Supply-Side Factors of Economic Growth in Bulgaria

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Summary:

The present article discusses five equilibrium approaches to estimating elasticities in Bulgaria's aggregate production function. The study has two objectives: first, to identify the best equilibrium approach to determining elasticity in Bulgaria's aggregate production function; and second, to measure quantitatively the contributions of capital, labor and total factor productivity to Bulgaria's economic growth under a currency board arrangement (CBA). An econometric procedure - ordinary least squares (OLS) estimation of Bulgaria's aggregate production function with annual and quarterly data - has been used to select the best equilibrium approach to determining elasticities in this function. The OLS estimation has demonstrated that the first equilibrium approach, which is based on the final expenditure structure of Bulgaria's gross domestic product (GDP), provides the most reliable results of all five equilibrium approaches. The second objective of the research has been accomplished by applying the growth accounting (GA) technique to Bulgaria for the period 1997-2013. The GA results imply total factor productivity and capital stock have been the main supply-side determinants of Bulgaria's economic growth under a CBA, while employment has had an insignificant negative impact on growth.

Key words: Bulgaria, currency board arrangement, economic growth

JEL Classification: O47

Introduction

In the wake of a heavy financial and economic crisis back in July 1997, Bulgaria introduced a Currency Board Arrangement (CBA) in order to restore the confidence in the national currency and banking system, to impose financial discipline and stabilize the economy. The Bulgarian CBA has proved to be successful. It is a type of a hard currency peg that relies on automatic mechanisms to restore macroeconomic equilibrium, limiting severely the discretion of policymakers (Stoilova, 2010). The state intervention in the economy was restricted, which may be considered "a fundamental precondition for the development of free market economy" (Patonov, 2013).

The introduction of the CBA in 1997 marked the beginning of a new stage in Bulgaria's economic history. This stage is characterized by a gradual recovery of the Bulgarian economy from the collapse in the 1990s and by an unstable and uneven growth. After a period of a relatively high growth of 6-7% per annum before the global crisis, the Bulgarian economy contracted by 5.01 % in 2009 and grew by less than 2%

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over the next years. The poor growth was accompanied by deflation trends in 2013 and 2014, which is a dangerous combination and requires a rapid and adequate response by Bulgarian macroeconomic policymakers.

Bulgaria's economic growth in the transition to a market-oriented economy was empirically investigated by Ganev (2005), Minassian (2008), Pirimova (2001 and 2014), Raleva (2013), and Statev (2009) and so on.

Ganev (2005), Minassian (2008) and Raleva (2013) employed a similar methodology - growth accounting, based on a two-factor Cobb-Douglas production function. However, there are some methodological differences among these studies:

- Ganev (2005) estimated the growth rate of capital stock by the perpetual inventory method, while Minassian (2008) and Raleva (2013) applied the constant capital-output ratio approach;
- Minassian (2008) used a capital-output ratio of 2.5, while Raleva (2013) employed a value of 2.3;
- Minassian (2008) and Ganev (2005) measured employment by the number of employed persons, while Raleva (2013) used the number of hours worked in the economy;
- When estimating the elasticity coefficients, Minassian (2008) employed the final expenditure structure of GDP, while Ganev (2005) and Raleva (2013) used the income structure of GDP.

Ganev (2005), Minassian (2008) and Raleva (2013) arrived at similar conclusions:

- Total factor productivity and changes in capital stock are the main supply-side determinants of Bulgaria's economic growth;
- Changes in employment have a weak negative effect on growth, which is offset by the impact of total factor productivity and changes in capital stock.

Pirimova (2001) employed the early classical models of Smith, Ricardo, Wicksell and Feldman, as wells as a basic Keynesian model to analyze Bulgaria's economic growth in the transition to a market-oriented economy. Pirimova's research confirmed the conclusion about the disequilibrium character of Bulgaria's economic growth during the transition to a market-oriented economy and implied that Bulgarian macroeconomic policymakers had to focus not on achieving a balanced proportional growth but on decreasing the big differences in annual growth rates.

Pirimova (2014) put more emphasis on the analysis of business cycle and its features than on economic growth. Unlike other authors, which assumed a closed economy, Pirimova (2014) stressed the openness of Bulgaria's economy and its dependence on global and regional factors. Pirimova's study demonstrated that the relative smoothing of business fluctuations required macroeconomic policies, which could affect simultaneously the real economy and the financial sector as well as common strategies for economic growth and economic development at the EU level.

Statev (2009) accentuated the role of the financial sector for Bulgaria's economic growth. This research is important because the transformation of savings into investments is a serious problem for the Bulgarian economy. Statev employed a complex methodology and made recommendations on improving the effectiveness of Bulgaria's financial sector and on increasing its positive impact on economic growth.

The present article has two objectives: first, to identify the best equilibrium approach to determining elasticities in Bulgaria's aggregate production function; and second, to measure quantitatively the contributions of capital, labor and total factor productivity to Bulgaria's economic growth under a currency board arrangement

(CBA). In order to achieve the goals of the study, the paper is structured as follows. Section 2 reviews the theoretical foundations of growth accounting. Section 3 deals with the issues related to the practical application of growth accounting: how to estimate the elasticity coefficients in the production function, how to measure labor input and how to measure the growth rate of capital stock. Section 4 provides an ordinary least squares (OLS) estimation of the Bulgaria's aggregate production function with annual and quarterly data to select the best equilibrium approach to determining elasticity in this function. Section 5 applies the growth accounting (GA) technique to Bulgaria for the period 1997-2013 using the best equilibrium approach to calculating elasticities in the production function. Section 6 makes conclusions.

