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The Armey Curve: An Empirical Analysis of Selected Balkan Countries and Russia for the Period 2006–2019

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ABSTRACT

The subject of the analysis is to check the validity of the Armey curve which is frequently used in the scientific literature and to establish the optimal level of the public sector. **The aim** of the present study is to analyze the impact of the public sector through public expenditure on the possibility of achieving economic growth. The estimation is based on annual data for the period 2006–2019 of selected Balkan countries and Russia. The authors apply the ordinary least squares (OLS) **method** for a nonlinear regression model. **The conclusion** is that the Armey curve is valid for some of the countries involved in the research among which Serbia, North Macedonia and Russia. The public expenditure to Gross Domestic Product ratio's threshold value, which maximizes economic growth, ranges from 32.94 to 42.37%. The average share of public expenditure in the analyzed countries is approximately equal to the threshold values that are obtained which is indicative of achievement to some extent the desired economic performance. However, the **results** of the study show that the growth of the public sector and its impact on economic development should not be underestimated.
Keywords: Armey curve; public expenditure; economic growth; Balkan countries; Russia

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ОРИГИНАЛЬНАЯ СТАТЬЯ

Кривая Арми: эмпирический анализ отдельных Балканских стран и России за период 2006–2019 годов

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АННОТАЦИЯ

Предметом анализа является обоснованность часто используемой в научной литературе кривой Арми и оптимальный уровень государственного сектора. **Цель** исследования — анализ влияния государственного сектора через государственные расходы на возможность достижения экономического роста. Оценка основана на годовых данных за период 2006–2019 гг. по отдельным Балканским странам и России. Авторы применяют **метод** обыкновенных наименьших квадратов (OLS) для нелинейной регрессионной модели. **Вывод** заключается в том, что кривая Арми действительна для некоторых стран, участвующих в исследовании, среди которых Сербия, Северная Македония и Россия. Пороговое значение отношения государственных расходов к валовому внутреннему продукту, которое максимизирует экономический рост, колеблется от 32,94 до 42,37%. Средняя доля государственных расходов в анализируемых странах примерно равна полученным пороговым значениям, что свидетельствует о достижении в определенной степени желаемых экономических показателей. Однако **результаты** исследования показывают, что рост государственного сектора и его влияние на экономическое развитие не стоит недооценивать.
Ключевые слова: кривая Арми; государственные расходы; экономический рост; Балканские страны; Россия

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INTRODUCTION

There is no consensus in the scientific literature on the impact of public expenditure on a country's social and economic development. The topic of the degree of government intervention in the economic activity is discussed in many scientific debates between different schools of economic thought. The object of analysis in both theoretical and empirical research is the size of the public sector (measured by public expenditure as a percentage of Gross Domestic Product), on the one hand, and determining the optimal levels of this sector that would have a positive effect on the economy, on the other hand. For this reason, various models have been developed and tested, which present theoretically, empirically and graphically the relationship between expenditure and economic growth. In this regard, the Armey curve is used as an appropriate tool.

The present study focuses on empirical testing of the relationship between public expenditure and economic growth, using the Armey curve, for five selected countries in the Balkan region and Russia. Some of the Balkan countries are members of the European Union (Bulgaria and Greece). Serbia and North Macedonia are candidates for European Union membership. Kosovo and the European Union have already signed a Stabilisation and Association Agreement, which is the formal start of the accession negotiations. Russia is also included in the analysis, as a country that has strengthened foreign trade, socio-economic and partnership relations with the Balkan countries. The time period used for the purposes of the analysis is from 2006 to 2019.

The study is structured in four sections. The first section outlines the theoretical and empirical foundations of the relationship between public expenditure and economic growth in the light of the Armey curve. The second section presents the methodological framework of the analysis and descriptive statistics for the variables that are included in the model. The third section consists of applying the developed regression model, assessing the optimal level of the public sector and discussing the results. The last section includes conclusions.

