6,500 utilities are supplying water to 81.6 million inhabitants and the industry sector in more than 13,000 municipalities in Germany. One million customers on average are supplied by more than 80 utilities; for other European countries such as France, the UK, or the Netherlands this number typically lies in the one-digit range (BMWA, 2005). These companies significantly differ in size. Whereas the large number of small water utilities typically supply rural areas with a low population density and are managed by the local public authorities, larger utilities typically are active in areas of a higher population density. Those more large-size suppliers often are characterized by private organizational forms, even if they remain public with respect to ownership. Only 6% of all water utilities operate under pure private ownership (see BDEW, 2008). The supply of water in rural areas is often carried out by special purpose associations (Zweckverbände) which are cooperations of several local public authorities to organize the provision of services concerning the extraction, treatment and distribution of water together and so to benefit from economies of scale with respect to reduced labor input or volume discounts for water imports in the case that deliveries from third parties are necessary.

Water distribution has the characteristics of a natural monopoly with a subadditiv cost function; hence there is no ex-post competition. Furthermore, the principle of territory protection holds; thus, third party access to networks is not enforceable under current legislation. Even though competition in the market is restricted, competitive bidding processes or tendering are employed in some cases in order to support competitive market outcomes; hence there may be ex-ante competition for the market.[3] Unbundling of transportation infrastructure from the production and marketing activities is under discussion.

Regulation is the task of the regulatory or cartel offices of the federal states as long as the water utility under consideration is only operating in one of the federal states; otherwise the national cartel office would be responsible. Thus, regulation of water utilities differs by federal state. Technical regulation monitors quality issues; price regulation is concerned about consumer prices. One has to distinguish between prices under private law ("Entgelt") and charges under public law ("Gebühren"). This differentiation is based on the organizational form of the water utility. If a utility is organized privately, even under public ownership, prices are set for the supply of water and corresponding services and are based on private law. In this case, the responsible cartel office has the possibility to control the prices set by the water utility. Charges on the other hand are set when the water utility is

[3] See Demsetz (1968) for a discussion of ex-ante competitive bidding processes and their impact on an efficient resource allocation; several authors (such as Williamson, 1976) have criticized this concept of monopoly franchise bidding arguing that due to the existence of transaction costs and the dynamism of markets there may be significant hazards of post contractual opportunism.

organized publicly. In this case, water supply is not subject to regulatory control and is based on public law.[4]

2.2 Working hypotheses

The following paragraph derives propositions on the impact of organizational form, the existence of scale economies as well as technological and structural characteristics of supply area and supplier on firm performance (i.e., end consumer retail prices).

Organizational form: If the responsibility of service provision is transferred from the public to the private sector, market forces should enhance the performance of service provision via ex-ante competition. Private operation should lead to higher efficiency, improved quality and higher incentives to develop innovations; hence, we would expect higher overall efficiency and lower consumer prices for operators where a private partner is involved in service provision. From this discussion we derive the following proposition:

<u>Proposition 1:</u> The participation of private companies in the operation of water supply should lead to an increase in overall performance due to the realization of economizing potential under competitive pressure; hence, we expect lower retail prices.

Scale economies: Water suppliers operate under very different conditions; a high population density in urban areas supports significant scale economies as opposed to sparsely populated rural areas. Furthermore, the portfolio of customers (large-scale industry versus households) should have an impact on the supplier's profitability.

<u>Proposition 2:</u> We expect that scale economies lead to higher firm performance values which should mirror in lower retail prices.

Technological and structural characteristics: Underground water – as opposed to reservoir-, sea-, or river water – has a very high quality reducing the need for heavy treatments (disinfection, filtration, deacidification, etc.). This in turn lowers the costs of water supply and should have a reducing impact on consumer prices. Network quality, indicated by parameters such as water losses in the system, also differs between different suppliers. Furthermore, the supply portfolios of water utilities differ significantly, whereas some companies produce the whole amount of water from own sources; other companies are totally dependent on water imports from third suppliers. With every further supplier

[4] Economically speaking, this traditional distinction between prices and charges does not make sense.

along the value added chain of production, profit margins should increase final consumer prices. We therefore derive the following propositions:

Proposition 3a: The higher the share of underground water in the supply portfolio of the company, the higher should be the performance value and the lower the retail price.

Proposition 3b: The higher the quality of the network, the higher should be the firm performance and the lower should be the retail price.

Proposition 3c: The higher the dependence on imports, the lower should be the performance and the higher should be the retail price.

3 Data and Methodology

3.1 Methodology

The objective of this paper is to estimate the impact of governance choice on firm performance (i.e., retail prices) using cross section data of German water supply companies. In a first step, we estimate an ordinary least squares (OLS) model explaining the price by an indicator of the organizational form of the supplying company and a set of exogenous variables:

$$PRICE_i = \alpha G_i + \beta X_i + \varepsilon_i \qquad (1)$$

where *PRICE* is the end consumer price, *G* indicates the chosen governance form of the respective water supplier, *X* is a vector of exogenous variables, and ε is the error term assumed to be independent and identically distributed (i.i.d.). We are especially interested in the coefficient α measuring the impact of governance choice on firm performance.