1. Theoretical fundamentals of growth accounting

The basic shortcoming of the Keynesian growth models - the use of short-term analytical tools, has been overcome by the neoclassical models. Therefore the neoclassical models are regarded as the first real models of economic growth. The growth analysis in the neoclassical theory is based on the Cobb-Douglas production function. The Cobb-Douglas production function underlies the concept of growth accounting, which was initially proposed by Abramovitz (1956) and Solow (1957) and further developed by Denison (1967 and 1985), Maddison (1982) and others. The growth accounting approach attempts to assess the impact of the main supply-side determinants on economic growth.

The output growth rate can be represented as a sum of growth rates of technology improvement (the so called total factor productivity), capital stock and labor input (with the latter two being weighted by their shares in the gross income):

$$\Delta Y / Y = \Delta A / A + \alpha * \Delta K / K + \beta * L / L \qquad (1)$$

where:

$\Delta Y/Y$ - rate of output growth;

$\Delta A/A$ - rate of productivity growth;

$\Delta K/K$ - rate of capital growth;

$\Delta L/L$ - rate of labor growth;

α - elasticity of output with respect to capital

β - elasticity of output with respect to labor.

In Formula (1) the elasticity of output with respect to capital α shows the percentage increase in output, caused by a one percent increase in capital stock and the elasticity of output with respect to labor β represents the percentage increase in output, caused by a one percent increase in the amount of labor input. Formula (1), referred to as growth accounting equation, is a production function modified to a growth rate form.

Formula (1) states that output growth $\Delta Y/Y$ can be broken into three components:

1) Output growth, caused by productivity growth - $\Delta A/A$;
2) Output growth, caused by increased capital stock - $\alpha\ \Delta K/K$;
3) Output growth, caused by increased labor inputs - $\beta\ \Delta L/L$.

The growth accounting technique rests on the following three assumptions:

1. Constant returns to scale;
2. Diminishing marginal productivity of capital and labor;
3. Perfect competition in the economy.

Growth accounting provides an empirical measure of the relative importance of the three components of output growth. Usually growth accounting includes four stages of analysis as follows:

Stage 1: Calculate the growth rates of output, capital and labor in the whole economy for the analyzed time periods.

Stage 2: Estimate the values of the elasticities of output with respect to capital (α) and labor (β).

Stage 3: Calculate the contribution of capital to economic growth as $\alpha\ \Delta K/K$ and the contribution of labor to economic growth as $\beta\ \Delta L/L$.

Stage 4: The part of economic growth that can be attributed neither to capital nor to labor growth is explained by a rise in the total factor productivity A. The rate of productivity change $\Delta A/A$ is calculated from the Formula:

$$\Delta A / A = \Delta Y / Y - \alpha^* \Delta K / K - \beta^* L / L \qquad (2)$$

Formula (2) is a modification of the growth accounting equation (Formula 1), with $\Delta A/A$ written on the left side of the equation. In this way the growth accounting approach treats the change in productivity as a residual - i.e. the share of growth which is left after the contributions of capital and labor are taken out.

Provided that the shares of capital and labor in gross income are given (constant), the output growth rate depends on the growth rates of capital stock, employment and total factor productivity. The growth rate of capital is subject to approximation by means of the perpetual inventory method or the constant capital-output ratio approach. If we assume that these methods provide a relatively accurate assessment of capital accumulation, the only unexplained component in the growth accounting equation (Formula 1) remains the growth rate of total factor productivity (the so called Solow residual), which can be calculated as in Formula (2).

The growth accounting concept has been further elaborated by adding new factors to the production function and by relaxing its strict assumptions. Denison (1967) explained economic growth not only by the accumulation of production factors (capital, labor and land) but also by the way these resources were used and by the improvement in their qualities. The studies of Mankiw et al. (1992), Dougherty and Jorgenson (1996) and Hall and Jones (1996) emphasized the importance of human capital either as a separate factor or as a factor affecting the total factor productivity. Maddison (1982) highlighted the need to make adjustments to the production factors in order to account for the improvement in their qualities.

Gradually the assumption of perfect competition has been abandoned and other variables such as market expansion and positive changes in resource allocation have been included in the production functions.

On the grounds of its characteristic features, the concept of growth accounting can be defined as a methodological approach to quantifying the contributions of main growth factors to economic growth in the long run. A merit of the growth accounting concept is that it can be easily applied in empirical studies. A shortcoming of growth accounting is the lack of analysis of the relationships between model variables and of the factors, which influence their dynamics.

2. Issues related to the practical implementation of growth accounting

In this paper the impact of the changes in labor, physical capital and total factor productivity on the changes in real gross domestic product (GDP) has been investigated by means of the basic growth accounting equation (Formula 1). The way of defining the total factor productivity’s contribution to economic growth (as a residual obtained by extracting from the output’s growth rate the contributions of the two basic growth factors), gives the term "total factor productivity" a specific broader meaning. The dynamics of the total factor productivity reflects the influence of all sources of real GDP growth which are not changes in employment and in physical capital accumulation, such as research and development and the formation of human capital.

