The Cost Equation of Sewage Services in Romania

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Abstract

The aim of the research is to achieve a multiple linear regression related to the cost of the sewerage service. This cost equation allows us to analyze the effect of changing the cost elements in the tariff structure of sewerage and wastewater treatment, both at the enterprise level and at the level of the national economy. It is a real challenge to shape the effect of changing social policies that have implications on wage, energy and other costs and on the sewerage tariff. The equation was based on data provided by regional water and sewerage operators in Romania for the period 2012-2019. With the help of the resulting multiple linear regression we can predict the level of increase of the sewerage-treatment tariff applied by the regional water and sewerage operators in Romania, as an effect of the changes of the different cost elements. The results of this research can be useful and interesting both for drinking water and sanitation regulators and for researchers.

Key words: water policy, wastewater cost, wastewater tariff, cost ecuation
J.E.L. classification: L95, Q25, M19

1. Introduction

Today, when one of the most important issues worldwide is the pollution of existing resources and the use of renewable resources, there is an increasing emphasis on the resource of drinking water and wastewater treatment. The importance of this theme can be captured by the countless articles in various scientific publications on the subject and the numerous reports by the World Bank and the UN on the subject.

Human activity has a major impact on the water cycle. The quantity and quality of available water stocks is influenced by the quality of wastewater discharged (Meran et ali, 2021). Taking into account the IWA statistics, it can be seen that water and wastewater prices in the world's cities are very low. It is therefore interesting to analyse the relationship between the tariffs applied and the costs of these activities.

Prior to 1990, the issue of efficient use of water resources and efficiency in the drinking water industry was not raised. However, the first steps in this direction have been made in the United States since the 1970s, when they began to study the optimal size of water and sewerage operators and the possibility of achieving economies of scale (Abbott, 2012).

Both in Romania and all over the World Water and sewage utilities have a geographical monopoly. This monopoly requires regulation and public control that replaces a competitive market (Tanner et al., 2018).

As the report by the UK Environment Agency shows demographic and environmental changes are reducing the access and availability of freshwater resources (EA, 2011). We are convinced that this is also true for Romania.

In these circumstances the regulatory and control authorities will demand continuous improvement of the quality and efficiency of water and sewerage services. An aspect of the efficiency of the service can also be measured in the level of costs related to that activity.

When an operator provides more services, then measuring costs and performance becomes more difficult (Torres and Morrison, 2006).

It is very important that the costs generated by public utilities such as water and sewerage services are constantly measured and monitored. Monitoring and control are important because most water and sewerage operators are publicly owned, so they indirectly use public money and operate on a mostly public infrastructure. Public Control can be achieved by means of performance indicators by which these public undertakings are monitored. In the set of performance indicators are usually included, technical indicators, quality of services and some financial indicators such as profit, profitability rate, etc. (Fülöp et al., 2017). Another way of control is to control the costs and tariffs applied by these water and sewage operators.

Analyzing the structure of the sewage tariff at the national level, we can diagnose whether at the level of water and sewage operators there are large deviations from the average per country and we can conclude what are the elements that lead to the increase in the tariff. These elements theoretically can be: expenditure on Energy, personnel, services provided by third parties, depreciation, royalty or the expected profit of the owners (Fülöp and Bakó, 2017).

In this context, it is important to achieve a linear equation on the cost structure of drinking water, with which it is possible to forecast the effects of changes in cost elements on the applied tariff.

In the present research we have made a linear regression on the water tariff and the related costs.

2. Literature review

In the literature, the ways of controlling tariffs in the field of drinking water and sewage sewerage are addressed. The manner in which this control is carried out influences the level of the accepted cost and profit. Today in theory and practice in the field we find two modalities of regulation (control) of the tariff (Reynaud and Thomas, 2013). This control carried out by a regulatory body can be done by regulating the tariff, namely by regulating the maximum rate of return that can be applied tariff formation (Fülöp et al., 2017).

In the practice of different countries both methods are applied with all the advantages and disadvantages that each method presents individually.

Their advantages and disadvantages were very clearly identified in a research conducted by Newbery (1997).

The market for water and sewerage services is a monopolistic market, because of this it can not function effectively without tariff regulation. It cannot be effective because there are no real incentives to make the business more efficient. (Marques and De Witte, 2011).

However, a virtual competition between water and sewerage operators can be created by comparing the performance achieved with the average and best practice (Maziotis et al., 2016).