However, econometric problems will arise if the governance form is endogenous. One might expect that strategic decisions such as the choice of governance form (e.g., vertical integration versus market procurement, public ownership versus PPP) are endogenous to their expected performance outcomes. Ignoring this self-selection will lead to biased estimates resulting from omitted variables affecting both strategy choice and performance. Hamilton and Nickerson (2003) discuss econometric methodologies which overcome this endogeneity problem.

Hence, in a second step, we estimate – based on a binary variable indicating governance form (i.e., private sector participation versus pure public service provision) – a switching regression model containing of three stages: i) Firstly, we employ a Probit model explaining governance choice *G* by all system exogenous variables *X* and an instrument *Z* (i.e., a variable affecting governance choice but not firm performance); ii) using estimation results of this regression, we calculate the inverse Mill's ratios for both, the companies which operate under private sector participation and those operating under pure public responsibility; and finally iii) we estimate the sample-selection corrected performance equations employing standard OLS:

$$G_i^* = \delta X_i + \gamma Z_i + v_i \text{ with } G_i = 1 \text{ if } G_i^* > 0 \text{ and zero otherwise.} \qquad (2a)$$

$$\begin{aligned} \lambda_i^1 &= \phi[\delta X_i + \gamma Z_i] / \Phi[\delta X_i + \gamma Z_i] \\ \lambda_i^0 &= \phi[\delta X_i + \gamma Z_i] / (1 - \Phi[\delta X_i + \gamma Z_i]) \end{aligned} \qquad (2b)$$

$$\begin{aligned} PRICE_i^1 &= \beta^1 X_i - \sigma_u^1 \phi[\hat{\delta} X_i + \hat{\gamma} Z_i] / \Phi[\hat{\delta} X_i + \hat{\gamma} Z_i] + e_i^1 \\ PRICE_i^0 &= \beta^0 X_i + \sigma_u^0 \phi[\hat{\delta} X_i + \hat{\gamma} Z_i] / (1 - \Phi[\hat{\delta} X_i + \hat{\gamma} Z_i]) + e_i^0 \end{aligned} \qquad (2c)$$

with ϕ being the normal density function, Φ being the cumulative normal distribution and λ being referred to as the "inverse Mill's ratios". Subscript one indicates private sector participation whereas subscript zero indicates pure public service provision. The inclusion of the inverse Mill's ratios in the above sample-selection corrected performance equations (2c) leads to expected values of the error terms equaling zero by construction; OLS estimation will deliver unbiased estimates of all parameters.

3.2 Data

We built up a unique dataset combining cross section data of two sources: i) A first database of the Bundesverband der Deutschen Gas und Wasserwirtschaft e.V. (BGW, 2005a) provides detailed information on the organizational form of 1,114 selected German water suppliers, their water supply structure and sales volumes by customer group, as well as technical details; ii) a second database of the BGW (2005b) provides information on retail prices of 1,037 utilities. Since some companies are part of only one dataset but are not included in the other, we had to reduce the dataset to 772 water suppliers. Omitting further observations with missing or implausible data as well as long-distance water transmission companies finally reduces our sample to 765 observations. The unit of analysis is a water supply company in 2003.

3.2.1 Endogenous variables

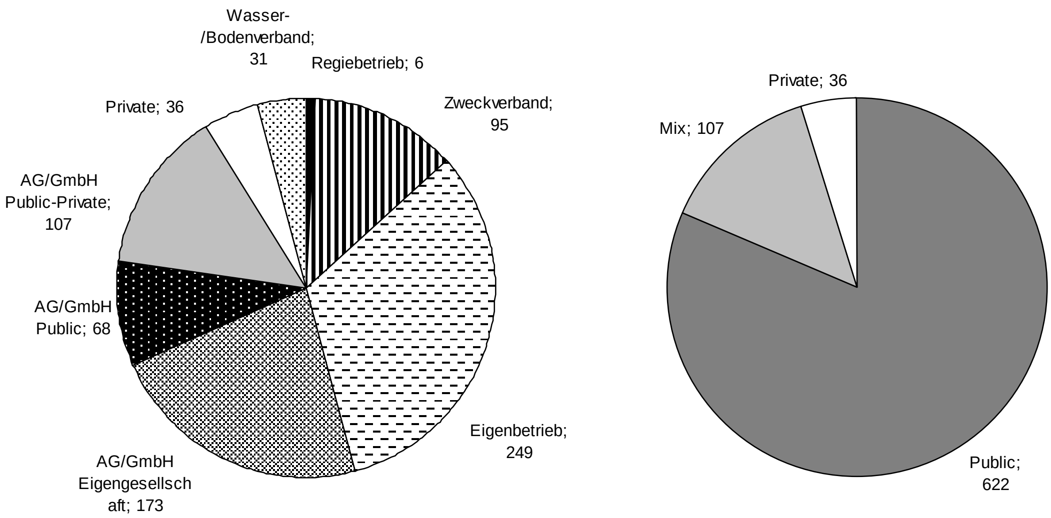
Governance choice: Local public authorities may pass the service of water supply to companies of varying organizational forms ranging from pure public provision over mixed public-private companies to pure private companies. BGW (2005a) differentiates between:

Table 1: Organizational forms in the German water distribution sector

Organizational form	Description	Index
Regiebetrieb	Judicial dependent company, incorporated into public administration	A
Zweckverband	Union of municipalities in order to organize the service of water provision	B
Eigenbetrieb	Public, judicial independent company of a municipality without own legal personality	C
AG/GmbH Eigengesellschaft	One public corporation with a private organizational form	D
AG/GmbH öffentliche Gesellschaft	Multiple public corporations with one private organizational form	E
AG/GmbH gemischt	Public as well as private companies with one private organizational form	F
Privater Betreiber	Companies under private law	G
Wasser- und Bodenverband	Union of municipalities	H

For this empirical study we distinguish between publicly operated companies (A, B, C, D, E, H) and water suppliers in which private companies participate (F, G). The largest part of the water supply companies in our dataset of 765 complete observations are publicly owned (622 or 81.3%), with the forms C (Eigenbetrieb) and D (Eigengesellschaft) covering more than 50% of the whole dataset. Pure private companies provide water supply in only 36 cases (4.7%), mixed publicly-private owned companies are active in 107 (14%) of the observations (see Figure 2).

Figure 2: Organizational forms in the German water supply sector



We define two alternative measures indicating the governance form of the water supply company. First, we use a dummy variable (PSP1) having the value of one, if a private company participates in service provision together with public entities or if a purely private company is responsible for water supply and zero otherwise:

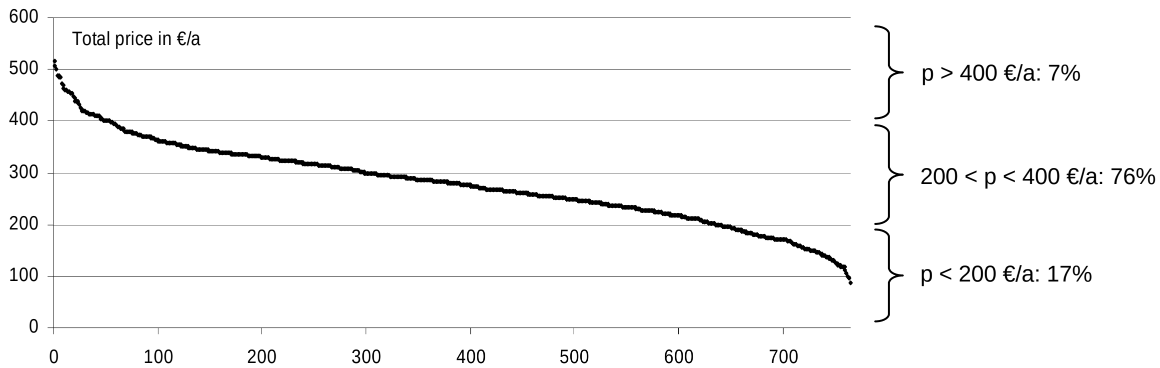
$$PSP1 = \begin{cases} 0 \quad \text{if governance form equals A, B, C, D, E, or H} \\ 1 \quad \text{otherwise} \end{cases}$$

Second, we define an ordinal variable increasing with a rising level of private sector characteristics in the organizational form (PSP2):

$$PSP2 = \begin{cases} 0 \quad \text{if governance form equals A, B, C, or H} \\ 1 \quad \text{if governance form equals D or E} \\ 2 \quad \text{if governance form equals F} \\ 3 \quad \text{otherwise} \end{cases}$$

Consumer price: In order to measure the performance of a water supplier we employ the retail price for a representative household consuming 150 m^3 of water per year (PRICE). This price includes fixed – monthly or yearly – fees as well as a variable price; taxes are excluded from the analysis. The total consumer price per year differs greatly; it varies between 88.20 €/a (Wasserverband Hümmling) and 517.20 €/a (Zweckverband Wasserversorgung Bornaer Land). Whereas 17% of all suppliers demand prices below 200 €/a, 7% of the utilities have very high prices above the 400 €/a level; the largest part of the companies supplies water at prices between 200 and 400 €/a (see Figure 3).

