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Routledge
Taylor & Francis Group

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In this paper, we analyse the performance of the tax administration using data envelopment analysis (DEA) and regression analysis in 13 European countries. In the first phase, a DEA input- oriented model with the three input and two output parameters for the efficiency evaluation has been used. The influence of selected independent variables on the grey economy, which represents an approximation of tax evasion and efficiency of tax administration, was conducted by regression analysis in the second phase. The main goal is to investigate the influence of the relative efficiency and number of employees in tax administration as well as country employment rate on the grey economy level.

Keywords: tax administration; data envelopment analysis; regression analysis

Jel classification: C44, C67, H21, H11

1. Introduction

Tax policy and tax administration are the most important part of every tax system reform. Administrative dimensions of tax system reform should not be ignored (Bird, 2004). In the situation with full tax compliance, which is extreme and an ideal situation, the role of tax administration would be restricted to the provision of facilities for citizens to discharge their responsibilities to the society. In the case of non-compliance, Tax Administration will have to play the role of policeman. Due to lack of resources and in the situation that it cannot play the role of a policeman to all taxpayers, Tax Administration has to support voluntary compliance and to fight against tax evasion. Tax evasion is one of the most common economic crimes, and has been present since the introduction of taxes. The fundamental role of the tax administration is to render quality taxpayer services and to encourage voluntary compliance of tax laws, and also to detect and penalise non-compliance. The extent of success of the Tax Administration in its role should be reflected through a higher level of tax compliance and a lower level of tax evasion. Only with collected taxes are governments able to provide all public services and to implement welfare programmes.

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†The views expressed in this paper are those of the author and do not necessarily represent those of Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH or the German Federal Ministry for Economic Cooperation and Development (BMZ).

An adequate Tax Compliance model is essential for every tax administration. The model is based on two elements: attitude to compliance and compliance strategy. The strategy of the Tax Administration should be to create pressure down, or in other words to use the compliance strategy to help taxpayers to pay taxes on one side and to fight against tax evasion on the other. Namely, the vast majority of taxpayers want to comply with their taxation obligation. This is very important, because the Tax Administration has to take an adequate compliance model in this respect. It includes all the initiatives that the authority might take to improve service delivery. In order to measure how efficient a tax administration is in implementing a compliance strategy several methods are used. The main methods have been developed by the European Commission (2007), and jointly by the International Finance Corporation, Price Waterhouse Coopers and the World Bank (2012), by the International Monetary Fund (2012), by the World Bank (2012), and by the OECD's Centre for Tax Policy and Administration for the Forum on Tax Administration (2009). Other models that have been used to assess the performance of a tax administration are the following: International Tax Dialogue (2010); Public Expenditure and Financial Accountability (PEFA) Framework (PEFA, 2013); the USAID′s Collecting Taxes Database (USAID, 2013); and Diagnostic Framework for Revenue Administration (Gill, 2000). The assessment of the efficiency of the tax administration using DEA is very rare, probably due to the lack of information regarding the tax administration. In the literature, the articles from Moesen and Persoon (2002), Gonzalez and Mile (2000), and Barros (2007) are the most prominent ones.

The rest of the paper is organised as follows. Section 2 explains the methodology that is used. Section 3 presents empirical results of DEA analysis, where the performance of the selected tax administration is assessed. Section 4 shows regression analysis that is conducted in order to assess the influence of the chosen variables on the grey economy, as an approximation of tax evasion and tax administration efficiency. Finally, Section 5 provides concluding remarks.

