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A NEW SIMPLE TEST TO EVALUATE THE EFFICIENCY OF GOVERNMENT SPENDING

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ABSTRACT. The main purpose of this study is to determine the conditions that enable optimal distribution of the government revenues between capital and current expenditures, one that would maximize the firms' and households' utility and provide the maximum impact of the government expenditures on economic growth rate. Research indicates that for such optimal distribution of the budget to be defined, the derivatives of output functions with respect to the government capital expenditure and the government current expenditure must be equal. The obtained theoretical results serve as a basis for a test that analyzes the efficiency of the allocation of government revenues between current and capital expenditure items. The test is based on intervals established at significance levels of 0.01-0.99. If the difference between the marginal value of the production function with respect to the government's current and capital expenditure falls into any of these established intervals, the distribution of government expenses in these two directions can be considered effective at the level of significance corresponding to that interval. Research results found that governments usually cannot efficiently allocate their revenues between capital and current expenditures.

Keywords: optimal composition, government expenditures, households' utility, economic growth rate, efficiency of the government spending.

Introduction

Since the middle of the previous century, in particular since the Great Depression, governments' fiscal policies have expanded their role in the regulation of the economy. Nowadays, fiscal policy is gaining significance (mostly in emerging markets) in terms of stimulating economic growth. However, as early as the 1890s, Wagner discussed the importance of the government's role in defining the contours of economic growth; unlike the classical economists, he gave weight to fiscal policy. In the 1930s, Keynes posited that the government budget is a powerful tool to affect aggregate demand and regulate the economy. While aggregate demand could be stimulated by high government spending, consumption and investment spending could be influenced by lowering or raising taxes. Nowadays, the share of government spending in the economy is increasing; discussions about the effectiveness of fiscal multipliers are ongoing (Chen, 2006, p. 123). Moreover, studies on endogenous growth make it clear that fiscal policy also has potential effects on the economy in the long run. Arrow and Kurz (1970), Barro (1990), and other researchers assumed that all government spending was productive. However, Chen (2006) argued that government consumption expenditures are a public good and should be included in households' utility functions. In this context, an investigation of the impact of government spending on economic activity becomes especially relevant in the post-crisis period.

Recently, the definition of the optimal composition of government spending to maximize the impact of expenditures on economic growth has garnered significant research interest. Barro (1990), Devarajan et al. (1996), Ghosh and Gregoriou (2008), Chen (2006), and others assumed that government revenues consist only of income tax and there is no deficit in the budget. However, in practice, tax revenues rarely cover budget expenditures and the oil factor plays a very important role in financing this deficit in most oil-rich countries. In these economies, the afore-mentioned deficit is mainly covered by the transfer of strategic funds, which are formed by oil revenues. This means that, the oil factor should be considered in constructing the optimization problem when optimal allocation of fiscal expenditures is studied. In this context, IMF staff (IMF, 2007) and Koeda and Kramarenko (2008) used a neo-classical growth model in which oil revenues are included in the government's budget constraint as a fixed value to investigate the economic growth of Azerbaijan. In fact, quick analysis of the data in state budget expenditures (G) and the transfers from the Oil Fund[1] (O) shows that O = [9905.0, 11350.0, 9337.0, 10388.0, 7615.0][2] and G = [17416.5, 19143.5, 18709.0, 17784.5, 17751.3][3] for the period of 2012–2016. Therefore, the share of the transfers from the Oil Fund can be constructed as $\theta = O/G = [0.57, 0.59, 0.50, 0.58, 0.43]$. As a small open emerging economy, Azerbaijan has experienced the oil boom era and periods of high economic growth. Most of these growth spikes were due to oil exports and large government infrastructure projects. Nowadays, oil prices are no longer as high, so it is essential for policymakers to estimate the contribution of government finance to real non-oil growth. Thus, we may consider the amount of transfers from the Oil Fund as the government's budget deficit. In this context, those transfers can be included in the model as a share of total government expenditure.

Consequently, the main goal of this study is to develop optimality conditions for the best composition of government expenditures and to establish a new simple test to evaluate whether government expenditures are optimal. Additionally, the secondary aim of this research is to analyse the effects of some macroeconomic indicators, such as the capital stock, the tax rate, the oil factor etc. on economic growth.

1. Literature review

The literature on the optimal composition of fiscal expenditures goes back to Barro (1990) and Devarajan et al. (1996). The literature on endogenous economic growth involves models in which private and social returns to investment diverge (Barro, 1990). Some researchers argue that the private return on scale may be diminishing while social returns can be constant or increasing (Arrow, 1962; Romer, 1986). Another research study concerns the models without externalities, which commit to constant returns to private capital (Rebelo, 1991). Also, Chen (2006) studied the optimal composition between public investment and consumption in government expenditures and its relationships with economic growth using a one-sector endogenous growth model. He has followed Barro (1990) by adding public

[1] The public stabilization fund accumulating revenues from oil export
[2] Source: http://www.oilfund.az/en_US/hesabatlar-ve-statistika/buedce-melumatlari.asp?start=10
[3] Source: https://www.stat.gov.az/source/finance/?lang=en

consumption into households instantaneous utilities function and productive public services entering private production in an external fashion (Chen (2006), p. 126). Besides, we can also see the various sides of optimal budget allocation in the papers that have been introduced by Chen et al. (2003), Lee (1992), and so on. Chen (2006) states that countries with a larger share of productive public expenditures have higher economic growth. However, *the first-order derivative of economic growth* with respect to the share of productive public expenditures is equal to a non-negative value. Devarajan et al. (1996) have introduced an interesting result about this statement, stating that government investment expenditures are productive only if *the derivative of economic growth* with respect to the share of productive public expenditures is positive. They believed that public expenditures had an impact on output growth after some time. On the basis of this statement, their dependent variable is the five-year forward moving average of per capita real GDP growth. However, the construction of the dependent variable as a five-year forward moving average of per capita real GDP growth causes a serial correlation in the error terms. Therefore, in order to correct the standard errors, Devarajan et al. (1996) extended the method of correlation correction outlined by Hansen and Hodrick (1980). Usually, households' utility function is used as the objective function in macroeconomic equilibrium models. We can mention Ramsey (1928) as a pioneer in the application of households' utility functions in macroeconomic analysis. In research introduced by Barro (1990), Devarajan et al. (1996), and Ghosh and Gregoriou (2008), the CES-type utility function was an objective function of the optimization problem. In contrast to these researchers, Chen (2006) applied the Cobb-Douglas-type households' utility function to investigate the relationship between economic growth and an optimal government spending composition. The logarithmic households' utility function had been included as the objective function by Chappell (1977), Braumann (2004), and other researchers. Chappell (1977) has taken the utility function with the discount rate, which is the sum of two components: the rate of pure time preference and the (exponential) growth rate of the population. However, Braumann (2004) used a simpler version of the logarithmic households' utility function with the discount factor. He analyzed the impact of the high inflation on the economy under the maximization of this household's utility function. We also looked through two papers, which were introduced by Tinbergen (1960) and Chakravarty (1962), who used the subsistence level of consumption in their utility function.

The link between the composition of government spending and economic growth was investigated by Marica (2015) and Bojanic (2013) for Italy and Bolivia, respectively. Hasanli et al. (2009) investigated the impact of state budget spending on some macroeconomic indicators (inflation, salary, economic growth, etc.) in Azerbaijan. Besides that, Abbasov and Aliyev (2018) tested Wagner's law and Keynesian hypothesis in selected post-Soviet countries and found that there is a long-run relationship between total GDP and government expenditures in Azerbaijan. In addition, Aliyev (2018), Hasanov and Mammadov (2010), Hasanov et al. (2018), Hasanov et al. (2016), Aliyev and Mikayilov (2016), and Abbasov (2012, 2013, 2018) have devoted research to the role of fiscal policy in the development of the economy in Azerbaijan.

Abbasov (2018) investigated the optimal allocation of government revenue between capital and current expenditures and found that optimal shares of government capital (ω_1^*) and current (ω_2^*) expenditures are equal to 0.248 and 0.752, respectively. On the basis of this result, we can compare the optimal composition of state budget expenditures with the actual allocation of budget expenditures. For example, in 2017 Q3, factual budget expenditures are as $g_1 = 1332.3$ and $g_2 = 2985.9$ in Azerbaijan. From this figure, we get that, $\omega_1 = 0.309$ and $\omega_2 = 0.691$. We encountered a similar picture at all points of the observed period. Hence, on average, in the period 2005Q1–2017Q3, the factual composition of the state budget between capital and current expenditures was 0.33 and 0.67, respectively. Meaning that state budget capital expenditures didn't have the maximum impact on steady state economic growth for the period 2005Q1–2017Q3 in Azerbaijan.

Abbasov et al. (2021) investigate the impact of the government's capital and current expenditures on economic growth, comparing the role of government expenditures on non-oil economic activity before and during the COVID-19 pandemic in Azerbaijan. Their results show that coefficients characterizing the impact of government current expenditures and capital expenditures on non-oil economic growth are almost the same for both periods. They stated that the COVID-19 pandemic did not affect the structure of the relationship between government expenditures and non-oil economic growth and found that a 1 percent increase in capital and current expenditures of the state budget increases the real non-oil GDP by 0.10 and 0.40 percentage points, respectively.

2. Optimization problem

Objective function:

On the basis of Ramsey's (1928) utility theory, we assume that households would have to maximize utility over two goods: consumption and leisure. As a result, we take the Cobb-Douglas-type households' utility function with a labor-leisure choice as the objective function of our optimization problem.

$$\max_{c,L\geq 0} U(c,L) \tag{1}$$

Where,

$$U(c,L) = \int_0^\infty [c^\varphi (1-L)^{1-\varphi}]\, e^{-pt} dt$$

Where, c is households' consumption, L is the labor supply, p is the rate of time preference, $0 < \varphi < 1$ and $0 < 1-\varphi < 1$ are the shares of households' consumption and households' leisure in utility, respectively.

Constraint conditions:

As mentioned in the introduction section, we construct the constraint conditions of the optimization problem considering the oil factor. For example, for the period 2012–2016, we can calculate the share of the transfers from the Oil Fund to the government budget (for details, see the introduction section) as θ = O/G = [0.57, 0.59, 0.50, 0.58, 0.43]. This approach will help us eliminate the mathematical complexity in the solution of the optimization problem.

