Measuring Total Factor Productivity: Growth Accounting for Bulgaria*

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Abstract

Total factor productivity measurement enables researchers to determine the contribution of supply-side production factors to economic growth. For Bulgaria, which is a transition economy, it is difficult to construct a production function with stable parameters, mostly because there are atypical developments of capital and labor during periods of economic growth, as well as due to the lack of sufficiently long and dependable data series. In this respect, growth accounting enables us to identify the basic sources and directions of influences. The calculations that have been carried out in this paper help in the identification of total factor productivity development as the main driving force of economic growth. The likely reasons for this strong influence have been also outlined.

Keywords: economic growth, total factor productivity

JEL code: E22, O47

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Contents

1 Introduction

The assessment of the economic development of Bulgaria since the beginning of the 90s of the XX century is not easy. The beginning of this so-called period of transition is usually associated with aggravation of the economic environment, decay of production and productive relations and consequently with a loss of economic welfare compared to the previous decades. Until 1997 the country went also through several inflationary and currency crises, which posed additional difficulties in the overcoming of the negative developments of incomes. Despite the largely illusionary outlooks for recovery in 1994 and 1995[1], for the period 1990-1997 the real gross domestic product of the country decreased by about 32 % compared to the 1989 levels.

The situation in the years after the introduction of currency board arrangements looks entirely different, and the economy of Bulgaria is invariably characterized with real GDP growth. The value of this growth is four or more percent on an annual base, except in 1999. Since the values of real GDP growth in the EU are lower, the economic growth of Bulgaria implies convergence to the EU averages of income. How long this convergence will be and whether its recorded speed matches the desired state is a topic for discussions, the conclusions from which would be most likely uncertain. The purpose of this paper is not to seek arguments in this direction, but mostly to find an answer to the question: Which are the driving forces of economic growth, given the fact that in a sufficiently large share of the years chosen for analysis the main factors of growth (labor and capital) do not change in the direction implied by the neo-classical models?[2]

[1]For those two years positive economic growth figures have been registered, respectively 1.8 % and 2.9 %. Source: AEAF.

[2]According to the neo-classical theory, the increase of the level of income, ceteris paribus, is implied by increases in the quantities of those two production factors, i.e. the marginal products of capital and labor are positive. As will become evident from the obtained results, during some years there is economic growth in Bulgaria, while capital and labor exhibit decreases.

In this paper an assessment of the contribution of the respective supply-side production factors[3] to the economic growth of Bulgaria for the period 1991-2007 has been made. The emphasis is put on the contribution of total factor productivity (which is considered as a measure of changes in the quality of the production process) to economic growth.

Total factor productivity is a concept, which has been formalized comparatively late. Although the origin of the idea on its existence might be sought as early as the classical school, a stricter definition, respectively more serious attempts to finds some quantitative measures, are observed after the 30s of the XX century.[4] Behind this concept most often stands the understanding that besides the traditional factors of production labor and capital there is something else that drives production to increase. Usually this 'thing' is associated with technological progress. The latter concept itself can be interpreted in various ways, but eventually it always implies that the combination of labor force, machines, human knowledge and skills, leads to changes in total income that are not expected by changes in capital or labor considered separately.

In the circumstances of transition to market-based economy, which Bulgaria undergoes since the beginning of the 90s of the XX century, the increase of total factor productivity contains in itself also the influences of other substantial factors, although not for the entire period. Firstly, the increase reflects the influence of financial stability, which is in place since the introduction of the currency board arrangements in 1997. We would not also want to omit the gradual building of institutions necessary for the normal modern functioning of market economies and which also play a significant role in the management of macroeconomic processes.[5]

[3]Due to the lack of dependable quantitative estimates of the human capital stock, the contribution of this factor has been rendered implicitly in the changes of total factor productivity.

[4]For a more thorough discussion of the historical development of the quantitative analysis of total factor productivity, see for example Griliches (1995) or Hulten (2000).

[5]For a thorough treatment of the role of financial stability in Bulgaria as a prerequisite for growth, see Minnasian (2002).