2. Methodology

The idea of efficiency measurement was developed by Farrell (1957) when he used a non-parametric efficiency limits approach to measure the efficiency of the relative distances from the efficient frontier. This measure, which is well known as an empirical or relative efficiency was later expanded in the work of other researchers. The DEA was introduced by Charnes, Cooper, and Rhodes (1978). Their model is known as the CCR model. Business units, their activities or processes in the DEA terminology are seen as Decision Making Units (DMU). DMU is the unit that actually makes business decisions, and whose performance is characterised by a set of inputs and outputs and their interdependence. It operates with constant returns to scale (CRS), which implies that a change in the amounts of the inputs leads to the same proportional change in the amounts of the outputs. The efficiency ratio is scaled between 0 and 1, and all efficient units have the same ratio equal to 1. Following this model, Banker, Charnes, and Cooper (1984) have extended the original CCR model by introducing the assumption of variable returns to scale (VRS). In the literature, this model is known as a BCC model. The VRS efficiency scores measure pure technical efficiency, excluding the effects of scale operations. They are greater than the corresponding CRS efficiency scores. The BCC model is able to distinguish between technical and scale inefficiency. Technical inefficiency is calculated by measuring how well the unit uses its inputs to create outputs, while scale inefficiency identifies whether increasing, decreasing, or constant returns to

scale exist. There are two main orientations of the DEA model: input and output orientation. The input-oriented DEA model aims to minimise the input with a given level of output. On the other side, the output-oriented DEA model aims to maximise the output with a given level of input. In the envelopment model, the number of degrees of freedom will increase with the number of DMUs and decrease with the number of inputs and outputs. A rule of thumb that can provide guidance is as follows (Cooper, Seiford, & Tone, 2000): $n \geq \max\{m \times s, 3 \times (m + s)\}$; where n is number of DMUs, m is number of inputs and s is number of outputs. This pre-condition has been fulfilled by the analysis in this paper.

Consider a set of n DMUs, with each DMUj ($j=1,\ldots,n$), using m inputs x_{ij} ($i=1,\ldots,m$) and generating s outputs y_{rj} ($r=1,\ldots, s$).Then the primal linear programme for the (input-based) CCR model, that gives optimal efficiency score θ^* for DMU$_0$, can be written as:

$$\theta^* = \min \theta$$

s.t.

$$\begin{aligned}
\sum_{j=1}^{n} \lambda_j x_{ij} &\leq \theta x_{i0}, & i &= 1, 2, \ldots, m \\
\sum_{j=1}^{n} \lambda_j y_{rj} &\geq y_{r0}, & r &= 1, 2, \ldots, s \\
\lambda_j &\geq 0, & j &= 1, 2, \ldots, n
\end{aligned} \tag{1}$$

where θ is the efficiency score for the particular DMU, x_{io} and y_{ro} are, respectively, the ith input and rth output for DMU$_0$ under evaluation, while λ_j represents the unknown value assigned to DMUj, $j=1,\ldots,n$. The efficient frontier consists of DMUs with $\lambda_j \geq 0$. The dual linear programme to Equation (1) is

$$\max \sum_{r=1}^{s} u_r y_{r0}$$

s.t.

$$\begin{aligned}
\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} &\leq 0, \quad j = 1, \ldots\ldots, n \\
\sum_{i=1}^{m} v_i x_{i0} &= 1 \\
u_i, v_i &\geq 0
\end{aligned}$$

where u_r is the weight assigned to output r, $r=1,\ldots,s$ and v_i is weight assign to input i, $i=1,\ldots,m$. A DMU$_0$ is said to be CCR efficient if and only if $\theta^*= 1$ and all optimum slack values in Equation (1) are zero.

In this paper, DEA is used for comparative analysis of tax administration efficiency in the selected countries. The procedure of applying the DEA method could be divided into the following steps (Popović & Martić, 2005):

1. Choosing and definition of DMUs,
2. Defining relevant inputs and outputs,
3. Choosing an adequate DEA model, and
4. DEA model solving, analysing and interpretation of results.