There are three methodological problems related to the practical application of the growth accounting technique:

1) How to estimate the elasticity coefficients in the production function;

2) How to measure labor input;

3) How to measure the growth rate of capital stock.

2.1. Estimating the elasticity coefficients

A basic assumption of the economic equilibrium theory is that each production factor is awarded its marginal productivity. The shares of capital α and labor β in gross income (GDP) can be determined as $\alpha = rK/Y$ and $\beta = wL/Y$, where r is the real interest rate and w is the real wage. Hence, β is the share of labor income in GDP and α is the share of capital income in GDP.

In the original version of the growth accounting technique β was set equal to $(1-\alpha)$ in accordance with the assumption of constant returns to scale. However, in many recent empirical studies (Krueger, 1999; Senhadji, 2000; Ganev, 2005; Tsalinski, 2007) β was determined as the share of compensation of employees in GDP, and α was obtained as $\alpha = (1-\beta)$. The rationale of the new approach is that α ought to show the share of capital income in GDP, which can be calculated by dividing the sum of the net operating surplus and the net mixed income by GDP. However, defining α as a residual actually means that its value is increased by the share of the consumption of fixed capital in GDP and the difference between the shares of the net taxes on production and the financial intermediation services indirectly measured in GDP. Another reason for overvaluing α is the fact that a part of the net mixed income is in reality a labor income and should be added to the compensation of employees.

The original approach to calculating α and β and its contemporary modifications have their merits and demerits. This paper analyzes five equilibrium approaches to calculating elasticities in an attempt to find out which approach provides the most accurate and reliable estimates of elasticities in the production function.

2.1.1. First equilibrium approach to estimating the elasticity coefficients

The first equilibrium approach to estimating the elasticity coefficients was used by Minassian (2008) and is based on the final expenditure structure of GDP. According to this approach, the elasticity α is set equal to the share of gross capital formation (gross investment) in GDP and the elasticity β is set equal to the share of final consumption in GDP. A specificity of this approach is that GDP is calculated as a sum of final consumption and gross capital formation, while net exports are not included in the calculation. A consequence of this way of calculating GDP is that the sum of the elasticities α and β equals 1. If net exports were included in GDP calculation, then the sum of α and β would not equal 1.

According to the first approach α and β are calculated as follows:

$$\alpha=GCF/(GCF+FC) \tag{3}$$

$$\beta=FC/(FCF+FC) \tag{4}$$

where:

GCF - gross capital formation;

FC - final consumption.

The values of the elasticities α and β obtained by the first approach are shown in Table 1.

2.1.2. Second equilibrium approach to estimating the elasticity coefficients

The second equilibrium approach to estimating the elasticity coefficients was used by Raleva (2013). It is based on the income structure of GDP and more precisely on the income from production factors, which is a sum of compensation of employees, net operating surplus and net mixed income. The coefficient β shows the

Table 1. Elasticity coefficients obtained in accordance with the five equilibrium approaches

	First approach		Second approach		Third approach		Fourth approach		Fifth approach	
Year	α_1	β_1	α_2	β_2	α_3	β_3	α_4	β_4	α_5	β_5
1997	0,11	0,89	0,62	0,38	0,42	0,58	0,46	0,54	0,57	0,43
1998	0,17	0,83	0,54	0,46	0,36	0,64	0,44	0,56	0,47	0,53
1999	0,20	0,80	0,51	0,49	0,34	0,66	0,44	0,56	0,43	0,57
2000	0,19	0,81	0,54	0,46	0,36	0,64	0,44	0,56	0,47	0,53
2001	0,19	0,81	0,54	0,46	0,36	0,64	0,44	0,56	0,47	0,53
2002	0,20	0,80	0,55	0,45	0,36	0,64	0,46	0,54	0,47	0,53
2003	0,20	0,80	0,53	0,47	0,35	0,65	0,46	0,54	0,44	0,56
2004	0,21	0,79	0,53	0,47	0,35	0,65	0,46	0,54	0,44	0,56
2005	0,24	0,76	0,52	0,48	0,35	0,65	0,46	0,54	0,43	0,57
2006	0,27	0,73	0,53	0,47	0,35	0,65	0,46	0,54	0,44	0,56
2007	0,29	0,71	0,54	0,46	0,36	0,64	0,46	0,54	0,46	0,54
2008	0,31	0,69	0,53	0,47	0,35	0,65	0,44	0,56	0,46	0,54
2009	0,27	0,73	0,50	0,50	0,34	0,66	0,43	0,57	0,43	0,57
2010	0,23	0,77	0,48	0,52	0,32	0,68	0,43	0,57	0,40	0,60
2011	0,22	0,78	0,51	0,49	0,34	0,66	0,44	0,56	0,44	0,56
2012	0,22	0,78	0,49	0,51	0,33	0,67	0,42	0,58	0,42	0,58
2013	0,21	0,79	0,46	0,54	0,31	0,69	0,40	0,60	0,40	0,60
Average	0,22	0,78	0,52	0,48	0,35	0,65	0,44	0,56	0,45	0,55

Source: Own calculation on the basis of data from the website of the National Statistical Institute of Bulgaria www.nsi.bg

share of compensation of employees in the income from production factors:

$$\beta = CE \div (CE+NOS+NMI) \quad (5)$$

where:

CE - compensation of employees;

NOS - net operating surplus;

NMI - net mixed income.