Virtual competition can be achieved by creating a benchmarking system both nationally and internationally. Such systems exist both nationally and internationally. At the national level it was created and is managed by the A.R.A. (Romanian Water Association), this is a functional benchmarking system that provides very practical data and comparisons for water and sewerage operators in Romania. Internationally there is a project managed by IBNet, which includes countries around the world, but unfortunately their database in 2018 is declining. Its place will probably be taken by the one designed and administered by IWA (International Water Association).

The regulation of the tariff through profitability rate aims to ensure the return on investments made in the water and sewerage activity. The rate of return is applied to the unit cost per m3 of wastewater.

At any major change in the cost structure, the applied tariffs are recalculated by applying at the level of production costs a regulated rate of return (Tariffs in Romania are approved by the ANRSC regulator). In this way, water and sewerage companies have the opportunity to reach the expected levels of profitability (profitability).

The second method of tariff regulation differs significantly from the first method and can be applied for the regulation of tariffs in the field of water and sewerage. When using this regulatory method, the regulatory authority imposes the pre-established conditions under which the water and sewerage tariff can be changed (Alexander and Irwin, 1996).

The alternative of the regulated tariff certainly leads to the efficiency of the water and sewerage activity, but at the same time to the minimization of investments in the field (Fülöp and Bakó, 2017).

It is an interesting fact that today in Romania both methods are applied. The basic method is the one based on profitability rates and appears through the regulation issued (A.N.R.S.C Order no. 65/2007 - Methodology for establishing, adjusting or modifying the prices / tariffs for public water and sewerage services) by the regulatory body A.N.R.S.C. (National Regulatory Authority for Community Public Utility Services) and applies to any sewerage tariff established except those established by financing contracts concluded for the realization of major infrastructure investments in this field. In the case of financing contracts concluded between water and sewerage operators and the Ministry of European Funds through the Large Infrastructure Operational Program (POIM), a tariff regulation is performed. This tariff regulation occurs through the tariff policies included in the financing contracts.

3. Research methodology

Our research is based on the analysis of the specialized literature and the case study. In the research we based on the literature review and as a method of research we used econometric modeling.

The econometric methods are applicable in almost all branches of the applied economy. Whether it is testing an economic theory or it shapes a business decision or a government policy, econometric models are useful and applicable.

Very often in the development of models we do not rely on economic theories, but on intuition, on a primary analysis of economic data, on the basis of which we assume that there are relations of cause and effect between different variables that are specific to the analyzed phenomenon.

For the realization of a econometric analysis, we usually choose an econometric model which we consider to be suitable on the researched phenomenon, without taking into account the details of the creation of the model, because these models have been validated and accepted by mathematical-statistical methods by specialists in this field.

To perform the sewerage tariff analysis we used a model based on a multiple linear regression.

Linear regression analysis is defined as “a statistical technique that can be used to analyze the relationship between a single dependent variable (criterion) and multiple independent variables (predictors)” (Bezerra et al., 2020). Statistical analysis based on multiple linear regression verifies the existence of a strong relationship between a dependent variable and several independent variables (Porto and Philippi, 2018).

In the case study we performed an econometric modeling of the cost of sewage in Romania.

4. Results

As the first step of econometric modeling we statistically analyze the available data and define the variables of the model, as the second step we devise an equation that we consider mathematically shaping the researched phenomenon and as the third step we test the model obtained and formulate conclusions and forecasts based on the model.

The econometric model developed and presented makes possible the analysis of the cost structure in the tariff, in the water and sewerage industry (the service sector) in Romania. Data were collected from 41 of the regional operators over the period 2012-2019 with the help of the Romanian Association of Water and is representative at the level of the sector of national industry, because two regional operators are missing from the database. Linear regression was performed on data from the year 2012-2019.

The econometric model developed is multiple linear regression and can provide a forecast for the dependent variable, which is the avarage water tariff, with the inclusion of independent variables, called predictors.

In terms of the literature, the multiple regression model has the following general formula:

$Y= \beta_0+\beta_1*X_1+\beta_2*X_2+\beta_3*X_3+\beta_4*X_4+\beta_5*X_5+\beta_6*X_6+\beta_7*X_7+\varepsilon$

Where,

Y = The water tariff, the dependent variable (endogenous);

β_0 = the constant parameter;

β_1 up to β_7 = the independent variables, the explanatory or exogenous;

ε = The error variable, interpreted as the residual error that explain the variation of Y due to factors that are not included in the model;

The above model will show a linear relation between the dependent variable and the independent variables. By applying the econometric model, by replacing the values for the independent variables to obtain the value for the dependent variable Y, with the margin of error with an error acceptable.