In this paper, the analysis will be done in two stages. The first stage is DEA analysis. The second stage is a regression analysis that explains the influence of DEA efficiency and other selected variables on the grey economy as an approximation of tax evasion and the efficiency of the tax administration. Namely, the first systematic theoretical analysis of tax evasion was done by Allingham and Sandmo (1972), where individuals pays taxes because they are afraid of getting caught and penalised if they do not report all income. The probability of getting caught is higher with a more efficient tax administration. Furthermore, according to Escobari (2012), a more efficient tax administration yields higher tax compliance levels and lower tax evasion. Lower tax evasion can be achieved by increasing the number of tax auditors and improving their skills in discovering tax evasion. Both of these theories have shown that the capacity of tax administration is a vital element for fighting against tax evasion. In this paper, the efficiency of the tax administration will be obtained through DEA analysis, and used in regression analysis as an explanatory variable in the tax evasion model. The assumption is that tax administration efficiency will have a negative impact on the level of tax evasion.

The following countries have been selected as a DMU: Bulgaria, Czech Republic, Hungary, Serbia, Slovak Republic, Slovenia, Latvia, Lithuania, Finland, Estonia, Ireland, Portugal, and Spain. The countries are selected based on the following criteria: countries that have a similar economic and political legacy to Serbia (Bulgaria, the Czech Republic, Hungary, the Slovak Republic, Slovenia, Latvia, Lithuania, and Estonia); EU members due to fact that Serbia wants to became member of the EU and to align its own taxation system according to the EU standards; countries in the region (Bulgaria, Hungary, and Slovenia); and developed countries (Finland, Ireland, Portugal, and Spain) whose standards Serbia wants to reach in the long term. As already mentioned, the analyses has been done in two phases and the results are given in the following sections.

3. DEA efficiency measurement

In the first stage, the following input and output parameters have been used. The parameters are determined by the goal definition, which is measuring the efficiency of the tax administration. The following inputs are used:

- Total expenditure of the tax administration /net revenue collected – X_1.
- Tax Payments – X_2.
- Time to comply – X_3.

On the other side, output parameters are:

- Tax collected/total amount for collection (theoretical tax) – Y_1.
- Value of completed actions/net revenue collected – Y_2.

The Tax payments and Time to comply are represented as a rank of the selected countries on the overall rank list given by the International Finance Corporation (2012). The main functions of every tax administrations are collection and audit. The goal is to collect as much tax revenue as possible, according to the tax law, with limited resources. All necessary data for the selected tax administrations are available. Values of inputs and outputs are related to 2012 and 2011 respectively. In order to follow the assumptions of cross-sectional data analysis, both data in DEA and regression analysis

refer to year 2012, except for output data in DEA analysis. Namely, output data related to the tax administration are produced every two years, and not every year. The reason is that output data are not changing significantly over one year. Actually, data on the economy are changing significantly only in the medium and long term, and not in such a short term. In addition, the output data are given as a ratio and not in nominal terms, which leads towards an insignificant difference in values over one year, if there is a difference at all. Value of inputs and outputs are given in Table 1.

For the efficiency assessment, an input-oriented CRS DEA model has been used, as explained in Equation (1). The CRS model was chosen because it is more rigorous in assessment of efficiency than the VRS model. In addition, it allows better discrimination between efficient and inefficient units. The Efficiency Measurement System (EMS) software, which is created within an MS Excel environment (Scheel, 1998), has been used for evaluation. We use an input-oriented model, as the assumption of CRS would mean reciprocal values for the results of the output-oriented model. Efficiency scores of the tax administration are shown in Table 2.

The relative efficient DMU are the following tax administrations: Slovenia, Finland, Ireland, Portugal and Spain. The relative inefficient tax administrations are in Bulgaria, the Czech Republic, Hungary, Serbia, the Slovak Republic, Latvia, Lithuania, and Estonia. The number of appearance of the relative efficient DMU as a benchmark for the relative inefficient DMU is given in Table 2. In total, five out of 13 tax administrations are relatively efficient. The benchmark for the Serbian Tax Administration (STA), according to this analysis, is the Finnish Tax Administration. Namely, in order to become relatively efficient and to reach the Finnish Tax Administration's performance, the STA has to move up to the 107th rank position regarding the number of tax payments (Input 2) and up to the 80th rank position regarding the total time to comply (Input 3). In the nominal terms, and looking into the rank of the other countries on the above-mentioned parameters (IFC, 2012), the tax payments should be approximately at

Table 1. Value of inputs and outputs.

