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International Comparisons of Public Sector Efficiency – DEA Methodology

Abstract: *The paper analysed and compared the public sector efficiency of the Republic of Serbia with the countries in the region, the new members of the European Union and the EU countries. The public sector efficiency is analysed by relevant methodology and the linear programming model - DEA (Data Envelopment Analysis). The aim of this research is analysis and comparison of the efficiency of the public sector of the Republic of Serbia with the European Union members are used for determining the level of efficiency, but also the need for state's intervention in Republic Serbia. Significant inefficiency of the public sector of the Republic of Serbia resulted in negative effects on the stability of the public finance system. The functioning of the Serbian public sector is marked with budget deficits followed by a constant growth of external and internal debt. Unreformed public sector will lead to the failure of fiscal consolidation, while implemented fiscal consolidation measures will not be effective without the reform of the public sector. The study indicates possibilities for reducing public spending by around 25% without reducing the efficiency of the public sector, which would be sufficient for elimination of the budget deficit.*

Keywords: *Data Envelopment Analysis, Public Sector, Efficiency, Efficiency Frontier, Republic of Serbia.*

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Međunarodna komparacija efikasnosti u javnom sektoru – DEA metodologija

Apstrakt: *U ovom radu je analizirana i komparirana efikasnost javnog sektora Republike Srbije sa zemljama u regionu, novim članicama Evropske unije i zemljama Evropske unije. Efikasnost javnog sektora je analizirana relevantnom metodologijom i modelom linearnog programiranja DEA (Data Envelopment Analysis). Cilj ovog istraživanja je da da osnovu analize i komparacije efikasnosti javnog sektora Republike Srbije sa zemljama Evropske Unije utvrđuje se nivo efikasnosti, ali i potreba za državnom intervencijom u Republici Srbiji. Izrazita neefikasnost javnog sektora Republike Srbije kao posledicu ima negativne efekte na stabilnost sistema javnih finansija. Funkcionisanje srpskog javnog sektora prate konstantni budžetski deficiti sa trendom rasta spoljne i unutrašnje zaduženosti. Nereformisani javni sektor će dovesti do neuspeha fiskalne konsolidacije. Sprovedene mere fiskalne konslidacije neće biti efikasne bez reforme javnog sektora. Istraživanje pokazuje mogućnosti za smanjenje javne potrošnje za oko 25% bez smanjenja efikasnosti javnog sektora, što bi bilo dovoljno za eliminaciju budžetskog deficita.*

Ključne reči: *Analiza obavijanja podataka, javni sektor, efikasnost, granica efikasnosti, Republika Srbija*

1. Introduction

The financial crisis of 2007 actualized the issue of public debt and budget deficit, introducing the debt crisis into the reality of many economies in the European Union. Fiscal expansion occurred in conditions of the recessionary trends in the Republic of Serbia. During the global economic crisis, public debt grew from pre-crisis 31.2% of GDP to 70% of GDP (http://stats.oecd.org/). The crisis was a mechanism for adjusting payment balance deficit, and forced the Republic of Serbia to borrow abroad and thus led it to indebted countries group. Public expenditure and fiscal deficit began to rise from mid-2011, because of the elections. The growth of public expenditures for antirecession measures, coupled with fiscal expansion because of the crisis and political elections led to an increase in public expenditure and fiscal deficit. According to IMF data, the public debt has already reached the maximum limits established by fiscal rules. The model of development of the Republic of Serbia, based on the service sector, high public spending and imports financed by borrowing is not sustainable in terms of insufficient inflow of foreign capital.

In such a macroeconomic environment, the Republic of Serbia would have to transform the public sector and public administration and adapt it to the EU acquis.

The Republic of Serbia, as a transition country, is not competitive and has low efficiency of the public sector, with negative effects on the stability of the public finance system. Characteristic of Public Finance of the Republic of Serbia is a long-standing imbalance between public revenues and expenditures, as a result of inefficient and unreformed public sector. Fiscal consolidation measures undertaken by the Republic of Serbia will not be effective without the reform of the public sector as a generator of high fiscal deficit, public debt and sources of inefficiency and illiquidity of the Serbian economy. The strategic orientation towards the EU accession largely contributed to the selection of research subjects in this study.

