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Estimating the Productivity of the Bosnian-Herzegovinian Water Operators

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Abstract. This paper deals with the issue of productivity of municipal water operators in Bosnia-Herzegovina (BIH). It demonstrates that Stochastic Frontier Analysis (SFA) could be a useful tool in assessing productivity and the relative efficiencies of water operators.

The principal aim of this paper is to show that it is worth assessing the productivity improvements that could result from better use of inputs, primarily labor. In spite of severe scarcity of data for the BIH water sector, collected data allowed us to develop a SFA model with a set of inputs (number of connections, number of workers, electrical energy costs and chemical costs) and outputs (water delivered) as required in the water sector empirical literature.

The research could serve as a benchmark against which future quantitative analysis of water operators' productivity can be measured. It could additionally provide policy-makers with comparable quantitative evidence on the functioning of water operators with the aim of regulating them more effectively and improving the performances of one of the most poorly functioning water sectors in Europe.

Keywords: Water Operators, Productivity, Stochastic Frontier Analysis (SFA),

1 Introduction

In BIH, responsibility for water service provision is decentralized and rests within municipalities. There are about 130 municipal water companies in BIH serving the needs of a population of 3.0 million.

There is only one type of ownership and operating in BIH i.e. there are only municipally owned water operators. As in the Communist time and as a legacy from that time, they operate as formally autonomous organizations, separated organizationally, administratively and financially from the municipal authorities. However, since the transfer of responsibilities to operator level is not clear-cut, operators are capable of functioning as productive and efficient providers of services.

By being forced to follow social criteria (and consequently on practicing overemployment and facing depressed tariffs), they amass costs and delay the desperately needed investments on mains and other parts of infrastructure.

Due to the lack of financial resources for maintenance and investments and inefficient water management in most of operators, percentages of water coverage and non-revenue water are unsatisfactory. More than 24 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 the highest in Europe indicating worn-out water pipe networks, weak rule of law and poor water supply management. (see Figure 1).

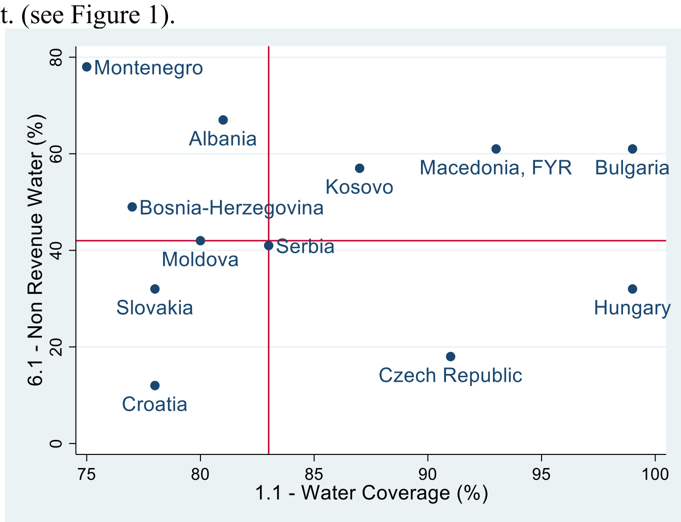

Fig. 1. Non-revenue water and water coverage; BIH and comparators, 2017

Bearing in mind the current ranking of BIH, it would be useful to properly access the productivity of water operators to find out what is behind them in order to improve the relative position of the country by introducing proper policy and regulatory measures.

2 Materials and Methods

This paper focuses on the examination of how productivity of operators has changed over time and decomposing it into its constituent parts. Such analysis can assist in examining the impact of regulation on the functioning of operators. Actually it can contribute to the idea of how to simulate market functioning within a non-market sector by comparing performances of operators and finding out how productive and efficient they are over time.

We examine whether the change in productivity for a particular operator has been driven by improving its relative efficiency, by scale improvement, or by general technological improvement.

We consider a single-output production function, which, with panel data and output-oriented technical inefficiency, is written as:

$$y_{it}=f\,(x_{it},\,t)\,\exp(-u_{it}) \tag{1}$$

where y_{it} is the output of the ith operator (i=1,….N) in period t (t=1,….T), f(.) is the production technology, x_{it} is a vector of J inputs, t is the time trend variable, and $u_{it} \geq 0$ is output-oriented technical inefficiency.

We simply focus on rate of change of output and examine how much of it is driven by (i) rate of changes in inputs, (ii) changes in technology, and (iii) changes in efficiency.

If we start from (1) and differentiate it totally with respect to t, we get

$$\dot{y} = \sum_j \varepsilon_j \dot{x}_j + TC + TEC \qquad (2)$$

where $\dot{y}$ rate of change of output, $\sum_j \varepsilon_j \dot{x}_j$ inputs growth, TC is technical change ($\frac{\delta \ln(.)}{\delta t}$), and TEC is technical efficiency ($-\frac{\delta u}{\delta t}$).

