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Stochastic Frontier Analysis of Water Supply Utility of Urban Cities in Bosnia-Herzegovina

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Abstract

Municipalities in Bosnia and Herzegovina (B-H) are responsible for both providing water supply services and maintaining and operating their infrastructure. The municipally owned companies, currently the only ones providing municipal water services, are in a perpetual crisis due to several reasons – the major being the inherited model from the communist period.
The characteristics of the inherited model are prices not covering operating costs, maintenance and investments, low quality standards, and water facilities not protected from potential hazards.

Despite the severe scarcity of data for B-H water sector, given the available data we developed a SFA model, a useful tool in assessing the relative efficiencies of water supply companies as well as for the selection of most critical companies for introducing public-private partnership (PPP) for improving the situation regarding efficiency.

Among the first steps in the efficiency analysis of B-H water operators, this research could serve as a benchmark against which future analysis of water utilities can be measured. Additionally, it provides policy makers with evidence on the water utility efficiency with the aim of focusing on the improvements in managing companies and on rebuilding the water sector infrastructure, beginning with the most inefficient ones to minimize huge water losses.

Keywords

Water, Efficiency, public-private partnership, Bosnia-Herzegovina

1. Introduction

Estimates of the Office of the High Representative and EU Special Representative to B-H reveal that the total investment sum in the water supply and sanitation sector to bring the B-H water services in line with the service level of EU Member Countries amount to around 6.9 billion USD for achieving full compliance with all relevant EU standards through the year 2030.
On its EU way, B-H will be obliged to follow the Directive 2000/60/EC stating that all costs incurred by water utility should be covered by revenues and estimates of relevant investment including forecasts of such investments. This principle of cost recovery for water supply is not understood adequately in B-H and is not included into the legislation for local public authorities.
The purpose of this paper is to highlight the low efficiency of the system and propose a strategy of achieving better results based on measuring the relative efficiency of B-H water utilities.

This paper is intended to deal with the issue of how to assess and improve the efficiency of the B-H water companies. Additionally, it will provide policy-makers and financial institutions with comparable quantitative evidence on the effectiveness of water utilities with the aim of rebuilding the water sector infrastructure components, beginning with the most inefficient municipalities in order to minimize huge water losses.

The paper is organized as follows: the first part is introductory, intended to inform how far B-H is from the fulfilment of the EU water directive. The second part presents the institutional and regulatory background and simple ratio analysis. The third part deals with statistical modelling with the emphasis on SFA. The fourth part applies SFA to available data from the B-H water industry and discusses some striking differences in their efficiency results. Summary and concluding comments are provided in the fifth part.

2. Institutional and regulatory background

In B-H, responsibility for water service provision is decentralised and rests with municipalities. There are about 130 municipal water companies in B-H serving the needs of a population of 3.5 million.

The municipally owned water companies operate as formally autonomous organisations, separated administratively and financially from the municipal government. However, devolution of responsibility to company level is substantially very weak. They are not empowered and enabled to function as efficient service providers. By being obliged on overemployment, artificially depressed tariffs, following political rather than economic criteria in signing up contracts and undertaking investments etc. they spiral costs, accrue losses and weaken quality of service.

Due to the lack of financial resources for investment and maintenance and inefficient water management in most of water companies, water coverage and service quality are unsatisfactory. The water service quality has been deteriorating markedly for at least the last twenty years. More than 23 years after the Dayton Peace Agreement, access to water services has been unacceptably low or unreliable.

Non-revenue water levels in the Balkan countries are highest in Europe ranging from 41.5 (Serbia) to 75.72 percent (B-H), except for Croatia (where they reach 12.32%) (see Figure 1). High level of non-revenue water of 75.72 % for 2007 B-H indicates worn-out water pipe network and poor water supply management.