Figure 3: Total price for a representative household consumer with 150m³/a consumption



3.2.2 Exogenous variables

In order to analyze the impact of governance choice on performance, we define the following variables accounting for exogenous parameters influencing the costs of water supply.

Scale economies: To test for Proposition 2 we include a set of variables measuring network and supply area characteristics and hence indicating potential scale economies. We use the ratio of sales destined to household consumers over the total water sales of the company (SALESHH) expecting that the higher this parameter the higher should be the retail price: the supplier has to rely on a more branched network to sell the same amount of water than a supplier delivering a large part to industry or other large scale customers. We include the number of inhabitants into the model to account for the market size supplied by the respective firm (POP); the squared value is included to test for a potential nonlinear impact of this variable. As a further control variable we include a dummy indicating large cities in the supply area (DCITY) having the value of one if the water is supplied to a city with more than 500,000 inhabitants and zero otherwise, expecting a negative relationship with the dependent variable. A last variable indicating economies of scale is the density of the distribution network (DENSITY), defined as the ratio of the inhabitants supplied over the network length. We expect a negative relationship between the density and the retail price reflecting cost advantages of a high density network.

Technological and structural characteristics: To test for Propositions 3a to 3c we use a first variable to account for the water source which varies by region. One distinguishes between underground-, spring-, river-, sea-, and reservoir water, bank filtration and enriched ground water. Typically, underground water has a better quality than the alternative sources, reducing the need for further treatment. We hence expect that the performance measured in a low retail price should increase the higher the share of underground water in the water supply portfolio (UNDERGROUND). To account for the complexity of water treatment before water distribution we employ a count index indicating the number of different treatment methods necessary (TREAT). Whereas few suppliers produce water from very high quality sources others are obliged to employ a number of pre-treatment, such as filtration and removal of iron and manganese particles, disinfection, de-acidification, etc. We expect that the retail price increases the more treatment is necessary before water distribution. To account for the quality of the network infrastructure we include the leak ratio (LEAK) defined as total water input (sum of own production and imports) minus supplies to all customers as well as to third companies over total water input. We further introduce a variable measuring the dependence on water imports from other regions (IMPORTDEP). This variable is defined as the ratio of water imports over total water input. A higher dependence on third suppliers should increase total costs and hence the retail price.

Control and instrumental variables: Finally we include a dummy indicating water suppliers in the Eastern part of Germany as a control variable (DEAST). During the last two decades significant investments have been realized which has increased the costs of the suppliers and should be reflected in retail prices. To estimate the first equation explaining governance choice of the switching regression model (Equation 2a) we have to include all system exogenous variables defined above (i.e., vector X) and additionally at least one instrumental variable Z which explains the governance choice but has no impact on the retail price. Hence, we further use a dummy variable having the value of one if the water utility only supplies water (i.e., no sanitation or other services) and zero otherwise (DWATER). The menu of activities should not influence the retail price of a particular service; however, we could expect that a local public authority could chose another organizational form for the provision of a single service than for the provision of a combination of services.

Table 2: Endogenous and exogenous variables – definition and descriptive statistics

Characteristic	Denotation	Unit	Mean	Min	Max	N
Retail price for a representative household consuming 150 m³/a	PRICE	€/a	279.13	88.20	517.20	765
Governance form: dummy equaling one for private sector participation	PSP1	Dummy	0.180	0	1	765
Governance form: increasing private sector characteristics	PSP2	Ordinal	0.736	0	3	765
Percentage of water sales to household customers (versus industry)	SALESHH	%	0.831	0	1	765
Population supplied in 1000	POP	In 1000	53.72	1	3416	765
Dummy equaling one for cities with more than 500,000 inhabitants	DCITY	Dummy	0.013	0	1	765
Network density: ratio of population supplied over network length	DENSITY	POP/km	159.47	17.09	478.01	765
Percentage of water production from underground sources	UNDERGROUND	%	0.593	0	1	765
Count index for the number of treatment steps before distribution	TREAT	Ordinal scale	1.083	0	4	654
Leak ratio: (total input – total sales) / total input	LEAK	%	0.114	0	0.429	765
Import dependence: percentage of water imports from third producers	IMPORTDEP	%	0.276	0	1	765
Dummy for suppliers in the Eastern part of Germany	DEAST	Dummy	0.148	0	1	765
Dummy for suppliers only supplying water (i.e. no sanitation or other services)	DWATER	Dummy	0.225	0	1	765

Table 2 provides a summary of all endogenous, exogenous and instrumental variables including their descriptive statistics. The consumer price for a representative household consuming 150 m³ per year ranges as discussed above between 88.20 €/a and 517.10 €/a with a mean of 279 €/a; hence there is a great variation in prices with the highest equaling 586% of the lowest.[5] Only 18% of all observations cover water supply companies which are privately operated or under a mixed public-private ownership. An average water supplier delivers 83% of the water to household customers. The population of the area delivered by the company differs greatly; very few customers of 1,000 people confront areas with very large populations of up to 3.4 millions of inhabitants (Berliner Wasserbetriebe). About 1.3% of the observations include very large cities with more than 500,000 inhabitants. Between 17 and 478 inhabitants are supplied per km network. An average water supplier produces 60% of the water input from underground water sources; however, whereas some suppliers rely totally on other sources others can benefit from 100% underground water. The leak ratio varies between zero and 43%; import dependence between zero (253 observations) and 100% (95 observations). 15% of all observations include companies of the Eastern German countries and finally 22.5% of the suppliers supply only water (i.e. no sanitation or other services such as electricity or natural gas).