So, assume that we have two types of government expenditures: capital expenditures and current expenditures from the state budget. Like Arrow and Kurz (1970) and Barro (1990), we suppose that both of the expenditures are productive. Therefore, both of them will be components of the production function in our optimization problem. On the basis of these statements, our constraint conditions are as follows:

$$y = f(k, g_1, g_2, L, X) \tag{2}$$

Where y is the output, f is an output-generating function assumed to be concave, k is the capital stock, g_1 is the government capital expenditure, g_2 is the government current expenditure, L is the labor supply, and X is any vector of control variables.

$$I = G \tag{3}$$

$$I = T + O,\ T = \tau y,\ O = \theta G \qquad (4)$$

Where I is the state budget revenues, G is the state budget expenditures, T is the tax revenue, O is the transfers from the oil fund to the state budget, θ is the share of the transfer from the oil fund in government expenditure, τ is the tax rate.

$$G = g_1 + g_2 \qquad (5)$$

$$g_1 + g_2 = \tau y + \theta G = \tau y + \theta(g_1 + g_2)$$

$$g_1 + g_2 = \tau y(1-\theta)^{-1} \text{ (the government budget constraint)} \qquad (6)$$

$$g_1 = \omega_1 \tau y(1-\theta)^{-1} \qquad (7)$$

$$g_2 = \omega_2 \tau y(1-\theta)^{-1} \qquad (8)$$

$$\omega_1 + \omega_2 = 1$$

Where ω_1 and ω_2 are the fractions of the capital expenditure (g_1) and the current expenditure (g_2) in total state budget expenditure, respectively.

$$\dot{k} = (1-\tau)y - c \qquad (9)$$

Where $\dot{k}$ is the derivative of capital stock with respect to time (t), y is the output, and c is households' consumption.

Thus, (1) is the objective function, and (2), (7), (8), and (9) are constraint conditions of our optimization problem. Note that (1) and (2) are households' utility and production functions, respectively.

3. Solutions and results

3.1. Optimal composition of the government expenditures

In this subsection, we tried to find the optimal composition of the state budget expenditures. This allocation will have the maximum contribution to the economic growth rate. Consequently, we suggested *Proposition 1* for the optimal solution.

Proposition 1*: If ω_1^* is the optimal share of the state budget capital expenditures of which the government has the maximum impact on the economic growth rate, then $\frac{\partial f}{\partial g_1}$ and $\frac{\partial f}{\partial g_2}$ must be equal to each other in (2).*

Proof of *Proposition 1* has been given in Appendix A. The solution of the equation $\frac{\partial f}{\partial g_1} - \frac{\partial f}{\partial g_2} = 0$ with respect to the share of state budget capital expenditure (ω_1) gives us the optimal composition of the state budget expenditure (ω_1^*). If ω_1^* is optimal, then the derivative of economic growth with respect to share of the state budget capital expenditure will be positive $\left(\frac{\partial \mu}{\partial \omega_1} > 0\right)$ on the left-hand side of this point and negative $\left(\frac{\partial \mu}{\partial \omega_1} < 0\right)$ on the right-hand side of this point. This result suggests that the derivative of economic growth with respect to the share of state budget capital expenditure is positive $\left(\frac{\partial \mu}{\partial \omega_1} > 0\right)$ if $\frac{\partial f}{\partial g_1} > \frac{\partial f}{\partial g_2}$ and negative $\left(\frac{\partial \mu}{\partial \omega_1} < 0\right)$ if, $\frac{\partial f}{\partial g_1} < \frac{\partial f}{\partial g_2}$ (see Appendix A, equation A.9). Note that, if the derivative of production (output) with respect to the state budget capital expenditure $\left(\frac{\partial f}{\partial g_1}\right)$ is greater than the derivative of production (output) with respect to the state budget current expenditure $\left(\frac{\partial f}{\partial g_2}\right)$, then the economic growth rate (μ) will increase as the share of the state budget capital expenditure increases and vice versa.

3.2. Effects on economic growth

According to *Proposition 1*, we defined the economic growth rate (μ) (see Appendix A) as follows:

$$\mu = k^{-1}(1-\tau)f(k, g_1(\omega_1, \tau, y, \theta), g_2((1-\omega_1), \tau, y, \theta), L, X) \tag{10}$$

In the previous subsection, we characterized the economic growth rate with respect to the share of state budget capital expenditures (ω_1) and found the optimal composition of the state budget expenditures.

In this subsection, additional comparative effects are presented, which analyze the changes in economic growth with respect to different variables. So, *the derivative of economic growth with respect to the capital stock* $\left(\frac{\partial \mu}{\partial k}\right)$ can be calculated by taking the first order derivative of (10).

$$\frac{\partial \mu}{\partial k} = (1-\tau)k^{-1}\left(\frac{\partial y}{\partial k} - \frac{y}{k}\right) \tag{11}$$

From (11) we can see that $\frac{\partial \mu}{\partial k}$ is negative (positive) if and only if $\frac{\partial y}{\partial k} < \frac{y}{k}$ $\left(\frac{\partial y}{\partial k} > \frac{y}{k}\right)$ in given value of k, g_1, g_2, τ, y, L and X. In general, a negative *derivative of economic growth with respect to the capital stock* is likely to reflect diminishing returns to capital. As the capital stock increases, the growth rate of capital diminishes, which is a purely neoclassical result.[4] But (11) shows us that it depends on two ratios. Thus, if the ratio of change in output to the change in capital stock is greater than the ratio of output to capital stock, then *the derivative of economic growth with respect to the capital stock* is positive, and vice versa.

Next, *the derivative of economic growth with respect to the income tax rate* $\left(\frac{\partial \mu}{\partial \tau}\right)$ is investigated. It has been done by calculating the first-order derivative of (10) with respect to τ. This *derivative* is given in (12) for values of k, g_1, g_2, τ, y, L and X.

$$\frac{\partial \mu}{\partial \tau} = k^{-1}\left((1-\tau)\left[\frac{\partial f}{\partial g_1}\frac{\partial g_1}{\partial \tau} + \frac{\partial f}{\partial g_2}\frac{\partial g_2}{\partial \tau}\right] - y\right) \tag{12}$$

We can see from (12) that *the derivative of economic growth* with respect to the income tax rate is positive, $\left(\frac{\partial \mu}{\partial \tau} > 0\right)$ if and only if

$$(1-\tau)\left[\frac{\partial f}{\partial g_1}\frac{\partial g_1}{\partial \tau} + \frac{\partial f}{\partial g_2}\frac{\partial g_2}{\partial \tau}\right] > y \tag{13}$$

Combining (7) and (8) gives

$$\frac{\partial g_1}{\partial \tau} = \omega_1(1-\theta)^{-1}y \tag{14}$$

[4] Discussions with Mr. Benedikt Braumann.

$$\frac{\partial g_2}{\partial \tau} = (1-\omega_1)(1-\theta)^{-1}y \tag{15}$$

Substituting (14) and (15) into (13) yields the following condition for $\frac{\partial \mu}{\partial \tau} > 0$ in given value of *k*, g_1, g_2, τ, *y*, *L* and *X*.

$$(1-\tau)(1-\theta)^{-1}y\left[\frac{\partial f}{\partial g_1}\omega_1 + \frac{\partial f}{\partial g_2}(1-\omega_1)\right] > y \tag{16}$$

From (16), we can get following result by simple mathematical logic

$$\tau < 1-(1-\theta)\left[\frac{\partial f}{\partial g_1}\omega_1 + \frac{\partial f}{\partial g_2}(1-\omega_1)\right]^{-1} \tag{17}$$

We would like to compare this result with some earlier theoretical frameworks. For example, Chen (2006) argued that the economic growth rate decreases with respect to the income tax hike without any conditions. It means that *the derivative of economic growth* with respect to the income tax rate is less than zero $\left(\frac{\partial \mu}{\partial \tau} < 0\right)$ without any conditions. But Devarajan et al. (1996) have included one condition for this statement. He found that, $\frac{\partial \lambda}{\partial \tau} \geq 0\ (<0)$, if $\frac{\tau^{\xi+1}}{\beta\phi^{-\xi}+\gamma(1-\phi)^{-\xi}} \leq (>) 1+\xi$. Where, λ is the economic growth rate, τ is the income tax rate, ξ is the constant elasticity of substitution in CES type production function, ϕ and $(1-\phi)$ are the shares of government productive and unproductive expenditures, respectively, β and γ are the coefficient of government productive and unproductive expenditures in CES type production function, respectively. Devarajan et al. (1996) also reduced the above conditions for the Cobb-Douglas technology and found that $\frac{\partial \lambda}{\partial \tau} > 0$, when $\tau < \beta + \gamma$ (see Devarajan et al. (1996), pp 319). So, we also found that *the derivative of economic growth with respect to the income tax rate* $\left(\frac{\partial \mu}{\partial \tau}\right)$ is positive under condition (17) for the countries where part of the government expenditures are covered by the oil fund as a direct transfer.

The next result is about the effects of the oil factor on economic growth. For this purpose, *the derivative of economic growth with respect to the share of the transfer from the oil fund in government expenditure* $\left(\frac{\partial \mu}{\partial \theta}\right)$ was studied by calculating the first order derivative of (10) with respect to θ. After few steps, final view of this derivative is as following:

$$\frac{\partial \mu}{\partial \theta} = \frac{y}{k}\tau(1-\tau)(1-\theta)^{-2}\left[\frac{\partial f}{\partial g_1}\omega_1 + \frac{\partial f}{\partial g_2}\omega_2\right] \tag{18}$$

Equation (18) gives intuition that the growth of the transfer from the oil fund to the government budget (θ) has a positive impact on economic growth (μ). However, it can be changed depending on the sign of *the derivative of the output (production) function with respect to government capital* $\left(\frac{\partial f}{\partial g_1}\right)$ *and current expenditure* $\left(\frac{\partial f}{\partial g_2}\right)$. We cannot argue that these derivatives $\frac{\partial f}{\partial g_1}$ and $\frac{\partial f}{\partial g_2}$ are always positive. Because macroeconomic theory says that increasing current expenditures are usually financed by higher taxes, which cause a lagged decrease in private investment. As a result, the literature concludes that there is a negative impact of increasing current expenditures on economic growth. Thus, if $\frac{\partial f}{\partial g_2}$ is negative, then the growth of the transfer from the oil fund to the government budget (θ) has a positive (negative) impact on economic growth (μ), if and only if $\frac{\partial f}{\partial g_1} > (<) \frac{\partial f}{\partial g_2}$. It means that if the marginal value of government capital expenditure is greater (less) than the marginal value of government current expenditure, then the transfers from the oil fund have a positive (negative) impact on economic growth with the existing negative impact of increasing current expenditures.