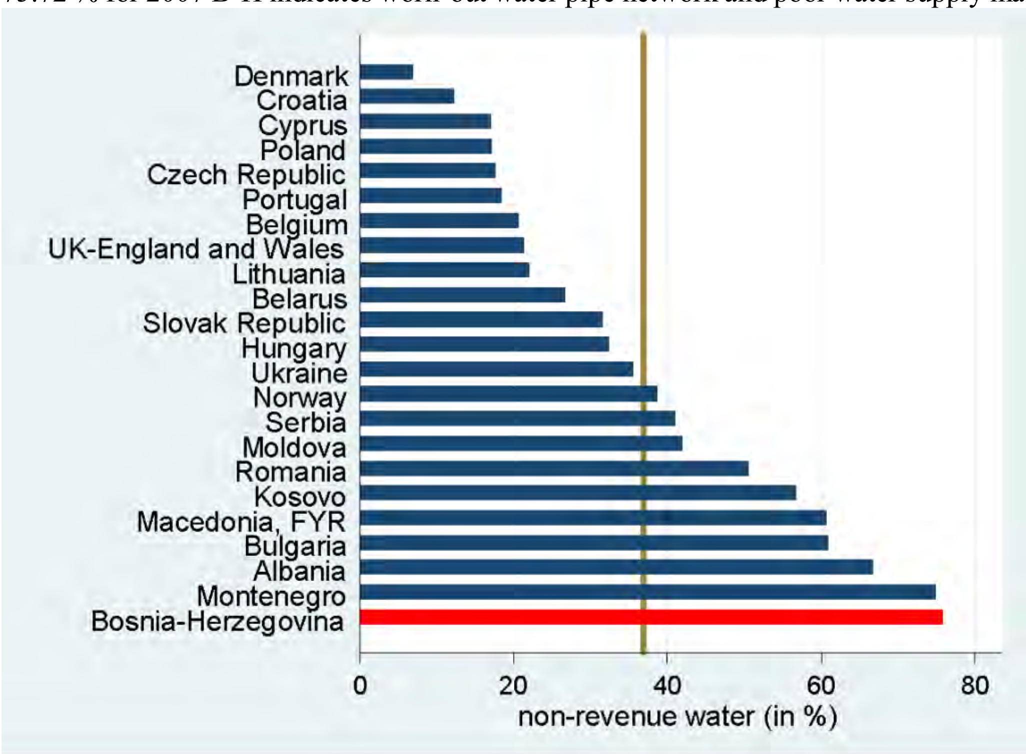

Figure 1: Non-revenue water; European countries, 2015

Bearing in mind the current ranking of B-H, it would be useful to assess properly the relative efficiency of water suppliers with the purpose of finding suppliers with the poorest performance i.e. those contributing most to such a position of B-H. This is of particular importance since the non-water revenues span from 0% (KP Park Mrkonjić Grad AD) up to 75.72% (KJKP ViK d.o.o. Sarajevo). (IBNET, 2018). Therefore some corrective measures such as introducing public-private partnership (PPP) could be introduced with the aim of efficiency improvements and input reductions.

3. Conceptual Framework and Methodology

Since its introduction by Aigner et al. (1977), stochastic frontier estimation has been extensively used to estimate technical efficiency in applied research (Kumbhakar et al, 2014). Among panel data models, which are the main focus in this paper, the inefficiency specification used by Battese and Coelli (1995) and Green (2005) are most frequently used in empirical studies (Kumbhakar et al, 2014).
In a standard panel data model, the focus is mostly on controlling firm effects (heterogeneity due to unobserved time-invariant factors). However, Kumbhakar et al. (2014) introduced a new model which fills several gaps in the standard panel data models by decomposing the time-invariant firm effect and a persistent technical inefficiency effec
The presence of such effects can be justified, for example, by making an argument that there are unobserved time-invariants inputs that are not inefficiency. The model is specified as (Colombi et al. 2014; Kumbhakar et al, 2014)

$$y_{it} = \alpha_0\alpha_0 + f(x_{it}; \text{б}) + \mu_i + \nu_{it} - \eta_i - u_{it} \qquad (1)$$

where μ_i are random firm effects that capture unobserved time-invariant inputs.

The model has four components two of which (η_i and u_{it}) are inefficiency and the other two are firm effects and noise (μ_i and v_{it}). These components appeared in other models in various combinations but not all at the same time in one model. Estimation of the model can be done in a multi-step procedure, for which purpose the model in (1) is rewritten as

$$y_{it} = \alpha_0^*\alpha_0^* + f(x_{it}; \text{б}) + \alpha_i + \varepsilon_{it} \qquad (2)$$

where a $\alpha_0^*\alpha_0^* = \alpha_0\alpha_0 - E(\eta_i) - E(u_{it})$; $\alpha\alpha_i = \mu_i - \eta_i + E(\eta_i)$; and $\varepsilon_{it} = \upsilon_{it} - u_{it} + E(u_{it})$. With this specification α_i and ε_{it} have zero mean and constant variance.

In a nutshell, it is possible to examine whether inefficiency is persistent over time or it is time-varying. The following questions related to the time-invariant individual effects is whether the individual effects represent (persistent) inefficiency, or whether the effects are independent of the inefficiency and capture (persistent) unobserved heterogeneity. Related to this is the question: whether the individual effects are fixed parameters or are realisations of a random variable. Comparing the efficiency of water operators, and recognising operator heterogeneity, it is possible to examine whether there is evidence of efficiency convergence, i.e. whether operators move toward the sector frontier or their relative inefficiencies remain unchanged. It is possible to find out the rate of efficiency change, whether the rate of frontier shift is significantly over time (Kumbhakar et al, 2015).