The approach that has been used here in the measurement of total factor productivity is the so-called growth accounting, which, although being simple with respect to the computation technique, leads to sufficiently illuminating results.

In growth accounting the concept 'total factor productivity' does not have a stand-alone meaning, until the influence of capital and labor is taken into consideration (and also other factors, for which statistics is available). Generally, the calculation of total factor productivity in addition to the contributions of labor and capital indicates an inability to identify or quantify the remaining objectively existing factors, which determine economic growth. This inability most frequently stems from the lack of suitable statistical data or from the lack of preliminary studies of the values of the omitted factors. When we isolate the influences of the production factors, for which we have available statistical data, there remains the contribution of all other factors, which are generalized in literature with the term 'total factor productivity'. When the computation of the increase of the total factor productivity is carried out using data on capital and labor, the analysis is incomplete by definition, since in modern theory and empirics of economic growth more than two factors of growth have been identified. As was mentioned above, in the current paper, for example, the factor 'human capital' is missing, while it is expected to have a significant contribution.[6] As far as technological development and human knowledge, skills, health status, etc. are interrelated, this 'inaccuracy by definition' should not pose a significant problem. Although, generally speaking, the more detailed is a set of results, the more valuable it is.

Besides growth accounting, in economic literature there is another approach for the identification of factors and their contributions – namely the application of econometric estimation. In the present case this approach has not been chosen, since it is characterized with certain shortcomings, the most important among them

[6]Mankiw et al. (1992), for example, show empirically that the elasticity of GDP with respect to this production factor is approximately 1/3 for a panel sample, including 98 countries.

underlying the fact that the factors of production might be found to be endogenous (which is the most common case) to the estimated model. There are appropriate techniques to solve the latter problem, but the restriction in the present case stems mostly from the fact that the available annual data on income formation by economic sectors are insufficiently long, which would not lead to stable parameters from regression analysis.

The paper is structured in the following way. In Part 2 a review of the theoretical foundations of economic growth accounting has been made. The fundamental relations have been outlined and the advantages and disadvantages of the two basic methods used in the computations have been sketched. In Part 3 the assumptions and the techniques, related to the calculation of indicators, the values of which cannot be extracted from national accounts or other statistical sources, have been described. In part 4 the results from the calculations have been presented and their major characteristics have been commented. Part 5 is entirely devoted to the conclusions relating to total factor productivity, as well as to general assumptions and considerations relating to the future developments of this indicator.

2 Fundamental relations in economic growth accounting

2.1 The Solow approach

In 1956 Robert Solow published a model representing a simplified but at the same time powerful framework for analysis of the causes and dynamics of economic growth. A year later, in 1957, he published a second paper[7] titled "Technological Change and the Aggregate Production Function". In this paper the rate of growth of aggregate production is represented as a combination of the contribu-

[7] See Solow (1957).

tions of growth rates of the respective production factors – physical capital, labor and technological change (or total factor productivity). Solow used the following specification of a production function with Hicks-neutral technology:

$$Y(t) = A(t) \cdot F[K(t), L(t)], \tag{1}$$

where $Y(t)$ stands for aggregate production (or aggregate income), $K(t)$ is the stock of physical capital used in production, $L(t)$ is the amount of labor inputs, and $A(t)$ is the level of technology.

Equation (1) can easily be transformed to the following[8]:

$$\frac{\dot{Y}(t)}{Y(t)} = \frac{\dot{A}(t)}{A(t)} + a(t) \cdot \frac{\dot{K}(t)}{K(t)} + b(t) \cdot \frac{\dot{L}(t)}{L(t)}, \quad a(t) + b(t) = 1, \tag{2}$$

where $a(t)$ and $b(t)$ are respectively the shares of capital and labor costs in total costs.