LITERATURE REVIEW

Public expenditure is an important tool in the conduct of any government financial, economic and social policy. The relationship between public expenditure and economic growth is modeled and presented in a large number of scientific studies. Some of them focus on establishing the direction of causality [1–3]. Meanwhile, other studies emphasize the impact of expenditure on growth, highlighting the structure of public expenditure and its effects on economic performance [4–6]. Moreover, in some of these researches, it is concluded that government activities have a stimulating role for the national economy. Other authors take the opposite side in this debate, arguing that rising public expenditure has a negative impact on economic growth. This provoked a group of authors, including R.J. Barro [7], G. Scully [8] and D. Armey [9], to find evidence to support the fact that the relationship is nonlinear. It is postulated that with the gradual increase in public expenditure, gross domestic product (GDP) also tends to grow, but this is valid until a certain point. The increase in expenditures, and hence the influence of the public sector above a certain threshold, is not accompanied by higher growth rates. D. Armey [9] argues that both low and very high levels of public expenditure can have adverse consequences in the pursuit of economic growth. This requires finding an optimal level (PubEXP*), at which the public sector will lead to an increase in GDP. The authors mentioned above derive and present the impact of public expenditure on economic growth in a similar way, using an inverted U–shaped curve (*Fig. 1*). The size of the public sector is shown on the horizontal axis (abscissa), represented by the public expenditure as a percentage of GDP, while the rate of economic growth is shown on the vertical axis (ordinate).

R.J. Barro [7] points out that improving a country's infrastructure through a public resource can be interpreted as a positive sign in terms of future investment activity, and hence for better economic performance. The subsequent expansion of the public sector (by increasing public expenditure) requires the provision of additional resources for its financing. This means that the public revenues have to be increased, which can create an additional tax burden for economic agents. The higher tax rates may lead to more adverse effects on private investors and their expected future rate of return, and this will also affect the incentives to invest in the economy [10]. The expansion of the public sector can be financed not only through taxes but also through the issuance of government debt. However, the participation of the government in the capital markets may lead to an increase in interest rates on borrowed funds and create a so-called *crowding out effect* on private investments [11]. C.N. García [12] derives two main characteristics of public expenditure. On the one hand, public expenditures contribute to tackling market failures, but on the other hand, their excessive growth and use in an ineffective way may lead to government failures. Thus, the Armey curve can be used as a tool for measuring the expenditure efficiency of the public sector.

In modern empirical studies, scholars have verified the validity of the theoretical foundations of the Armey curve, which describes the relationship between public

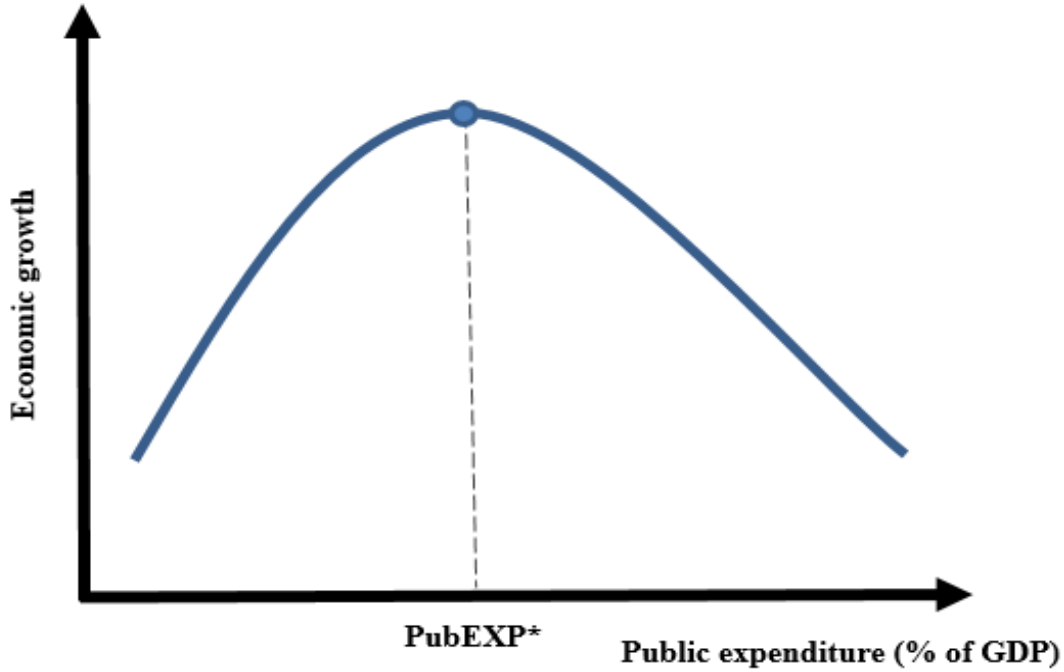

Fig. 1. **Armey curve**
Source: adapted from [7].