The research subject presented in this paper are the public sector and its efficiency. The study is characterized by a macroeconomic approach to the issue of the public sector. The efficiency of the public sector is analysed by relevant methodology and the linear programming model - DEA (Data Envelopment Analysis).

The aim of the research is to compare the efficiency of the public sector of the Republic of Serbia with the countries in the region, the new members of the European Union and the EU countries. Comparing the efficiency of the public sector of the Republic of Serbia with the countries in the region, the new members of the European Union and the EU countries helps define the level of efficiency of the public sector, but also the need for state's intervention in the economy of the Republic of Serbia, both in terms of scale and in terms of the objectives and methods.

The paper is composed of four parts. The first part presents literal review. The second part presents methodology applied to the issue of public sector efficiency of the Republic of Serbia. There are also indicators and mathematical methods applied in the analysis of public sector efficiency. The third part presents the research results and comparison of the efficiency of the public sector of the Republic of Serbia with the countries in the region and the developed market economies. The fourth part of the paper, based on the research, provides recommendations for the reform of the public sector for increasing its efficiency, but also sustainability of fiscal consolidation program in times of economic crisis and the crisis of over-indebtedness faced by Serbia but many developed countries as well.

2. Literary Review

DEA – Data Envelopment Analysis is a technique for measuring the efficiency of complex entities and enables the analysis of efficiency, taking into account the combination of input and output variables (Knežević, Marković, Barjaktarović Rakočević, 2012:76). The efficiency of the public sector has been frequently analysed in recent years, due to the possibility of measuring the efficiency of a large number of complex units that use different types of inputs for producing different outputs. Data Envelopment Analysis is a technique of mathematical programming that determines whether the entity, based on data on its inputs and outputs, is effective or not in comparison with other entities covered by the analysis. A non-parametric approach does not assess performance in relation to the average performance, but as a marginal method consists of a series of optimization for each entity included in the analysis. The method is developed for measuring the efficiency of non-profit service sector (schools, hospitals) where the output is not measured in monetary units, but the effectiveness depends on the quality and scope of services provided. It is mainly used in the production and distribution of electricity, as well as in the non-profit sector, such as schools, hospitals and police. The method is also suitable for profit and non-profit sector of the economy.

Data Envelopment Analysis is a method for empirical determination of the practical limits of efficiency. Efficiency can be expressed as the distance from the efficiency frontier. The limit is the maximum output a unit can achieve with the available inputs (Grujčić, Cvijanović, Lazić, 2010.) When analysing the frontiers, efficiency acts as an envelope for inefficient units, when relatively inefficient units are enveloped, while efficient units form the efficiency frontier.

Data Envelopment Analysis was created by Abraham Charnes, William Cooper and Eduardo Rhodes in 1978 (Charnes, Cooper and Rhodes, 1978). Since its inception, thirty years ago, DEA method has become one of the most widely used technique for the analysis of efficiency in comparing companies, regions and countries. Development of DEA method has led to a large number of DEA models and software solutions.

Original DEA methods were input-oriented, with constant returns to scale (CRS). In the eighties, output-oriented DEA models and models with variables return to scale (BBC models) were proposed. Färe, Grosskopf and Lowell wrote the first book in 1985 dealing with DEA method (Grujčić, Cvijanović, Lazić, 2010). In the nineties, DEA model was extended, while additive DEA model and a number of software solutions were created. In addition, a model of efficient DMU ranking (Decision Making Units) and measuring super efficiency was proposed (Andersen, Petersen, 1993).

3. Research Methodology

Vito Tanzi, Ludger Schuknecht and Antonio Afonso developed the methodology of macroeconomic analysis, of the public sector by redefining the original approach and creating a more sophisticated analysis of the public sector used in this study. This method has comparative character and correlates the level and growth of public expenditure and changes in socio-economic indicators. The greater the impact of growth of public spending on socio economic indicators, the greater the efficiency of the public sector. The model makes a clear distinction between the public sector performance (PSP), defined as the results of public policy, and public sector efficiency, defined as a result of the resources engaged. It is assumed that the public sector performance (PSP) depends on the values of certain indicators (I). If the model incorporates i countries and j sectors of authority, it is possible to define the overall performance of the country i, while the performance of the public sector (PSP$_i$) of the country i, can be defined as follows (Alfonso, Schuknetcht, 2003:17):

$$PSP_i = \sum_{j=1}^{n} PSP_{ij,} \tag{1}$$

If $PSP_{ij} = f(I_k)$ (2)