In general data on $Y(t)$, $K(t)$ and $L(t)$ are available (or can be calculated from other variables), so that the only expression, which remains unknown is $\dot{A}/A$. However, it can be easily calculated as a residual from equation (2):

$$\frac{\dot{A}(t)}{A(t)} = \frac{\dot{Y}(t)}{Y(t)} - a(t) \cdot \frac{\dot{K}(t)}{K(t)} - b(t) \cdot \frac{\dot{L}(t)}{L(t)} \tag{3}$$

The latter calculation is also known as 'finding the Solow residual'. The discrete form of this equation when working with real data should be:

$$\frac{\Delta A(t)}{A(t-1)} = \frac{\Delta Y(t)}{Y(t-1)} - a(t) \cdot \frac{\Delta K(t)}{K(t-1)} - b(t) \cdot \frac{\Delta L(t)}{L(t-1)} \tag{4}$$

In practice, exactly this form of the equation had been used many years for the calculation of total factor productivity, including by Solow himself.

[8]The transformations and the corresponding assumptions that have been made are presented in Appendix 1.

2.2 Alternative approach for empirical analysis

The Solow framework presented so far, is extremely informative on the relations among the various variables, but as far as continuous data are used. Measurement in economics, however, is rarely done continuously. The modification, presented in equation (4), is a purely mechanical transformation of the continuous case and may lead to inaccuracy in the obtained results.

With discrete data it is better to use the trans-logarithmic specification of production function, presented by Diewert[9]:

$$\begin{aligned} \ln Y(t) &= \alpha_0 + \alpha_K \cdot \ln K(t) + \alpha_L \cdot \ln L(t) + \alpha_t t + \\ &+ \frac{\beta_{KK}}{2}[\ln K(t)]^2 + \frac{\beta_{LL}}{2}[\ln L(t)]^2 + \frac{\beta_t}{2}t^2 + \\ &+ \beta_{KL} \ln K(t) \cdot \ln L(t) + \beta_{Kt} \ln K(t) \cdot t + \beta_{Lt} \ln L(t) \cdot t, \end{aligned} \tag{5}$$

where:

$$\alpha_K + \alpha_L = 1$$
$$\beta_{KK} + \beta_{KL} = 0$$
$$\beta_{LL} + \beta_{KL} = 0$$
$$\beta_{Kt} + \beta_{Lt} = 0$$

If we assume that the labor and capital markets are competitive, then:

$$a(t) = \frac{\partial \ln Y(t)}{\partial \ln K(t)} = \alpha_K + \beta_{KK} \ln K(t) + \beta_{KL} \ln L(t) + \beta_{Kt} t \tag{6}$$

$$b(t) = \frac{\partial \ln Y(t)}{\partial \ln L(t)} = \alpha_L + \beta_{LL} \ln L(t) + \beta_{KL} \ln K(t) + \beta_{Lt} t \tag{7}$$

If we have discrete data, the rates of change of the variables are calculated as first differences of the logarithms. In our case we have:

[9] See Diewert (1976)

$$\Delta \ln Y(t) = \frac{1}{2}[a(t) + a(t-1)]\Delta \ln K(t) + \frac{1}{2}[b(t) + b(t-1)]\Delta \ln L(t) + \Delta \ln A(t) \quad (8)$$

From the latter equation we obtain the measure of the total factor productivity growth rate:

$$\Delta \ln A(t) = \Delta \ln Y(t) - \frac{1}{2}[a(t) + a(t-1)]\Delta \ln K(t) - \frac{1}{2}[b(t) + b(t-1)]\Delta \ln L(t) \quad (9)$$

Although the latter equation presents more precisely the matter from a purely technical point, in our case, when calculating total factor productivity, the Solow approach contained in equation (4) will also be used for entirely illustrative purposes.

3 Notes on the supplementary calculations

3.1 Data selection and preparation for calculations

The gross domestic product published by the National Statistical Institute has been used as a measure of $Y(t)$, and the number of employed persons published by the Employment Agency - as a measure of $L(t)$.[10]

Data on $K(t)$ are not published and this requires that it should be calculated additionally. The most common method for its calculation is the so-called 'permanent inventory method', which can be described briefly with the equation:

$$K_t = I_t + (1-\delta)K_{t-1}, \quad (10)$$

[10] All indicators of value used in the calculations are taken at 1998 constant prices.

where $I(t)$ is gross investment, and δ is the rate of depreciation. As a measure of gross investment the indicator 'gross fixed capital formation' from the national accounts has been used. The only challenge here stands in the determination of the initial condition for equation (10) – i.e. the value of the initial capital stock.