DMU	X_1^*	Inputs X_2^{**}	X_3^{**}	Outputs Y_1^{***}	Y_2^{***}
Bulgaria	1.31	59.00	166.00	11.10	2.50
Czech Rep.	1.43	17.00	169.00	5.10	1.80
Hungary	1.60	46.00	124.00	9.90	8.90
Serbia****	0.90	177.00	125.00	2.71	3.38
Slovak Rep.	1.65	103.00	100.00	17.70	9.60
Slovenia	0.86	83.00	109.00	55.70	1.60
Latvia	1.31	11.00	128.00	18.00	4.10
Lithuania	0.91	40.00	61.00	34.30	2.50
Finland	0.64	17.00	19.00	28.00	5.20
Estonia	0.77	17.00	16.00	12.50	2.00
Ireland	0.76	17.00	9.00	13.40	1.60
Portugal	1.55	17.00	121.00	14.40	9.70
Spain	0.87	17.00	66.00	34.60	4.90

Note: The meaning of input and output parameters has given earlier; the output elements for the Serbian Tax Administration have been calculated by the authors.
Source: *IOTA (2013); **IFC (2012); ***OECD (2011).

Table 2. Efficiency scores.

	DMU	Score	Benchmarks
1	Bulgaria	0.23	9 (0.48)
2	Czech Rep.	0.23	12 (0.14) 13 (0.09)
3	Hungary	0.68	9 (1.71)
4	Serbia	0.46	9 (0.65)
5	Slovak Rep.	0.72	9 (1.85)
6	Slovenia	1.00	1
7	Latvia	0.99	12 (0.20) 13 (0.44)
8	Lithuania	0.77	6 (0.20) 9 (0.82)
9	Finland	1.00	6
10	Estonia	0.53	9 (0.37) 11 (0.16)
11	Ireland	1.00	1
12	Portugal	1.00	2
13	Spain	1.00	2

Source: Authors' calculation.

the level of 32 days instead of the current 66 days, and the total time to comply should be approximately at the level of 207 days instead of the current 279 days. The total expenditure of the tax administration/net revenue collected (Input 1) should remain at the same level.

4.   Regression model measurement

In the second stage we use the grey economy[1] as an approximation of tax evasion that indirectly refers to the level of efficiency of the tax administration. As was mentioned, the main aim of the tax administration is to decrease levels of tax evasion. In that context, the term 'grey economy' is strongly connected with tax evasion. The grey economy is the basis for tax evasion and refers to that part of the economy that generates income, but goes untaxed. It comprises a wide range of economic activities. For this aspect of the economy there are a lot of adjectives that can be used to describe this activity (Brooks, 2001, p. 8): grey, black, cash, etc. The level of the grey economy will be used as a proxy to measure tax evasion. The first boundary lies between transactions that constitute production and those that do not. The second boundary is the official production boundary, which represents what actually appears in a country's national accounts. It is inside the first boundary because official statistics more strictly define what constitutes production than do economists. The third boundary delimits the grey (black) economy. Three different types of economic activity can be distinguished within the grey economy category. Two of them (δ and γ) belong to both categories (formal and grey economies) because some activities may successfully be concealed from the tax authorities but show up in estimated expenditures (the reason is that statistics on national accounts are cross-checked from several sources). The third part of the grey economy is the benefit from fraud and tax evasion outside the production sector.

   It can be assumed that a more efficient tax administration leads toward a lower level of the grey economy. The following explanatory variables have been used in regression analysis in order to explain factors that influence on the size of the grey economy (y):

- DEA efficiency score (presented in the Table 2) – Z_1.
- Rate of unemployment (%) – Z_2.
- Total number of employees in tax administration – Z_3.