The coefficient α equals the share of the sum of net operating surplus and net mixed income in the income from production factors:

$$\beta = (NOS+NMI) \div (CE+NOS+NMI) \quad (6)$$

The values of the elasticities α and β obtained by the second approach are shown in Table 1. Calculated in accordance with the second approach, the coefficients α and β are the real weights of the production factors in GDP. A shortcoming of the second approach is the overvaluation of the share of capital income and the undervaluation of the share of labor income, which arises from treating the whole net mixed income as capital income.

2.1.3. Third equilibrium approach to estimating the elasticity coefficients

The third equilibrium approach to estimating the elasticity coefficients is a modification of the second approach and was also used by Raleva (2013). According to the third approach the whole net mixed income is treated as labor income. Labor income is calculated by adding to compensation of employees one third of the sum of net mixed income and net operating surplus. Capital income equals two thirds of the sum of net mixed income and net operating surplus. The coefficients α and β are calculated as

$$\alpha = \frac{2}{3}(NOS + NMI)/(CE + NOS + NMI) \quad (7)$$

$$\beta = [CE + 1/3\,(NOS + NMI)] / (CE + NOS + NMI) \quad (8)$$

The sum of α and β is 1. The values of α and β obtained according to the third approach are shown in Table 1.

A flaw of the third approach is the overvaluation of share of labor income β and the undervaluation of the share of capital income α since net mixed income does not consist entirely of labor income. Besides the property of overvaluing or undervaluing the real shares of labor income and capital income in GDP, the second and the third approaches to estimating α and β have another serious drawback. The calculated according to the second and the third approach coefficients α and β are not in fact GDP elasticities, because their calculation base includes only the income of production factors. However, if the calculation base were GDP, then the sum of α and β would not be 1.

2.1.4. Fourth equilibrium approach to estimating the elasticity coefficients

The fourth equilibrium approach was used by Raleva (2013). According to this approach, the coefficient β is calculated as the share of the sum of the compensation of employees and the net mixed income in GDP:

$$\beta = [CE + \frac{1}{3}(NOS + NMI)]/GDP \quad (9)$$

Assuming constant returns to scale, α is treated as a residual and equals (1-β).

When the fourth approach is applied, both α and β are overvalued. β is overvalued because in labor income is included the whole income of the non-corporate enterprises. α is overvalued because the other elements of the income structure of GDP are added to capital income. The values of α and β derived in accordance with the fourth approach can be seen in Table 1.

2.1.5. Fifth equilibrium approach to estimating the elasticity coefficients

The fifth equilibrium approach was used by Raleva (2013) and returns to the original model construction of the growth accounting concept. According to this approach, α is calculated first as

$$\alpha = (NOS + NMI)/GDP \quad (10)$$

β is treated as a residual and equals (1-α). Capital income is obtained as a sum of net operating surplus and net mixed income, which leads to an overvaluation of α because net mixed income contains some labor income. β is overvalued too because of its residual character. The fourth and the fifth approach restrict the distortion of the proportions between α and β caused by the different interpretation of net mixed income. The values of α and β derived in accordance with the fifth approach are shown in Table 1.

2.2. Measuring labor input

Two indicators can be used to measure labor input L in the production function - the number of employed persons or the number of hours worked in an economy. In this paper the first indicator is employed. The growth rates of the number of employed persons compared to the previous year are shown in Table 4.

2.3. Measuring the growth rate of capital stock

The most complex methodological problem related to the practical application of the growth accounting approach is how to measure the growth rate of capital stock. Two different approaches can be used to solve this problem - the perpetual inventory method (Ganev, 2005) and the constant capital-output ratio approach (Minassian, 2008; Raleva, 2013). In this paper the constant capital-output ratio approach has been employed. According to this approach, the growth rate of capital ΔK/K depends on gross investment I, the rate of depreciation d and the value of capital stock K in the base period:

$$\Delta K/K = I/K - d \quad (11)$$

I/K can be written as a proportion between the rate of accumulation I/Y and the capital-output ratio K/Y:

$$I/K = (I/Y)/(K/Y) \quad (12)$$

If I/K is substituted in Formula (11) with the right-hand side of Equation (12), then growth rate of capital ΔK/K can be calculated as

$$\Delta K/K = (I/Y/K/Y) - d \quad (13)$$

Like in many empirical investigations (Hernandez and Mauleon, 2003; Cororaton, 2002; Felipe, 1997 etc.), the assumed rate of depreciation d in this paper is 0.05.

The capital-output ratio K/Y is considered constant in economic theory. In empirical studies this ratio varies between 2 and 3. For Bulgaria the used values of the capital-output ratio are 2.5 (Minassian, 2008) and 2.3 (Raleva, 2013). For the purpose of this study the used value of the capital-output ratio is 2.2. It has been calculated as the average gross-capital-formation-to-change-in-real-GDP ratio for the period 1998-2008 (in accordance with the assumption of Harrod and Domar that the average and the marginal productivity of capital are equal).