3.3 Estimation model

In a first step we estimate Equation 1 using OLS with the retail price as endogenous variable and the above defined variables as well as the organizational form of the respective water supplier as explanatory variables. Equation 3a includes PSP1; Equation 3b includes PSP2:

$$\begin{aligned} PRICE_i &= \beta_0 + \alpha PSP1_i + \beta_1 SALESHH_i + \beta_2 POP_i + \beta_3 POP_i^2 \\ &+ \beta_4 DCITY_i + \beta_5 DENSITY_i + \beta_6 UNDERGROUND_i + \beta_7 TREAT_i \\ &+ \beta_8 LEAK_i + \beta_9 IMPORTDEP_i + \beta_{10} DEAST_i + \varepsilon_i \end{aligned} \tag{3a}$$

$$\begin{aligned} PRICE_i &= \beta_0 + \alpha PSP2_i + \beta_1 SALESHH_i + \beta_2 POP_i + \beta_3 POP_i^2 \\ &+ \beta_4 DCITY_i + \beta_5 DENSITY_i + \beta_6 UNDERGROUND_i + \beta_7 TREAT_i \\ &+ \beta_8 LEAK_i + \beta_9 IMPORTDEP_i + \beta_{10} DEAST_i + \varepsilon_i \end{aligned} \tag{3b}$$

where *i* indexes the observation in form of a water supplier. However, since the organizational form may not be chosen randomly but instead may represent a self-selection of the managers into the strategy with the highest expected performance, the governance form may be an endogenous variable and we estimate the following switching regression model:

[5] Broken down to governance forms the total price ranges between 117.84 and 487.44 €/a for private sector participation in the supply of water (with a mean of 305.17 €/a) and between 88.20 and 517.20 €/a for public service provision (with a mean of 273.39 €/a).

$$
\begin{aligned}
&PSP1_i = \delta_0 + \delta_1 SALESHH_i + \delta_2 POP_i + \delta_3 POP_i^2 \\
&+ \delta_4 DCITY_i + \delta_5 DENSITY_i + \delta_6 UNDERGROUND_i + \delta_7 TREAT_i \\
&+ \delta_8 LEAK_i + \delta_9 IMPORTDEP_i + \delta_{10} DEAST_i + \gamma DWATER_i + v_i
\end{aligned} \tag{4a}
$$

$$
\begin{aligned}
&PRICE_i^1 = \beta_0^1 + \beta_1^1 SALESHH_i + \beta_2^1 POP_i + \beta_3^1 POP_i^2 + \beta_4^1 DCITY_i \\
&+ \beta_5^1 DENSITY_i + \beta_6^1 UNDERGROUND_i + \beta_7^1 TREAT_i + \beta_8^1 LEAK_i \\
&+ \beta_9^1 IMPORTDEP_i + \beta_{10}^1 DEAST_i - \sigma_u^1 \lambda^1 + e_i^1
\end{aligned} \tag{4b}
$$

$$
\begin{aligned}
&PRICE_i^0 = \beta_0^0 + \beta_1^0 SALESHH_i + \beta_2^0 POP_i + \beta_3^0 POP_i^2 + \beta_4^0 DCITY_i \\
&+ \beta_5^0 DENSITY_i + \beta_6^0 UNDERGROUND_i + \beta_7^0 TREAT_i + \beta_8^0 LEAK_i \\
&+ \beta_9^0 IMPORTDEP_i + \beta_{10}^0 DEAST_i + \sigma_u^0 \lambda^0 + e_i^0
\end{aligned} \tag{4c}
$$

with the Lambdas (i.e., inverse Mill's ratios) being defined as described above and the Sigmas as the respective estimation coefficients. A positive selection into the alternative strategies (i.e., a competitive advantage) can be identified when estimation results show coefficients of the inverse Mill's ratios of $\sigma_u^1 < 0$ and $\sigma_u^0 > 0$ respectively.