expenditure and economic growth. Different groups of countries are subject to analysis. The basis of these studies is not only to establish the relationship between public expenditure and economic growth but also to determine the optimal level (threshold) of public expenditure that would promote a higher growth rate of the national economies. H. Mavrov [13] concludes that there is a nonlinear relationship between public expenditure and economic growth in Bulgaria, where the public expenditure to GDP ratio's threshold value is 28% for the period 1990–2004. In addition, the study investigates the impact of public expenditure categories (classified by function). The validity of the Armey curve is confirmed for some of them (for example education, healthcare services and social security), while for the categories of economic activities and services, general public services and other expenditures only the hypothesis of the linear relationship is established.

O.F. Altunc and C. Aydin [14] test the validity of the Armey curve for selected Balkan countries, including Turkey, Bulgaria and Romania. They find the presence of a nonlinear relationship based on available data for the period 1995–2012. The obtained results show that the threshold values of public expenditure vary between 22% and 25% of GDP, which does not correspond directly to the situation in the analyzed countries. It should be noted that the share of public expenditure to GDP significantly exceeds the calculated optimal levels in these countries. Therefore, governments need to focus on the opportunities to improve public sector efficiency. C. Yüksel [15] points out that the public expenditure and economic growth nexus are extremely dynamic, and differences can be observed not only for individual countries but also for different periods, including within the same economy.

De K. Witte and W. Moesen [16] also investigate and confirm the existence of the Armey curve using time series data for the member countries of the Organization for Economic Co–operation and Development (OECD). Through applying a DEA analysis, they find that the average value of the optimal level of public expenditure to GDP for 23 countries is equal to 41.22% in the long run. This result is significantly higher than the conclusions reached by H. Mavrov [13], O.F. Altunc and C. Aydin [14] for some of the Balkan economies. De K. Witte and W. Moesen [16] explain the higher expenditure to GDP ratio with the concept of the household size. According to this concept, the number of children in families is gradually declining in modern societies and this provokes parents to expect the government to take on more responsibilities. In other words, it strengthens the government's role in promoting social responsibility. Furthermore, P.V. Iyidogan and T. Turan [17] emphasize that the future challenge to the fiscal policy of the countries and the size of the public sector may be the growing ageing population and hence the rising social security expenditure. The differences in the obtained results may also be due to the specification of the empirical models and the explanatory variables included in the analysis. For example, some studies use

government consumption expenditure (as part of the expenditure approach to calculating GDP) as a measure of the public sector, while other investigations use the value of public expenditure from the budget execution reports.

F. Forte and C. Magazzino [10] examine the relationship between the size of the public sector and the economic growth of the European Union Member States for the period 1970 to 2009. The countries under analysis are very heterogeneous. That is why, the authors divide them into groups, which they study separately. The differences between the groups arise from the labor market development, the structure of public expenditure and the level of welfare. The authors conclude that the optimal levels of public expenditure to GDP are as follows: for Eastern European countries — 40%, for Western European countries — 38.32%, for the Anglo–Saxon countries — 40.77% and for the Mediterranean countries — 42.06%. C.N. García [12] reaches similar estimates for the Spanish economy by calculating a threshold of 40% for the period 1980–2016.

There are scientific studies in which the theoretical foundations of the Armey curve are partly confirmed. For instance, D. Lupu and M. Asandului [18] conduct a study for eight Eastern European countries and conclude that only in three of them the validity of the curve is proved. G. Bozma, S. Basar and M. Eren [19] confirm the existence of the Armey curve only for some of the G7 countries (USA, France and Canada). This is not valid for Germany, United Kingdom, Japan and Italy.

DATA AND METHODOLOGY

In the present study, we use a nonlinear regression model to conduct econometric analysis. The dependent variable is economic growth (EGR) defined as the growth rate of real GDP. Economic growth is presented as a function of public expenditure (PubEXP) and other selected exogenous factors (ExVariables).

$$\mathrm{EGR} = f\left(\mathrm{PubEXP},\ \mathrm{ExVariables}\right). \qquad (1)$$