If the persistent inefficiency component is large for an operator, then it is expected to operate with a relatively high level of inefficiency over time, unless some changes in policy and/or management take place. Thus, the high value of u_i is of more concern form a long-term point of view because of its persistent nature. The advantage of the present specification is that it enables to test the presence of the persistent nature of technical inefficiency without imposing any parametric form of time-dependence. By including time in the x_{it} vector, it is possible to separate exogenous technical change from technical inefficiency. (Kumbhakar et al, 2015).

4. Results from the application of SFA to the B-H water industry

The data is collected from a survey of 130 water suppliers in B-H. The panel data in this case is unbalanced because the number of observations is not the same for each operator, and it spans from six to ten. In addition, the case is considered as a short panel since the number of operators (32) is greater than the number of time periods (10).
We estimated the production frontier for a sample of 32 water suppliers covering the 2000-2009 period.

Table 1 : A Sample Summary Statistics

Variables	Obs	Mean	Std.Dev.	Min	Max
Volume of delivered water (m^3/year)	296	1974548	5494382	4120	33690372
Volume of paid water (m^3/year)	296	934773	1736827	950	10647274
Delivered to households (m^3/year)	296	1512693		3290	27177083
			4410008		
Delivered to commercial consumers (m^3/year)	296	415179		640	6526282
			1116436		
Number of connections	296	6401	11637	162	66618
Number of connections with operating meter	296	5943	11703	14	66285
Household Connections	296	5648	10087	14	57778
Commercial Connections	296	718.9	1570	2	8839
Length of network (km)	296	148.1	189.9	7	1043
Length of main lines (km)	296	45.63	38.61	5	180
Number of employees	296	79.66	186.6	2	1075
Number of employees (in *hours*)	296	83.01	196.9	2	1130
Total salaries (in BAM)	296	1104055	2967563	21340	20488832
Total costs (in BAM)	296	3971942	12377229	73456	73910865
Total electricity costs (in BAM)	296	342639	1070050	2006	6840285
Total chemical costs (in BAM)	296	10167	29767	108	237925

Source: Domljan (2011)

By dropping one by one the statistically insignificant variables whilst ensuring that the model passed a number of other diagnostic tests for panel data it has got

$$\text{Ln(volume of paid water)} = \underset{(5.79)}{4.08} + \underset{(7.92)}{0.79}\ \text{ln(no. hous. connect.)} + \underset{(5.63)}{0.69}\ \text{ln(no. of employees)} \quad (3)$$

where *t*-ratios are given in parentheses.

The model suggests that, at least for this data set, the main production driver (volume of water paid) is the number of residential water connections followed by the number of employees.

As previously mentioned, the B-H water industry suffers from underinvestment. Accordingly, it is not surprising that inclusion of time (T) as a proxy for technological changes the variable T in the equation (3) is not of significant importance in explaining the production function.

Table 3 : Regression model

VARIABLES	(1) Model final
ln(no. household connection)	0.789***
	(0.0996)
ln(no. of employees)	0.694***
	(0.123)
Constant	4.082***
	(0.706)
Observations	296
Number of operators	32
R-squared	0.387

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The logarithmic specification is consistent with a standard multiplicative production function and enables the direct estimation of elasticities. The model appears to be a "good fit" with R^2 = 0.387 (R^2 between = 0.895; R^2-overall = 0.887). All the variables are statistically significant and they have their expected signs. The sum of the coefficients on the two output variables reflects, at a value of 1.48, i.e. the presence of scale economies.

The interpretation of the coefficient of ln (number of household connections) of about 0.79 is that if the number of household water connections (proxy for capital) is increased by 1%, on average, the volume of paid water (m^3 per year) goes up by about 0.79%, holding the number of employees constant. Similarly, holding the number of employees constant, if the number of household water connections increased by 1%, on average, the volume of water paid (m^3 per year) goes up by about 0.69%. Relatively speaking, a percentage increase in the capital input contributes more towards the output than a percentage increase in the labour input (Gujarati, 2015).

Table 4 : Overall, persistent and residual efficiency of the B-H operators

Variables	Obs	Mean	Std. Dev.	Min	Max
TE_R_klh	296	0.8374192	0.0730689	0.5049769	0.9597189
TE-P_klh	296	0.6470689	0.1336849	0.2669283	0.8673154
OTE_klh	296	0.5423738	0.1226274	0.1892366	0.8003429

As illustrated in the Table 4, persistent efficiency is estimated to be 65 percent on average, residual efficiency 84%, and overall efficiency 54%. The average (across operators) of these efficiency measures is plotted over time in Figure 2 (Kumbhakar et at, 2015).