4. Empirical analysis

Starting with Keynes, the role of governments in economic development has become an object of detailed discussion in economic literature. At the end of the 20th century, Barro (1990) put forward a more in-depth analysis of government spending and argued that current and capital government spending is an important driving force of any country's total production. Indeed, governments' current and capital expenditures have different characteristics due to their economic nature, and therefore it is natural to expect that their contributions to economic development also have different characteristics. It is known that the main goal of government spending should be to make the maximum contribution to economic growth, as expressed by equation (10), which takes into account the utility of households and the real sector. This macroeconomic phenomenon has the essence of characterizing the efficiency of government spending. In the previous sections, a new optimality condition for analyzing the efficiency of government spending was developed by discussing theoretical concepts available in the scientific literature. In this context, Proposition 1 provides a theoretical basis for analyzing the efficiency of the government's choice between current and capital expenditures. Thus, we determined that the marginal values of the government's current and capital expenditures in the production function given in (2) should be equal to each other in order to have the maximum impact on economic growth expressed by equation (10). Thus, in this section, the theoretical results obtained in the previous sections will be strengthened on the basis of empirical results, and we will construct a specific approach for the analysis of the efficiency of government expenditures. For this, first of all, the production function given in (2) should be evaluated for different countries. Of course, in this regard, many empirical examples can be found in the literature. These examples are discussed in detail in Section 2. Here, the quadratic terms of both types of expenditures will be included in the model to estimate the impact of current and capital expenditures by governments on economic growth (Devarajan et al., 1996). The main reason for including quadratic terms in the model relates to the nature of government spending. Although it is known that government spending has a positive effect on economic growth at first, after a certain period, this effect can be reversed. Governments often prefer increasing tax burdens to finance increased expenses, which may result in a negative impact on economic growth after a certain period of time. In some countries, the opposite of this process may happen. Thus, the negative effect of government spending on economic growth in initial periods due to financing of expenses by increasing tax burden may turn into a positive effect after a certain period of time due to the multiplicative effect. Including quadratic terms of current and capital expenditures of the government into the production function, as done by Devarajan and his co-authors, creates an opportunity to characterize both directions mentioned above (Devarajan et al., 1996).

4.1. Data

Capital stock (k), labor force (L), government capital (g1), current expenditures (g2), and world GDP (x) were used as independent variables of the production function (2). The dependent variable of the model is the country's GDP (y). All variables were converted to the real value using a deflator at the prices of 2015. Moreover, variables were expressed in dollars using the exchange rate between national currencies and the US dollar. At the same time, we used per capita variables based on the population of each country. Information about the sources of variables is provided in Table 1.

Table 1. The sources of variables

GDP	IMF	Investment and Capital Stock (ICSD)[1]
Capital Stock	IMF	Investment and Capital Stock (ICSD)[1]
Labor force	IMF, World Bank	World Economic Outlook (WEO)[2], World Development Indicators[3]
Government expenditure	IMF	Government Finance Statistics (GFS)[4]
Population	World Bank	World Development Indicators[3]
Deflator	IMF, World Bank	World Economic Outlook (WEO)[2], World Development Indicators[3]
Official exchange rate (LCU per US$, period average)	World Bank	World Development Indicators[3]

1. https://data.imf.org/?sk=1CE8A55F-CFA7-4BC0-BCE2-256EE65AC0E4&sId=1390030341854
2. https://www.imf.org/en/publications/weo
3. https://databank.worldbank.org/source/world-development-indicators
4. https://data.imf.org/regular.aspx?key=60991462

The maximum observation period covers the date range of 1970–2019. However, for some countries, the observation period existed in a smaller date range. Data on all variables were collected for only 39 countries because we failed to obtain statistical data on governments' current and capital expenditures for all countries.

4.2. Estimation of production function (2)

As mentioned above, Proposition 1 provides a theoretical basis for analyzing the efficiency of the government's choice between current and capital expenditures. More clearly, the marginal values of the government's current and capital expenditures in the production function given in (2) must be equal to each other to maximally affect the equilibrium economic growth expressed by equation (10). Therefore, for the analysis of this feature, the production function (2) should be evaluated for countries. The variables whose sources are shown in Table 1 were used for estimation. It should be noted that in some countries there are certain limitations in obtaining data on governments' current and capital expenditures. For this reason, it was possible to estimate the production function given in (2) only for 39 countries. Initially, we defined the shape of the function to be evaluated. By citing Devarajan et al. (1996), we construct an empirical structure of the production function given in (2) as follows:

$$f(\Psi) = \beta_0 + \beta_1 k + \beta_2 l + \beta_3 w + \alpha g_1 + \gamma g_1^2 + \zeta g_2 + \vartheta g_2^2 + \boldsymbol{\theta D} + \varepsilon \tag{19}$$

Where,

$f(\boldsymbol{\Psi})$ = GDP per capita, real (2015=100), in dollars

k = Capital stock per capita, real (2015=100), in dollars

l = Labor force, persons

w = The World GDP per capita, real (2015=100), in dollars

g_1 = Government capital expenditure per capita, real (2015=100), in dollars

g_2 = Government current expenditure per capita, real (2015=100), in dollars

β = parameters of the explanatory variables

Ψ = a vector of explanatory variables

θ = a vector of the parameters

D = a vector of time dummies

ε = error term

The observation period of variables is 1970–2019, but due to the unavailability of data for some countries, the length of the time series was shorter. Thus, as mentioned, since the data set is in the form of a time series, it is important to analyze the stationarity of variables. It should be noted that given variables are non-stationary for all countries, except for a few cases (see Appendix B, Table B1). Therefore, the first-order differences of variables will be used to estimate the model (19).

The results of the estimation of model (19) are given in Table B3 (see Appendix B). Before proceeding to the explanation of the outcomes, it is important to discuss some statistics. As can be seen, the coefficient of determination of evaluated models for all countries is around 0.9, which is appropriate. Thus, selected explanatory variables and time dummy variables could explain well the dependent variable, i.e., per capita GDP. Another adequacy indicator is the homoscedasticity of the model. The BPG test probability greater than 0.05 for all countries indicates that the residuals of all evaluated models are homoscedastic. At the same time, the lack of autocorrelation of residuals is important in econometric evaluations. According to the results of the DW test, the residuals of almost all evaluated models (except for the results for 3 countries) did not have the autocorrelation problem.

As mentioned above, in the evaluation of the model (19), along with explanatory variables, time dummy variables were also used, which allow for measuring time breakpoints. The coefficients of these variables, or, in other words, the information on the coefficients of the impact of instabilities in the world economy on economic growth in different periods, are given in Table B2 (see Appendix B). Figure 1 shows the distribution of time effects over years based on the data given in Table B2. As can be seen from the picture (see Figure 1), statistically significant time effects in the model (19) were mainly manifested in the periods of 2006–2009 and 2013–2020. It is no coincidence that these dates cover the periods of the most recent world crises. Figure 1 shows that in some countries, despite the recession in the world economy during the mentioned periods, time effects were in a positive zone. This suggests that during world crises, the opportunity curve moved from the country in the negative zone to the country in the positive zone. Explanations can be continued on the basis of the results obtained for the time dummy variables used in the estimation of the model (19). However, since the main question of the research is the analysis of the efficiency of government spending, this explanation of the results on time dummy variables is satisfactory.

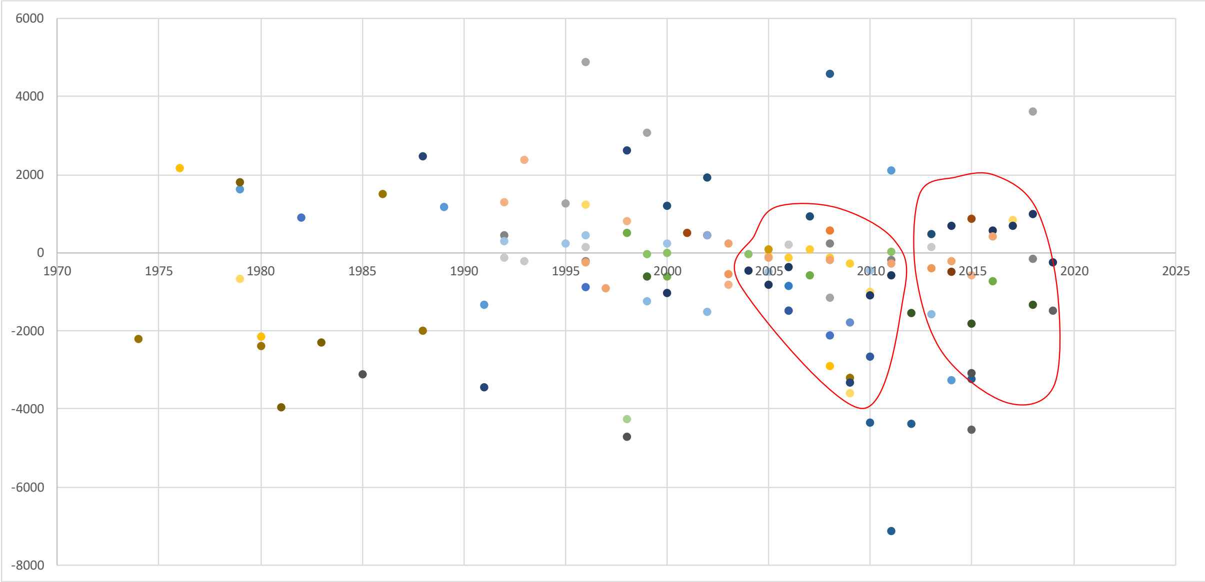

Figure 1. Distribution of the time effects in model (19)
Source: own calculation

As mentioned above, the model (19) proposed by Devarajan et al. (1996) was used to measure the effects of governments' current and capital expenditures on economic growth in the analyzed countries. The results obtained from assessments are given in Table B3 (see Appendix B).