The approach that will be used in the calculation of the initial capital stock makes use of the value of capital depreciation and because of that the exposition of assumptions for the determination of this value are needed first. In literature various values of the depreciation rate are used. Here we assume that $\delta = 0.05$, which means that the full depreciation of a given capital unit takes place within 20 years. The choice of this value is not arbitrary but is based on estimates found in various pieces of research. Examples of such studies are Hernández and Mauleón (2003) for the economy of Spain, Cororaton (2002) for the Philippines, Felipe (1997) for a group of countries in East Asia, etc. The choice of this value is not arbitrary also because the average ratio between consumption of fixed capital and the gross domestic product for the period 1980-1990 is 0.138,[11] which with an expected capital-output ratio of about 3,[12] gives a depreciation rate of about 5 %.

The initial capital stock is calculated using the formula:

$$K_0 = I_0/\delta \tag{11}$$

According to the latter equation, in practice we assume that the initial capital stock is equal to the gross investment, made during the initial year, multiplied by 20.[13] Of course, the analysis is influenced to some extent by the exact value that

[11]See "Main Economic Indicators '98", published by the National Statistical Institute, 1999.

[12]The database for 93 countries of Nehru and Dhareshwa published by the World Bank has been used. The average ratio for this group of countries for 1997 is 2.91. For more details, see http://www.worldbank.org/research/growth/ddnehdha.htm.

[13]This does not mean that the investments for the preceding 19 years are equal to those for the year, for which the initial capital is calculated; in practice, their value is considerably higher, since they have also depreciated in the course of time. The exact value of the average yearly investment for this 19-year period depends on whether a linear or a geometric method of depreciation calculation will be chosen. For details on the methods of depreciation calculations, see the part devoted

we will use for the initial capital stock, but this influence dies out gradually in time; i.e., the farther the initial moment from the present, the weaker the influence of the initial capital stock on the obtained results.

3.2 Methodology for calculation of the capital stock

The permanent inventory method exposed in equation (10) implies the possibility for a recursive substitution back in time. For example, if we rewrite the formula for time $(t-1)$, we have:

$$K_{t-1} = I_{t-1} + (1-\delta)K_{t-2}.$$

The latter we substitute back in equation (10)and we get:

$$K_t = I_t + (1-\delta)I_{t-1} + (1-\delta)^2 K_{t-2}. \tag{12}$$

We may continue in a similar fashion to an arbitrary moment in the past to get:

$$K_t = \sum_{i=0}^{n-1}(1-\delta)^i I_{t-i} + (1-\delta)^n K_{t-n}, \tag{13}$$

where n is the fixed moment in time, from which we take the initial capital stock. It can be shown that even with $n \to \infty$ the expression for the amortized value of the initial capital stock never becomes exactly zero, i.e. this way of calculation implies 'eternal life' for some part of the capital stock. For the purposes of our analysis the capital has to have a finite life – i.e. to depreciate entirely for a finite number of years. The latter is also required from a practical point of view, since after a specified spell of time the capital stock loses its ability to create new value. For this reason the following variant of equation (13) has been used here:

to the calculation of the capital stock.

$$K_t = \sum_{i=0}^{n-1}(1 - i\delta)I_{t-i} + (1 - n\delta)K_{t-n}, \tag{14}$$

Equation (14) implies a constant and an even (linear) reduction of the value of the initial capital, as well as of the value of investments that are made between the initial and the present moment. Also, in such a way we allow for full depreciation of a capital unit for $1/\delta$ periods.

3.3 Calculation of the capital stock by economic sectors

Data on the final use components of the gross domestic product by economic sectors are still not available from the National Statistical Institute. In this situation to eventually compute the capital stock by economic sectors it is necessary to make the respective assumptions. A possible approach would be to assume that capital dynamics by economic sectors fully coincide with the dynamics of the acquired fixed assets by years.[14] In other words, this means to assume that the share of the capital of the respective sector in the total capital stock is equal to the share of the same sector in the total acquired fixed assets.[15]

The inaccuracies in this assumption would amount to the following:

- The dynamics of capital in the sectors are not determined entirely by the consecutive accrual of fixed assets, but also by the share of the initial capital of the sector in the total initial capital stock, as well as by the sector-specific rate of depreciation. It is logical that these two values may not coincide with the shares of the respective sectors in the total fixed assets for the initial year

[14] A similar consideration can be made by analogy using consumption of fixed capital, for which data is available.

