Price Mimicking under Cost-of-Service Regulation: The Swedish Water Sector

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Price Mimicking under Cost-of-Service Regulation: The Swedish Water Sector

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Abstract

This study provides an empirical test of price mimicking among publicly owned water utilities. Using a fixed effects spatial Durbin model with data from Swedish municipalities during 2002-2012, I estimate the elasticity of the own relative to neighbors' average price to 0.14. This behavior can be explained in terms of an informal yardstick competition: When consumers use neighboring municipalities' prices as benchmarks for costs or as behaviorally based reference prices, policy makers will face the risk of consumer complaints and reduced voter support if deviating too much from neighboring municipalities' prices. Further, I find some evidence that price mimicking is more pronounced in municipalities where voter support for the ruling coalition is weak.

Keywords: Yardstick competition, spatial econometrics, public economics, public utilities, price mimicking

JEL classification: D4, L1, L5, L9

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1 Introduction

Ever since Tiebout (1956) pointed out that citizens evaluate the policies of their local governments in relation to the policies of other jurisdictions, the interdependence in policy decisions among local governments has been a major interest in public economics. Especially, the focus has been on tax setting and the provision of public services. This paper extends the existing literature by examining spatial interaction in the pricing decisions of regulated utilities. It also adds to the regulatory literature by noting that yardstick competition may also arise in regulated industries that are not subject to a formal yardstick regulation. Specifically, I examine the pricing decisions of Swedish water utilities over 2002-2012. Publicly owned water utilities in Sweden are governed by a cost-of-service ("c-o-s") regulation, providing an upper bound on the price. If utilities are entirely financed by payments from customers, prices in neighboring municipalities should not affect the own price other than through spatially correlated cost factors. In contrast, utilities are found to mimic the prices of their neighbors. It should be noted though, that since municipalities are allowed to finance part of the costs using the municipal budget, price mimicking does not necessarily suggest non-compliance with the regulation.

The basic setup in a model of yardstick competition typically involves a regulator and a number of local monopolists with identical cost functions. For a seminal contribution, see Shleifer (1985). The cost function is unknown to the regulator. For any given firm, the price that the firm gets is equal to the average self-reported cost of the other firms. If a firm reduces costs when its twin firms do not, it profits. If it fails to reduce costs when other firms do, it incurs a loss. Thus, firms are incentivized to achieve productive efficiency. But if the citizens of a jurisdiction evaluate the performance of the local policy makers by comparing with the surrounding jurisdictions this can also generate a type of yardstick competition even in absence of a central regulator. A presumption is then that citizens can punish the firm, either by lobbying for lower prices or the replacement of managers, or by voting the local policy maker out of office.

Informal yardstick competition is not unknown in public economics. For instance, Besley and Case (1995) have adapted Schleifer's original model to describe a system with asymmetric information between voters and politicians. The latter are assumed to know more about the cost of providing public services than the former. Consonant with the large literature on multiagent incentive schemes (see e.g. Holmström, 1982) they show that it makes sense for voters to appraise their incumbent's relative performance if neighboring jurisdictions face correlated cost shocks. Since tax rates are a proxy for the price of public production, citizens will evaluate the performance of their local policy makers by comparing their tax rates with those of neighboring jurisdictions. This induces local policy makers to mimic their neighbors' tax policies in order not to look bad in comparison and be voted out of office. Geys (2006) notes that even in absence of correlated cost shocks, informal yardstick competition may arise if neighbors' tax rates serve as behaviorally based *reference prices* by which the own tax rate is compared, thereby generating the so-called *transaction utility* introduced by Thaler (1985). The most important factor for determining the reference price is fairness, and the transaction utility for buying a certain good is positive if the realized price is less than the reference price. Thus, if citizens believe that it is fair that they pay the same tax as their neighbors, the transaction utility will depend on the difference between their own and their neighbors' taxes.

Is informal yardstick competition also at play in utility markets? Theoretically it should be easier for citizens to compare the performance of individual utilities than the total production of public services. First, utilities produce comparatively homogeneous goods, e.g., electricity distribution, water provision, district heating, and telecommunications. By contrast, a bundle of public services, or even a single one, may vary a lot in quality. Therefore, public services are harder to compare both in relation to quality and fairness principles. Further, the tax rate is merely an approximation of the price of public services, while a well-defined price for a utility service serves as a natural benchmark for efficiency. Recently, some studies have found evidence of yardstick competition in the pricing decisions of unregulated utilities, see Klien (2015); Söderberg and Tanaka (2012). However, to the best of my knowledge, this is the first study to observe informal yardstick competition in a market subject to a c-o-s regulation.

Arguably, the Swedish water sector provides an excellent testing ground for the existence of informal yardstick competition among regulated utilities. Water services have for a long time been provided by publicly owned utilities, independently organized by each municipality. They are regulated by a loosely monitored c-o-s regulation, and Haraldsson

(2013) notes that 45 percent of the municipalities do not even fulfill basic legal accounting requirements. Many of the utilities also belong to publicly owned energy conglomerates, facilitating cross-subsidization between divisions. This should make leeway for a fair degree of arbitrariness in the pricing decisions. As of 2012, price differences were substantial, ranging from 3,000 to 10,000 SEK (1 SEK ≈ 0.1 EUR) per year for a regular household. Many municipalities have price trends that follow closely the trend of their neighbors, for no apparent reason. As an illustrative example, Figure 1 shows the price trends in two neighboring municipalities, Ockelbo and Sandviken. In both municipalities, prices have increased by 120 percent during the last decade, compared to the industry average of 42 percent. The price increase in Ockelbo could largely be explained by high investments, which are on average 1,000 SEK per year and resident for the years when data on investments were available, compared to the industry average of 600 SEK per year. By comparison, the neighboring municipality Sandviken invested only 300 SEK per year, which is well below the industry average. Sandviken's water utility is both physically and organizationally isolated from every other water system in the region. Further, Sandviken's water utilities are part of a publicly owned energy conglomerate, which should facilitate cross-subsidization. This raises questions whether Sandviken raised its price in response to the price increases in Ockelbo, and if so, whether such pricing strategies have been adopted on a systematic basis.

Using a fixed effects spatial Durbin model with data from almost all Swedish municipalities during 2002-2012, I estimate the elasticity of the own relative to neighbors' average price to 0.14. Thus, if the neighboring municipalities raise their prices by on average 10 percent, the causal increase in the own price due to the neighbors' increase is 1.4 percent. Results from cross-sectional data using even more detailed information about the technical characteristics of the utilities suggest an even higher degree of spatial dependence. However, due to the absence of fixed effects these estimates should be interpreted with care. Further, I find that price mimicking is more pronounced in municipalities where voter support for the ruling coalition is weak. This suggests that politicians facing a higher risk of loosing office are more concerned by reduced voter support if voters perceive them as inefficient.