It would be useful to provide some brief analysis based on Table B3. Thus, the coefficient of influence of governments' current expenditures on economic growth was statistically significant in 32 out of 39 countries (see Appendix, Table B3). Four of the statistically significant coefficients were negative, while others were positive. So, in 4 out of 32 countries (which was statistically significant), the rise in governments' current expenses reduced economic growth, and in 28 countries, it increased economic growth.

In 16 countries (Australia, USA, Denmark, Finland, Egypt, Germany, India, Jordan, Mauritius, Mexico, Netherlands, Paraguay, Singapore, Sweden, Switzerland, and Thailand), where current government spending has a positive effect on economic growth, the coefficient was less than 1, in 9 countries (UK, Bulgaria, Canada, Croatia, Estonia, Hungary, Kenya, Morocco, and South Africa), it was between 1 and 2, and in 3 countries (Nicaragua, Norway, and Peru), it was greater than 2. In 1 (Belarus) out of the 4 countries where current government spending has a negative impact on economic growth, the impact coefficient ranged between -1 and 0, and in 3 countries (Guatemala, Iceland, and Spain), the impact coefficient ranged between -1 and -2.

Similarly, it is possible to make judgments about the coefficient of the government's capital expenditures. Thus, this coefficient was statistically significant in 29 out of 39 countries (see Appendix, Table B3). 14 of the statistically significant coefficients were negative, and 15 were positive. So, in 14 out of 32 countries, the increase in government capital expenditures reduced economic growth, and in 15 it increased economic growth.

In 1 (Lesotho) out of 15 countries where the impact of government capital expenditure on economic growth is positive, the influence coefficient is less than 1, in 6 countries (Croatia, Estonia, Hungary, Kenya, Mauritius, and Nicaragua) between 1 and 2, and in 8 countries (Australia, Finland, Cyprus, Egypt, Iceland, Latvia, Mexico, and Thailand), it was greater than 2. In 3 (Bulgaria, France, Spain) of the countries where the impact of government capital expenditures on economic growth is negative, the impact coefficient is in the range of -1 and 0, in 3 (Morocco, Singapore, Sweden), the impact coefficient is in the range of -1 and -2, and in 8

(Belgium, Belarus, Canada, Germany, Norway, Paraguay, South Africa, Switzerland), it was less than -2.

Thus, as a result of the assessment across different countries, it can be concluded that in the period 1970–2019, the influence of the government's capital expenditures on economic growth was much higher than the influence of current expenditures, probably due to the larger multiplier effect of government capital spending.

It is known that when the GDP is used as an indicator of economic growth, the participation of capital stock and labor variables as the main control variables of the econometric model is important. As can be seen from Table B3, the effect of capital stock on economic growth was statistically significant in 36 of the 39 studied countries, while the effect of the labor force was statistically significant in only 16 countries (see Appendix, Table B3). Statistically significant effect coefficients on capital stock are in the range of -1 and 1 for all countries (34 are in the range of 0 and 1, and 2 are in the range of -1 and 0). Almost all statistically significant coefficients of the labor force are in the range of -1 and 1.

Another control variable in the model (19) is the global per capita GDP. The coefficients of this variable were statistically significant in 33 out of 39 countries (see Appendix, Table B3). Out of 33 countries, the coefficient of influence of the global per capita GDP was negative only in Morocco. In all other countries, the coefficient of influence is positive. In 8 of the countries where the influence of this variable is positive, the influence coefficient is in the range of 0-1, in 14 in the range of 1-5, in 6 in the range of 5-10, in 1 (Sweden) in the range of 10-20, and in 3 (Norway, Iceland, Belarus) was greater than 20.

5. The test to evaluate the efficiency of the government spending

In this section, we will construct a test to analyze the efficiency of the distribution of government expenses between current and capital expenditure items. For this, we already have a theoretical justification (see Section 4, Proposition 1) and empirical results (see Section 5). According to Proposition 1, to allow the distribution of government expenditures between current and capital expenditure items to have a maximum effect on economic growth expressed by equation (10), the marginal values of the government's current and capital expenditures in the production function given in (19) should be equal to each other. Then we can calculate these marginal values as follows:

$$\frac{\partial f(\mathbf{\Psi})}{\partial g_1} = \psi(g_1) \tag{20}$$

$$\frac{\partial f(\mathbf{\Psi})}{\partial g_2} = \psi(g_2) \tag{21}$$

$$\xi(g_1, g_2) = \psi(g_2) - \psi(g_1) \tag{22}$$

The calculation of the marginal values of $\psi(g_1)$ and $\psi(g_2)$ based on empirical results is shown in Table B4 (see Appendix B). Therefore, according to the developed optimality condition in Section 4, the difference between these two marginal values, i.e., ξ (see equation 22) should be equal to zero. The results obtained in Table B4 show that this condition is not satisfied in any country. In fact, this is obvious because the mentioned optimality condition characterizes an ideal situation. That is, if the distribution of the government's expenditure between current and capital expenditure items in any country is on an ideal level, then ξ should be zero. But as it is known, in reality, this can rarely be possible. The obtained results (see Appendix B, Table B4) confirm this. So, as we can see from Table B4, this new parameter (ξ) has different values for the analyzed 39 countries. We can observe that in some countries this value (ξ) is very close to zero, and in some countries it is significantly far from zero. Thus, we get a new statistical quantity, ξ, and as this quantity approaches and moves away from zero, we get the opportunity to analyze the efficiency of the distribution of government expenditures between capital and current items. But here, such a question arises. How should ξ be close to zero (in fact, zero is the most ideal level) for us to accept the current allocation of government spending between capital and current expenditures as optimal or efficient? Or in which interval built close to zero ξ should be, so that we could accept the current distribution of government expenditures on capital and current expenditure items as optimal or efficient with a certain probability. For this, the probability distribution of ξ must be determined. Grouping of ξ, frequency of each group, and some other characteristics (Sturges, 1926) have been realized to define the probability distribution, and the results are given in Table 2.

Table 2. İntervals for ξ

Intervals		Midpoints	Observed Frequency	Observed Probability
-19.6	-14.1	-16.9	1	0.03
-14.1	-8.7	-11.4	0	0.00
-8.7	-3.2	-6.0	3	0.08
-3.2	2.2	-0.5	22	0.56
2.2	7.7	4.9	11	0.28
7.7	13.1	10.4	2	0.05
Sturges' rule		6.29		
Range		5.45		
Average		0.58		
St.Dev.		4.88		
Max.		13.11		
Min.		-19.59		

Source: own calculation

Based on the results obtained in Table 2, the probability distribution of ξ was established and graphically depicted in Figure 2.

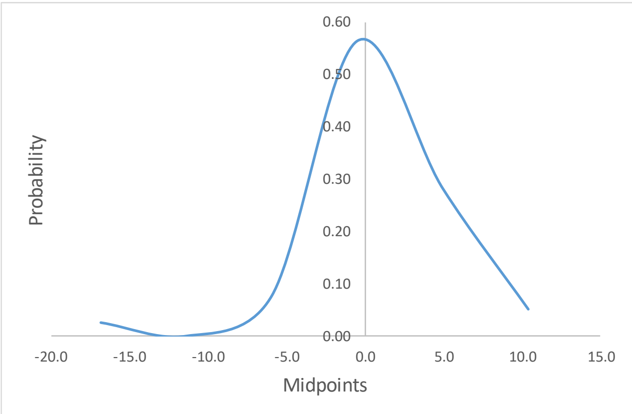

Figure 2. Probability distribution of ξ

It can be clearly seen from the graph (Figure 2) that the probability distribution of ξ is very similar to the normal probability distribution. But this should be scientifically justified. In scientific literature, the normality of any random variable can be checked with many tests, the most common of which is the chi-square test. It is known that for the application of this test, the number of elements in the intervals established in Table 2 should not be less than 5. Therefore, the intervals falling in the tails of the distribution, the number of which is less than 5, should be combined. In this case, only two intervals will remain, which does not allow applying the chi-square test. Because when applying this test, the degree of freedom is 3, which requires at least 4 intervals. As it can be seen, although the graphical representation of the probability distribution of ξ is very similar to the graph of the normal probability distribution, it is not possible to statistically test the normality of its distribution. The reason for this is the insufficient number of observations. For this, a Monte Carlo simulation of 5000 elements was performed based on the mean (0.5822) and standard error (4.8817) of ξ calculated for 39 countries. This simulation was repeated more than 100 times, and the mean and standard error of each simulation were calculated and recorded. The averages of more than 100 averages and standard errors were determined to be 0.5842 and 4.8826, respectively. This result is very close to the mean (0.5822) and standard error (4.8817) of ξ calculated for the 39 countries. Thus, whether ξ with 5000 elements obtained by Monte Carlo simulation has a normal distribution was checked by the chi-square test. First, the following null and alternative hypotheses were accepted:

H_0: ξ has normal distribution.

H_a: ξ does not have normal distribution.

13 intervals were constructed to perform the steps of the Chi-square test, but since the number of elements on the tails of the distribution was less than 5, these intervals were combined with the closest intervals, and 11 intervals were obtained. The steps of the chi-square test based on these intervals are summarized in Table 3.

Table 3. Chi-square test results for the normality of ξ on the base of Monte Karlo simulations

	Intervals		Midpoints	Observed Frequency (O)	Observed Probability	Expected Probability	Expected Frequency (E)	(O-E)^2/E
1	-15.8	-10.8	-13.3	45	0.01	0.01	43	0.12
2	-10.8	-8.3	-9.6	111	0.02	0.02	114	0.09
3	-8.3	-5.8	-7.1	297	0.06	0.06	291	0.14
4	-5.8	-3.3	-4.6	583	0.12	0.11	571	0.25
5	-3.3	-0.8	-2.1	848	0.17	0.17	866	0.37
6	-0.8	1.7	0.4	987	0.20	0.20	1013	0.69
7	1.7	4.2	2.9	932	0.19	0.18	916	0.29
8	4.2	6.7	5.4	650	0.13	0.13	639	0.20
9	6.7	9.2	7.9	346	0.07	0.07	344	0.01
10	9.2	11.7	10.4	136	0.03	0.03	143	0.33
11	11.7	16.7	14.2	65	0.01	0.01	57	1.08
				5000	**1.00**	**1.00**	**4996**	**3.57**

Source: own calculation

Based on Table 3, the chi-square quantity is as follows.

$$\chi^2 = \sum_{i=1}^{k} \frac{(O-E)^2}{E} = 3.57$$

Next, the critical value of the chi-square quantity at the 0.95 significance level and 8 degrees of freedom was determined and compared with the calculated value. Thus,

$$\chi^2 = 3.57 < \chi^2_{(0.95,8)} = 15.51$$

since the null hypothesis may not be rejected. That is, ξ is assumed to have a normal probability distribution. We mentioned above that the Monte Carlo simulation was repeated more than 100 times. The calculations and results given in Table 3 are the results of only one of them.