[15] Analytically the assumption would look like:

$$\frac{K_j}{K} = \frac{TFA_j}{TFA}, \quad \sum_j K_j = K, \quad \sum_j TFA_j = TFA,$$

where K is the capital stock, TFA are the fixed tangible assets, and j is an index of the respective sector.

and the economy's depreciation rate;

- The acquired fixed assets are not always new. As a result of this, on the one hand their inclusion in the value of the capital stock for the corresponding period is not quite precise since to a certain extent the prices at which they are acquired do not necessarily reflect their degree of depreciation. On the other hand, the calculation of depreciation of a capital unit in time would also be imprecise since the value of the factor of multiplication in equations (13) and (14) would not be correct in general by definition;

- The influence of intangible fixed assets is not taken into consideration; in such a case we assume that their dynamics are the same as that of the tangible assets. Moreover - we do not take into account the fact that the intangible fixed assets are by large unevenly distributed among the various sectors (e.g., it is expected that their smallest share is found in agriculture).

This first proxy may serve to some extent as a guideline for the state of capital stock by sectors. The respective calculations have been made, but are not included in the paper since they most probably do not reflect the true dynamics of the indicator. By the same token the inclusion on the obtained results on total factor productivity by sectors is also omitted.

3.4 Calculation of the shares of labor and capital incomes in total income

The easiest way to calculate the share of labor income is to take the ratio of the compensation of employees from the national accounts and the gross domestic product (or the gross value added). However, if we do this, there is a chance that income, which is by virtue labor income, is attributed to capital income.[16] Since

[16] For a detailed discussion of this approach, see for example Krueger (1999).

such a detailed representation of the sources of income is not available, we will use only the consideration that a share of the total of the net operating surplus and the net mixed income, for which data is available, may be characterized as labor income. More specifically, this is the value of the net mixed income, which is comprised of the income from unincorporated enterprises and which is received by the owners and the members of their families. Since this income is usually not reported as wages, salaries and related expenditure, but basically performs such a function, we add it to the compensation of employees. As statistics on the net mixed income is available only for the period 1998-2001, we use the average ratio for those four years:

$$\frac{\text{Net mixed income}}{\text{Net mixed income } + \text{ Net operating surplus}}$$

and apply it to the whole period, which we analyze. The obtained value in the present case is approximately 0.33, which means that we assume 1/3 as the share of mixed income in the above mentioned total.

It follows that:

$$a(t) = \frac{COE(t) + NMI(t)}{GDP(t)}, \quad b(t) = 1 - a(t), \tag{15}$$

where COE is the compensation of employees, and NMI is the net mixed income.

4 Results

4.1 Capital stock

The results of the calculations on the capital stock according to the two methods in equation (13) and equation (14) are displayed respectively in Figures 1 and 2 and in tabular form in Appendix 2.

In both cases the value of the initial capital stock is the same and is calculated

Figure 1: Capital stock calculated with the geometric method (thousands of BGN)