Improving socio-economic indicators leads to the growth of the public sector performance:

$$\Delta PSP_{ij} = \sum \frac{\partial f}{\partial I_k} \Delta I_k \tag{3}$$

Socio-economic indicators that affect the growth of the public sector performance can be divided into seven areas:

1. Administration,

2. Education,

3. Health care,

4. Infrastructure,

5. Income distribution,

6. Stability, and

7. Economic performance.

Figure 1 Socio-economic indicators and sub-indicators of the public sector performance
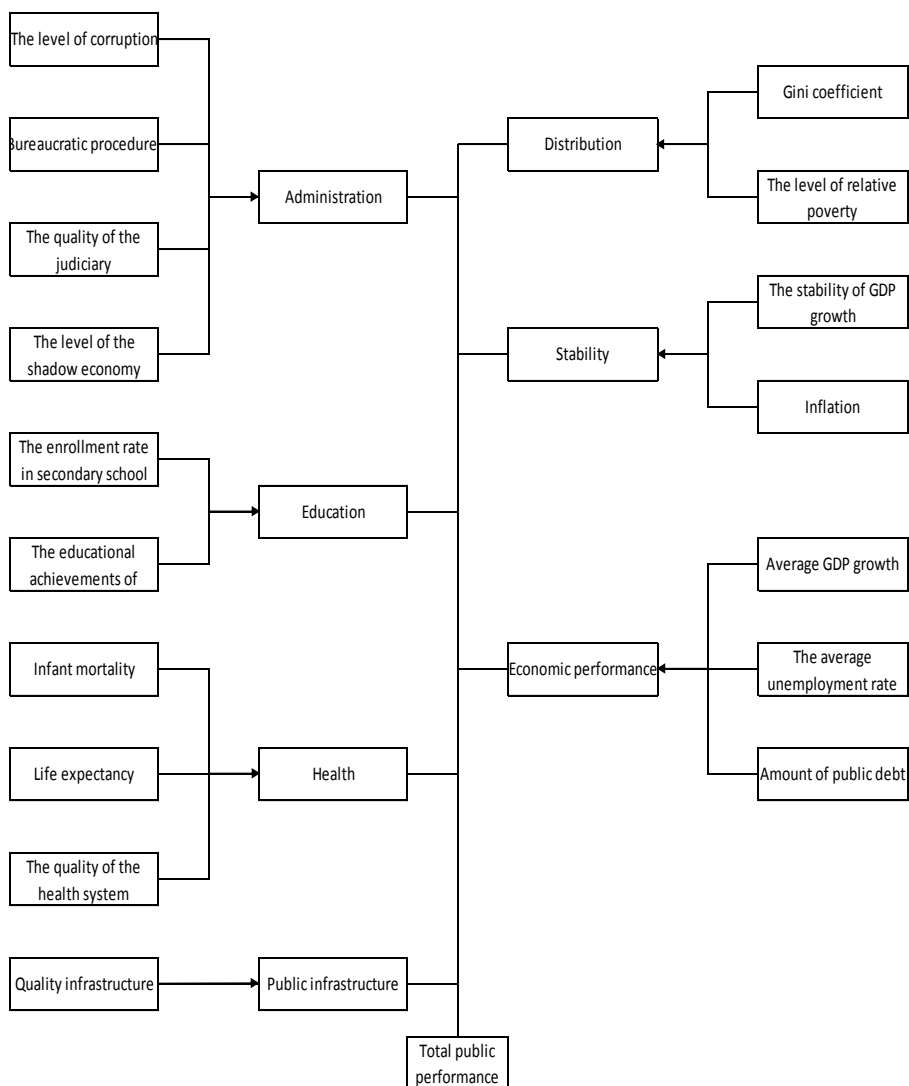
Figure 1 shows the process indicators and their sub-indicators. Process indicators include the largest systems in the public sector. Administrative

indicator consists of four sub-indicators: the first three sub-indicators were measured by the World Economic Forum in the Global Competitiveness Report, while the size of the shadow economy measured in terms of gross domestic product in the period of ten years was taken from various publications.