The rest of this paper is structured as follows. Section two reviews the related litera-

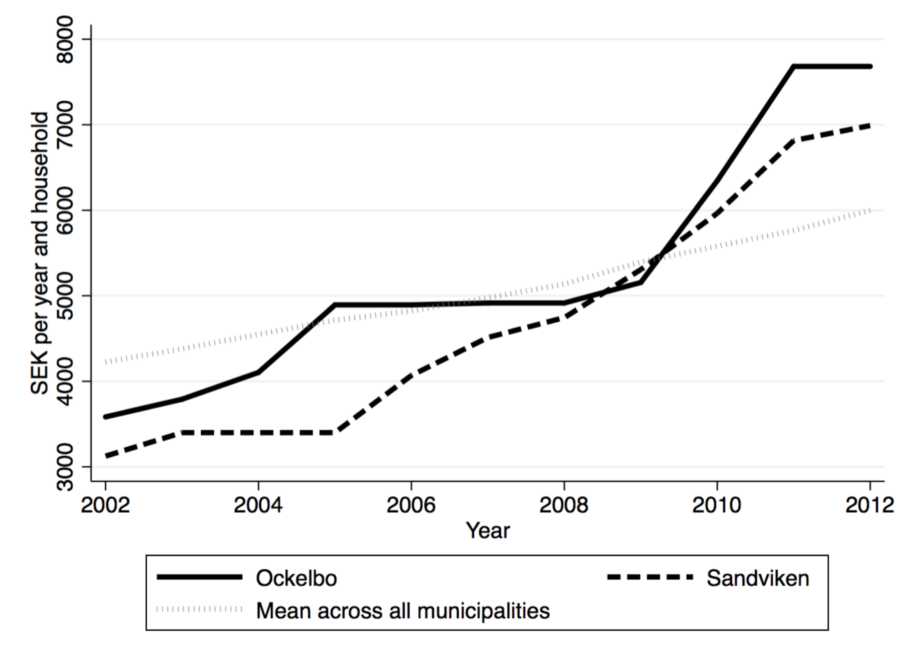

Figure 1: Trends in water prices for a typical household

Note: This table depicts time trends in the water price for the two neighboring municipalities Ockelbo and Sandviken, as well as the mean across all 288 municipalities in the sample. The unit of measurement is the total cost (fixed plus variable cost) in SEK for a typical stand-alone house consuming 150 m^3 per year.

ture and discusses some theoretical predictions, section three describes the institutional framework and the data, section four presents the model, section five presents the results, section six provides a further discussion on the underlying mechanisms and implications for efficiency, and section seven concludes.

2 Related literature

What predictions can be made based on previous literature? The strategic interactions between local governments can be divided into two broad categories: "spillover models" and "resource flow models".[1] In the spillover framework each jurisdiction chooses the level of a decision variable, but the jurisdiction is also affected by decisions elsewhere (without triggering any physical flows of goods, residents or capital across borders). The resource flow model, on the other hand, recognizes that policy makers adjust their policy decisions

[1]For a more thorough review of these models, see Brueckner (2003); Revelli (2005).

in order to attract certain residents or capital to the jurisdiction, or to attract cross-border shopping. While it is true that water prices in theory could be an important determinant for the location of water intensive industries, 94 percent of the water used in industrial production is extracted from water sources owned by the firms themselves (Statistics-Sweden, 2013). Regarding migration flows, water prices are likely to affect the choice of living only on the margin. Water prices have a much smaller impact on the regular household's budget than other policies that differ between municipalities, such as local income tax rates. Hence, spillover models are more relevant in the present setting.

Yardstick competition is an example of a model in which spillovers help citizens to judge the performance of their government. The studies most closely related to the present one are Klien (2015) and Söderberg and Tanaka (2012).[2] Klien investigates yardstick competition among Austrian water utilities using a panel data set covering 2000-2009. He finds some evidence of yardstick competition, but since utilities are free to set their own prices, nothing can be said about the utilities' regulatory compliance. Söderberg and Tanaka study price setting in the Swedish unregulated district heating sector using cross-sectional data from 2004. They find that privately owned utilities mimic the prices of their publicly owned neighbors, since the privately owned utilities are threatened by customer complaints that may lead to retaliations from local elected officials (publicly owned utilities are assumed to set prices to maximize social welfare).

A related strand of literature examines yardstick competition in the provision of social services and tax rates. For instance, Solé-Ollé (2003) finds evidence of yardstick competition in tax rates among Spanish municipalities. He also finds a positive relation between tax mimicking and a low electoral margin, suggesting that politicians facing a higher risk of being voted out of office are relatively more prone to mimic their neighbors. Allers and Elhorst (2005) find a similar result using Dutch data. In another study, Revelli (2006) finds evidence of yardstick competition in the social service provision of UK local

[2]As discussed in the introduction, these markets are not subject to a c-o-s regulation. Still, it should be noted that in none of these markets utilities are completely free to set their own prices. The Austrian utilities are not allowed to set prices that exceed twice the total cost of production. However, Klien (2015) notes that "...price setting appears very ad-hoc and discretionary..." (p.6) and that "...the Austrian water sector...is characterized by the absence of a regulator..." (p.6) Similarly, the Swedish market for district heating is in theory regulated by a specific district heating law. But this regulation does not cover price setting per se, so the market may be characterized as unregulated, as argued by Konkurrensverket (2013).

authorities. Other studies try to instead examine yardstick competition in the productive efficiency of local governments directly. For instance, Revelli and Tovmo (2007) find evidence of yardstick competition in the productive efficiency of Norwegian municipalities. Geys (2006) does the same for Flemish local governments, and uses the ratio of tax revenues to the quantity of locally provided public goods as the decision variable. With respect to the decision variable, the two latter studies lie closest to the present study since water prices are expressed in terms of price over quantity directly. Another related study is Francese et al. (2012), finding spatial dependence in the incidence of caesarean sections among Italian regions, where the frequency of caesarean sections is interpreted as a proxy for inefficiency in the health care sector in general. However, in their setting spatial dependence is instead found to be *negative*. This relationship may arise in settings where the decision variable is a strategic substitute to neighbors' policies: for a given caesarean rate in neighboring regions, there is an incentive for regional governments to reduce their use in order to signal to their citizens their commitment towards spending efficiency.

For fundamental insights in the strategic interactions between the regulator and the firm under asymmetric information, see Laffont and Tirole (1993). For instance, they describe how a c-o-s regulation may lead to over investment, lack of incentives to reduce costs and subsequent distorted prices.