Our assumptions of the research were the following:

- *H_1: Companies in the water and sewerage sector which increase staff costs per m_3 of sold water will significantly increase the waste water tariff per m_3.*
- *H_2: The companies in the water and sewerage sector where third-party services are grown per m^3 of sold water will significantly increase the waste water tariff per m^3.*
- *H_3: The companies in the water and sewerage sector where electricity costs are increased per m^3 of sold water will significantly increase the waste water tariff per m^3.*
- *H_4: The companies in the water and sewerage sector where the costs of the consumed materials per m^3 of sold water increase will significantly increase the waste water tariff per m^3.*
- *H_5: The companies in the water and sewerage sector where they increase cost with depreciation per m^3 of sold water will significantly increase the waste water tariff per m^3.*
- *H_6: The companies in the water and sewerage sector where they increase cost with depreciation per m^3 of sold water will significantly increase the waste water tariff per m^3.*
- *H_7: The companies in the water and sewerage sector where they increase cost with depreciation per m^3 of sold water will significantly increase the waste water tariff per m^3.*

The data were prepared, following the steps provided in the statistical analysis. It was checked if the data is parametric. Although not all data have a normal distribution, based on the Central Limit Theorem, if the data exceeds 40 positions the data can be considered normal. There were no multidimensional outliers and the correlations between the average sewage tariff and the defined variables were studied.

The dependent variable is the average tariff of water and potential predictors are the following: staff costs per m^3, costs of services provided by third parties per m^3, costs of raw water per m^3, electricity cost per m^3, costs of the consumed materials per m^3, depreciation cost per m^3, royalty costs per m^3.

We have analyzed the correlations between the dependent variable and the above mentioned variables.

In the model on the basis of correlations have been introduced the variables from Table no.1.

Table no. 1 The variables in the model of linear regression

Indicators	**Staff costs per mc**	**Costs with services provided by third parties per mc**	**Electricity costs per mc**	**Material costs per mc**
Pearson Correlation	,698**	,479**	,439**	,476**
Sig. (2-tailed)	,000	,000	,000	,000
N	333	333	332	332
Indicators	**Depreciation costs per mc**	**Royalty costs per mc**	**Maintenance and repair costs per mc**	**Other operating costs per mc**
Pearson Correlation	,388**	,255**	,334**	,185**
Sig. (2-tailed)	,000	,000	,000	,001
N	331	331	328	333

Note: **. The correlation is significant at p<0.01, meaning an estimation error of less than 1%.
*. The correlation is significant at p<0.05, meaning an estimation error of less than 5%.

Source: benchmarking system of the Romanian Water Association - http://h2obenchmark.org/

Summary of the model is presented in Table no.2.

Table no. 2 Model Summary for the dependent variable the average tariff of water

Model	R	R^2	Ajusted R^2	Standard estimation error	Durbin - Watson test result
1	,698[a]	,487	,485	,46171	
2	,770[b]	,593	,591	,41187	
3	,788[c]	,621	,618	,39789	
4	,803[d]	,646	,641	,38558	
5	,812[e]	,660	,654	,37852	
6	,827[f]	,685	,679	,36486	1,791
a. Predictors: (Constant), Staff costs per mc					
b. Predictors: (Constant), Staff costs per mc, Costs with services provided by third parties per mc					
c. Predictors: (Constant), Staff costs per mc, Costs with services provided by third parties per mc, Material costs per mc					
d. Predictors: (Constant), Staff costs per mc, Costs with services provided by third parties per mc, Material costs per mc, Royalty costs per mc					
e. Predictors: (Constant), Staff costs per mc, Costs with services provided by third parties per mc, Material costs per mc, Royalty costs per mc, Maintenance and repair costs per mc					
f. Predictors: (Constant), Staff costs per mc, Costs with services provided by third parties per mc, Material costs per mc, Royalty costs per mc, Maintenance and repair costs per mc, Other operating costs per mc					
g. Dependent Variable: Average waste water tariff					

Source: benchmarking system of the Romanian Water Association - http://h2obenchmark.org/

Since R^2 has the value of 0.685 and the adjusted R^2 has the value close to it, the economotric model is a good model. R^2 shows us that the econometric model explains 68.5% of the cases in the sample.