Education Indicator is composed of two sub-indicators - enrolment rates in secondary schools and educational achievements of students. Given that primary school attendance is compulsory and that many of the countries included in this study reached such level of development that a large number of children have primary education, the enrolment rate in secondary schools provides better information on public education. Data were taken from the Global Competitiveness Index by the World Economic Forum (Global Competitiveness Report). Education outcomes were measured by students' achievement on standardized PISA tests in the field of mathematics. Choice of mathematics is often taken as an indicator of performance in relation to the natural sciences or reading and comprehension (the other two components of the PISA tests), because it has more influence on formal logic needed for the acquisition of knowledge and making independent judgments.

Infant mortality is measured by the number of stillborn babies per 1,000 births. Data were taken from the Global Competitiveness Index by the World Economic Forum (Global Competitiveness Report) and national statistics. For life expectancy measured by the average number of years of life, the data are taken from the Global Competitiveness Index by the World Economic Forum (Global Competitiveness Report) and from the publication of the World Health Organization. The quality of the health care system is analysed by health system efficiency with a grade of the Global Competitiveness Index of the World Economic Forum (Global Competitiveness Report).

Quality of infrastructure is measured by data from the Global Competitiveness Index by the World Economic Forum (Global Competitiveness Report).

The second group of indicators corresponds to the most important functions of the state - the allocation of resources, stability and distribution). Each indicator is trying to express the results of interaction between state and market. In this study, all economic categories are expressed in the ten-year period, in order to better observe the changes in economic performance and structural changes in the public sector. The distribution of income is measured by first indicator composed of two sub-indicators:

1. The level of relative poverty measured by the percentage of the population living below the national poverty line. Data were taken from the World Development Indicators of the World Bank, and

2. Gini coefficient.

The second indicator measures the performance of a country in achieving the stabilization goal of economic policy. Economic stability is measured by the variation coefficient of GDP growth, and the average ten-year inflation rate. Data were taken from the database of the World Economic Outlook of the International Monetary Fund.

Economic performance of the economic system consists of three sub-indicators:

1. Economic growth is measured by the ten-year average growth in gross domestic product. Data were taken from the database of the World Economic Outlook of the International Monetary Fund,

2. The unemployment rate is measured by ten-year average value, and the data were obtained from the database of the World Economic Outlook of the International Monetary Fund,

3. The level of public debt is measured by the participation in the gross domestic product, and data were taken from the database of the World Economic Outlook of the International Monetary Fund.

Based on these 7 indicators of the same weights and 17 sub-indicators, the overall performance of the public sector (PSP) is obtained. All indicators are normalized to the average value, so that the value of the average performance in the sample is 1. Unit value implies the average size of performance (simple arithmetic mean), while the average values are used for calculating overall average performance. It is a relative indicator, as it measures deviations from the average of the sample. Most of the indicators and sub-indicators are analysed as a ten-year average, since the analysis covers structural changes in the public sector, but not changes on an annual basis. PSP analyses only the results of the public sector, without taking into account public spending. To get the overall efficiency of the public sector, it is necessary to weigh the efficiency performance of the public sector by the corresponding public expenditure. In order to calculate the efficiency indicators of the public sector it is necessary to normalize each of the seven categories of public expenditure to the average value:

1. Total public expenditure (for administration indicator),

2. Public expenditure on health (for health care indicator),

3. Public expenditure on education (for education indicator),

4. Public investment (for public infrastructure indicator),

5. Transfers and subsidies (for distribution indicator),

6. Total public expenditure, since it is believed that the larger public sector leads to stabilization of the economy (for stability indicator), and

7. Total public expenditure (for economic efficiency indicator).

In this study, the DEA method is applied to the problem of public sector efficiency of the Republic of Serbia. In measuring the efficiency, the methods applied in the study measure whether the state provides public services in an efficient manner, and not whether it should provide a particular service. On the basis of data on inputs and outputs, DEA method assesses whether the public sector is efficient in relation to the public sectors of other countries in the sample, i.e. whether it is on the efficiency frontier. Therefore, DEA is a technique of mathematical programming for determining whether the public sector, on the basis of data on its inputs and outputs, is efficient or not, relative to other public sectors included in the analysis. The efficiency frontier in economic terms represents empirically derived maximum output achievable by public sector with the given input, and acts as an envelope for the inefficient units. Consider a set of Distribution of points is observed and line around them is constructed, enveloping them, and thus the name of the method - Data Envelopment Analysis.