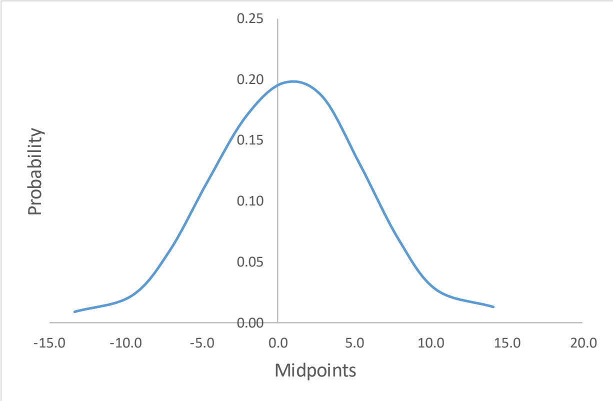

Figure 3. Probability distribution of ξ by Monte Karlo simulations

Note that in only 4 out of 100 results, the calculated value of the chi-square was greater than its critical value at the 0.95 significance level and 8 degrees of freedom. In all other cases, the null hypothesis was accepted. For illustrative purposes, a graphical representation of the probability distribution based on any of the 100 results is given in Figure 3. It should be noted that graphical representations of repeated 100 iterations are very similar to each other.

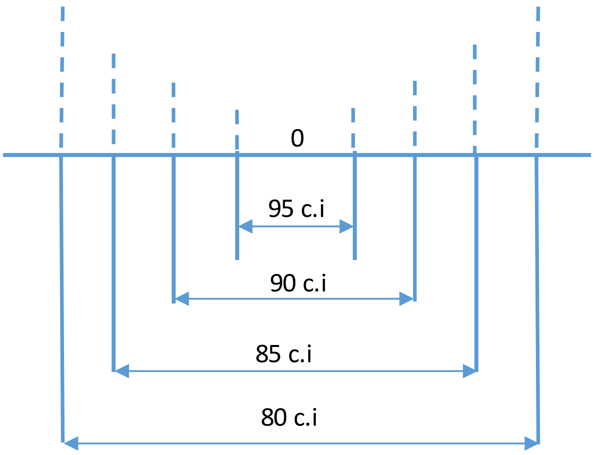

Figure 4. Confidence intervals around zero (around ideal value of $\xi = 0$)

Thus, after determining that ξ has a normal probability distribution, we can now begin to construct a test for analyzing the efficiency of the allocation of government spending between current and capital expenditure items. It is known that the value of ξ defined in (22) should be equal to zero to allow the distribution of government expenditures between current and capital expenditure items to have the maximum effect on economic growth. However, this is only possible in an ideal situation (ξ is equal to zero). The obtained empirical results showed that in some of the analyzed countries, this quantity was much closer to zero, and in others, it was significantly different from zero. In other words, as we mentioned above, an interval built close to zero should ξ be built so that we could accept the current allocation of government expenditures on capital and current items as efficient with a certain probability. We can describe such a pyramid of intervals as in Figure 4.

The confidence intervals given in Figure 4 represent a subset of all the intervals constructed. In fact, confidence intervals are constructed from the 99 percent significance level to the 1 percent significance level. Some of them are described here as examples. As it can be seen from the figure, as the significance level of the intervals increases, their boundaries are also closer to zero, which is related to the essence of ξ. So, as we have mentioned, the value of ξ defined in (22) should be equal to zero to allow the distribution of government expenses between current and capital expenditure items to have the maximum effect on economic growth. Therefore, as the confidence intervals around zero widen, the significance level decreases too.

At the next stage, based on the mean (0.5822) and standard error (4.8817) of ξ calculated for 39 countries, the new ξ was constructed consisting of 5000 elements by Monte Carlo simulation. Then appropriate confidence intervals were established around all elements of this new ξ. After that, the intervals, which included zero, were chosen. So, the test intervals for the current simulation were constructed on the basis of the average of both lower and upper bounds of the above-selected intervals from 5000 iterations. This procedure was repeated 100 times, and test intervals were set for each time. After several times, the bounds of the test intervals were averaged, and the change for each additional procedure was measured as a percentage. It was found out that the result of each subsequent procedure could change the result of previous procedures by less than one percent.

Table 4. Critical intervals for ξ

	Critical intervals for ξ	
Confidence levels	L	U
0.99	-0.06	0.06
0.95	-0.31	0.31
0.90	-0.61	0.62
0.85	-0.92	0.93
0.80	-1.23	1.26
0.75	-1.54	1.58
0.70	-1.86	1.92
0.65	-2.18	2.26
0.60	-2.52	2.62
0.55	-2.86	3.00
0.50	-3.22	3.39
0.45	-3.60	3.80
0.40	-4.00	4.25
0.35	-4.43	4.73
0.30	-4.90	5.26
0.25	-5.42	5.85
0.20	-6.03	6.53
0.15	-6.75	7.36
0.10	-7.70	8.42
0.05	-9.16	10.04
0.01	-12.08	13.16

Source: own calculation

So, as a result of repeating 100 times the above-mentioned procedure, appropriate critical intervals were constructed for measuring the efficiency of the current distribution of government expenditures on capital and current items at the significance level of 0.01-0.99. These critical intervals are listed in Table 4. These intervals can be used to measure the efficiency of the allocation of government expenditures, both current and capital. The hypothesis testing is constructed as follows:

H_0: ξ is not equal to zero

H_a: ξ is equal to zero

So, if calculated ξ based on the nonlinear production function for any country falls within any of these critical intervals in Table 4, then we can reject the null hypothesis at the appropriate significant level. Meaning that the allocation of the government expenses of that country into current and capital items can be considered effective at the appropriate significant level. For example, suppose that ξ calculated from a non-linear production function for any country is equal to 0.02. Actually, this result shows that ξ is not zero; that is, we cannot reject the null hypothesis, but since the value of $\xi = 0.02$ falls in the first critical interval given in Table 4, there is a 99 percent probability that we are wrong. Thus, we accept the alternative hypothesis at a significance level of 0.99.

Finally, we can conclude the analysis of the efficiency of government spending by determining which of these intervals includes the calculated ξ for the analyzed countries (see Appendix B, Table B4). The results are summarized in Table 5.

Table 5. Significant levels for the government spending in the analyzed countries

Countries	ξ	Confidence level	Countries	ξ	Confidence level
Australia	-1.82	0.70	India	0.32	0.90
Angola	0.04	0.99	Jordan	0.09	0.95
Bahamas	-4.53	0.30	Kenya	0.51	0.90
UK	2.78	0.55	Latvia	-5.32	0.25
Belgium	3.05	0.50	Lesotho	-0.71	0.85
USA	-2.06	0.65	Mauritius	-0.15	0.95
Belarus	2.24	0.65	Mexico	-19.59	0.01
Bulgaria	1.18	0.80	Morocco	3.35	0.50
Canada	0.15	0.95	Netherlands	3.62	0.45
Denmark	1.64	0.70	Nicaragua	4.00	0.40
Finland	-2.15	0.65	Norway	9.10	0.05
Croatia	-0.14	0.95	Paraguay	2.53	0.60
Cyprus	5.56	0.25	Peru	0.66	0.85
Egypt	-0.87	0.85	Singapore	1.96	0.65
Estonia	-0.09	0.95	South Africa	5.39	0.25
France	0.72	0.85	Spain	-0.86	0.85
Germany	5.20	0.30	Sweden	3.30	0.50
Guatemala	-1.60	0.70	Switzerland	13.11	0.01
Hungary	0.05	0.99	Thailand	-2.08	0.65
Iceland	-5.89	0.20			

Source: own calculation

Thus, table 5 shows that the current allocation of government spending on current and capital expenditures may be accepted as effective at a 99 percent significant level in Angola and Hungary, at a 95 percent significant level in Canada, Croatia, Estonia, Jordan, and Mauritius, and at a 90 percent significant level in India and Kenya. In all the remaining countries, the current distribution of government spending on current and capital expenditures is considered efficient at a significant level below 90 percent.

Conclusion

The main result of this paper is that if the optimal distribution of the government's expenditures exists, which enables it to make the maximum contribution to the economic growth rate, then the derivative of the output function with respect to the government's capital expenditure must be equal to the derivative of the output function with respect to the government's current expenditure. This is a theoretical optimality condition with the maximum impact of government expenditures on the economic growth rate.

Also, we defined some theoretical conditions on marginal economic growth with respect to the income tax rate, the capital stock, and the share of the transfer from oil revenues in the government's expenditures for oil-rich economies.

In other words, we found that *the marginal economic growth with respect to the capital stock* is negative and is likely to reflect diminishing returns to capital. As the capital stock increases, the growth rate of capital diminishes, which is a purely neoclassical result.

The next result is about *marginal economic growth with respect to the tax rate*. Accordingly, *marginal economic growth with respect to the tax rate can be* positive under certain conditions by considering the transfer of oil revenues.

Finally, something about the effects of the oil factor on economic growth. The obtained result gives intuition that the growth of the transfer from oil revenues to the government budget has a positive impact on economic growth. However, it can be changed depending on the sign of the derivative of the output (production) function with respect to the government's capital and current expenditure. We cannot argue that these derivatives are always positive. Because macroeconomic theory says that increasing current expenditures are usually financed by higher taxes, which cause a lagged decrease in private investment. As a result, the literature concludes that there is a negative impact of increasing current expenditures on economic growth. Thus, if the marginal value of the government's capital expenditure is greater (less) than the marginal value of the government's current expenditure, then the transfers from oil revenues have a positive (negative) impact on economic growth, despite the negative impact of increasing current expenditures.