Therefore, public expenditure (presented as percentage of GDP) is included as an independent variable in the model. The square of the variable public expenditure as a percentage of GDP is also included in the regression model. This is frequently used when testing for the presence of the Armey curve and proving a nonlinear relationship between the dependent and the independent variable. This approach is applied in the studies of R.K. Vedder and L.E. Gallaway [20], H. Mavrov [13], F. Forte and C. Magazzino [10] and O.F. Altunc and C. Aydin [14]. In addition, an exogenous variable is added to the independent variables in the econometric model specification of the present study. In the empirical literature, this approach is commonly used in research on this topic. The following indicators are widely used as exogenous variables: unemployment rate [14, 18], trade openness [21–23], investment and consumption expenditures [21, 22], population and tax rates [24]. The public revenue as a percentage of GDP is chosen as an exogenous variable in the present analysis. In this way, the impact of both the expenditure and the revenue side of the budget on economic growth can be investigated. M.G. Attinasi and A. Klemm [25], F.T. Boldeanu, I. Tache and M. Ion [26] use a similar technique and thus aim to show the impact of fiscal policy on overall growth. Furthermore, in the literature review section of our study, it is emphasized that the expansion of the public sector requires additional resources in government budgets, which further affects economic development.

We use ordinary least squares (OLS) method as econometric technique of analysis. Following regression model is used to test the validity of the Armey curve:

$$EGR_{i,t} = \beta_0 + \beta_1 PubEXP_{i,t} + \\ + \beta_2 \left(PubEXP_{i,t}\right)^2 + \beta_3 \left(PubREV_{i,t}\right) + \varepsilon_{i,t}, \qquad (2)$$

where: EGR — economic growth, presented as a growth rate of real GDP;

PubEXP — public expenditure as a percentage of GDP;

PubREV — public revenue as a percentage of GDP;

ε — residual component;

$i = 1...6$;

$t = 2006, \ldots 2019$.

To assume the validity of the Armey curve, the coefficient β_1 has to be positive ($\beta_1 > 0$), while the sign of the coefficient β_2 has to be negative ($\beta_2 < 0$). For countries where the Armey curve is valid, we can calculate the threshold value of the public expenditure to GDP, which promotes higher economic growth. F. Facchini and M. Melki [24], F. Forte and C. Magazzino [10], O.F. Altunc and C. Aydin [14], D. Lupu and M. Asandului [18] determine this optimum (threshold) using the value of the coefficients before the parameters of the model as follows:

$$PubEXP^* = -\frac{\beta_1}{2\beta_2}. \qquad (3)$$

In the present study, we test the validity of the Armey curve for the economies of Bulgaria, Kosovo, Serbia, Greece, North Macedonia and Russia. The countries, which we include in the scope of our study, are positioned in Southeast Europe. Most of them are located in the Balkans. Russia is included in the analysis due to the

Table 1

Descriptive statistics

Variables	Mean	Min	Max	Median	Std. Dev.	Coefficients of variation	Skewness	Kurtosis
Serbia								
EGR	2.39	–2.70	6.40	2.45	2.74	1.15	–0.37	–0.82
PubEXP	42.87	40.41	45.16	42.87	1.34	0.03	–0.01	–0.32
PubREV	40.04	37.32	42.11	40.05	1.57	0.04	–0.30	–1.24
North Macedonia								
EGR	3.04	–0.50	6.50	3.15	2.01	0.66	–0.26	–0.42
PubEXP	34.04	31.62	36.03	33.99	1.16	0.03	–0.24	–0.22
PubREV	31.75	29.65	35.41	31.44	1.74	0.05	0.65	–0.63
Russia								
EGR	2.43	–7.80	8.50	2.15	4.17	1.72	–0.78	0.83
PubEXP	35.20	31.12	41.35	34.80	2.42	0.07	0.97	1.41
PubREV	35.59	32.40	40.21	34.83	2.52	0.07	0.67	–0.84
Bulgaria								
EGR	2.83	–3.37	6.80	3.30	2.79	0.98	–0.48	–0.06
PubEXP	36.91	33.70	43.30	36.45	2.70	0.07	0.92	0.29
PubREV	36.37	31.90	38.80	36.70	2.27	0.06	–0.53	–0.93
Kosovo								
EGR	3.94	1.20	8.30	3.90	1.51	0.38	1.42	3.73
PubEXP	26.27	17.35	29.40	27.48	3.42	0.13	–1.69	1.69
PubREV	25.53	22.82	28.18	26.12	1.49	0.06	–0.19	–0.76
Greece								
EGR	–1.19	–10.15	5.65	–0.37	4.30	3.61	–0.56	–0.37
PubEXP	51.65	45.10	62.70	50.75	4.63	0.09	0.82	0.34
PubREV	45.43	38.90	50.30	47.35	4.32	0.10	–0.42	1.52