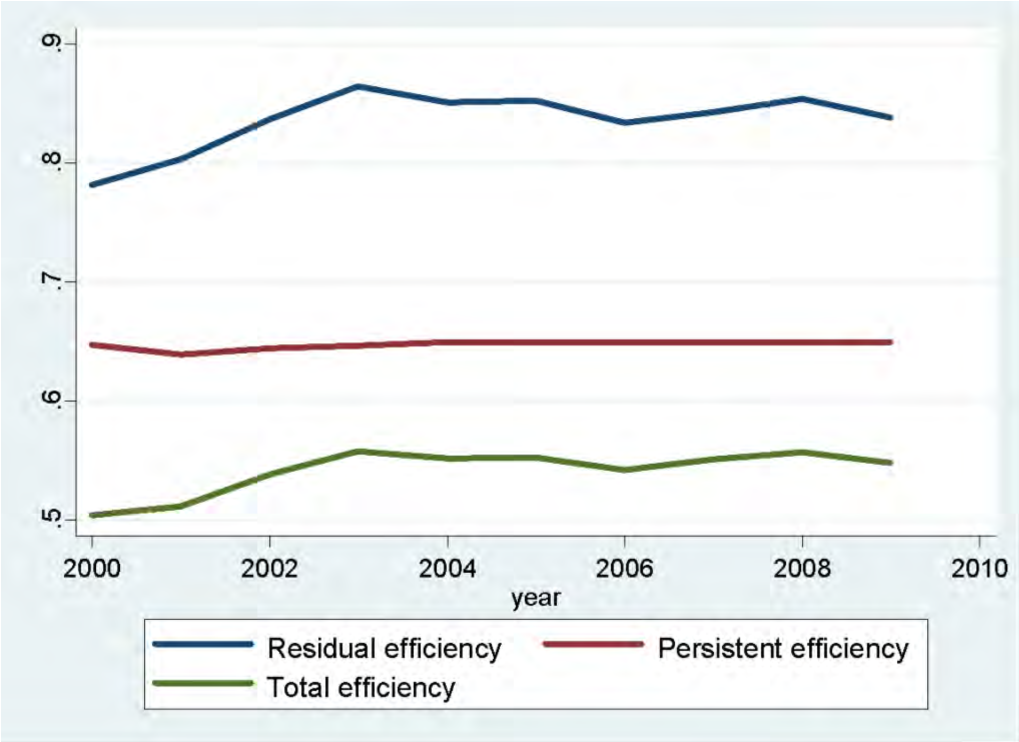

Figure 2: Efficiency of the B-H water operators

5. Proposal of introducing PPP

Bearing in mind that today's market is radically different from those of the1990s (when dominated by the large concession model and a strong interest of private investors to finance projects) or the 2000s (contract terminations and nervousness about the benefits that PPP could bring in the water supply sector) (Rigby Delmon, 2015), two models of PPP in water supply sector seem feasible in B-H (see Table 5).

Table 5: Potential models of private sector involvement in the B-H water sector

	Management contract	Lease/affermage contract
Definition and responsibility of the operator	a private contractor takes responsibility for management services to the utility in return for a fee	a private contractor operate and maintain utility, employ staff, retains revenues from customer tariffs, pays lease fee to the contracting authority
Profit function for operator	Fixed fee+ bonus- managers' salaries and related expenses	Revenue from customers – operating and maintenance costs – lease fee
Asset ownership and capital investment	Public	Public
Commercial risk	Public/private	Public/Private
Repair and renewal of existing system	No	Yes
Operations/maintenance	Private	Private
Contract duration	3-5 years	5-10 years

Source: Adapted from Budds and McGranahan (2003) and Rigby Delmon (2015)

Under a management contract, the municipal authority makes a private contractor responsible for running the distribution system but retains responsible for investment and expansion and employing the workforce. It transfers certain operation and maintenance responsibilities to a private company for three and five years. Remuneration for managing the water service is either fixed in the form of a flat rate or rather performance-related.

Affermage/lease contracts are similar to management contracts, but with a rather important difference: the private sector operator takes responsibility for all operation and maintenance, including billing and revenue collecting. Under this type of contract, a private company is responsible for delivery of water service, and for necessary investments in reparing and renewing the existing assets, while the public authority remains responsible for new investments and for the investments in extensions. Affermage/lease contracts involve private investment in renewing the network, but not in extending the system making fiscal space less of a limitation (Domljan and Domljan, 2010).