3 Institutional background and data

3.1 The Swedish water sector

The Swedish public sector has three layers of government: national, county, and municipal. The local units are responsible for the provision of important welfare services. The municipalities supply education, child care, social assistance, and care for the elderly, while medical care and public transport are organized at the county level. Municipalities have the constitutional right of self-government. The degree of autonomy refers both to the right to decide on the provision of public services and the right to set income tax rates. The income tax is also the municipalities' main source of income. For a long time, the municipalities have also been responsible for the provision of water- and sewerage services, electricity distribution, and district heating. Due to the privatization wave in the 1990s, the electricity distribution and district heating sectors are now a mix of public and private ownership. Water provision is still the legal responsibility of the municipalities. About 30 percent of the municipalities operate parts their water systems jointly with their neighbors, either by outsourcing the operation to the same private firm, or through a common publicly owned utility. Each municipality still owns the pipes and the treatment plants within its borders, and prices are set individually by the ruling coalition in each municipality. However, since these municipalities are likely to exhibit a higher degree of spatially correlated unobserved cost-shocks than other municipalities, I provide robustness tests to reassure that these municipalities are not driving the results.

The pricing of water provision is regulated by law, stating that "The fees must not exceed what is necessary to cover the costs necessary to organize and operate the water facilities" (excerpt from the Swedish Water and Sewage Act (SCS, 2013), freely translated from Swedish). The Water and Sewage Act follows the traditional Swedish legal principle stating that publicly owned utilities are not allowed to make profits (*självkostnadsprincipen*). A noteworthy addendum is found in 29 §, in which the legislator distinguishes between connection fees and user fees. The connection fees should be set to cover the costs of connecting a new property to the system, and the user fees should be set to cover the operating costs of the water facilities. The present study will focus on the user fees, although in theory one could instead have chosen to study the connection fees. However, since the user fees change more frequently than the connection fees, user fees are better suited to estimate a fixed effects model. There is no official regulatory supervisor, but the Swedish Water Supply and Sewage Tribunal adjudicate legal disputes relating to water supply and sewerage. Complaints occur on a relatively frequent basis, and there are several cases where residential consumers have initiated complaints that have led to price revisions (SWSST, 2013). In at least one recent case, customers have based their complaint on the difference in price compared to a neighboring region. The Water Supply and Sewage Tribunal found that the price discrimination was illegal, and prices were revised. Specifically, this case was concerned with price discrimination within a municipality. Municipalities are only allowed to price discriminate between geographical regions if it can be justified

Table 1: Descriptive statistics

Variable	Mean	Std. Dev.	Min.	Max.	Obs.
Dependent variable					
Water price	5050	1281	2015	9745	3168
Cost factors					
Single-family houses	6913	6180	517	54840	3168
Apartment buildings	8398	27303	151	405452	3168
Population	31598	62128	2420	880008	3168
Wage	21560	692	20100	24500	243
Purification plants	15	13	0	71	243
Pipeline length	264	243	16	2157	243
Capacity utilization	8	7	0	62	243
Connected residents	30246	67445	1200	850100	243
Investment	12812	37272	-9879	475000	243
Other factors					
Extraordinary gain (net)	3168	39130	-1071406	1341354	3168
Government grant	190278	295530	-1199547	3975628	3168
Tax base	5152	11571	302	195528	3168
Municipality surplus	51897	303241	-3756467	8722432	3168
Leftwing	0.47	0.49	0	1	3168

Note: This table shows descriptive statistics of each variable. For a detailed description of each variable and its source, see Figure A2.

by differences in the costs of water provision.

3.2 Data

The data set consists of 288 Swedish municipalities during 2002-2012.[3] Some variables are only available for 2004, and only for 243 of the municipalities. Therefore, the fixed effects estimates are also complemented by cross-sectional estimates. Table 1 shows descriptive statistics for each variable, and Figure A2 shows detailed descriptions of the variables including data sources.

The main variable of interest is “Water price”which is defined as the total cost for water- and sewerage services paid by a typical single-family house consuming 150 m^3 water each year. It is constructed as a a two-part tariff. For a typical household, the fixed part accounts for 43 percent of the total cost of the water service (the standard deviation of

[3]In total there are 290 municipalities. Huddinge municipality has been excluded due to missing data on water prices, and Knivsta municipality has been excluded since it was formed in 2003 (Knivsta was earlier a part of Uppsala municipality).

this figure is 11 percent). Figure 2 depicts a map illustrating the dependent variable for the year 2012, and Figure A1 shows a density plot of the dependent variable for the whole sample. Moran's I [4] for the dependent variable is 0.24 (the raw correlation between the own and neighbors' price is 0.46).

The independent variables can be divided into two groups. The first group contains cost factors. The included cost factors are the number of single-family houses, number of apartment buildings, population, the average wage for a public servant, the number of purification plants, pipeline length, capacity utilization (expressed as m^3 of delivered water per meter of pipeline), number of residents connected to the water system, and investments. The last six of these variables are only available for the year 2004.

The second group contains variables that are not directly related to costs. These variables could influence the price if water provision is partly subsidized by tax money, surplus from other municipality-owned firms, or government grants. The first variables consist of accounting data from the municipalities. Extraordinary gain (net of loss) is income not included in the regular activities of the municipality. Examples include the sale of shares and other fixed assets, and extraordinary depreciation. Extraordinary gain could prevent politicians from raising prices, so the expected sign is negative. To avoid reverse causality, this variable has been lagged by one year. Government grants constitute an extra income for the municipality, so the expected sign is negative. The expected sign for the municipality surplus is negative, since economic problems could be partly compensated for by raising prices and vice versa. This variable has also been lagged by one year, since the municipality surplus also includes the surplus from the water utility. Income taxes are the municipalities' only source of tax revenues. Tax rates are always proportional, so the tax base is computed by dividing the tax revenues by the tax rate. The expected sign is negative, since increased tax revenues leads to a stronger financial situation for the municipalities. Last, I also include a dummy variable indicating the political affiliation of the ruling coalition. This variable takes the value one if the Social Democrats or the Left Party are members of the ruling coalition. The expected sign is ambiguous.

[4] Moran's I is a measure of spatial autocorrelation, see Moran (1950) for a technical discussion.