4 Results and Discussion

4.1 Simple OLS model

Table 3 displays estimation results of nested models explaining the consumer price based on simple OLS estimation not accounting for the possible endogeneity of governance choice. The first group of specifications includes the binary variable indicating private sector participation (i.e., PSP1); the second group includes the degree of private sector characteristics in the governance form (i.e., PSP2). Model 1 includes only the dummy variable indicating the governance mode of the water supplier and exhibits a very low explanatory power. Model 2 includes all exogenous variables measuring potential scale economies. The adjusted R^2 has improved to Model 1, even though still at a very low level. Model 3, which adds our measures of technological and structural characteristics, increases the R^2 to 0.35 (0.36) and hence offers a significant improvement over Model 2.

We find for all specifications that consumers pay more when private operators are involved in the supply of water; respectively, the higher the degree of private sector participation; controlling for potential scale economies as well as individual technical and structural characteristics of the water suppliers, we find that water utilities under private participation demand on average a retail price of 18.40 €/a higher than pure public service providers. There are several possible explanations; on the one hand, private operators have different objectives than public operators. Whereas the last may focus on service provision and customer satisfaction, private firms focus on the realization of profits. On the other hand, it might be that local public authorities decide to outsource water supply in situations with more difficult environmental conditions.

The higher the share of households in the customer portfolio the higher are average retail prices. This reflects scale economies and cost reduction potential which can be realized supplying industry and large scale customers. Furthermore, as expected, utilities delivering water to large cities demand significantly lower prices than other suppliers. However, we found counter-intuitive results for the impact of network density; the more customers are supplied per km network, the higher seems to be the retail price in our analysis, even though the effect is very small compared to the parameter values of other variables.[6] Market size, measured by the number of inhabitants in the supply area, has a positive and decreasing effect on retail prices. However, this effect, too, is negligibly small.

Concerning the technical and structural characteristics we can show that water quality indeed has a significant impact on firm performance. The higher the share of high-quality underground water in the supply portfolio and the lower the need for pre-treatment of the water, the lower will be the retail price, mirroring cost advantages of certain suppliers. As expected, the leak ratio has a significant positive impact on the price, which can easily be explained by increasing costs of service provision the higher the water losses during transportation. For the dependence of imports from third suppliers the regression analysis presents a positive parameter but lacking statistical significance.

The control variable provides another interesting finding; for water suppliers in the Eastern federal states of Germany, water prices are significantly higher on average. On the one hand this mirrors significant investments which have been realized during the last two decades; on the other hand network over-dimension might be an explanation for some cases, where a large part of the industry has been closed down reducing total demand.

The estimation of an alternative specification of Models 3 excluding the variable TREAT in order to benefit from the whole sample leads to qualitatively exactly the same findings. Estimation results are available from the authors on request.

[6] Furthermore, the variables DCITY and DENSITY show a correlation of 0.29; hence, a part of the effect of scale economies resulting from a high population density is already mirrored in the estimation parameter of DCITY. In fact, the highest density values in our dataset represent large cities such as Frankfurt am Main (Mainova AG) or Berlin (Berliner Wasserbetriebe).

Table 3: Estimation results OLS

Specification	OLS Dependent variable: PRICE					
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
CONSTANTE	273.39 *** (3.09)	219.56 *** (16.83)	221.47 *** (19.50)	265.43 *** (3.53)	218.08 *** (16.77)	219.15 *** (19.43)
PSP1	31.77 *** (7.28)	22.79 *** (7.31)	18.40 *** (6.68)			
PSP2				18.61 *** (3.19)	13.50 *** (3.32)	11.08 *** (3.04)
SALESHH		33.71 * (18.77)	31.93 * (16.85)		33.23 * (18.68)	31.20 * (16.77)
POP		0.19 *** (0.06)	0.15 *** (0.06)		0.18 *** (0.06)	0.15 *** (0.06)
POP squared		-0.00 *** (0.00)	-0.00 ** (0.00)		-0.000 *** (0.000)	-0.000 ** (0.000)
DCITY		-42.89 (39.10)	-62.57 * (35.47)		-37.95 (38.96)	-58.77 * (35.35)
DENSITY		0.12 *** (0.04)	0.09 ** (0.04)		0.10 ** (0.04)	0.08 * (0.04)
UNDERGROUND			-64.57 *** (10.97)			-63.62 *** (10.93)
TREAT			10.93 ** (4.45)			11.37 ** (4.43)
LEAK			155.29 *** (38.69)			156.96 *** (38.52)
IMPORTDEP			20.33 (12.89)			21.00 (12.84)
DEAST			55.53 *** (7.57)			54.71 *** (7.54)
Adjusted R^2	0.02	0.07	0.35	0.04	0.08	0.36
p-value F.-stat.	0.000	0.000	0.000	0.000	0.000	0.000
N	765	765	654	765	765	654

*** Statistically significant at a 1%-level; ** statistically significant at a 5%-level; * statistically significant at a 10%-level. All levels of statistical significance are based on two-tailed test statistics; standard deviations in parentheses.