Based on the obtained theoretical results, a test was established to analyze the efficiency of the composition of government income between current and capital expenditure items. The test is based on intervals established at significance levels of 0.01-0.99. If the difference between the marginal value of the production function with respect to the government's current and capital expenditure falls into any of these established intervals, then the current distribution of government expenses can be considered effective at the appropriate level of significance for that interval. As a result, it was found that the composition of government expenses is efficient in very few countries with a significance level higher than 95 percent. In other words, governments cannot efficiently allocate their income between capital and current expenditures.

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Appendix A

Proof of Proposition 1

Substituting (7) and (8) into (2) yields the output function as following:

$$y = f(k, g_1, g_2, L, X) = f(k, g_1(\omega_1, \tau, y, \theta), g_2(\omega_2, \tau, y, \theta), L, X) \quad \text{(A.1)}$$

Now let's consider (A.1) in equation (9),

$$c = (1 - \tau)y - \dot{k}$$

$$c = (1 - \tau)f(k, g_1(\omega_1, \tau, y, \theta), g_2(\omega_2, \tau, y, \theta), L, X) - \dot{k} \quad \text{(A.2)}$$

In the next step, (1) utility function $U(c, L)$ will be rewritten as following by using equations (A.2).

$$U = \int_0^\infty [c^\varphi (1 - L)^{1-\varphi}]\, e^{-pt} dt \quad \text{(A.3)}$$

$$U = \int_0^\infty \left\{ \left((1 - \tau)f(k, g_1(\omega_1, \tau, y, \theta), g_2(\omega_2, \tau, y, \theta), L, X) - \dot{k} \right)^\varphi (1 - L)^{1-\varphi} \right\} e^{-pt} dt \quad \text{(A.4)}$$

First order conditions:

$$\frac{dU}{dk} = \varphi e^{-pt} (1 - L)^{1-\varphi} \left((1 - \tau)f(k, g_1(\omega_1, \tau, y, \theta), g_2(\omega_2, \tau, y, \theta), L, X) - \dot{k} \right)^{\varphi - 1} (1 - \tau) \frac{\partial f}{\partial k}$$

$$\frac{dU}{dL} = -(1 - \varphi) e^{-pt} \left((1 - \tau)f(k, g_1(\omega_1, \tau, y, \theta), g_2(\omega_2, \tau, y, \theta), L, X) - \dot{k} \right)^\varphi (1 - L)^{-\varphi}$$

Note. $\dot{k}$ is equals to $\frac{\Delta k}{\Delta t}$. Since Δt is typically equal to unity, $\frac{\Delta k}{\Delta t} = \Delta k$. Thus $\Delta k = k_t - k_{t-1} = investment$. Therefore, $\dot{k}$ is not taken into account in the calculation of $\frac{dU}{dk}$.

It is clear that if U is a differentiable function at k_0 and the extremum of this function exists at this point (k_0), then for the maximizing of households' utility, $U'(k_0)$ must be equal to zero (a first-order necessary condition for the existence of an extremum). So,

$$\frac{dU}{dk} = 0$$

$$\varphi e^{-pt} (1 - L)^{1-\varphi} \left((1 - \tau)f(k, g_1(\omega_1, \tau, y, \theta), g_2(\omega_2, \tau, y, \theta), L, X) - \dot{k} \right)^{\varphi - 1} (1 - \tau) \frac{\partial f}{\partial k} = 0$$

We can easily see that the following condition is enough for the satisfying above equality.

$$\left((1 - \tau)f(k, g_1(\omega_1, \tau, y, \theta), g_2(\omega_2, \tau, y, \theta), L, X) - \dot{k} \right)^{\varphi - 1} = 0$$

From the last one we can get the solution

$(1-\tau)f(k, g_1(\omega_1, \tau, y, \theta), g_2(\omega_2, \tau, y, \theta), L, X) - \dot{k} = 0$

$$\mu = \frac{\dot{k}}{k} = k^{-1}(1-\tau)f(k, g_1(\omega_1, \tau, y, \theta), g_2((1-\omega_1), \tau, y, \theta), L, X) \quad \text{(A.5)}$$

It is known that, $\frac{\dot{k}}{k} = \frac{\dot{c}}{c} = \frac{\dot{y}}{y} = \frac{\dot{g_1}}{g_1} = \frac{\dot{g_2}}{g_2}$ on the base of classical assumption. Moreover, we can encounter this approach in some papers that have been introduced by Futagami et al. (1993), Chen (2006) and some other researchers. Therefore, for given values of k, ω_1, ω_2, τ, y and θ we can introduce μ like the economic growth rate. Because we are using a general form of production function (see equation 2), we cannot show a balanced growth path (BPG) on the basis of equation A.5. Therefore, we assume that BPG exists in this model. So, if μ is the economic growth rate, then we can define *the derivative of the economic growth rate* with respect to the share of government capital expenditure $\left(\frac{d\mu}{d\omega_1}\right)$ by using the chain rule on the base of equation (A.5) as follows:

$$\frac{d\mu}{d\omega_1} = k^{-1}(1-\tau)\left[\frac{\partial f}{\partial g_1}\frac{\partial g_1}{\partial \omega_1} + \frac{\partial f}{\partial g_2}\frac{\partial g_2}{\partial \omega_1}\right] \quad \text{(A.6)}$$

Where, (see (7) and (8))

$$\frac{\partial g_1}{\partial \omega_1} = \tau y(1-\theta)^{-1} \quad \text{(A.7)}$$

$$\frac{\partial g_2}{\partial \omega_1} = -\tau y(1-\theta)^{-1} \quad \text{(A.8)}$$

Let's consider (A.7) and (A.8) in (A.6), then we can get following solution:

$$\frac{d\mu}{d\omega_1} = k^{-1}(1-\tau)\tau y(1-\theta)^{-1}\left[\frac{\partial f}{\partial g_1} - \frac{\partial f}{\partial g_2}\right] \quad \text{(A.9)}$$

From this derivative, we can calculate the optimal share of government capital expenditure (ω_1^*) on the basis of the *necessary condition* $\frac{d\mu}{d\omega_1} = 0$. It is clear that below equality provides satisfying of this necessary condition, because $k^{-1} > 0$, $1-\tau > 0$ and $\tau y(1-\theta)^{-1} > 0$

$$\frac{\partial f}{\partial g_1} = \frac{\partial f}{\partial g_2} \quad \text{(A.10)}$$

So, the solution of equation (A.10) yields the optimal share of government capital expenditure (ω_1^*) which will maximize the growth rate of the economy.

The result in equation (A.10) can be modified as $\frac{\partial f}{\partial \omega_1} = \frac{\partial f}{\partial \omega_2}$ by rewriting of the equation (A.5) as follows using equations (7) and (8):

$$\mu = \frac{\dot{k}}{k} = k^{-1}(1-\tau)f(k, \omega_1\tau y(1-\theta)^{-1}, \omega_2\tau y(1-\theta)^{-1}, L, X) \quad \text{(A.11)}$$

$$\frac{d\mu}{d\omega_1} = k^{-1}(1-\tau)\left[\frac{\partial f}{\partial \omega_1} + \frac{\partial f}{\partial \omega_2}\frac{\partial \omega_2}{\partial \omega_1}\right] \quad \text{(A.12)}$$

For $\omega_1 + \omega_2 = 1$

$\frac{\partial \omega_2}{\partial \omega_1} = -1$

Then,

$$\frac{d\mu}{d\omega_1} = k^{-1}(1-\tau)\left[\frac{\partial f}{\partial \omega_1} - \frac{\partial f}{\partial \omega_2}\right] \quad \text{(A.13)}$$

For the *necessary condition*, $\frac{d\mu}{d\omega_1} = 0$, $\frac{\partial f}{\partial \omega_1} - \frac{\partial f}{\partial \omega_2}$ must be equals to 0. So,

$$\frac{\partial f}{\partial \omega_1} = \frac{\partial f}{\partial \omega_2} \quad \text{(A.14)}$$

Appendix B

Table B1. The results of unit root test

	y	g2	g1	k	l	w
Australia	-1.72	-1.26	-2.19	-2.29	-1.81	2.51
Angola	-56.6*	-2.39	-54.5*	-31.1*	40.6	0.07
Bahamas	-1.99	-1.41	-2.70	-1.95	-0.66	1.54
UK	-2.31	-1.28	-3.38**	-4.04*	0.83	2.84
Belgium	-1.11	-1.16	-4.03*	-1.11	2.48	2.40
USA	-1.03	-0.42	-1.29	-0.48	-1.43	1.54
Belarus	-13.4*	-9.19*	-0.67	-12.6*	-1.62	0.28
Bulgaria	-35.6*	-27.9*	-3.39**	-33.6*	-1.93	0.28
Canada	-0.91	-1.74	-1.40	-1.31	0.94	1.54
Denmark	-1.35	-1.64	-1.69	-1.79	-1.43	2.51
Finland	-1.72	-1.15	-1.40	-2.17	-2.63	2.51
Croatia	-1.11	-0.97	-2.27	-0.98	-2.42	0.28
Cyprus	-1.40	-1.69	-1.66	-1.35	-2.49	0.29
Egypt	-0.54	-1.59	-2.42	-1.28	-0.01	1.07
Estonia	-0.64	-0.59	-1.46	-0.71	-3.26**	0.28
France	-1.31	-1.37	-1.75	-1.32	-0.17	1.54
Germany	-0.82	-0.91	-2.53	-0.91	0.89	2.40
Guatemala	1.62	1.73	-060	0.46	1.17	1.54
Hungary	-4.15*	-4.65*	-3.44**	-5.08*	1.38	0.28
Iceland	-6.42*	-7.04*	-14.5*	-5.19*	-0.71	2.51
India	-2.33	-1.98	-2.01	-1.51	-3.31**	2.58
Jordan	-1.75	-1.13	-1.34	-1.28	0.03	1.54
Kenya	-3.94*	0.56	-2.99**	-7.73*	1.84	1.20
Latvia	-1.54	-1.42	-1.64	-1.18	-1.89	0.28
Lesotho	-1.96	-2.33	-5.30*	-0.99	-1.94	1.54
Mauritius	-1.03	-1.80	-2.98**	-0.61	-0.98	1.54
Mexico	-2.56	-2.76***	-4.24*	-4.04*	0.56	1.54
Morocco	-0.47	-1.00	-1.94	-0.18	-4.12*	1.54
Netherlands	-0.76	-0.91	-2.95**	-0.88	-0.65	2.28
Nicaragua	-6.13*	-504.5*	-1.84	-1.23	0.20	1.54
Norway	-1.19	-1.30	-2.40	-1.95	-0.18	2.40
Paraguay	-2.92**	-1.96	-8.24*	-1.44	1.50	1.54
Peru	-1.02	-0.95	-9.91*	-3.46**	-0.56	1.54
Singapore	0.72	1.26	-3.06**	1.07	0.50	2.51
South Africa	-3.08**	-2.09	-1.16	-4.25*	-0.01	2.52
Spain	-0.86	-0.76	-1.86	-0.88	-1.22	2.40
Sweden	-1.89	-2.14	-3.86*	-3.09**	0.14	2.40
Switzerland	-0.30	-0.34	-3.31**	-0.71	-1.46	2.40
Thailand	-0.62	-0.06	-1.64	-0.42	-2.90**	1.54

Note: y = GDP per capita, real (2015=100), in dollars, k = Capital stock per capita, real (2015=100), in dollars, *l* = Labor force, persons, w = The World GDP per capita, real (2015=100), in dollars, g1 = Government capital expenditure per capita, real (2015=100), in dollars, g2 = Government current expenditure per capita, real (2015=100), in dollars. The marks *, **, *** represent the significant levels 0.01, 0.05 and 0.10, respectively.