In this paper, the focus is on the relationship between a dependent variable (y) and more independent variables (Z_1, Z_2, and Z_3). The equation can be written as:

$$y_i = \beta_0 + \beta_1 Z_1 + \beta_2 Z_2 + \beta_3 Z_3 + \varepsilon_i$$

where coefficients β are defined as regression parameters. The residual has to be distributed as: $\varepsilon_i \sim N(0,\sigma^2)$. Values of variables are given in the Table 3. The null hypothesis is that the regression parameters (β_1, β_2, and β_3) are each equal to zero (which is done with the t-test on each of the coefficients) at significance level 0.10. All data in the Table 3 regarding variables y, Z_2, and Z_3 are related to 2012.

The assumption is that an increase in DEA efficiency score and in the total number of employees in the tax administration will have a negative impact on the level of the grey economy. Improving the efficiency of the tax administration and hiring more efficient tax auditors (Escobari, 2012) will lead to higher tax compliance and a lower level of the grey economy. In other words β_1 and β_3 should be negative. On the other hand, an increase in the rate of unemployment will have a positive impact on the level of the grey economy (β_2 is positive). Namely, the unemployment rate is one of the standard factors that is included in the econometric models of the informal economy (Schneider & Erste, 2000), and the empirical studies often show that a rise of unemployment leads to an increase in the grey economy (Krstić et al., 2013; Schneider, Büehn, & Montenegro, 2010). Table 4 presents the results of the Linear regression at the 90% confidence level, using the Stata software.

Table 3. Value of dependent (y) and independent variables (Z_i).

DMU	DEA efficiency score – Z_1	Rate of unemployment (%)[*] – Z_2	Total number of employees in tax administration[**] – Z_3	Grey economy (% of GDP)[***] – y
Bulgaria	0.23	12.30	7.708	32.30
Czech Rep.	0.23	7.00	14.710	16.40
Hungary	0.68	10.90	22.482	22.80
Serbia	0.46	22.40	6.856	30.10
Slovak Rep.	0.72	14.00	8.781	16.00
Slovenia	1.00	8.90	2.330	16.00
Latvia	0.99	14.90	4.069	26.50
Lithuania	0.77	13.30	3.296	29.00
Finland	1.00	7.70	5.130	13.70
Estonia	0.53	10.20	1.555	28.60
Ireland	1.00	14.70	6.874	12.80
Portugal	1.00	15.90	11.566	19.40
Spain	1.00	25.00	27.613	19.20

Note: In the case of Serbia, the Rate of unemployment is published by Statistical office of the Republic of Serbia (2013), and the Grey economy (%GDP) in the research of Krstić, G. et al. (2013).
Source: *Eurostat (2013); **IOTA (2013); ***Schneider (2012).

Table 4. Linear regression result.

Variables	Coefficient	t test	Prob
DEA efficiency score – Z_1	−14.07136	−2.55	0.031
Rate of unemployment (%) – Z_2	0.6663669	1.99	0.078
Total number of employees in tax administration – Z_3	−0.0003495	−1.59	0.147
Cons.	26.37869	4.84	0.001
R-squared = 0.509	Adj R-squared = 0.345	F (3, 9) = 3.11	Prob (F statistic) = 0.0814

Source: Authors' calculation using the Stata software.

For verifying that the residuals are normally distributed, which is a very important assumption for regression, the Shapiro-Wilk W test for normal data has been used. The null hypothesis for this test is that the residuals are normally distributed. If the p-value is greater than 0.10, then the null hypothesis will not be rejected. The p-value is 0.26855 and does not result in rejection of the null hypothesis, and residuals are normally distributed.

Another important test is the test for heteroscedasticity, as the presence of heteroscedasticity can invalidate statistical tests of significance. One of the basic assumptions for the ordinary least squares regression is the homogeneity of variance of the residuals. Namely, the Cook-Weisberg test for heteroscedasticity has been conducted. If the p-value is 0.10 or smaller, then the null hypothesis is rejected and there is significant evidence of heteroscedasticity. The p-value is 0.8611 and there is no heteroscedasticity in this case.