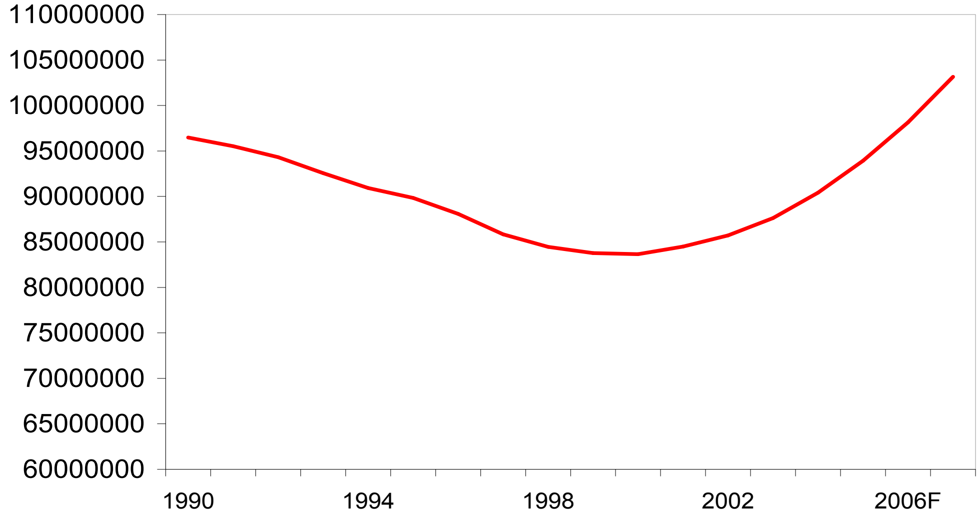
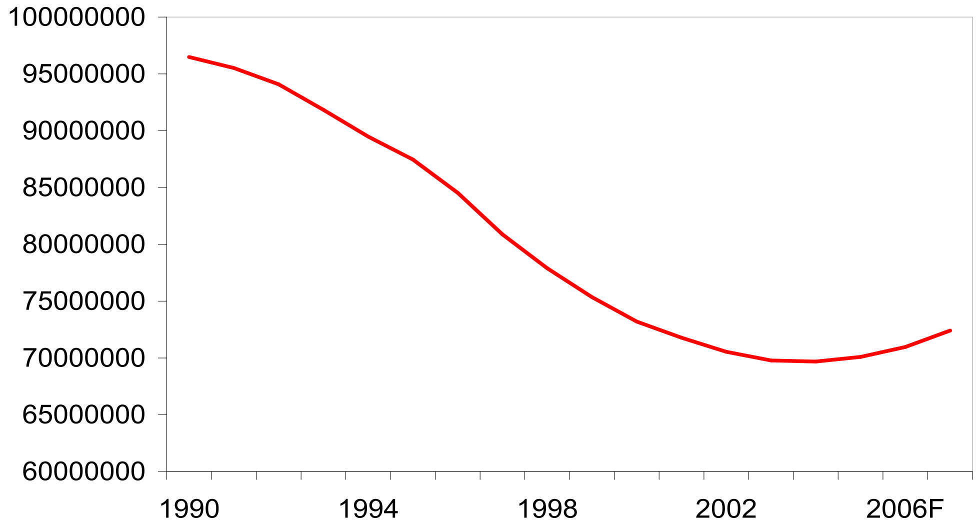


Figure 2: Capital stock calculated with the linear method (thousands of BGN)



by multiplying the gross fixed capital formation for 1990 by 20. In the first case the capital stock displays a tendency of decrease until 2000 inclusive. In the second the capital stock decreases until 2004, while its rate of decrease switches from increasing to decreasing.

As for the relation 'capital stock/gross domestic product', in the first case at the beginning of the period it has a value of 3.36,[17] and at the end of the period - 3.18.[18] In the second case at the beginning of the period the value is also 3.36, but at the end it is 2.54.

The numbers for Bulgaria look comparatively high, but they can be explained by the fact that in the early nineties the state of the economy implies a low efficiency of capital in the creation of value. A part of the reasons are as follows:

- A decrease in the demand for goods produced in the country – at the beginning of the period the share of industry in the economy is extremely high. The services sector is small and under-developed and because of that the economy is not capable of producing the quantity of goods and services with the respective quality that matches the characteristics of demand and the increased competition from imports;

- A decrease in external demand – due to the restructuring of the former CMEA a number of industries find themselves in a situation of drastically shrunk markets;

- The investments made so far are characterized with the usage of outdated technologies, which cannot secure efficient production, etc.

[17] For comparison, according to data from the Statistical Yearbook of the Republic of Bulgaria for 1991, in 1990 the ratio between the value of productive assets in the national economy and the gross domestic product is 3.09. However, it should be mentioned here that the productive assets understate the value of capital for the economy, as far as for the same period there is no precise estimate of the intangible fixed assets. Therefore, it can be concluded that the value 3.09 understates the real situation.