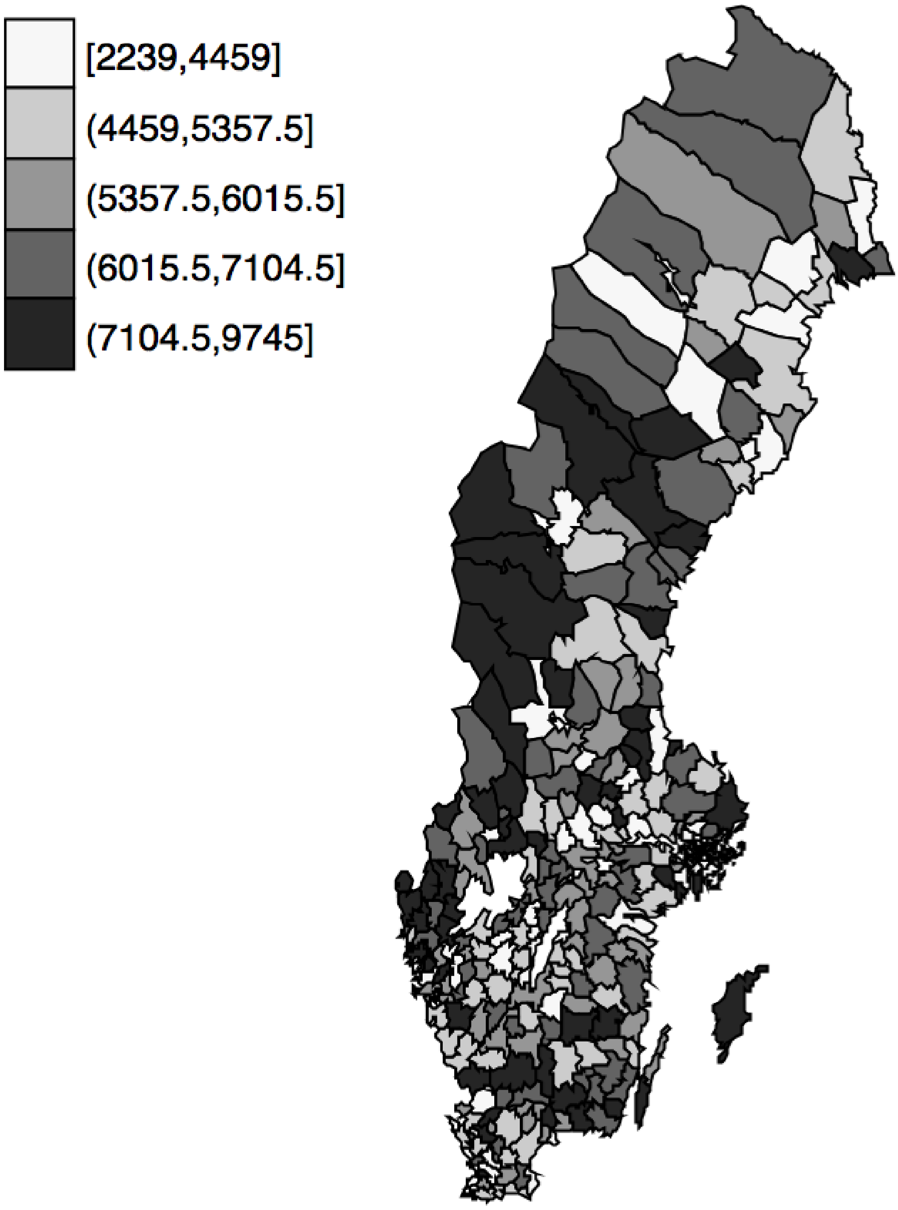

Figure 2: Water price in 2012

Note: This figure depicts the water price in SEK. It is the total cost (fixed plus variable cost) of water in 2012 for a typical stand-alone house consuming 150 m^3 per year. The lowest cost is 2,239 SEK, the highest cost is 9,745 SEK and the median cost is 5,735 SEK. Darker shading represents a higher price.

4 The model

4.1 The fixed effects model

Even though the control variables should reflect the relevant cost factors as well as other potential determinants of the water price, there may be spatially correlated time-varying omitted variables. I estimate two main models to control for such correlation, referred to as the *spatial mixed model* and the *spatial Durbin model*.

Intuitively, the identifying assumption of the Durbin model is that the omitted variables follow the same spatial structure as the included control variables. By exploiting the spatial correlation in the observed variables, the spatial dependence in the water price is identified. *Ceteris paribus*, the estimated spatial dependence in the water price will be high if the spatial correlation in the observed control variables is low. For technical details, see Anselin (1980). The mixed model, on the other hand, makes no precise assumptions about the spatial structure of the omitted variables other than that they are responsible for any linear spatial correlation in the error term. The mixed model nests the spatially autoregressive model ("SAR") and the spatial error model ("SEM"). The SAR is the most "naive" model, since it only assumes spatial dependence in the dependent variable. Conversely, the SEM model only assumes spatial dependence in the error term. LeSage and Pace (2009) show that the mixed model suffers from identification issues if the control variables do not make a material contribution towards explaining the variation in the dependent variable. Therefore, they argue that the Durbin model should be used as a general benchmark. Then, the researcher should test models against each other using nested hypothesis testing. I follow this procedure, and also estimate the SAR and SEM models separately to see how coefficients differ in comparison to their corresponding coefficients in the mixed model.

Formally, the models can be expressed as:

$$p_{it} = \alpha + \mathbf{y}_{\mathrm{t}} + \mathbf{m}_i + \mathbf{X}_{it}\boldsymbol{\beta} + \rho\mathbf{W}_i\boldsymbol{p}_t + u_{it} \qquad (SAR) \tag{1}$$

$$p_{it} = \alpha + \mathbf{y}_{\mathrm{t}} + \mathbf{m}_i + \mathbf{X}_{it}\boldsymbol{\beta} + \lambda\mathbf{W}_i\boldsymbol{\eta}_t + u_{it} \qquad (SEM) \tag{2}$$

$$p_{it} = \alpha + \mathbf{y}_{\mathrm{t}} + \mathbf{m}_i + \mathbf{X}_{it}\boldsymbol{\beta} + \rho\mathbf{W}_i\boldsymbol{p}_t + \lambda\mathbf{W}_i\boldsymbol{\eta}_t + u_{it} \qquad (Mixed) \tag{3}$$

$$p_{it} = \alpha + \mathbf{y}_{\mathrm{t}} + \mathbf{m}_i + \mathbf{X}_{it}\boldsymbol{\beta} + \rho\mathbf{W}_i\boldsymbol{p}_t + \mathbf{W}_i\mathbf{X}_{it}\boldsymbol{\gamma} + u_{it} \qquad (Durbin) \tag{4}$$

Where p_{it} is the water price in municipality i in year t, α is a constant, and $\mathbf{y}_t$ and $\mathbf{m}_i$ are year and municipality fixed effects. $\mathbf{X}_{it}$ is a matrix of time-variant control variables with its corresponding coefficient vector $\boldsymbol{\beta}$. The coefficient of interest is ρ, which determines the spatial dependence in the water price. $\mathbf{W}_i$ is a municipality-specific vector of spatial weights, and u_{it} is the error term. The coefficient λ determines the spatial dependence in the error term in the SEM and mixed models. The coefficient vector $\boldsymbol{\gamma}$ determines the spatial dependence in the control variables. The notation is similar across models, even though the models are somewhat different. This is common practice in spatial econometrics, and the notation follows that of LeSage and Pace (2009).