Regarding Table 4, R-squared is 0.509 (for social science this is fairly high), and the Adjusted R-squared is 0.345. If the adjusted R-square value is much lower than the R-square value, it is an indication that the regression equation may be over-fitted to the sample. These values are close, anticipating minimal shrinkage based on this indicator.

In order to test significance, which is the statistical significance of the estimated coefficient, the general rule is that the p-value has to be less than the significance level (0.10). Since the p-value (0.0814) is less than 0.10 we do reject the null hypothesis that the regression parameters are zero at significance level 0.10. It can be concluded that the parameters are jointly statistically significant at significance level 0.10. Analysing separately, the DEA efficiency score and Rate of unemployment (%) are statistically significant with the p-value of 0.031 and 0.078 respectively. Furthermore, the DEA efficiency score is statistically significant at significance level 0.05 as well. On the other hand, the number of employees in the tax administration is statistically insignificant at significance level 0.10. Furthermore, a t-statistic above 2 or below –2 is considered significant at the 90% level, and this is in line with the previous conclusions.

The coefficient tells how much the dependent variable is expected to increase when that independent variable increases by one, holding all the other independent variables constant and the sign on the coefficient (positive or negative) gives the direction of the effect. If the rate of unemployment and number of employees in the tax administration are fixed, then for each change (increase) of one unit in DEA efficiency score, the level of the grey economy changes (decreases) by 14.071 units. Also, if the DEA efficiency score and the number of employees in the tax administration are fixed, then for each change (increase) of one unit in the rate of unemployment, the level of the grey economy changes (increases) by 0.666 units. At the end, there is no statistically significant

linear dependence of the grey economy and the total number of employees in the tax administration.

The findings have shown that increasing the efficiency of the tax administration leads to a lower level of the grey economy. Improving the capacity of the tax administration is an important element in fighting tax evasion, which is the most important part of a grey economy. Also, making it easier for taxpayers to comply with the tax obligations should result in lower tax compliance costs. High tax compliance costs are sometimes the reason for evading paying taxes. Regarding the rate of unemployment, the result indicates that there is a positive relationship between the grey economy and the rate of unemployment. The greater is unemployment, the greater is the grey economy. Unemployed people either start their own business that is not registered or accept working as a non-registered employee. This has a direct impact on the size of the grey economy.

5. Conclusion

In this paper, analysis has been done in two stages. In the first stage the study utilises an input oriented efficiency DEA model to assess the performance of the selected tax administration under the assumptions of CRS. In the second stage, a regression analysis has been conducted in order to assess the influence of chosen variables on the grey economy, as an approximation of tax evasion and tax administration efficiency. The limitation of the paper relates to the methodology of the research. Namely, the identification of input and output parameters in DEA analysis on one side and the selection of dependent and independent variables in the regression analysis on the other side are the crucial elements for conducting research and the obtained results. The identification and selection of parameters and variables are done based on already existing research in this area and the professional experience of the authors, but this could be done in other ways as well.

As mentioned, the three input and two output parameters are used for the DEA analysis. For the regression analysis, three explanatory variables have been selected. The obtained results have shown that five out of 13 tax administrations are found to be relatively efficient under DEA analysis. Based on the conducted analysis, the Serbian Tax Administration has to use the Finnish Tax Administration as a benchmark. Comparing results from both analyses, it can be generally concluded that countries with a relatively efficient tax administration have a significantly lower level of the grey economy. Namely, the average grey economy in Slovenia, Finland, Ireland, Portugal and Spain, as a relative efficient DMUs under the DEA analysis, is 16.2% of GDP. The average level of the grey economy for all analysed countries is 21.7% of GDP, and for the relative inefficient DMU under the DEA analysis it is 25.2%. It has become obvious that an efficient tax administration is necessary to combat the grey economy and for creating an environment where evading paying taxes is punishable.

Disclosure statement

No potential conflict of interest was reported by the authors.

Note

1. The grey economy topic is discussed in the paper by Schneider and Klinglmair (2004).

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