The growth rates of capital are shown in Table 4.

3. An OLS estimation of Bulgaria's aggregate production function

For the OLS estimation a two-factor Cobb-Douglas production function is employed:

$$Y = A * (K \wedge \alpha) * (L \wedge \beta) * (e \wedge u) \quad (14)$$

where:

Y - real GDP;

A - total factor productivity (TFP);

K - capital stock;

L - labor input;

α - elasticity of GDP with respect to capital;

β - elasticity of GDP with respect to labor;

u - error term.

The Function (14) has been linearized by a logarithmic transformation:

$$\ln Y = \ln A + \alpha * \ln K + \beta * \ln L + u \quad (15)$$

The OLS estimation of Bulgaria's aggregate production function has been performed in two variants - with annual data and with quarterly data.

3.1. OLS estimation with annual data

The first variant of the OLS estimation of Bulgaria's aggregate production function uses annual data of the National Statistical Institute of Bulgaria for real GDP (at prices of 2010), for real gross fixed capital formation (at prices of 2010) and for the number of employed persons for the period 1996-2014.

The results from estimating Equation (15) with annual data are shown in Table 2. Because of the small number of observations (19) the OLS estimation of the production function with annual data should be treated with caution and is made solely for the purpose of comparing its results with the results from the OLS estimation with quarterly data and with the results from GA.

At the 5% level, the elasticity coefficients α and β are statistically significant, but the intercept (total factor productivity A) is not. The estimated value of α (0.254070) indicates that a 1% change in gross fixed capital formation will cause a 0.25% change in GDP in the same direction, provided that the number of employed persons is held constant. The estimated value of β (0.985005) means that a 1% change in the number of employed persons will lead to a 0.99% change in GDP in the same direction, if gross fixed capital formation remains unchanged. The OLS estimate of **α** obtained with annual data (0.25) is close to the average value of α, obtained via the first equilibrium approach (0.22). However, the OLS estimate of β o obtained with annual data (0.99) differs significantly from the average value of β derived via the first equilibrium approach (0.78). The OLS estimates of α and β obtained with annual data are higher than the average values of α and β calculated in accordance with the first equilibrium approach.

The coefficient of determination (R^2 = 0.842440) shows that 84.24% of changes in GDP during the period of investigation can be explained by changes in gross fixed capital formation and the number of employed persons. The probability of the F-statistic (0) indicates that at the 5% level of significance the alternative hypothesis for the adequacy of the regression model is accepted. The acceptance of the alternative hypothesis does not mean that the model specification is the best possible but only that the regression model adequately reflects the relationship between dependent variable and independent variables.

The value of 0.32 of the Durbin-Watson statistic presumes the existence of serial correlation (autocorrelation) of residuals. At the 5% level of significance the serial correlation LM test confirms the alternative hypothesis that residuals are serially correlated. The serial correlation of residuals is not unusual for time-series data. In the presence of serial correlation OLS estimates and based on them forecasts are inefficient but still unbiased and consistent. Since the regression model will not be used for forecasting, the serial correlation has not been removed from the model.

The residual heteroskedasticity test (Breusch-Pagan-Godfrey) confirms the null hypothesis for the absence of heteroskedasticity at the 5% level of significance.

The residual normality test (Jarque-Bera) confirms the null hypothesis for the presence of normal distribution of residuals at the 5% level of significance.

Table 2. Results from the OLS estimation of Bulgaria's aggregate production function for the period 1996-2014 with annual data

Variable	Coefficient	Standard error	t-statistic	Probability
ln A	0.609769	3.232859	0.188616	0.8528
α	0.254070	0.034093	7.452281	0.0000
β	0.985005	0.408935	2.408707	0.0284

Source: Own calculation on the basis of data from the website of the National Statistical Institute of Bulgaria www.nsi.bg

The estimated regression equation is

$$Y = 1.84 * (K\text{^}0.25) * (L\text{^}0.99) \qquad (16)$$

Since both α and β are less than one, GDP is non-elastic to both gross fixed capital formation and the number of employed persons.

The Wald test confirms the null hypothesis that α+β=1 at the 5% level of significance. This agrees with the assumption of constant returns to scale of the neoclassical growth theory.

3.2. OLS estimation with quarterly data

The second variant of the OLS estimation of Bulgaria's aggregate production function employs quarterly seasonally adjusted data of the National Statistical Institute of Bulgaria for real GDP (at prices of 2010), for real gross fixed capital formation (at prices of 2010) and for the number of employed persons for the period from the first quarter of 1996 to the fourth quarter of 2014.

The performed Augmented Dickey-Fuller Unit Root Tests produced the following results:

- Log values of real GDP and their first differences are not stationary, but their second differences are stationary;
- Log values of real gross fixed capital formation are stationary;
- Log values of the number of employed persons and their first differences are not stationary, but their second differences are stationary.

In order to make the time series stationary, Equation (15) has been modified by using the second differences of log values of variables:

$$\ln Y_t - \ln Y_{t-2} = \ln A + \alpha * (\ln K_t - \ln K_{t-2}) + $$
$$+ \beta * (\ln L_t - \ln L_{t-2}) + u \qquad (17)$$

The results from estimating Equation (17) are displayed in Table 3.