The entries in the symmetric spatial weights matrix $\mathbf{W}$ are:

$$w_{ij} = \begin{cases} \frac{1}{d_{ij}} & \text{If } j \text{ is a neighbor of } i \\ 0 & \text{Otherwise} \end{cases}$$

Where d_{ij} is the normalized distance between municipalities i and j. Normalization implies that all rows sum to one. This means that even in regions where municipalities' areas are large, the impact of neighbors' prices is assumed to be of the same magnitude as for regions where municipalities' areas are small. Distance is calculated based on the coordinates of the municipal office in each municipality, which is usually located in the most densely populated area. For each municipality, neighbors are defined as the ten nearest municipalities. Since **W** is symmetric, OLS estimates of ρ suffer from a mechanical simultaneity bias (see Azomahou and Lahatte (2000) for a formal proof). Therefore, a maximum likelihood approach is used. Technical details of the estimation procedure are provided by LeSage and Pace (2009)[5]. All variables are logged, and standard errors are clustered by municipality.

4.2 The cross-sectional model

For the cross-sectional data to provide valid estimates, it is necessary that the covariates capture all price determinants, including the time-invariant ones. Therefore, these estimates should be interpreted with care. Still, it is of interest to see how much of the price variation that can be explained by data on the technical characteristics that only are available for 2004. In the cross-sectional estimates I drop the population variable, since it is merely a proxy for the number of residents connected to the water system (the cross-sectional Pearson correlation with the number of residents is around 0.98). The tax base is also highly correlated with the number of connected residents, but since the tax base is a measure of the financial strength of the residents, I keep it in the main estimation.

4.3 Robustness and placebo tests

I conduct two types of robustness tests. First, I estimate the models using alternative specifications of the spatial weight matrix. Second, I estimate the SAR model using an IV-approach.

When constructing the alternative weight matrices, I first vary the number of neighbors in **W** between five and fifteen, since it is impossible to know exactly where the appropriate cutoff point should be. Then, I construct a row-standardized, binary matrix where entry

[5]The models are estimated using Stata's *xsmle* command, which is described by Belotti et al. (2013). Coordinates of the municipal offices have been obtained using Stata's *geocode* command, which is described by Ozimek and Miles (2012).

ij equals unity if municipality i and j share a common border. The matrix is then row-standardized. Last, I construct a "no cooperation" matrix based on the main ten-neighbor specification, but where entry ij is zero if the utilities in municipalities i and j engaged in any type of cooperation within the sample period. This applies to about 30 percent of all utilities in the sample. The resulting matrix is then row-standardized.

Even with a correctly specified spatial weight matrix, the Durbin model may not provide a complete fix for omitted variables. What about the existence of cost factors that have a higher degree of spatial correlation than the included ones? For example, the availability of water could constitute such a cost shock. In the case of a drought or water contamination in one location, nearby regions are also bound to be affected. Therefore, as a complement to the Durbin model I also estimate the SAR model using an instrumental-variable approach. I use neighbors' prices during the preceding year as instruments for neighbors' current prices. The exclusion restriction is then that any correlation between the own price and neighbors' past prices must go through neighbors' current prices. Thus, it is important to note that if municipalities base their price revisions on neighbors' *past* prices rather than the current ones, the exclusion restriction is violated. For the cross-sectional estimates, I instead employ the generalized spatial two-stage least squares estimator proposed by Kelejian and Prucha (1998). The idea is to instrument for neighbors' prices using neighbors' characteristics (as opposed to the Durbin model, where neighbors' characteristics are included directly in the regression). The exogeneity assumption is that any correlation between neighbors' characteristics and the own price must go through neighbors' price (conditional on the own characteristics). [6]

As a placebo test, I estimate the Durbin model using a ten-neighbor spatial weight matrix, but assign neighbors according to alphabetical proximity by sorting the rows of the original weight matrix in alphabetical order.

[6] The estimator has been implemented using Stata's *spreg* command, which is described in detail by Drukker et al. (2013).

5 Results

5.1 Results from the fixed effects model

Results from the main specification are presented in Table 2. For reference, the first column displays the OLS results. The OLS estimate of $\hat{\rho}$ (i.e. the spatial dependence in the water price) is 0.29, and since it is upward biased by construction any higher estimate should be questioned. In the other specifications, $\hat{\rho}$ ranges between 0.14-0.17. The interpretation is that if my neighbors raise their price by on average 10 percent (weighted by their relative inverse distances), the own price will increase by 1.4-1.7 percent. Thus, the effect is relatively modest but still economically significant. It is statistically significant in all specifications except for the mixed model, which is likely due to the identification issues discussed above. Wald tests show that the Durbin model is preferred over the SAR and SEM models, so for the remaining part I will discuss results from the Durbin model.[7]

The only cost factor that has a statistically significant impact on price is population, with a coefficient of -0.16. The interpretation is that a ten percent increase in the population is associated with a 1.6 percent decrease in the water price. Given that population is a good proxy for population density, the result indicates that higher capacity utilization is associated with lower costs. The reason why the number of apartment buildings or single family houses have no significant impact on the price could be due to the connection fee, which in theory should finance the cost of connecting new properties to the network. It is also due to a relatively small within-municipality variation in these variables. Moving to the variables reflecting the financial situation of the municipality, the tax base has the expected sign, with a coefficient of -0.13, although the effect is not statistically significant. However, it is worth noting that some of the effect may be picked up by the population variable, due to multicollinearity. The rest of the coefficients related to the financial

[7]Since the SAR model is nested within the Durbin model, the first procedure is to test the null hypothesis $\hat{\gamma}$=0, i.e., that all coefficients on the spatially lagged independent variables in the Durbin model are zero. The p-value is 0.035, so the null hypothesis is rejected. Further, even if the Mixed model provides no statistically significant results on the presence of autocorrelation, Wald tests indicate that there is a stronger case for spatial dependence in the dependent variable than in the error term: Since the mixed model nests both the SAR and the SEM models, the procedure is to first test the restriction $\hat{\rho}$=0, which yields a p-value of 0.16. When instead testing the restriction $\hat{\lambda}$=0 the p-value is 0.97.