The equation (2) shows that output growth is driven by input growth, that technical change (TC) will affect output positively if there is technical progress, and that technical efficiency (TEC) will affect output positively if technical efficiency improves over time.

3 Results

The first step in our analysis is to estimate a Cobb-Douglas production function. From a statistical viewpoint, it yields a balanced panel of 21 operators but we estimated it as pooled cross section.

By dropping one by one the statistically insignificant variables whilst ensuring that the model passed a number of other diagnostic tests for the dataset we got:

$$lwd = 5.08 + 0.85lc + 0.45lm + 0.09le - .06lch - 0.03t \qquad (3)$$

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 = 0.934. All the variables are statistically significant at 5% and they have their expected signs except for electricity costs. The sum of the coefficients on independent variables reflects, at a value of 1.3, the presence of scale economies (see Table 1).

Table 1. Regression

Variables	Model
lc	0.845***
	(0.0658)
lm	0.451***
	(0.0878)
le	-0.0644**
	(0.0315)

lch	0.0873***
	(0.0135)
t	-0.0268**
	(0.0118)
Constant	5.075***
	(0.404)
Observations	210
R-squared	0.934

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

The dependent variable in the regression model is the volume of water delivered (measured annually in m^3) (w d), and the independent variables are the number of connections (c), the yearly average number of employees (in the hours of work) (m), yearly electrical energy costs in BAM (e), and the yearly chemical costs (in BAM) (ch). In addition, a time variable (t) is included in the model.

In the second step, we estimated the productivity (see Table 2). This is achieved by running a stochastic frontier model (Kumbhakar, Wang and Horncastle, 2015*)*.

Table 2. SFA

Variables	Model
lc	0.844***
	(0.0652)
lm	0.451***
	(0.0866)
le	-0.0645**
	(0.0311)
lch	0.0874***
	(0.0134)
t	-0.0352
	(0.0339)
Constant	5.190***
	(0.538)
Observations	210

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

In the third step, we estimated productivity change and related it to efficiency (see Table 3). In order to derive components of changes in productivity we allow operators to be technically inefficient. (Kumbhakar, Wang and Horncastle, 2015*)*.

Table 3. SFA

Variables	Results
dot_wd	0.009752
TC	-0.03525
input_driven	0.032642
TEC	-0.00806
expl_output	-0.01067
unexpl_output	0.020422
dot_wd	0.009752

This demonstrates, that output growth, of around 1% percent, has been driven by increase in inputs of 3.3 percent, what is offset by reduction in technical progress of 3.6% and technical efficiency of 0.8%.

4 Discussion

The IBNET's Apgar score of 4.8 for the BIH operators is "fairly low". It places them among the worst within the group of comparators countries (small Central and South East European countries).

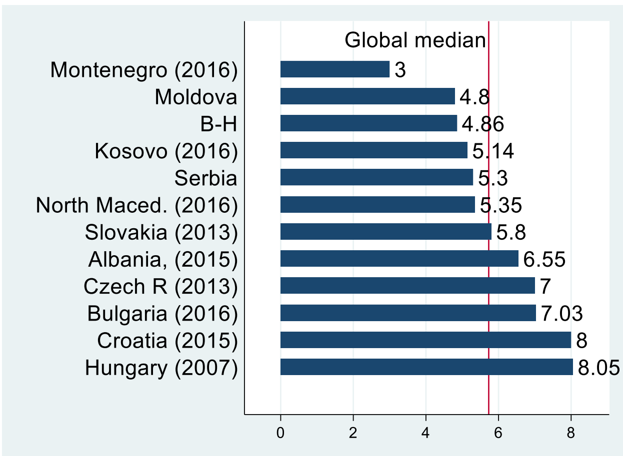

Fig. 2. Apgar score; BIH and comparators, 2017

The score is just below the median score of comparators countries (5.80) but even below the global median score (5.73) (see the Figure 2 at which years in brackets state the latest data available for the respective country, if data for 2017 is not available).

How much certain types of inputs contribute to such a "fairly low" position can be seen in the Table 4.

Table 4. Inputs of water production; BIH and comparators countries, 2017

Countries	13.1 Labor Costs	3.2 Electrical Energy Costs	100.13 Chemical Costs	100.14 - Other Costs
BIH	64	9	1 (2016)	54 (2016)
Albania	41 (2015)	38 (2015)		
Bulgaria	37 (2015)	16 (2015)		
Croatia	39 (2015)	9 (2015)		
Czech R	13 (2013)	7 (2013)		
Hungary	42 (2007)	17 (2007)		
Kosovo	62 (2016)	21 (2016)		3 (2016)
North Macedonia	51 (2016)	8 (2016)		0 (2016)
Moldova	45 (2017)	26 (2017)		
Montenegro	39 (2016)	39 (2016)		
Serbia	48 (2017)	12 (2017)		
Slovakia	32 (2013)	8		
Median-comparators	40.5	16	-	1.5
Median-all countries	36	16	2	5

NB: Years for which the latest data available are stated in brackets.