β becomes statistically significant. The estimated value of α (0.219426) indicates that a 1% change in gross fixed capital formation will cause a 0.22% change in GDP in the same direction, provided that the number of employed persons is held constant. The estimated value of β (0.390322) means that a 1% change in the number of employed persons will lead to a 0.39% change in GDP in the same direction, if gross fixed capital formation remains unchanged. The OLS estimate of α obtained with quarterly data (0.22) coincides with the average value of α calculated according to the first equilibrium approach (0.22). However, the OLS estimate of β obtained with quarterly data (0.39) is significantly lower than the average value of β derived in accordance with the first equilibrium approach (0.78).

The coefficient of determination (R^2 = 0.570997) shows that 57.1% of changes in GDP during the period of investigation can be explained by changes in gross fixed capital formation and the number of employed persons. The probability of the F-statistic (0) indicates that at the 5% level of significance the alternative hypothesis for the adequacy of the regression model is accepted. The acceptance of the alternative hypothesis does not mean that the model specification is the best possible but only that the regression model adequately reflects the relationship between dependent variable and independent variables.

Table 3. Results from the OLS estimation of Bulgaria's aggregate production function for the period 1996-2014 with quarterly data

Variable	Coefficient	Standard error	t-statistic	Probability
ln A	0.000242	0.019729	0.012242	0.9903
α	0.219426	0.023909	9.177619	0.0000
β	0.390322	0.230159	1.695884	0.0944

Source: Own calculation on the basis of data from the website of the National Statistical Institute of Bulgaria www.nsi.bg

At the 5% level, the elasticity coefficient α is statistically significant, but the elasticity coefficient β and the intercept (total factor productivity A) are not. At the 10% level

The value of 2.79 the Durbin-Watson

statistic presumes the existence of serial correlation (autocorrelation) of residuals. At the 5% level of significance the serial correlation LM test confirms the alternative hypothesis that residuals are serially correlated. The serial correlation of residuals is not unusual for time-series data. In the presence of serial correlation OLS estimates and based on them forecasts are inefficient but still unbiased and consistent. Since the regression model will not be used for forecasting, the serial correlation has not been removed from the model.

The residual heteroskedasticity test (ARCH) confirms the null hypothesis for the absence of heteroskedasticity at the 5% level of significance.

The residual normality test (Jarque-Bera) confirms the null hypothesis for the presence of normal distribution of residuals at the 5% level of significance.

Since A = 1, the estimated regression equation is

$$Y = (K\hat{\ }0.22)*(L\hat{\ }0.39) \quad (18)$$

Since both α and β are less than one, GDP is non-elastic to both gross fixed capital formation and the number of employed persons.

The Wald test confirms the null hypothesis that $\alpha+\beta=1$ at the 1% level of significance. This agrees with the assumption of constant returns to scale of the neoclassical growth theory.

4. Results from the growth accounting of Bulgaria

The values of the elasticities α and β obtained through the five equilibrium approaches can be seen in Table 1. The comparison with the OLS procedure results (see Tables 2 and 3) suggests that the first equilibrium approach provides the most accurate and reliable estimates of the elasticities α and β in Bulgaria's aggregate production function. Therefore, the first equilibrium approach has been used in the implementation of the growth accounting technique to Bulgaria.

The calculated results for the contributions of capital, labor and total factor productivity to economic growth in Bulgaria via the first equilibrium approach are displayed in Table 4.

As a whole the dynamics of Bulgaria's output under a CBA has been positive (see Table 4). For the entire period 1997-2013 the real GDP of Bulgaria decreased in three years only – in 1997, 1997 and 2009. However, the average growth rate for the whole period is not high - 2.78%. The standard deviation of growth rates of 3.8% implies that Bulgaria's economic growth under a CBA has been unstable and uneven. In 1997 the fall in real output was small (1.09%) but in 1999 and in 2009 it was disastrous (5.65% and 5.01% respectively). The main contributor to the serious drop in real GDP in 1999 was employment (with a fall of 3.45%) and in 2009 - total factor productivity (with a fall of 5.98%).

The period 2000-2008 was characterized by a relatively high and steady economic growth with an average rate of 5.70% and a standard deviation of 1.01%. In the first part of this period (from 2000 till 2004) the total factor productivity was the main driving force of growth with an average contribution of 4.06%. However, in the second part of the period (from 2005 till 2008) the growth of real GDP was determined mostly by changes in capital stock, whose average contribution was 2.27%.

After the collapse in 2009 (a 5% decline in real output) the recovery of Bulgarian economy has been slow and weak. In the years 2010-2013 Bulgaria recorded a faint economic growth of less than 2% per annum and 1.05% on average. This weak growth has been determined mainly by negative changes in employment (an average drop of 1.75%).