Source: Authors' own calculations based on: Republic of North Macedonia. Ministry of Finance. URL: https://finance.gov.mk/budget-execution-reports/?lang=en; Republic of Serbia. Ministry of Finance. URL: https://mfin.gov.rs/en/documents2-2/macroeconomic-data-2; Republic of Kosovo. Ministry of Finance. URL: https://mf.rks-gov.net/Page.aspx?id=2,125; Eurostat. URL: https://ec.europa.eu/eurostat/web/products-statistical-books/-/ks-ek-20-001; Russian Federation. The Federal Treasury. URL: https://roskazna.gov.ru/ispolnenie-byudzhetov/konsolidirovannye-byudzhety-subektov/; Republic of North Macedonia. Ministry of Finance. URL: https://finance.gov.mk/%d0%b4%d0%be%d0%ba%d1%83%d0%bc%d0%b5%d0%bd%d1%82%d0%b8-2/; International Monetary Fund. URL: https://www.imf.org/en/Publications/WEO/Issues/2020/09/30/world-economic-outlook-october-2020 (accessed on 11.07.2021).

Table 2

Testing the Validity of the Armey Curve in Serbia, North Macedonia, Russia, Bulgaria, Kosovo and Greece

Dependent variable: Economic growth (EGR)					
	Intercept	**PubEXP**	**PubEXP2**	**PubREV**	**Validity of the Armey curve**
Serbia					
Coefficients	−9.15455	41.65213	−49.14776	0.90650	Yes
P-value	0.07870*	0.08452*	0.08130*	0.04512**	
Standard Error	4.67566	21.75230	25.35596	0.39611	
t Stat	−1.95791	1.91483	−1.93831	2.28850	
North Macedonia					
Coefficients	−6.22163	36.63494	−55.60289	0.72802	Yes
P-value	0.04321**	0.04274**	0.03828**	0.01179**	
Standard Error	2.68878	15.78825	23.31375	0.23694	
t Stat	−2.31391	2.32039	−2.38498	3.07251	
Bulgaria					
Coefficients	1.93843	−11.68344	14.25340	1.23959	No
P-value	0.07319*	0.05154*	0.06413*	0.00225***	
Standard Error	0.96846	5.28614	6.85072	0.30467	
t Stat	2.00156	−2.21020	2.08056	4.06852	
Greece					
Coefficients	2.46763	−8.87279	7.64825	0.10496	No
P-value	0.00591***	0.00721***	0.01122**	0.51642	
Standard Error	0.70897	2.63917	2.46599	0.15605	
t Stat	3.48057	−3.36195	3.10148	0.67262	
Kosovo					
Coefficients	0.34540	−3.17306	5.89730	0.44706	No
P-value	0.05642*	0.02648**	0.04901**	0.11495	
Standard Error	0.16015	1.22031	2.63281	0.25893	
t Stat	2.15670	−2.60021	2.23992	1.72653	
Russia					
Coefficients	−2.27366	11.45220	−16.85436	1.02351	Yes
P-value	0.05689*	0.06423*	0.04844**	0.00531***	
Standard Error	1.05663	5.50676	7.50161	0.28871	
t Stat	−2.15178	2.07966	−2.24676	3.54504	

Note: * indicate significance at 10% level; ** indicate significance at 5% level; *** indicate significance at 1% level.

Source: Authors' own calculations based on: Republic of North Macedonia. Ministry of Finance. URL: https://finance.gov.mk/budget-execution-reports/?lang=en; Republic of Serbia. Ministry of Finance. URL: https://mfin.gov.rs/en/documents2-2/macroeconomic-data-2; Republic of Kosovo. Ministry of Finance. URL: https://mf.rks-gov.net/Page.aspx?id=2,125; Eurostat. URL: https://ec.europa.eu/eurostat/web/products-statistical-books/-/ks-ek-20-001; Russian Federation. The Federal Treasury. URL: https://roskazna.gov.ru/ispolnenie-byudzhetov/konsolidirovannye-byudzhety-subektov/; Republic of North Macedonia. Ministry of Finance. URL: https://finance.gov.mk/%d0%b4%d0%be%d0%ba%d1%83%d0%bc%d0%b5%d0%bd%d1%82%d0%b8-2/; International Monetary Fund. URL: https://www.imf.org/en/Publications/WEO/Issues/2020/09/30/world-economic-outlook-october-2020 (accessed on 11.07.2021).