Table 2: Fixed effects estimates. Dependent variable: Water price

	OLS	SAR	SEM	Mixed	Durbin
$\hat{\rho}$ (W $\times$ Water price)	0.29**	0.17***		0.18	0.14***
$\hat{\lambda}$ (W $\times$ Error term)			0.17***	-0.0058	
Population	-0.28**	-0.23	-0.25	-0.23*	-0.16*
Apartment houses	0.022	0.020	0.019	0.020	0.010
Single-family houses	0.097	0.084	0.074	0.084	-0.0055
Tax base	-0.11	-0.11	-0.12	-0.11	-0.13
Extraordinary gain	0.0034***	0.0030***	0.0024***	0.0030***	0.0032***
Government grant	-0.0086***	-0.0086***	-0.0085***	-0.0086***	-0.0082***
Municipality surplus	0.0013**	0.0010*	0.00060	0.0010	0.0012*
Lefwing	0.0069	0.0062	0.0058	0.0062	0.0055
W $\times$ Apartment house					0.063
W $\times$ Single-family house					0.25**
W $\times$ Population					-0.27
W $\times$ Tax base					0.044
W $\times$ Extraordinary gain					0.019***
W $\times$ Government grant					-0.0026
W $\times$ Municipality surplus					0.014*
W $\times$ Leftwing					0.012
Log lik.	5312	5327	5325	5327	5345
Observations	3168	3168	3168	3168	3168

* $p < .10$, ** $p < 0.05$, *** $p < 0.01$

Note: Panel model estimates using data from 2002-2012. All variables have been logged. Year- and municipality fixed effects are included in all models. Standard errors are clustered on the municipality level.

situation of the municipalities are statistically, but not economically, significant. Finally, the political affiliation of the ruling coalition has no economically or statistically significant effect on the price.

5.2 Results from the cross-sectional model

Results from the cross-sectional specification are presented in Table 3. Estimates of $\hat{\rho}$ are consistently higher than in the panel estimates, ranging between 0.24-0.32. The OLS estimate is 0.46, i.e. about twice as large compared to the Durbin model. All estimates are significant on the 10 percent level or lower. Unlike in the fixed effects model, the covariates can now explain a substantial part of the variation in the data, and the SAR model cannot be rejected in favor of the Durbin model.[8] Moreover, since several of the cost factors have statistically and economically significant effects on the dependent variable, the mixed model is identified. We also see that $\hat{\lambda}$ is both statistically and economically insignificant, suggesting that spatial correlation in the error term is not an issue. However, since the Durbin model provides a more conservative estimate I will mainly comment on the results from this model.

Several of the covariates have a non-trivial impact on the price. A ten percent increase in pipeline length leads to a 1.1 percent decrease in the price. This indicates returns to scale, which previously has been documented in the water sector for other countries (Nauges and Berg, 2008; Mizutani and Urakami, 2001). The technical variable that has the strongest impact is capacity utilization (i.e. amount of water delivered per meter pipeline). If capacity utilization increases ten percent, price drops by almost two percent. This confirms results from the panel estimates, given that the "population" variable in the panel data is a good proxy for the amount of delivered water. The coefficient on the number of connected residents is also negative, which is expected as it is also an indicator of returns to scale. However, since pipeline length and the number of connected residents are highly correlated, the relative sizes of these coefficients should be interpreted with care. As expected, the number of purification plants has a positive impact on the price, showing that it is more costly to supply a given amount of water using several plants, although the coefficient is not statistically significant in the Durbin model. Investment cost also has the expected sign. Given that around half of the investments are financed by user fees (and the rest by connection fees), back-of-the-envelope calculations indicate a depreciation time of around 35 years, which seems reasonable. Finally, the mean wage for a civil servant has a large and positive effect on the price, although the precision is low in most specifications.

Of the variables reflecting the financial situation of the municipality, government grant and municipality surplus have statistically significant effects. A ten percent increase in the municipality surplus leads to a one percent decrease in the water price. This result is consistent with the idea that municipalities with good finances transfer surplus from

[8] Testing the null hypothesis $\hat{\gamma}=0$ yields a p-value of 0.24, so there is a relatively high probability that the SAR model is appropriate.

Table 3: Cross-sectional estimates. Dependent variable: Water price

	OLS	SAR	SEM	Mixed	Durbin
$\hat{\rho}$ (W × Water price)	0.46***	0.32***		0.34**	0.24*
$\hat{\lambda}$ (W × Error term)			0.37***	-0.034	
Pipeline length	-0.14***	-0.12***	-0.11***	-0.13***	-0.11***
Capacity utilization	-0.21***	-0.19***	-0.18***	-0.19***	-0.18***
Connected residents	-0.14***	-0.13***	-0.12**	-0.13***	-0.12**
Purification plants	0.029**	0.023*	0.032**	0.022	0.020
Wage	0.23	0.51	0.46	0.52	0.72*
Investment	0.014**	0.013**	0.011**	0.013**	0.013**
Apartment Houses	0.012	-0.0043	0.0079	-0.0056	0.014
Single-family houses	0.026	0.0052	0.00096	0.0061	0.0089
Tax base	0.049	0.079	0.053	0.082	0.043
Extraordinary gain	-0.34	-0.38	-0.43	-0.37	-0.21
Government grant	0.071**	0.085***	0.078**	0.086***	0.074**
Municipality surplus	-0.094***	-0.11***	-0.10***	-0.11***	-0.10***
Leftwing	0.022	0.012	0.012	0.012	0.011
W × Pipeline length					-0.16
W × Capacity utilization					-0.15
W × Connected residents					-0.091
W × Purification plants					-0.045
W × Wage					0.016
W × Investment					0.016
W × Apartment houses					0.15
W × Single-family houses					0.27**
W × Population					-0.53
W × Tax base					0.056
W × Extra income-cost					2.56
W × Government grant					-0.16
W × Municipality surplus					0.15
W ×Leftwing					0.060
Log lik.		167	165	167	172
Observations	243	243	243	243	243

* $p < .10$, ** $p < 0.05$, *** $p < 0.01$

Note: Cross-sectional estimates using data from 2004. All variables have been logged. The dependent variable is water price.

the general budget to the water utilities. Moving to the government grant variable, the coefficient instead has the opposite sign of what would be expected if government grants are used to finance the water utilities, although the economic significance is modest: A ten percent increase in the government grant leads to a 0.7 percent increase in the water price.