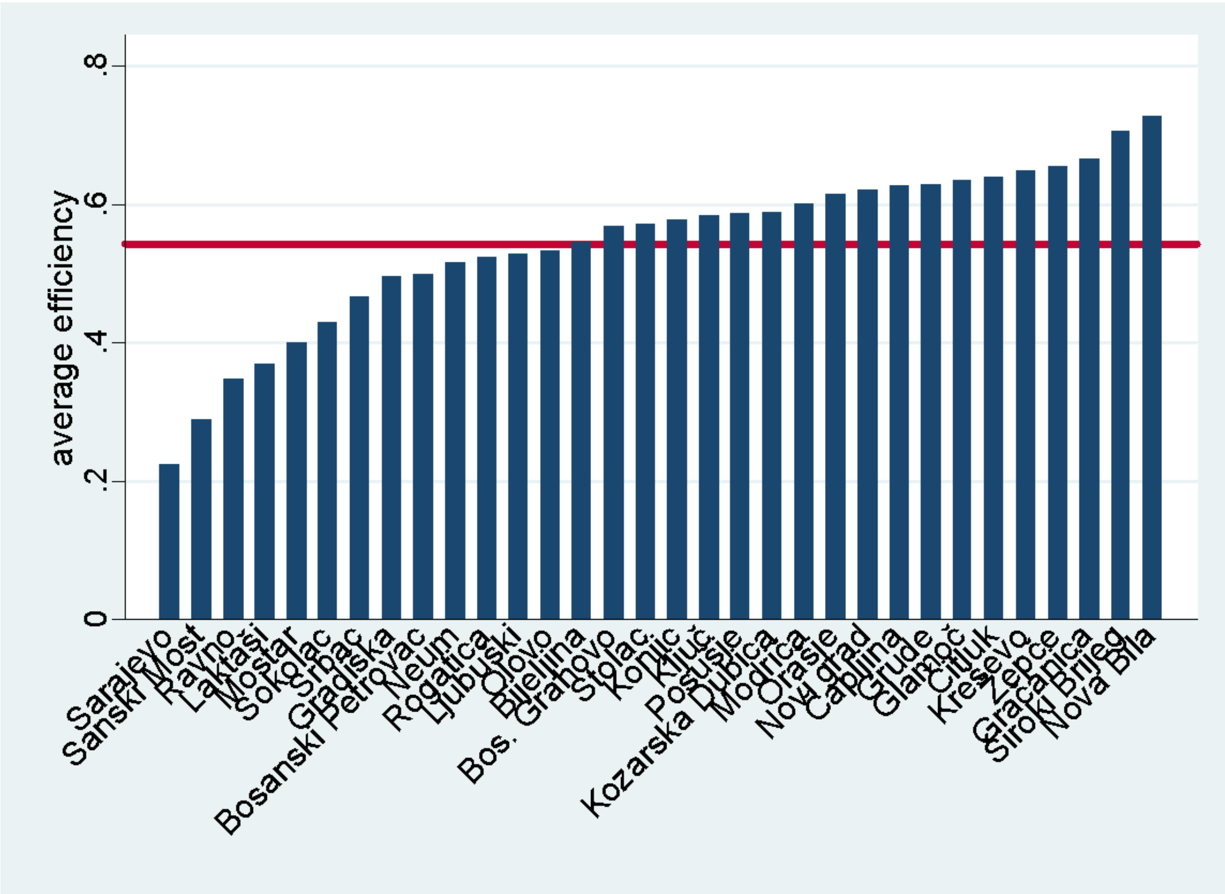

Figure 3: Efficiency of water operators; B-H, 2000-2009

The first candidate for introducing the PPP in B-H should be the least efficient and at the same time the largest operator, KJKP ViK d.o.o. Sarajevo (see Figure 3).

5. Conclusions

The research demonstrated that the B-H policy makers should focus on reforming the water system commencing with the most inefficient operators in order to minimize enormous water losses. A large number of the operators do not seem to be operating at the minimum level of resource input. It is necessary to make radical changes in the water sector in having it closer to the EU acquis communitaire (see the Water Framework Directive).

The B-H small and fragmented i.e. municipally owned and regulated water sector suffers from weak financial strength and lack of qualified and trained staff. A high level of investment in the water system should be undertaken in the years to come to improve the network and to meet more demanding water quality standards. However, municipalities find it difficult to deal with the financial and technical issues posed by water. It seems that the acceptable approach for the B-H would be to employ the two-step approach: first, a short-mid term management contract then a longer-term lease contract with a private operator.

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