Table 3

Adequacy of regression models

	Serbia	North Macedonia	Bulgaria	Greece	Kosovo	Russia
Significance F	0.03216	0.01439	0.01248	0.00167	0.00613	0.00105
Multiple R	0.75437	0.79760	0.80428	0.87564	0.83389	0.88768
R Square	0.56908	0.63616	0.64687	0.76675	0.69538	0.78799
Adjusted R Square	0.43980	0.52701	0.54093	0.69677	0.60400	0.72439
Standard Error	0.02051	0.01383	0.01888	0.02368	0.00949	0.02188
Observations	14	14	14	14	14	14

Source: Authors' own calculations based on: Republic of North Macedonia. Ministry of Finance. URL: https://finance.gov.mk/budget-execution-reports/?lang=en; Republic of Serbia. Ministry of Finance. URL: https://mfin.gov.rs/en/documents2-2/macroeconomic-data-2; Republic of Kosovo. Ministry of Finance. URL: https://mf.rks-gov.net/Page.aspx?id=2,125; Eurostat. URL: https://ec.europa.eu/eurostat/web/products-statistical-books/-/ks-ek-20-001; Russian Federation. The Federal Treasury. URL: https://roskazna.gov.ru/ispolnenie-byudzhetov/konsolidirovannye-byudzhety-subektov/; Republic of North Macedonia. Ministry of Finance. URL: https://finance.gov.mk/%d0%b4%d0%be%d0%ba%d1%83%d0%bc%d0%b5%d0%bd%d1%82%d0%b8-2/; International Monetary Fund. URL: https://www.imf.org/en/Publications/WEO/Issues/2020/09/30/world-economic-outlook-october-2020 (accessed on 11.07.2021).

country's historical, economic and political relations with other Balkan economies. The study is based on annual time series data for the period from 2006 to 2019. The data set used in the analysis is obtained from the reports on the execution of the consolidated budget, published by the Ministries of finance of the countries and other fiscal institutions. We also use the International Monetary Fund's macroeconomic statistics and Eurostat as a source of data.

The descriptive statistics of the variables used in the regression model for the six selected countries are shown in *Table 1*.

EMPIRICAL RESULTS

The results of the applied model are presented *in Table 2, Table 3, Table 4* and *Table 5*. Based on the results shown in *Table 2*, we confirm the validity of the Armey curve for three of the analyzed countries — Serbia, North Macedonia and Russia. As can be seen from *Table 2*, all independent variables in the nonlinear regression model for these countries are statistically significant in levels at 1, 5 and 10%. Thus, the increase of the public sector in Serbia, North Macedonia and Russia contributes to a better economic performance, but this is valid up to a certain threshold value of the public expenditure to GDP ratio.

According to the results shown in *Table 2*, it can be concluded that the Armey curve is not valid for Bulgaria, Kosovo and Greece. As already mentioned above, the sign of the regression coefficient β_2 has to be negative while the regression coefficient β_1 has to be positive in order to confirm the existence of the curve.

The adequacy of the regression models is also checked (*Table 3*). The obtained results verify that all nonlinear regression models are adequate at 5% significance level. The models are characterized by a relatively high explanatory power, measured by the coefficient of determination (*R Square*) and the adjusted coefficient of determination (*Adjusted R Square*). Taking into account the obtained values of the coefficients of determination, it is concluded that the differences in the economic growth can be to a large extent explained by the simultaneous influence of the expenditure and revenue of the public sector.

All regression models are additionally tested for heteroskedasticity (by the Breusch–Pagan test), autocorrelation (by the Breusch-Godfrey test) and normal distribution of the residuals (by the Chi-square test). The results in Table 4 highlight that the regression models for all countries included in the analysis can be accepted as accurate. The residuals are homoskedastic, normally distributed and lack of first-order autocorrelation.

In addition, we calculate the public expenditure to GDP ratio's threshold value (PubEXP*) for the countries where the Armey curve is valid. The results are published in *Table 5* below.