In the model the variables were introduced one by one and its done the ANOVA analysis, whose results are presented in tables no.3

Table no. 3 ANOVA analysis for the dependent variable the average tariff of water

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	65,588	1	65,588	307,667	,000[b]
	Residual	69,070	324	,213		
	Total	134,659	325			
2	Regression	79,865	2	39,932	235,394	,000[c]
	Residual	54,794	323	,170		
	Total	134,659	325			
3	Regression	83,682	3	27,894	176,194	,000[d]
	Residual	50,977	322	,158		
	Total	134,659	325			
4	Regression	86,934	4	21,734	146,183	,000[e]
	Residual	47,724	321	,149		
	Total	134,659	325			
5	Regression	88,810	5	17,762	123,970	,000[f]
	Residual	45,849	320	,143		
	Total	134,659	325			
6	Regression	92,192	6	15,365	115,421	,000[g]
	Residual	42,467	319	,133		
	Total	134,659	325			
a. Dependent Variable: Average waste water tariff						
b. Predictors: (Constant), Staff costs per mc						
c. Predictors: (Constant), Staff costs per mc, Costs with services provided by third parties per mc						
d. Predictors: (Constant), Staff costs per mc, Costs with services provided by third parties per mc, Material costs per mc						
e. Predictors: (Constant), Staff costs per mc, Costs with services provided by third parties per mc, Material costs per mc, Royalty costs per mc						

f. Predictors: (Constant), Staff costs per mc, Costs with services provided by third parties per mc, Material costs per mc, Royalty costs per mc, Maintenance and repair costs per mc
g. Predictors: (Constant), Staff costs per mc, Costs with services provided by third parties per mc, Material costs per mc, Royalty costs per mc, Maintenance and repair costs per mc, Other operating costs per mc

Source: benchmarking system of the Romanian Water Association - http://h2obenchmark.org/

From the results of the ANOVA test it can be seen that the value of the Fisher test has high values which confirms the overall significance of the variables selected in the model. The degree of significance p> 0.01, ie the probability of model error is 1%.

When performing the statistical analysis, collinearity tests were performed that confirmed the validity of the model and the non-correlation test of errors with Durbin-Watson was performed, which has corresponding values.

After following the steps above outlined, as a result of the statistical analysis we have the following coefficients in the model (table no.4).

Table no. 4 Coefficients of linear regression

Model	Coeficienți nestandardizați		Coeficienți standardizați	T	Sig.
	B	Eroarea std.	Beta		
(Constant)	,873	,064		13,564	,000
Staff costs per mc	,751	,049	,528	15,259	,000
Costs with services provided by third parties per mc	1,735	,202	,296	8,572	,000
Material costs per mc	1,047	,280	,138	3,738	,000
Royalty costs per mc	,736	,151	,164	4,887	,000
Maintenance and repair costs per mc	1,600	,485	,111	3,297	,001
Other operating costs per mc	,724	,144	,162	5,040	,000

Source: benchmarking system of the Romanian Water Association - http://h2obenchmark.org/

The resulting linear regression model has the following formula:

Average waste water tariff =0,873 + 0,751*Staf cost/m^3 + 1,735* Costs serv. prov. third part./m^3 + 1,047* Costs of the consumed materials/m^3 + 0,736*Royalty cost/m^3 + 1,600* Maintenance and repair costs per mc /m^3 + 0,724,* Other operating costs/m^3 + Ɛ.

Interpretation of the result: If the staff costs increase by one unit, i.e. 1 ron/m^3, and the other variables remain constant, then the average waste water tariff /m^3 increases 0,751 lei.

If the royalty cost/m^3 increases with 1 Ron, the other variables remain constant, then the average tariff of water/mc increases with 0,736 Ron.

5. Conclusions

The construction of a linear regression for a branch of the national economy is a real challenge today. We believe that through the present research we make it possible for the non-specialists in the field of water and sewage, by applying the linear regression to be able to predict changes in the water tariff, the product of the inflationary effects and the increase of the minimum wage on the economy.

From the assumptions made in this research confirmed the H1, H2, H4, H6, H7, i.e. through statistical analysis or found links between dependent variable the average tariff for potable water/m^3 and the costs with the staff/m^3, the expense fee costs services rendered by third parties costs with electrical energy, depreciation costs, all calculated based on m^3.

It is noteworthy that the variable cost of raw water purchased, could not be included in the model. This is explained by the fact that the level of water losses is very different from operator to operator.

Under current conditions when there is an increase in the minimum wage on the economy, knowing that the salary scales of water and sanitation operators are based on a minimum wage, we can calculate a 10% increase in wage costs. By applying the above model, it results that the national effect will be an average increase of 0.07 lei / m^3 of the average water tariff. And the effect on the basket of a household will be 1 leu /month/ household.

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