Table 4. Contributions of capital, labor and total factor productivity to economic growth in Bulgaria in accordance with the first equilibrium approach

Year	ΔY/Y	α	ΔK/K	α*ΔK/K	β	ΔL/L	β*ΔL/L	ΔA/A
1997	-1.09%	0.11	-0.80%	-0.09%	0.89	-3.07%	-2.74%	1.74%
1998	3.46%	0.17	0.53%	0.09%	0.83	-1.03%	-0.85%	4.22%
1999	-5.65%	0.20	3.48%	0.70%	0.80	-4.32%	-3.45%	-2.90%
2000	6.04%	0.19	3.05%	0.57%	0.81	-2.38%	-1.93%	7.40%
2001	3.80%	0.19	3.67%	0.71%	0.81	-0.75%	-0.61%	3.70%
2002	4.48%	0.20	3.94%	0.78%	0.80	0.23%	0.18%	3.52%
2003	5.36%	0.20	4.23%	0.86%	0.80	2.96%	2.36%	2.14%
2004	6.56%	0.21	4.58%	0.96%	0.79	2.59%	2.05%	3.55%
2005	5.96%	0.24	6.44%	1.54%	0.76	2.70%	2.05%	2.36%
2006	6.47%	0.27	7.55%	2.01%	0.73	3.34%	2.45%	2.01%
2007	6.91%	0.29	8.41%	2.40%	0.71	3.18%	2.27%	2.24%
2008	5.75%	0.31	10.0%	3.13%	0.69	2.36%	1.62%	1.00%
2009	-5.01%	0.27	8.26%	2.22%	0.73	-1.71%	-1.25%	-5.98%
2010	0.66%	0.23	5.61%	1.30%	0.77	-3.88%	-2.98%	2.33%
2011	1.98%	0.22	4.73%	1.02%	0.78	-2.20%	-1.72%	2.68%
2012	0.49%	0.22	4.83%	1.06%	0.78	-2.50%	-1.95%	1.38%
2013	1.07%	0.21	4.70%	1.01%	0.79	-0.43%	-0.34%	0.40%
Average	2.78%	0.22	4.90%	1.19%	0.78	-0.29%	-0.29%	1.87%
St. Dev.	3.80%	4.59%	2.66%	0.81%	4.59%	2.58%	2.00%	2.81%

Source: Own calculation on the basis of data from the website of the National Statistical Institute of Bulgaria www.nsi.bg

The total factor productivity (with a standard deviation of 2.81%) has been the most volatile of the three growth determinants. Capital stock (with a standard deviation of 0.81%) has been the most stable contributor to Bulgaria's economic growth under a CBA.

The contribution of labor to economic growth was positive in 2002-2008 but negative in 1997-2001 and 2009-2013. The average contribution of employment to economic growth for the whole period 1997-2013 is negative (-0.29%). The comparison of the dynamics of output and employment demonstrates that positive changes in the labor market occurred after two years of high and steady economic growth. However, the response of labor market to poor output developments has been immediate.

The fluctuations of output and the total factor productivity show similar patterns. This fact is due to the specificity of the calculation of the change in total factor productivity as a residual obtained from the growth rate of output by subtracting the growth rates of capital stock and labor input.

The contribution of changes in capital stock to economic growth was positive in all years of the period 1997-2013 except for the year 1997, when it was negative. The average contribution of capital stock to economic growth for the period 1997-2013 is 1.19%, which makes it the second largest contributor to Bulgaria's economic growth under a CBA after TFP (with an average contribution of 1.87%). The peak contributions of changes in capital stock to economic growth were in the years 2003-2008 (an average of 1.82%). After the upward movements in 1997-2008, the impact of capital stock on economic growth decreased in 2009-2013 (an average of 1.32%, or a decline of 0.5% compared to the period 2003-2008). It may be inferred that the increase in capital stock in 1997-2008 resulted from an improvement of the business environment in Bulgaria. This improvement of the business environment was caused by the following events:

- The introduction of the CBA in 1997, which led to financial and macroeconomic stability;
- The increase in lending in 2003-2008, which was due to the purchase of Bulgarian banks by foreign banks and to the massive inflow of foreign capital to Bulgaria;
- The accession of Bulgaria to the European Union, which increased the certainty for foreign investors in Bulgaria.

As a result of the global and domestic economic crisis and the slow recovery of Bulgarian economy from this crisis, the influence of changes in capital stock on economic growth fell in 2009-2013, when the uncertain political and economic environment led to a sharp drop in investment.

It can be concluded that total factor productivity and capital stock have been the main supply-side determinants of economic growth in Bulgaria under a CBA while the influence of changes in employment on the dynamics of real GDP has been weaker. The dynamics of total factor productivity under a CBA has been rather chaotic, which may be attributed to the inconsistent development of the transition to a market-oriented economy in Bulgaria. The ineffective use of labor resources has contributed to lowering the growth rates of real GDP. This small negative impact of employment has been offset by rises in total factor productivity and capital stock. The decline in employment has been accompanied by increased influence of scientific progress and organizational factors. Economic effectiveness has increased in the process of privatization and restructuring of the Bulgarian economy.

Conclusions

The OLS procedure results suggest that the first equilibrium approach provides the most accurate and reliable estimates of the elasticities α and β in Bulgaria's aggregate production function. This inference could be explained by two circumstances:

1) The first equilibrium approach is based on the final expenditure structure of Bulgaria's GDP, while the other four equilibrium approaches are based on the income structure of Bulgaria's GDP;
2) The estimation of GDP by the income approach in the official Bulgarian statistics is not reliable because it is obtained post factum, as a residual and reflects only the primary distribution of income and does not take into account the redistribution of income.