The calculated threshold value of the public expenditure to GDP ratio in Serbia is 42.37% for the period 2006–2019. When we compare this value with the data from the descriptive statistics given in *Table 1*, it is established that the average value for the period in the scope of the analysis (42.87%) is approximate to the determined optimum. For instance, the public expenditure accounted for 45.16% of Serbia's gross

Table 4

Regression diagnostics and specification tests

Model	Breusch-Pagan test for heteroskedasticity	Breusch-Godfrey test for first-order autocorrelation	Test for normality of residual (Chi-square)
Model (Serbia)	H0: heteroskedasticity not present Test statistic: LM = 2.54598 p-value = 0.467039	H0: no autocorrelation Test statistic: LMF = 0.0248925 p-value = 0.878118	H0: error is normally distributed Test statistic: Chi-square(2) = 5.68269 p-value = 0.0583471
Model (North Macedonia)	H0: heteroskedasticity not present Test statistics: LM = 1.69645 p-value = 0.637723	H0: no autocorrelation Test statistic: LMF = 0.277351 p-value = 0.611174	H0: error is normally distributed Test statistic: Chi-square(2) = 1.82067 p-value = 0.40239
Model (Bulgaria)	H0: heteroskedasticity not present Test statistic: LM = 1.02946 p-value = 0.794123	H0: no autocorrelation Test statistic: LMF = 0.538966 p-value = 0.481549	H0: error is normally distributed Test statistic: Chi–square(2) = 2.68648 p-value = 0.260999
Model (Kosovo)	H0: heteroskedasticity not present Test statistics: LM = 5.07455 p-value = 0.166419	H0: no autocorrelation Test statistic: LMF = 1,66776 p-value = 0,228738	H0: error is normally distributed Test statistic: Chi-square (2) = 0.340242 p-value = 0.843563
Model (Greece)	H0: heteroskedasticity not present Test statistics: LM = 4.93886 p-value = 0.176329	H0: no autocorrelation Test statistic: LMF = 2.44049 p-value = 0.152675	H0: error is normally distributed Test statistic: Chi-square (2) = 5.07709 p-value = 0.0789811
Model (Russia)	H0: heteroskedasticity not present Test statistics: LM = 1.41689 p-value = 0.701581	H0: no autocorrelation Test statistic: LMF = 0.00723785 p-value = 0.934064	H0: error is normally distributed Test statistic: Chi-square (2) = 3.24816 p-value = 0.197093

Source: Authors' own calculations based on the results from the regression model.

domestic product in 2014. It is significantly higher than the calculated threshold. The period under review is characterized by volatility in the GDP growth rate, ranging from –2.7% to 6.4%.

The obtained optimal values for the size of the public sector in North Macedonia and Russia are quite similar. The real growth rate of GDP would maximize when the public expenditure to GDP ratio is equal to 32.94% in North Macedonia, while in Russia the threshold is 33.97%. For both countries the annual average data shows that the economies are close to their optimum, which maximizes economic growth. However, it should be noted that while public expenditure varies between 31.62% and 36.03% of GDP for the period 2006–2019 in North Macedonia, in Russia this share varies more widely — from 31.12 to 41.35% of GDP. The dynamics in the ratio for Russia are observed primarily for the period up to 2011.

Table 5

Public expenditure to GDP ratio's threshold value

Country	Threshold value, %
Serbia	42.37
North Macedonia	32.94
Russia	33.97

Source: Authors' own calculations based on the results from the regression model.

In *Figure 2* we show a simulation model of the Armey curve in Serbia, North Macedonia and