4.2 Switching regression model

To control for the possible endogeneity of governance choice we employ in a second step a switching regression model. Table 5 displays in the first columns the estimation results of a Probit model explaining the governance choice (i.e., private sector participation versus public service provision). The instrumental variable indicates that pure water companies typically remain under public control whereas private companies tend to be active in a combination of sectors (i.e., multi-utilities delivering typically water and sanitation and/or other services such as natural gas, electricity, etc.); they may actively benefit from synergies of combining different services. With the density of inhabitants supplied per km network length the probability of private sector participation increases. Water quality seems to have an impact on governance choice; the lower water quality (i.e., low share of underground water, high need of pre-treatment) the higher the probability of private sector participation, supporting the argumentation that local public authorities may outsource water supply in the presence of more challenging conditions.

Different other exogenous variables have no statistically significant impact on the probability that private operators participate in service provision; however; this is very similar to the empirical study of Chong et al. (2006) employing a similar method to the French water sector. Since the explanatory power of the governance choice model is very low,[7] further research should focus on the improvement of the model specification and definition of the variables. The Probit model has furthermore an asymmetric predictive power; whereas 99% of all cases of public service provision are predicted correctly; the model predicts only 5% (8%) of the cases of private sector participation correctly. Hence, the model predicts too often public service provision.

Table 4: Predictive power of Probit model estimating governance choice

	Subsample (654 observations including TREAT)	Total sample (765 observations not including TREAT)
$D\_hat_i = k$ and $D_i = k$	534 (82%)	633 (83%)
$D\_hat_i = 1$ and $D_i = 1$	6 (5%)	11 (8%)
$D\_hat_i = 0$ and $D_i = 0$	528 (99%)	622 (99%)

The switching regression model following Hamilton and Nickerson (2003) leads to similar results with functional relationships as described above even though estimation results loose in statistical significance. We run two regressions; a first including all exogenous variables and a second excluding the variable TREAT in order to benefit from a larger sample. Estimation results are very similar. Coefficients of the inverse Mill's ratios indicate a positive selection into the strategy which is the more advantageous in terms of higher prices under consideration of the utilities' individual characteristics. However, since these coefficients are not significant for the sub-sample with PSP1 = 1, we conclude that there is no endogeneity problem with respect to the choice of a governance form in the German water distribution sector. In fact, our unit of analysis is the water supply company, whereas local authorities decide on outsourcing of traditionally public services. Furthermore, suppliers typically are active in more than one municipality. Hence, it is not reasonable in this case to calculate any treatment (or 'strategy') effects.

[7] An alternative specification explaining PSP2 employing an ordered probit model shows no significant improvement of the explanatory power and leads to very similar estimation results.

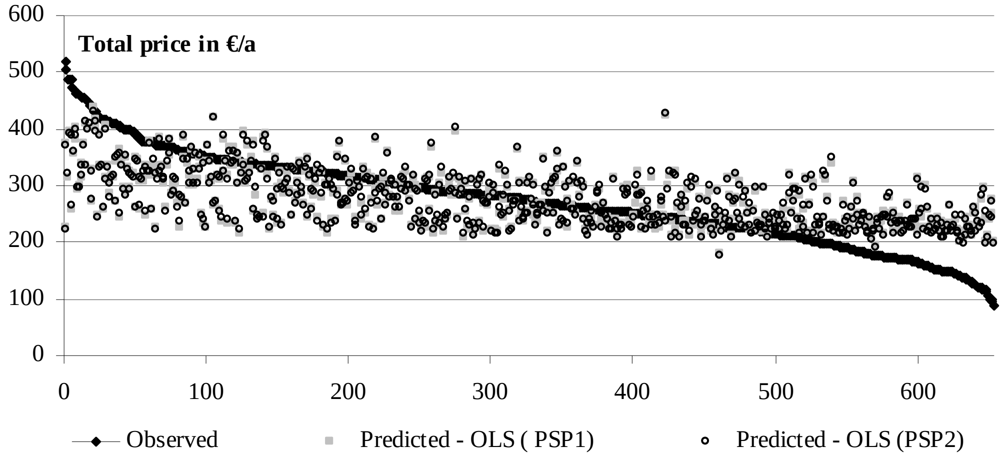
Table 5: Estimation results switching regression