Table B2. The coefficients of time dummy variables in model (19)

	1974	1976	1977	1978	1979	1980_89	1980	1981	1982	1983	1985	1986	1988	1989	1991	1992	1993	1995	1996	1997	1998	1999
Australia	----	----	----	----	**1630**	----	----	----	----	----	----	----	----	**1168**	**-1345**	----	----	----	----	----	----	----
Angola	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Bahamas	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	**1271**	**4876**	**-27107**	----	**3088**
UK	----	**2183**	----	----	----	----	**-2153**	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Belgium	----	----	----	----	----	----	----	----	**909**	----	----	----	----	----	----	----	----	----	**-884**	----	----	----
USA	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	**522**	----
Belarus	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Bulgaria	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Canada	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Denmark	**-2215**	----	----	----	----	----	**-2397**	----	----	----	----	**1518**	**-2002**	----	----	----	----	----	----	----	----	----
Finland	----	----	----	----	----	----	----	----	----	----	----	----	**2485**	----	**-3442**	----	----	----	----	----	**2610**	----
Croatia	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	**-605**
Cyprus	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Egypt	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Estonia	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
France	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Germany	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Guatemala	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	**-33**
Hungary	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Iceland	----	----	**184981**	**80512**	----	----	----	**36882**	**31954**	----	----	----	----	----	----	----	----	----	----	----	----	----
India	----	----	----	----	----	**17**	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Jordan	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	**435**	----	----	**-214**	----	----	----
Kenya	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Latvia	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Lesotho	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Mauritius	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	**286**	----	**232**	**443**	----	----	----
Mexico	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	**1283**	**2381**	----	----	----	**797**	----
Morocco	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	**-129**	**-218**	----	**145**	----	----	----
Netherlands	----	----	----	----	**-683**	----	----	----	----	----	----	----	----	----	----	----	----	----	**1231**	----	----	----
Nicaragua	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Norway	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	**-4266**	----
Paraguay	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Peru	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Singapore	----	----	----	----	----	----	----	----	----	----	**-3104**	----	----	----	----	----	----	----	----	----	**-4699**	----
South Africa	----	----	----	----	**1801**	----	**9179**	**-3952**	----	**-2287**	----	----	----	----	----	----	----	----	----	----	----	----
Spain	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Sweden	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Switzerland	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	**-1242**
Thailand	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	**-240**	**-907**	----	----

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Continuation of Table B2

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Australia	----	----	----	----	----	----	**-1497**	----	----	----	----	**2116**	----	----	**-3254**	----	----	----	----	----
Angola	----	----	----	----	----	----	----	----	**581**	----	----	----	----	----	----	----	----	----	----	----
Bahamas	----	----	----	----	----	----	----	----	**-1164**	----	----	----	----	----	----	----	----	----	**3607**	----
UK	----	----	----	----	----	----	----	----	**-2897**	----	----	----	----	----	----	----	----	----	----	----
Belgium	----	----	----	----	----	----	----	----	**-2109**	----	----	----	----	----	----	----	----	----	----	----
USA	**-603**	----	----	----	----	----	----	**-584**	----	----	----	----	----	----	----	----	**-728**	----	----	----
Belarus	----	----	----	----	----	----	----	----	**4597**	----	**-4363**	**-7143**	**-4377**	----	----	**-3241**	----	----	----	----
Bulgaria	----	**501**	**439**	----	----	----	----	----	----	----	----	----	----	----	----	**882**	----	----	----	----
Canada	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	**-4524**	----	----	----	**-1496**
Denmark	----	----	----	----	----	----	----	----	----	**-3196**	----	----	----	----	----	----	----	----	----	----
Finland	----	----	----	----	----	----	----	----	----	**-3311**	----	----	----	----	----	----	----	----	----	----
Croatia	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Cyprus	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Egypt	----	----	----	**-557**	----	----	----	----	----	----	----	----	----	**-387**	----	----	----	----	----	----
Estonia	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
France	----	----	----	----	----	**-83**	**-112**	**94**	**-120**	**-286**	----	----	----	----	----	----	----	----	----	----
Germany	----	----	----	----	----	----	----	----	----	**-1781**	----	----	----	----	----	----	----	----	----	----
Guatemala	**-19**	----	----	----	**-23**	----	----	----	----	----	----	**30**	----	----	----	----	----	----	----	----
Hungary	----	----	----	----	----	----	**-835**	----	----	----	----	----	----	----	----	----	----	----	----	----
Iceland	----	----	----	----	----	----	**-26010**	----	----	----	----	----	----	----	----	----	----	----	----	----
India	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Jordan	----	----	----	----	----	----	----	----	**249**	----	----	**-180**	----	----	----	----	----	----	**-168**	----
Kenya	----	----	----	----	----	**93**	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Latvia	----	----	----	----	----	----	**-1470**	----	----	----	**-2668**	----	----	----	----	----	----	----	----	----
Lesotho	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Mauritius	**234**	----	----	----	----	**-491**	----	----	----	----	**-459**	----	----	----	----	----	----	----	----	----
Mexico	----	----	----	**-821**	----	----	----	----	----	----	----	----	----	----	----	**-574**	----	----	----	----
Morocco	----	----	----	----	----	----	**206**	----	----	----	----	----	----	**155**	----	----	----	----	----	----
Netherlands	----	----	----	----	----	----	----	----	----	**-3591**	**-1012**	----	----	----	----	----	----	**833**	----	----
Nicaragua	----	----	**459**	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Norway	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	**-9989**	----	----	----	----
Paraguay	**1194**	----	**1943**	----	----	----	----	**918**	----	----	----	----	----	**487**	----	----	----	----	----	----
Peru	----	----	----	----	----	----	----	----	----	----	----	----	----	----	**-487**	----	----	----	----	----
Singapore	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	**-3084**	----	----	----	----
South Africa	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Spain	**-1032**	----	----	----	**-455**	**-820**	**-360**	----	----	----	**-1088**	**-578**	----	----	**690**	----	**567**	**706**	**987**	**-245**
Sweden	----	----	----	----	----	----	----	----	----	----	----	----	**-1555**	----	----	**-1822**	----	----	**-1322**	----
Switzerland	----	----	**-1517**	----	----	----	----	----	----	----	----	----	----	**-1583**	----	----	----	----	----	----
Thailand	----	----	----	**252**	----	**-137**	----	----	**-189**	----	----	**-275**	----	----	**-221**	----	**414**	----	----	----