5.3 Results from robustness and placebo tests

Results from the robustness and placebo tests are reported in Table 4. When varying the number of neighbors between five and fifteen in the fixed effects model, $\hat{\rho}$ is consistently significant on the 5 percent level, and magnitudes vary between 0.12-0.14. For the cross-sectional model, estimates range between 0.22 and 0.31. The more neighbors are included, the less precise is the estimate, consistent with the notion that price mimicking is stronger among municipalities that are located close to each other. When including thirteen or more neighbors in the weight matrix, coefficients turn insignificant. When using the binary border matrix in the panel model, $\hat{\rho}$ is 0.12 and significant, confirming that results are not too sensitive to the choice of weight matrix. In the cross-sectional model, $\hat{\rho}$ is of the same magnitude as the main ten neighbor specification, but the precision is even higher. When estimating the model using the "no cooperation" matrix in the fixed effects model, the effect is statistically significant although the magnitude is somewhat lower than in the main specification ($\hat{\rho} = 0.1$). In the cross-sectional model, both the precision and the magnitude is comparable to the main result. In the fixed effects model, the IV-estimate (not reported in the table) is in fact greater than the OLS estimate. This indicates that the IV-estimate is biased upwards, likely due to the identifications discussed above. In the cross-sectional model, on the other hand, the effect is comparable to the Durbin model both in terms of precision and magnitude. In contrast to the panel model, there is no apparent reason why the IV-estimate should be biased here. The last row of Table 4 displays the placebo estimates, where municipalities have been sorted in alphabetical order. The coefficient is now negative and significant in both columns, which is somewhat surprising. Therefore, I also conducted 30 placebo tests by instead sorting the municipalities using a random number generator. Then, t-tests of the coefficients could not reject the hypothesis that the mean was in fact zero in both models.

Table 4: Results using alternative neighborhood definitions.

Neighbors	$\hat{\rho}$ (Fixed effects)	$\hat{\rho}$ (Cross-section)
Nearest n neighbors		
5	.116***	.215**
6	.123***	.214**
7	.122***	.305***
8	.128***	.300***
9	.125***	.246**
10	.140***	.237*
11	.135***	.239*
12	.130**	.238*
13	.123**	.209
14	.126**	.221
15	.123**	.210
Bordering	.115***	.231***
No cooperation	.10**	.23**
Random	-.12***	-.24*

* p < .10, ** p< 0.05, *** p< 0.01

Note: Robustness and placebo results. The first ten rows displays estimates of $\hat{\rho}$ when varying the number of neighbors between 5 to 15. The "Bordering" matrix is a binary matrix based on a border sharing criteria, where all neighbors are given the same weight.

6 A further discussion on underlying mechanisms and implications for efficiency

As noted by previous studies, mimicking can be more pronounced in municipalities with a politically unstable leadership, since those politicians face a higher risk of loosing office if voters perceive them as inefficient. To test if this is relevant also in the present setting, I estimate a generalized version of the Durbin model according to

$$p_{it} = \alpha + \mathbf{y}_{\mathrm{t}} + \mathbf{m}_i + \mathbf{X}_{it}\boldsymbol{\beta} + \rho\mathbf{W}_i\boldsymbol{p}_t + \rho_2\mathbf{W}_{2i}\boldsymbol{p}_t + \mathbf{W}_i\mathbf{X}_{it}\boldsymbol{\gamma} + \mathbf{W}_{2i}\mathbf{X}_{it}\boldsymbol{\gamma_2} + u_{it} \quad (5)$$

This specification is identical to the main specification, with the addition of the variables constructed from the second weight matrix $\mathbf{W}_2$. This matrix is an interaction between the original weight matrix $\mathbf{W}$ and a vector identifying municipalities with a politically unstable leadership. The resulting matrix is no longer symmetric, and the entries are:

$$w_{ij} = \begin{cases} \frac{1}{d_{ij}} & \text{If } j \text{ is a neighbor of } i \text{ and } i \text{ is politically unstable} \\ 0 & \text{Otherwise} \end{cases}$$

Where political stability is defined in terms of the voter share of the ruling coalition. In total there were three elections; 2002, 2006, and 2010. All municipalities carry out elections simultaneously, and there are no term limits. As a benchmark, I define a municipality as unstable if the mean voter support of the ruling coalition was 53 percent or less during the sample period. As there is no clear theoretical reason for setting the appropriate cutoff, I also estimate the model using thresholds ranging between 51 and 55 percent. In effect, between 40 and 70 percent of the municipalities are then classified as unstable. The reason why such a large amount of municipalities fall under this category is that 30 percent of the coalitions ruled in minority. This is due to the proportional electoral system, where several small parties often have to be included for the coalition to rule in majority. In the sample, the median number of parties in a coalition is three. Results are depicted in Table 5. Looking at the fixed effects estimates, $\hat{\rho}_2$ is statistically significant and positive all specifications, although the magnitude varies between 0.046 and 0.123 depending on the choice of threshold. The interpretation is that if my neighbors raise prices by on average ten percent, the own price will increase between 0.46 and 1.13 percent *more* in the group consisting of politically unstable municipalities. However, since the effect varies quite a lot depending on the chosen threshold, results should be interpreted with care. Moving to the cross-sectional estimates, we see that $\hat{\rho_2}$ is positive and economically significant under most thresholds (varying between 0.079 and 0.262). However, it is only statistically significant on the ten percent level under the 53 and 54 percent threshold, and insignificant otherwise. This also suggests that politically unstable municipalities are relatively more prone to mimic their neighbors, although results should be interpreted with care due to the lack of precision and high variability in the coefficients.

Table 5: Price mimicking and political stability

	Fixed effects		Cross-section	
Vote share	$\hat{\rho}$	$\hat{\rho}_2$	$\hat{\rho}$	$\hat{\rho}_2$
51	.114***	.074***	.204**	.166
52	.120***	.046*	.194**	.165
53	.108***	.062**	.129	.262*
54	.057	.129***	.135***	.190*
55	.052	.123***	.221*	.079

* p < .10, ** p< 0.05, *** p< 0.01
Note: Table showing the relationship between political stability and price mimicking. Depending on the vote share, about 40-70 percent of the municipalities are defined as unstable.

Another topic that has been overlooked so far is implications for efficiency. While allocative efficiency should be more or less unaffected by yardstick competition due to a highly inelastic demand, there is presumably a positive effect on productive efficiency. One of the main rationales behind yardstick regulation is to incentivize firms to reduce costs, since the prices that firms receive are independent of their own costs. A conjecture is then that informal yardstick competition induces a similar mechanism, since the firms that are able to cut costs more than their neighbors will incur profits. However, an important feature of formal yardstick regulation is that firms have identical cost structures, or that the regulator is able to distinguish differences in cost structures across regions. In the present setting, benchmarks are instead rather arbitrary. In sum, even though informal yardstick competition is a less precise mechanism than formal yardstick regulation, economic reasoning suggests that the presence of informal yardstick competition has a positive effect on productive efficiency.