Source: adapted from IBNET (2019)

As Table 4 shows labor costs of BIH operators amounts for 64 percent of total operational costs. Obviously, there is a mistake in the IBNET databases. To have a total of annual operational costs of 100%, the item o*ther costs* should be reduced to 26 percent of total costs, or alternatively the item *labor costs* should be reduced to 36 percent.

BIH's total annual labor costs, expressed as a percentage of total annual operational costs, of 64% are pretty high in comparison to both the comparators countries and the world, since their respective median values are 40.5 and 36 percent. For instance, that size of the BIH operators' labor costs are in line with the labor costs of Camerun (77%), Dominican Republic (71%), Jordan (65%), Papua New Guinea (64%), Argentina (64%), Kosovo (62%) and Ecuador (61%) (IBNET, 2019).

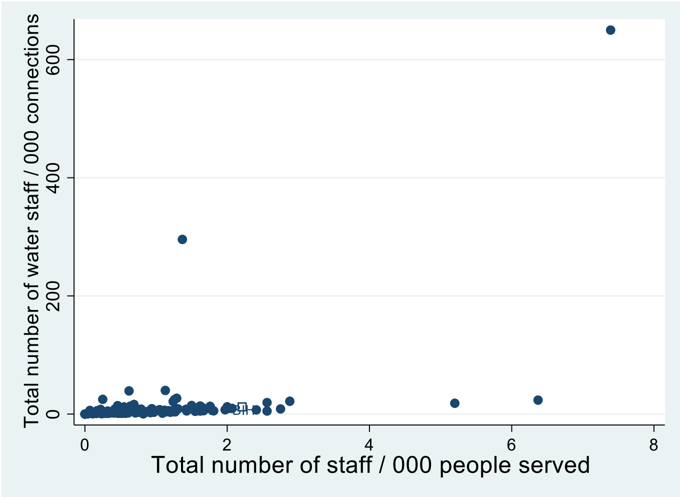

Fig. 3. Staff of water operators; BIH and world, 2017

Figure 3, showing staff productivity of operators, measured as the total number of staff members per 1000 connections (vertical axis) and per 1000 people served (horizontal axis), clearly demonstrates that by both indicators, BIH operators are overstaffed – global median of staff per 1000 connections is 5.12 and per 1000 persons served is 0.74 while BIH's respective medians are 7.24 and 1.97.

According to our dataset - which is not quite comparable with the IBNET dataset, since it relates to the period 2000-2009, and embraces 15% of total number of operators - ratios of respective costs i.e. labor, electrical energy, chemicals and other costs are 37.5, 10.2, 0.2 and 48.0 percent respectively.

In addition, it was not possible to use the length of mains or network length, usually used in the production function as an indicator of capital, since data is missing or is not reliable in the case of many operators. Further, the number of operators was reduced to allow the dataset to establish balance panel data.

Regardless of these and other limitations, we did not expect that technical change would have a negative impact on productivity change. In our view it could stem from the worsening methods in using inputs (disembodied technical change) or alternatively and less likely through the use of quality with worsening quality (embodied technical change) in the respective period. If the former case, it could be due to the replacing of people leaving the sector due to retirement, shifting to other domestic sectors or emigrating abroad with less skillful workers. In addition, there are broadly spread negative comments coming from associations of employers about the worsening quality of employees.

Globally, the water sector is generally characterized by slowly changing technology. In BIH, the R&D expenditure is at a very low level (around 0.15 percent of GDP) and top managers are not appointed by professional but political criteria.

If prices of inputs were available, the estimation of the cost function and an another stochastic frontier model would have been carried out, shedding more light on the issue of technical progress.

5 Conclusions

In this paper we have examined how to estimate productivity and efficiency of Bosnian-Herzegovinian water operators.

In spite of their deficiencies, partial productivity indicators clearly state that BIH operators have weaker performances than their counterparts in comparators countries (small Central and South East European countries) not to mention other European countries.

The research demonstrated that BIH policy makers should focus on reforming the water system by introducing more economic criteria in their operating e.g. introducing benchmarking techniques with the purpose of stimulating the introduction of more innovative activities, particularly in the field of operational processes and organizational changes. Introducing private organizations e.g. through public-private partnership could contribute to the improvement of the currently very weak sector. The IBNET's Apgar score demonstrates that clearly.

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