Table B3. The results of the estimation of model (19). Dependent variable *y*

	d(g2)	sq.(d(g2))	d(g1)	sq.(d(g1))	d(k)	d(l)	d(w)	c	R-sq.	DW	BPG test
Australia	**0.47**	**-0.00020**	**3.02**	-0.0017	**0.33**	**-0.01**	**7.75**	**727.00**	0.98	2.06	prob. F(13,33)=0.52
Angola	-0.17	**-0.00300**	0.45	**0.0020**	**0.15**	**0.00**	**3.56**	**1003.50**	0.99	2.05	prob. F(8,11)=0.58
Bahamas	0.28	**0.00223**	1.39	**-0.0258**	-0.01	**0.18**	**2.95**	**-1049.32**	0.99	1.36	prob. F(12,14)=0.57
UK	**1.28**	**-0.00009**	-0.42	**-0.0111**	**0.20**	0.00	**3.01**	233.19	0.97	1.34	prob. F(12,14)=0.95
Belgium	0.05	0.00001	**-2.90**	**-0.0301**	**0.34**	0.00	**2.54**	-141.52	0.99	2.10	prob. F(10,28)=0.94
USA	**0.94**	**-0.00114**	0.82	**0.0145**	**-0.22**	**0.00**	**4.14**	44.86	0.96	1.66	prob. F(11,15)=0.86
Belarus	**-0.52**	**-0.00001**	**-2.75**	**0.0001**	**0.21**	**0.06**	**22.37**	**-3755.11**	0.99	1.87	prob. F(12,11)=0.79
Bulgaria	**1.18**	0.00001	**0.00**	0.0000	**0.34**	0.00	**1.98**	**-522.61**	0.99	2.28	prob. F(10,12)=0.92
Canada	**1.61**	**0.00040**	**-2.80**	-0.0120	0.05	**0.00**	**6.03**	**-1296.00**	0.96	1.48	prob. F(9,19)=0.78
Denmark	**0.97**	-0.00003	-0.87	-0.0012	**0.16**	**0.00**	**5.54**	**-306.79**	0.98	2.10	prob. F(12,24)=0.48
Finland	**0.67**	0.00000	**2.52**	**0.0047**	**0.03**	**0.01**	**5.70**	**-804.96**	0.97	1.81	prob. F(11,25)=0.89
Croatia	**1.03**	0.00011	**1.72**	-0.0022	**0.20**	**0.00**	**2.79**	**-440.19**	0.98	1.71	prob. F(8,15)=0.72
Cyprus	-0.85	**0.00134**	**2.03**	**-0.0013**	**0.20**	-0.03	**4.71**	-212.90	0.98	1.76	prob. F(8,14)=0.96
Egypt	**0.72**	**-0.00193**	**2.11**	**-0.0173**	**0.19**	0.00	0.14	8.64	0.99	1.28	prob. F(9,15)=0.26
Estonia	**1.58**	**-0.00007**	**1.43**	-0.0013	**0.23**	0.00	**0.56**	-68.01	0.99	2.19	prob. F(7,16)=0.55
France	-0.05	**0.00000**	**-0.27**	**-0.0022**	**0.04**	**0.00**	**0.21**	-11.22	0.99	1.71	prob. F(12,15)=0.86
Germany	**0.32**	-0.00001	**-4.80**	-0.0020	**0.30**	**0.00**	**2.29**	-209.79	0.99	2.14	prob. F(8,29)=0.92
Guatemala	**-1.69**	0.04862	0.10	0.0723	**0.30**	0.00	**0.05**	**8.31**	0.97	1.91	prob. F(11,17)=0.52
Hungary	**1.32**	0.00007	**1.04**	**0.0026**	**0.13**	0.00	**2.69**	**-415.90**	0.99	2.62	prob. F(8,15)=0.15
Iceland	**-1.53**	**0.00000**	**4.52**	**0.0001**	**0.41**	**1.41**	**26.50**	**-4034.72**	0.99	1.63	prob. F(12,34)=0.85
India	**0.15**	**-0.00321**	-0.12	-0.0100	**0.01**	0.00	-0.01	1.97	0.83	1.80	prob. F(8,35)=0.40
Jordan	**0.60**	-0.00039	0.47	**0.0044**	**-0.03**	**0.00**	**0.69**	30.70	0.90	1.93	prob. F(12,16)=0.60
Kenya	**1.89**	**-0.00647**	**1.25**	0.0056	**0.21**	0.00	-0.07	32.30	0.98	1.66	prob. F(8,19)=0.97
Latvia	-0.09	-0.00009	**2.42**	**-0.0080**	**0.45**	0.00	**5.84**	**-653.80**	0.98	2.25	prob. F(9,14)=0.31
Lesotho	0.16	-0.00048	**0.99**	**0.0042**	**0.14**	0.00	**0.48**	**-62.02**	0.92	1.98	prob. F(7,23)=0.42
Mauritius	**0.44**	-0.00024	**1.72**	**0.0385**	**0.36**	0.01	**0.96**	**-281.76**	0.99	2.13	prob. F(13,15)=0.67
Mexico	**0.51**	**0.00050**	**13.90**	**-0.1900**	**0.23**	0.00	**3.75**	**-730.90**	0.99	1.98	prob. F(12,16)=0.97
Morocco	**1.69**	**-0.00553**	**-1.20**	**0.0117**	**0.32**	0.00	**-0.49**	18.94	0.94	2.24	prob. F(12,16)=0.74
Netherlands	**0.94**	**0.00003**	-1.01	**-0.0144**	**0.21**	0.00	**2.90**	-121.25	0.99	1.56	prob. F(12,31)=0.64
Nicaragua	**5.99**	**0.00008**	**1.47**	**-0.0682**	**0.08**	**0.00**	0.07	**203.18**	1.00	1.70	prob. F(8,20)=0.75
Norway	**2.52**	0.00002	**-4.63**	**-0.0047**	-0.09	**0.03**	**21.51**	**-3264.19**	0.92	1.89	prob. F(9,29)=0.48
Paraguay	**0.93**	**0.00801**	**-2.87**	0.0111	**0.47**	0.00	0.40	-92.70	0.98	1.76	prob. F(11,17)=0.90
Peru	**2.17**	**0.00027**	1.53	0.0007	**0.23**	0.00	0.56	-100.64	0.99	1.91	prob. F(8,20)=0.80
Singapore	**0.69**	-0.00037	**-1.48**	**0.0007**	**0.20**	0.00	**4.26**	165.69	0.86	1.91	prob. F(10,36)=0.94
South Africa	**1.23**	-0.00009	**-4.82**	**-0.0150**	**0.15**	0.00	**2.62**	**-439.38**	0.99	2.13	prob. F(11,30)=0.29
Spain	**-1.42**	**0.00005**	**-0.77**	**0.0051**	**0.54**	**0.00**	**0.47**	-23.43	0.99	1.64	prob. F(18,20)=0.99
Sweden	**0.82**	**0.00004**	**-1.94**	**0.0088**	**0.18**	0.00	**11.95**	**-1772.02**	0.98	2.01	prob. F(10,28)=0.71
Switzerland	**0.91**	0.00000	**-7.38**	**-0.0381**	**0.22**	0.00	**7.35**	**-472.00**	0.99	2.17	prob. F(13,25)=0.75
Thailand	**0.77**	0.00024	**2.26**	**-0.0321**	**0.25**	0.00	**0.55**	2.91	0.97	2.04	prob. F(15,13)=0.96

Note: y = GDP per capita, real (2015=100), in dollars, k = Capital stock per capita, real (2015=100), in dollars, *l* = Labor force, persons, w = The World GDP per capita, real (2015=100), in dollars, g1 = Government capital expenditure per capita, real (2015=100), in dollars, g2 = Government current expenditure per capita, real (2015=100), in dollars. BPG test is for heteroscedasticity. Coefficients (excluding R-sq., DW and BPG test) in bold are statistically significant. All of the results on R-sq., DW and BPG test are statistical significant.

Table B4. Calculation of marginal values in model (19)

	ζ	ϑ	α	γ	d(g_2)	d(g_1)	$\psi(g_2)$	$\psi(g_1)$	$\xi(g_1, g_2)$
Australia	0.47	-0.00020	3.02	-0.0017	-1252.50	66.60	0.96	2.78	-1.82
Angola	-0.17	-0.00300	0.45	0.0020	-83.50	-40.30	0.33	0.29	0.04
Bahamas	0.28	0.00223	1.39	-0.0258	411.60	-101.91	2.12	6.65	-4.53
UK	1.28	-0.00009	-0.42	-0.0111	-834.15	42.20	1.42	-1.35	2.78
Belgium	0.05	0.00001	-2.90	-0.0301	598.01	1.39	0.06	-2.98	3.05
USA	0.94	-0.00114	0.82	0.0145	545.33	32.25	-0.30	1.76	-2.06
Belarus	-0.52	-0.00001	-2.75	0.0001	-16.77	-13.32	-0.52	-2.76	2.24
Bulgaria	1.18	0.00001	0.00	0.0000	-177.35	1605671.81	1.18	0.00	1.18
Canada	1.61	0.00040	-2.80	-0.0120	-179.09	-171.67	1.47	1.32	0.15
Denmark	0.97	-0.00003	-0.87	-0.0012	-1680.99	-121.15	1.07	-0.58	1.64
Finland	0.67	0.00000	2.52	0.0047	653.38	31.70	0.67	2.82	-2.15
Croatia	1.03	0.00011	1.72	-0.0022	-138.34	132.20	1.00	1.13	-0.14
Cyprus	-0.85	0.00134	2.03	-0.0013	1299.56	1971.73	2.62	-2.93	5.56
Egypt	0.72	-0.00193	2.11	-0.0173	-169.57	-3.99	1.38	2.24	-0.87
Estonia	1.58	-0.00007	1.43	-0.0013	-53.55	-91.18	1.59	1.68	-0.09
France	-0.05	0.00000	-0.27	-0.0022	-1133.31	113.58	-0.05	-0.77	0.72
Germany	0.32	-0.00001	-4.80	-0.0020	-605.19	15.66	0.34	-4.86	5.20
Guatemala	-1.69	0.04862	0.10	0.0723	3.91	1.31	-1.31	0.29	-1.60
Hungary	1.32	0.00007	1.04	0.0026	-287.81	35.08	1.28	1.23	0.05
Iceland	-1.53	0.00000	4.52	0.0001	-3305.95	-530.18	-1.50	4.39	-5.89
India	0.15	-0.00321	-0.12	-0.0100	1.60	2.86	0.14	-0.18	0.32
Jordan	0.60	-0.00039	0.47	0.0044	-6.60	4.42	0.60	0.51	0.09
Kenya	1.89	-0.00647	1.25	0.0056	7.42	3.53	1.80	1.29	0.51
Latvia	-0.09	-0.00009	2.42	-0.0080	-151.28	-177.50	-0.07	5.25	-5.32
Lesotho	0.16	-0.00048	0.99	0.0042	-53.74	-9.21	0.21	0.92	-0.71
Mauritius	0.44	-0.00024	1.72	0.0385	-27.45	-14.53	0.45	0.60	-0.15
Mexico	0.51	0.00050	13.90	-0.1900	-19.74	-16.26	0.49	20.08	-19.59
Morocco	1.69	-0.00553	-1.20	0.0117	7.52	-23.33	1.61	-1.75	3.35
Netherlands	0.94	0.00003	-1.01	-0.0144	-1001.12	60.30	0.88	-2.74	3.62
Nicaragua	5.99	0.00008	1.47	-0.0682	-32.98	-3.81	5.99	1.99	4.00
Norway	2.52	0.00002	-4.63	-0.0047	-1045.72	212.16	2.48	-6.62	9.10
Paraguay	0.93	0.00801	-2.87	0.0111	-34.21	32.26	0.38	-2.15	2.53
Peru	2.17	0.00027	1.53	0.0007	31.06	-2.15	2.19	1.53	0.66
Singapore	0.69	-0.00037	-1.48	0.0007	-411.87	392.60	0.99	-0.96	1.96
South Africa	1.23	-0.00009	-4.82	-0.0150	-101.23	-22.54	1.25	-4.14	5.39
Spain	-1.42	0.00005	-0.77	0.0051	-389.31	16.70	-1.46	-0.60	-0.86
Sweden	0.82	0.00004	-1.94	0.0088	-2088.39	-40.02	0.64	-2.65	3.30
Switzerland	0.91	0.00000	-7.38	-0.0381	-188.15	63.28	0.91	-12.20	13.11
Thailand	0.77	0.00024	2.26	-0.0321	66.94	-9.54	0.80	2.87	-2.08