[18] In the first method of calculation the value of the indicator does not decrease substantially, which is attributed to the already outlined deficiency in the method.

Under the outlined conditions it is completely natural to expect a comparatively low production per capital unit, since in the short run the capital cannot be changed or follow the dynamics of production.

The decrease in the value of the indicator may be interpreted on the one hand as decapitalization of the economy, as far as the capital stock decreases also in absolute value. On the other hand, the lower value can be viewed as an increase in the efficiency of production. This means that capital in modern times is more productive that at the beginning of the period. The latter statement is logical considering that within the period of economic restructuring there are major changes with respect to the type of investment activity and to the sources of investments and there is a gradual transition to a market-based economy, in which the agents aim at optimizing their costs. This, of course, implies also introduction of the new technologies, which by definition lead to a more efficient production. Last, but not least, the decreasing value of the indicator at times of relative high unemployment and low levels of payment, which is the typical case of the so-called transition economies, may be viewed as a reflection of the tendency to compensate the lack of capital with the equivalent in labor resources. The establishment of the right balance among these effects might provide some notion on the net change in production efficiency on a macroeconomic scale. However, the latter effect is expected to have limited influence, since labor cannot be characterized as a perfect substitute of capital at all.

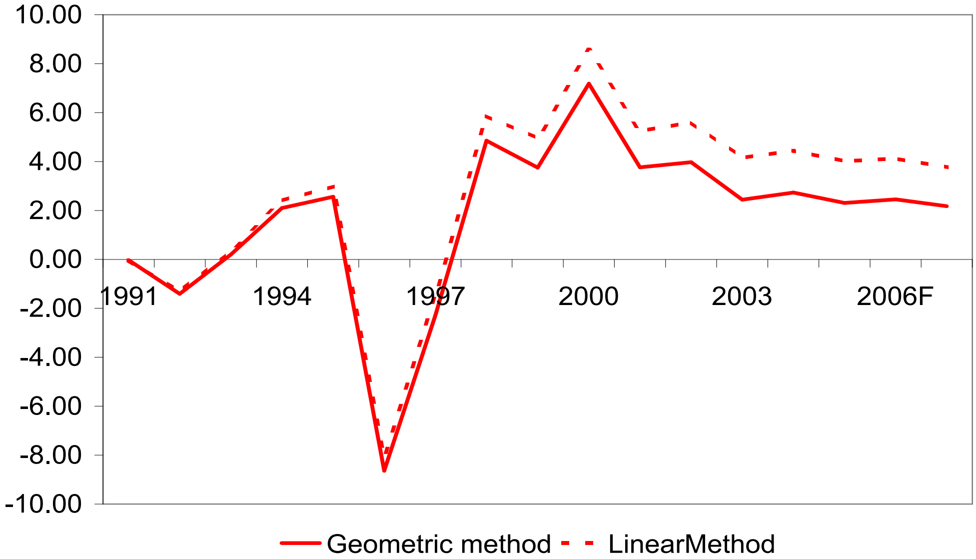
The forecasted values of capital for the period 2004-2007, which are displayed on the two figures, are calculated using the forecasts on the investments growth rates, used in the preparation of the Pre-accession Economic Program for the period 2004-2007.

4.2 Total factor productivity

The calculations with respect to total factor productivity have been made for the period 1991-2003.[19] Similarly to the capital stock, forecasts have been made on the development of the indicator until 2007; to do that, the forecasts on the investments growth rate, the employment and the gross domestic product from PEP 2004-2007 have been used.