7 Conclusion

This study provides an empirical test of price mimicking in the pricing decisions of regulated utilities. Using a spatial Durbin model with fixed effects, the elasticity of the own relative to neighbors' average price is estimated to 0.14. Cross-sectional data is also examined, using more detailed data on the technical characteristics of the utilities.

These estimates point towards an even stronger spatial dependence. However, due to the increased risk of misspecification in the absence of fixed effects, results from the cross-sectional sample should be interpreted with care. The presence of price mimicking can be explained in terms of an informal yardstick competition: When consumers use neighboring utilities' prices as benchmarks for costs or as behaviorally based reference prices, politicians are perceived as managing utilities inefficient if deviating too much from neighbors' prices. Just as under formal yardstick regulation, there are incentives to reduce costs. If a utility is able to cut costs relative to its neighbors, only a part of the cost reduction needs to be translated into a lower price. Thus, economic reasoning suggests that the presence of informal yardstick competition has a positive effect on productive efficiency. Further, I find some evidence that price mimicking is strengthened in municipalities where voter support for the ruling coalition is weak. This suggests that politicians facing a higher risk of loosing office are more concerned by reduced voter support if water utilities are perceived as inefficient.

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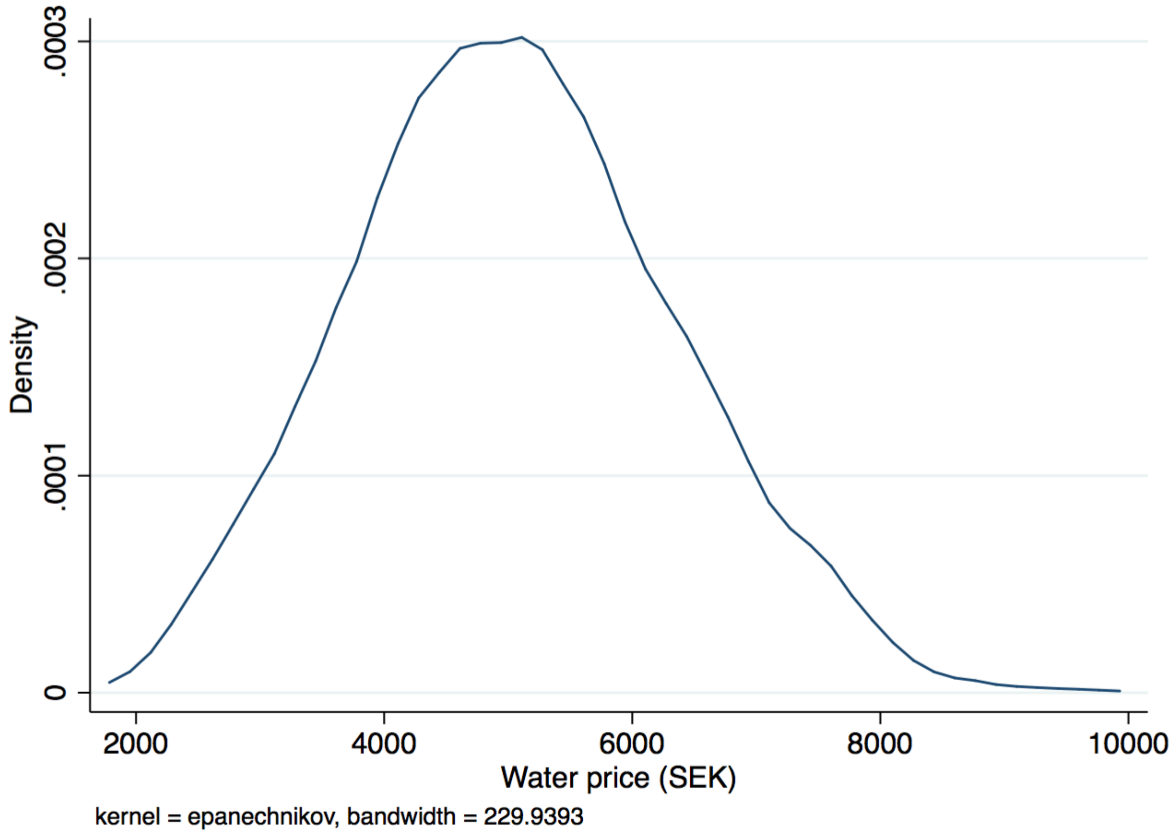
Appendix A

Figure A1: Density plot of the water price



Note: This figure depicts a kernel density plot of the water price for the whole sample, i.e., a total of 3168 observations for 288 municipalities during 2002-2012. The unit of measurement is the total cost (fixed plus variable cost) in SEK for a typical stand-alone house consuming 150 m^3 per year.

Figure A2: Detailed description of the variables

Variable	Description	Measurement	Source
Water price	Yearly cost of water for a stand-alone house with one family consuming 150 m^3 per year.	SEK	VASS
Single-family houses	Nr. of single-family houses.	-	SCB
Apartment houses	Nr. of apartment houses.	-	SCB
Extraordinary loss	Extraordinary cost for the municipality (from the municipalities´ income statements).	SEK (thousands)	SCB
Extraordinary gain	Extraordinary income for the municipality (from the municipalities´ income statements).	SEK (thousands)	SCB
Government grant	Transferred grant from the national government to the municipality.	SEK (thousands)	SCB
Tax base	Tax revenue divided by municipality income tax rate (always proportional). One year lag.	SEK (thousands)	SCB
Population	Nr. of residents.	-	SCB
Municipality surplus	Total surplus of the municipality (from the municipalities´ income statements). One year lag.	SEK (thousands)	SCB
Purification plants	Total nr. of purification plants (both for wastewater, ground water and surface water).	-	VASS
Pipeline length	Total length of pipeline	km	VASS
Capacity utilization	Quantity of delivered water per meter of pipeline.	m^3/m	VASS
Connected residents	Nr. of residents connected to the water system.	-	VASS
Investment	Total investment.	SEK (thousands)	VASS
Wage	Mean monthly wage for a public servant.	SEK	SCB
Leftwing	Takes the value one if the Social Democrats or the Left Party are members of the ruling coalition.	Dummy	SKL

Note: VASS is Vattentjänstbranschens statistisksystem (data has been downloaded from www.vass-statistik.se). SCB is Statistics Sweden (data has been downloaded from www.scb.se). SKL is Sveriges Kommuner och Landsting (data has been downloaded from www.skl.se).