Specification	Probit Dependent variable: PSP1		Switching Regression A Dependent variable: PRICE (PSP1 = 1)		Switching Regression B Dependent variable: PRICE (PSP1 = 0)	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
CONSTANTE	-1.26*** (0.47)	-1.10*** (0.40)	592.86*** (218.26)	561.89*** (195.17)	57.76 (72.64)	45.31 (66.18)
SALESHH	-0.10 (0.42)	-0.12 (0.39)	-20.92 (39.13)	9.35 (37.14)	54.18*** (18.98)	64.80*** (18.04)
POP	0.003 (0.002)	0.003** (0.001)	0.16 (0.25)	0.20 (0.23)	0.11 (0.07)	0.12* (0.07)
POP squared	-0.000 (0.000)	-0.000 (0.000)	-0.00 (0.00)	-0.00 (0.00)	-0.00 (0.00)	-0.00 (0.00)
DCITY	-0.26 (0.87)	-0.06 (0.83)	48.03 (81.01)	35.35 (75.98)	-34.07 (49.22)	-45.33 (46.95)
DENSITY	0.003*** (0.001)	0.002*** (0.000)	-0.14 (0.16)	-0.11 (0.15)	-0.01 (0.07)	-0.04 (0.06)
UNDERGROUND	-0.25 (0.25)	-0.22 (0.23)	-49.56* (28.08)	-58.09** (24.56)	-53.32*** (12.83)	-61.41*** (10.84)
TREAT	0.11 (0.10)		8.34 (10.66)		5.31 (5.31)	
LEAK	-0.14 (0.95)	-0.34 (0.89)	203.21* (102.56)	184.32* (98.44)	158.51*** (42.39)	138.31*** (39.10)
IMPORTDEP	0.03 (0.29)	-0.001 (0.24)	22.48 (29.48)	6.85 (23.43)	18.70 (14.47)	5.18 (11.79)
DEAST	0.02 (0.18)	0.008 (0.17)	35.65** (16.71)	34.96** (15.42)	56.61*** (8.63)	58.99*** (7.92)
DWATER	-0.53*** (0.18)	-0.54*** (0.16)				
LAMBDA			-413.79 (286.67)	-380.65 (265.22)	176.96** (81.83)	205.83*** (72.66)
Adjusted R²			0.36	0.32	0.33	0.32
Pseudo R²	0.08	0.08				
p-value F.-stat.			0.000	0.000	0.000	0.000
p-value Chi²	0.000	0.000				
N	654	765	119	138	535	627

*** Statistically significant at a 1%-level; ** statistically significant at a 5%-level; * statistically significant at a 10%-level. All levels of statistical significance are based on two-tailed test statistics; standard deviations in parentheses.

Regarding the distribution of predicted retail prices we find that the OLS model predicts mainly prices in the middle range between 200 and 400 €/a; positive or negative peak values are out of the predicted range.

Figure 4: Predicted retail prices OLS model (including TREAT)[8]



5 Conclusions

This paper uses different econometric techniques to asses the impact of governance choice on firm performance (i.e., retail prices) using cross section data of German water suppliers in 2003. Following a simple OLS regression we employ a switching regression model in which we allow for possible endogeneity of the local public authority's choice of organizational structure (i.e., private sector participation versus pure public service provision).

While the responsibility for water supply is public, its management can be public, private, or a partnership of public and private players; local public authorities may decide to transfer some of their decision and revenue rights to an external operator. Both, public and private operation have their advantages and disadvantages (see Carpentier et al., 2006) explaining the co-existence of a menu of different governance forms; whereas public service provision supports the local authority's monitoring ability of service provision and may benefit from certain financial advantages (e.g., on a tax level), private provision should enhance technical and economic efficiency due to competitive forces.

The discussion about the optimal level of private sector participation in network industries is often associated with a discussion on consumer prices. As other empirical studies (e.g., Chong et al., 2006; Carpentier et al., 2006) we found that retail prices on average are higher if water is supplied under private sector participation. This result is robust to different model specifications and the switching regression accounting for possible endogeneity of the governance choice. Possible explanations for

[8] The picture looks very similar for the models excluding the variable TREAT.

higher retail prices in the presence of private operators are diverging objectives between public and private firms (i.e., focus on profit realization) or the supposition that public authorities prefer outsourcing in situations with more difficult environmental conditions (i.e., low water quality). Amongst others, we furthermore found that structural parameters such as a high share of underground water or the delivery to a large city may decrease consumer prices whereas Eastern states on average feature higher prices mirroring significant investments during the last two decades as well as in some cases network over-dimension.

However, some open questions and starting points for further research remain. It is not totally explained what causes higher retail prices in the case of private sector participation going beyond scale economies and individual technical and structural characteristics. One should investigate whether there is functioning competition for the market. Furthermore, there may be a transaction cost reasoning explaining potential inefficiencies of public private partnerships (see Williamson, 1976). Beside ex-ante transaction costs of contracting, there may be significant ex-post transaction costs due to the fact that the market is dynamic and complex long-term contracts will be unavoidably incomplete due to uncertainties about future market parameters. Chong et al. (2006) conclude that the primary trade-off is between pure public service provision in terms of low incentives but low transaction costs and private sector participation in terms of higher incentives but higher transaction costs. Another interesting extension of this analysis would be the use of further measures of firm performance such as technical efficiencies or the use of revenue data.

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