DEA model may be constructed to either minimize inputs or maximize outputs. The output-oriented model aims at reducing public expenditure as much as possible but with maintaining the lowest existing levels of performance of the public sector, while output-oriented model aims at maximizing the performance of the public sector without increasing used public expenditures. If public sector can be enveloped, it is relatively inefficient, and if it cannot be, then the public sector participates in the formation of efficiency frontier that is equivalent to the marginal production function.

DEA model can be expressed as a function for each public sector of country i:

$$Y\_i = f(X\_i) \ , i=1,\dots\dots,n \tag{4}$$

where Y_i – is the overall performance of the public sector (output) of the country i, X_i – is public spending (inputs) in the country i. If $Y_i < f(X_i)$, it can said that the public sector of the country i is inefficient. For specific level of public expenditure, the performance of the public sector is low compared to the best one, and it is possible to calculate inefficiency, as well as the distance from efficiency frontier.

The inefficiency of the public sector is determined depending on the distance from the efficiency frontier. The public sector of countries that form the border efficiency are considered efficient, since it is not possible to improve the performance of the public sector with a given level of spending. Countries with

inefficient public sector are located within the boundaries of efficiency and the public sector's efficiency can be increased with a given level of public spending. The efficiency frontier is a relative measure of efficiency. Besides DEA method for measuring the efficiency of the public sector, there is also SFA – Stochastic Frontier Analysis (Radulović, Dragutinović, 201.).

The study covers a ten-year period 2003-2013. The quantitative-recording basis of the research is the data of official international and domestic institutions. The study of the phenomenon of efficiency in the public sector was conducted on a sample of 35 countries. The variables in the study are the size of public spending and performance of the public sector.

3. Results and discussion

MaxDEABasic 6.4. was used for calculation. The column with presented results of input-oriented DEA analysis shows how it is possible to reduce public spending without changing the performance of the public sector. The column of output-oriented DEA analysis does not show how much it is possible to increase the performance of the public sector without increasing public expenditure. The third column in the Table presents Constant Returns to Scale (CRS). The last row in the table shows the average efficiency of the public sector in the sample.

The public sector of developed countries has gone through various forms of transformation and has increased the number of new functions after every political and economic crisis. Throughout history, they alternately took turns pleading for a greater state intervention with the concept of minimal role of the state in the economy. The European Union countries have opted for higher public sector within the accepted concept of the welfare state, while the Anglo-Saxon countries have adopted for a minimalist role for the state in the economy. Countries that have adopted the concept of the welfare state and which have a higher public sector achieved a higher efficiency compared to countries with a minimalist role of the state in the economy. From the standpoint of the efficiency of the public sector, state intervention is justified in developed countries.

The analysis of the sample can determine that the most efficient public sectors are in the countries that joined the European Union in 2004 (Poland, Slovakia, Slovenia, Lithuania, Latvia and Hungary). The most effective public sector in the Czech Republic, and the most inefficient in Bosnia. Average value of the overall efficiency of the public sector, in addition to the Czech Republic have been made by Hungary, Slovenia, Estonia and Croatia. We note that countries with smaller public sector have higher efficiency than countries with a large public sector. This research suggests that countries in

transition should have a smaller public sector in the transition period. The greater volume of state intervention is justified after the end of the transition period.