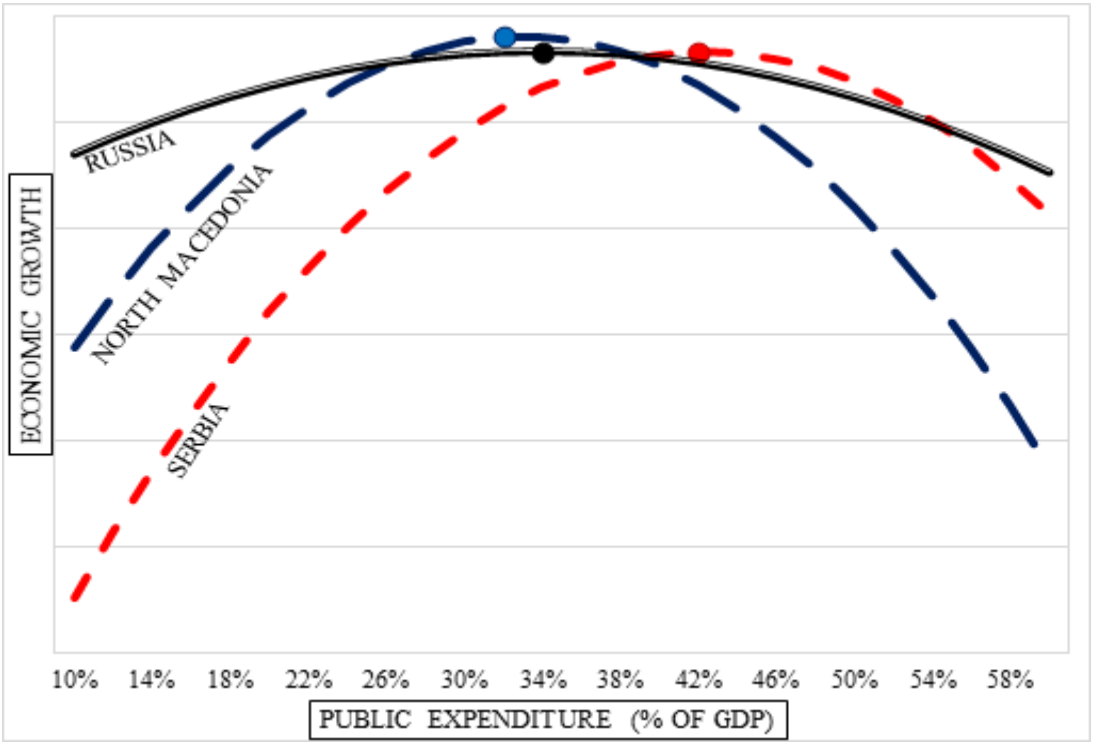

Fig. 2. **Modelling the Armey curve in Russia, North Macedonia and Serbia**
Source: authors' own calculations based on the results from the regression model.

Russia. The illustration of the curves is based on the results from the regression model developed and applied above, taking into account the effect of public expenditure and the calculated threshold in *Table 5*. The data shows that in Serbia the changes in the size of the public sector (with a change in public expenditure in the range of 10% to 60% of GDP) would significantly affect the rate of economic growth, especially when the government is not actively involved in economic processes. At the same time, the dynamics of the public expenditure to GDP ratio in North Macedonia can also have a substantial impact on economic development. This can be seen from the concave shape of the Armey curve for North Macedonia. When the share of public expenditure to GDP decreases (below the certain threshold), this would lead to a slowdown in the growth rate in North Macedonia, but this decline would be significantly less than the decline that would be observed in the economy of Serbia. On the other hand, the higher size of the public sector (above the set optimum) would have a significantly more negative effect on the economic growth of North Macedonia. The Armey curve for Russia is smoother than the curves for Serbia and North Macedonia. This suggests that more tangible changes in the public expenditure to GDP ratio would not lead to large variations in the level of Russia's real gross domestic product.

CONCLUSIONS

Empirical testing of the validity of the Armey curve allows us to conclude that the nonlinear model representing the relationship between public expenditure and economic growth is partly applicable. This permits us to further assess the optimal size of the public sector in countries where the Armey curve is valid. The results from this assessment show that in the period 2006–2019, countries such as Serbia, North Macedonia and Russia manage their public sector in a way that to some extent allows the desired economic performance to be achieved. The obtained thresholds are approximately equal to the average values of the analyzed fiscal indicators. However, in certain years of the analyzed period, these countries also show some changes in the ratio of public expenditure to GDP, which contributes to the stimulating or restraining effects on the national economies. This is a particularly actual problem in the current COVID-19 pandemic. Attempts by countries around the world (including Serbia, North Macedonia and Russia) to deal with the crisis lead to a sharp rise in the public expenditure in 2020. The uncontrolled increase in public expenditure during the pandemic, whether in the form of anti-crisis measures, can lead to fiscal imbalances if the effectiveness of these expenditures is not taken into account. That is why further research can focus on different types of public expenditure and

analyze their optimal levels, which would maximize economic growth. This analysis could also be extended by prioritizing the importance of public expenditure to a national economy. In this way, it will be possible to analyze in more detail the policies pursued so far and to draw conclusions about whether the financial resources have been used in a sufficiently reliable manner.

In conclusion, it is necessary to find the necessary balance between the optimal size of the public sector, the structure of public expenditure and their efficiency in order to pursue higher rates of economic growth.

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