The comparison of the results from the two OLS estimations (with annual and quarterly data) and the first equilibrium estimation of Bulgaria's aggregate production function leads to the following conclusions:

- The estimated values of the elasticity of output with respect to capital α via different methods are close or even coincide (the OLS estimate of α is 0.25 with annual data and 0.22 with quarterly data, while the first equilibrium approach generated an average value of 0.22 for the period 1997-2013);

- The estimated values of the elasticity of output with respect to labor β via different methods significantly differ from each other: (an OLS estimate with annual data of 0.99, an OLS estimate with quarterly data of 0.39 and an average of 0.78 by the first equilibrium approach for the period 1997-2013);
- The coefficient α is significant at the 1% level in both OLS procedures (with annual and quarterly data);
- The coefficient β is significant at the 5% level in the OLS procedure with annual data and at the 10% level in the OLS procedure with quarterly data;
- The OLS estimation with annual data indicates increasing returns to scale ($\alpha + \beta = 1.24 > 1$), while the OLS estimation with quarterly data shows decreasing returns to scale ($\alpha + \beta = 0.61 < 1$). However, in both OLS procedures the Wald test confirms the null hypothesis that $\alpha+\beta=1$ at the 5% level of significance. This agrees with the assumption of constant returns to scale of the neoclassical growth theory;
- The intercept A is insignificant in both OLS procedures ((with annual and quarterly data).
- Both OLS estimations should be treated with caution for different reasons: the one with annual data because of the short time series (19 observations) and the other with quarterly data because of spillover effects and seasonal fluctuations.

When growth accounting is applied to Bulgaria, it is recommended that the first equilibrium approach to calculating elasticity coefficients be used.

The results of growth accounting using the first equilibrium approach provide evidence that total factor productivity and capital stock have been the main supply-side determinants of Bulgaria's economic growth under a CBA, while employment has had an insignificant negative impact on growth. This inference implies that Bulgarian policymakers have to concentrate their efforts on encouraging productivity improvement and investment in order to stimulate economic growth.

Labor productivity per person employed and per hour worked in Bulgaria is 30-40% of EU average, which makes Bulgarian workforce the least productive one in the EU (Todorov, 2014).

The experience of Bulgaria and other transition economies has proved that investment activity is determined mainly by institutional and macroeconomic environment, while tax stimuli and other preferences have relatively weaker impact on investors' decisions. In spite of its low corporate tax rate of 10%, Bulgaria has attracted less investment than other transition economies from Central and Eastern Europe with higher corporate tax rates.

Bulgaria's institutional environment is characterized by high levels of bureaucracy and corruption and by sluggish and ineffective work of state administration. The lack of good legislation and quality institutions, the absence of quality infrastructure and the shortage of well-qualified and highly-productive labor force are the main obstacles to investment (local and foreign). Other factors, which impede investment, are the political instability and the absence of succession and continuity in macroeconomic policies of different Bulgarian governments.

Bulgaria may create favorable conditions for increasing productivity and investment by:

1) Improving the quality of its legislation and institutions;
2) Building good public infrastructure;

3) Encouraging and investing in the formation of human capital;
4) Stimulating and investing in research and development (R&D) activities.

Considering the slow and painful process of institutional transformation in Bulgaria, as well as the low share of investment in public infrastructure, human capital and research and development in Bulgaria's GDP compared to EU levels, the supply-side prospects of Bulgaria's economic growth cannot be good.

The present study has some similarities to and some differences from the other investigations in Bulgaria's economic growth in the transition to a market-oriented economy:

- In terms of its first objective (to identify the best equilibrium approach to calculating elasticities in Bulgaria's aggregate production function) the present empirical investigation differs from the previous studies of Bulgaria's economic growth in the transition to a market-oriented economy;
- In terms of the used methodology (a combination of an OLS estimation and five equilibrium approaches to estimating elasticities in the production function) the present empirical investigation differs from the previous studies of Bulgaria's economic growth in the transition to a market-oriented economy;
- In terms of the indicator used to measure employment (the number of employed person) the present research resembles the investigations of Minassian (2008), but differs from the studies of Ganev (2005) and Raleva (2013), where employment was measures by the number of hours worked;
- In terms of the approach used to estimate the growth rate of capital stock (constant capital-output ratio), the present study is similar to the investigations of Minassian (2008) and Raleva (2013), but differs from the research of Ganev (2005), where the growth rate of capital stock was estimated by the perpetual inventory method;
- In terms of the equilibrium approaches used to calculate the elasticity coefficients in the production function, the present research employs and compares five approaches based on both the final expenditure structure and the income structure of GDP. The previous studies about Bulgaria's economic growth use either expenditure-based equilibrium approaches (Minassian, 2008), or income-based equilibrium approaches (Ganev, 2005, Raleva, 2013) but not both.

A contribution of the present study to empirical research into Bulgaria's economic growth is the conclusion that the equilibrium approach based on the final expenditure structure of GDP provides more accurate and reliable estimates of the elasticities α and β in Bulgaria's aggregate production function than the other analyzed four approaches, which are based on the income structure of GDP.

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