Table 1. DEA analysis of public sector efficiency

| Country	Input oriented DEA	Output oriented DEA	CRS TE
Albania	0.673813	0.701115	0.533924
Australia	0.614525	0.838569	0.602254
Austria	0.782847	0.970845	0.529018
Belgium	0.481108	0.836030	0.430012
Bosnia	0.447154	0.607406	0.339724
Bulgaria	0.587764	0.618556	0.432141
Czech Republic	0.591859	0.835304	0.535656
Denmark	0.554216	0.896463	0.428274
Estonia	0.560510	0.757491	0.514112
Finland	0.651991	0.935573	0.467238
France	0.718834	0.978594	0.480012
Greece	0.546928	0.861892	0.456981
Netherlands	0.750975	0.949977	0.524924
Croatia	0.474752	0.760820	0.451133
Ireland	1.000000	1.000000	0.572094
Italy	0.568261	0.861050	0.475786
Japan	1.000000	1.000000	0.651874
Canada	0.682901	0.869362	0.567509
Latvia	0.578947	0.676584	0.468320
Lithuania	0.583245	0.717984	0.499232
Hungary	0.438684	0.736049	0.403876
Macedonia	0.637127	0.729518	0.535988
Germany	0.686229	0.890949	0.538811
New Zealand	0.463158	0.758400	0.439138
Poland	0.503087	0.699113	0.438334
Portugal	0.825023	0.982791	0.547453
Romania	0.602740	0.570766	0.405002
Russia	0.611111	0.687970	0.492378
Slovakia	0.575916	0.678567	0.468189
Slovenia	0.465116	0.799282	0.46469
Spain	0.513624	0.813321	0.493960
Serbia	0.482986	0.565588	0.340962
Sweden	0.838778	0.995731	0.535161
USA	1.000000	1.000000	1.000000
United Kingdom	0.528846	0.794093	0.520572
Average	0.629230	0.810736	0.502420

Source: Authors' calculations

DEA analysis (Table 1) shows that the Republic of Serbia has a poor performance of the public sector, and holds the bottom of the table, above Bosnia and Herzegovina. High public spending (as the Republic of Serbia has above average public spending in comparison with countries in the region) implies the oversized and expensive public sector. If we analyse the data obtained from input-oriented DEA analysis, we can see that the level of public sector's performance is achievable with 50% less public expenditure. Output-oriented DEA analysis reveals that the public sector of the Republic of Serbia is the least efficient in the observed sample at 70% of the sample average. If the efficiency of the public sector is raised to the average, it could lead to a significant reduction in public spending of about 25% of GDP, which would surely enough to eliminate the budget deficit. If we analyse the efficiency of the public sector in the countries in the region, we can conclude that all public sectors are characterized with low efficiency and that Serbia achieves average efficiency of the public sector compared with the countries in the region. When comparing the efficiency of the public sector with the countries that have joined the European Union in the past ten years, we can unambiguously conclude that the public sector of the Republic of Serbia is below the average efficiency of these countries.

Efficiency can be expressed as the distance from the efficiency frontier. Efficiency frontier represents the ultimate possibility of producing outputs with the available inputs (Grujčić, Cvijanović, Lazić, 2010:96). The public sector of countries that are on the production frontier is efficient, because they cannot achieve better performance of the public sector with the same level of public spending, while countries located within the efficiency frontier are inefficient, because with a given level of public spending they provide less optimal performance of the public sector. The efficiency of the public sector of countries that are on the efficiency frontier should be interpreted as relative efficiency, i.e. efficiency in relation to the public sectors of the countries being compared to.

Figure 2 shows the position of Serbian public sector, which is the furthest point from the efficiency frontier. In addition, it is obvious that many countries in the region are far from the efficiency frontier, which points to the fact that low efficiency of the public sector is a regional characteristic and that there are possibilities for improvement of the public sector efficiency in the entire region. For DEA analysis and graphical presentation, it must be taken into account that only the direct costs of the inefficiency of the public sector and public services provided are calculated.

Figure 2. Public sector efficiency frontier
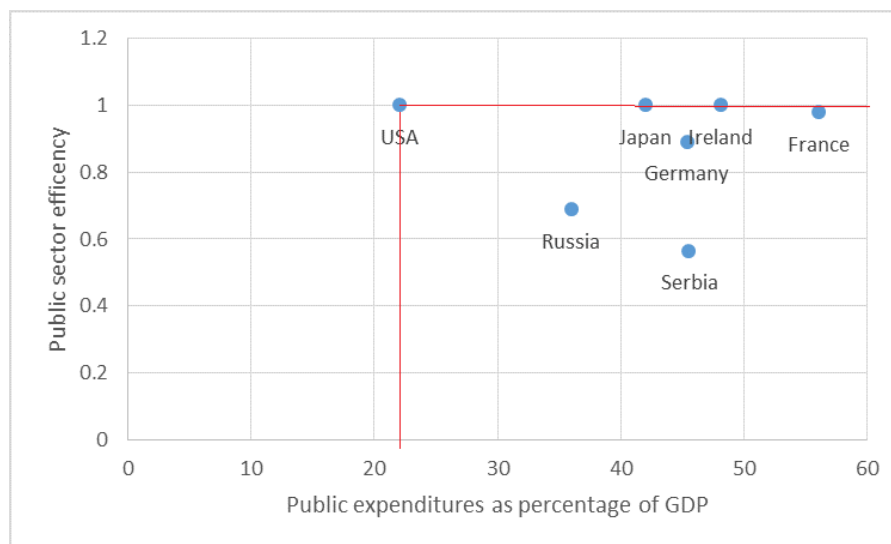
4. Conclusions

The public sector is below average efficient in comparison with EU countries, but also when compared to the countries in the region. The study indicates possibilities for reducing public spending by around 25% without reducing the efficiency of the public sector, which would be sufficient for elimination of the budget deficit.

Public spending in the Republic of Serbia is high, at the level of countries in the region with pronounced consumer-oriented character. The high share of public spending is the result of a legacy network of public services (which are oversized in relation to the current needs, financial capabilities and the size of the country), public sector inefficiency, corruption and low GDP compared to the pre-transition peak.

Excessive level and inadequate structure of public spending adversely affect the sustainability of public finances and economic growth. High costs generated by the public sector are a threat to budgetary balance, while a long-term budget deficit is the most important factor in the growth of the public debt of the Republic of Serbia. In conditions of the global financial crisis and the possibility of the indebtedness crisis outbreak in the Republic of Serbia, unreformed public sector is a factor of instability in public finances and the

cause of the failure of fiscal consolidation. The implementation of fiscal consolidation without the public sector reform will be ineffective. The current financial crisis has exacerbated the problem of fiscal deficit and public debt.

In accordance with long-term foreign policy strategy of Serbia, by which the future of Serbia lies in European integration process, it is necessary to reform the public sector and state administration. An integral part of the Stabilisation and Association Process refers to the government sector and includes several of the most important segments of the public sector reform: tax reform and the reform of public spending, reduction of the hypertrophic public sector and the reduction of public spending to about 40% of GDP, corporatization of public sector enterprises and public utilities, as well as their partial privatization, increasing management efficiency in the public sector and in state administration, and harmonization with European standards in the governance of the state and state property management.

In Serbia, the transition delayed in comparison with other former post-socialist countries, due to the dissolution of Yugoslavia. The delay and postponement of the transition processes by nearly a decade has affected the results of transition in Serbia. The public sector remains unreformed, generating fiscal deficits. The transformation of the public sector includes restructuring, privatization and liquidation of state-owned enterprises, which have the status of companies undergoing restructuring. The experience of transition countries has shown that the privatization of the public sector can be made relatively quickly. The liberalization and introduction of competition in the business of the public sector is essential, wherever it is possible to implement. The increase in public investment or in cooperation with the private sector is necessary due to the obsolescence of equipment and infrastructure. The government policies should be controlling the price of products and services of the public sector. Privatization of public enterprises should be conducted in line with the strategy focused on the functioning of the public sector, harmonized with the regulations and practices of the European Union.

In the state ownership should remain companies engaged in activities that have the character of a natural monopoly and introducing competition where it is not rational. It is necessary to carry out the regulation of natural monopolies, in reference to the quality product and service, with the implementation of the restructuring and privatization of non-core activities, while retaining state ownership. Public companies should participate in the programs of regional cooperation and integration, because such programs lead to greater efficiency and higher levels of public investment.

European Union accession implies observance of the principle of subsidiarity, which is necessary to take into account and in determining the functioning and role of local governments in the state administration system. Greater responsibility of local governments includes transparent public finance system

and the professionalization of civil servants. In the context of fiscal decentralization, it is important to allow bankruptcy of local governments, as an instrument of financial discipline, better management of public investment and greater transparency in financial reporting and implementation of projects of local governments. Financing public investment projects should be conducted with municipal bonds and public-private partnerships.

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