The results on the total factor productivity growth, calculated using equation (3) and equation (9), are represented respectively in Figures 3 and 4, as well as in Table 3, Appendix 2.[20]

Figure 3: Total factor productivity growth (%)

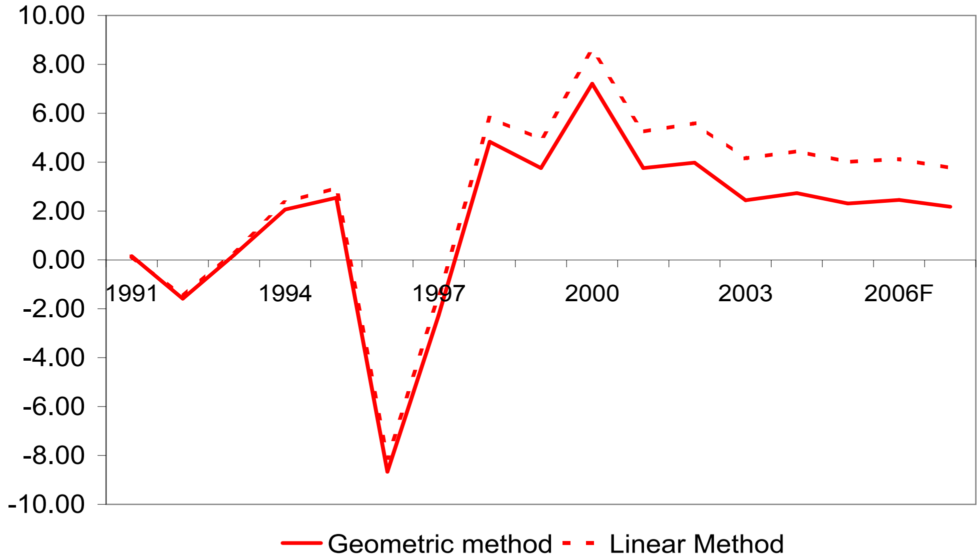


As can easily be seen from the graphs and from the table with results included

[19]With respect to the statistical data on income formation by economic sectors, for the period 1990-1997 the values published in the "Main Macroeconomic Indicators '98" of the National Statistical Institute have been used; for the period 1998-2003 the database with final and preliminary NSI data has been used.

[20]The forecasts on total factor productivity calculated using equations (3) and (9) respectively coincide, since the capital and labor income shares have been assumed constant from 2003 onwards.

Figure 4: Total factor productivity growth (%)

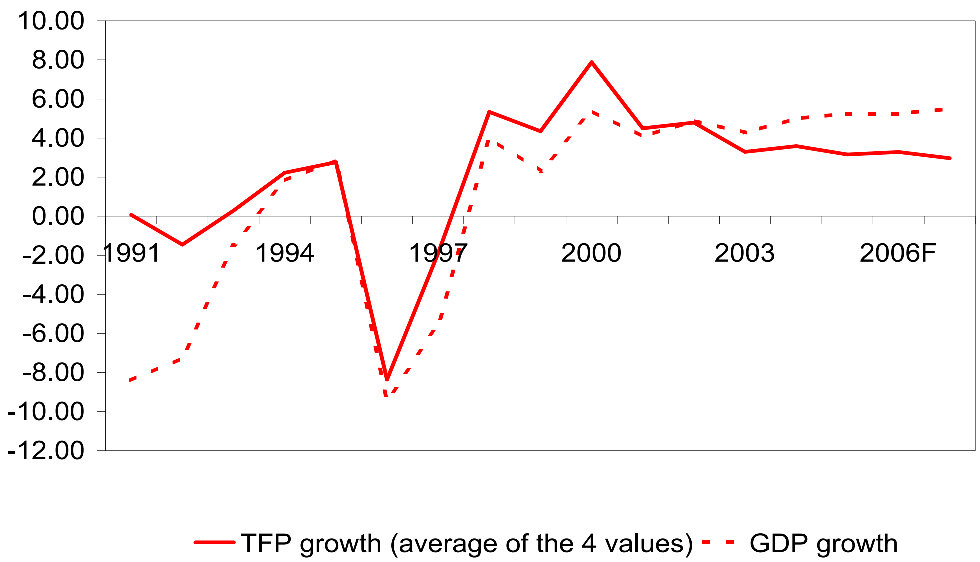


in Appendix 2, the values of total factor productivity obtained from the two equations do not differ substantially. The reason for this is that the shares of income components in the gross domestic product have very close values for any two successive periods. This gives grounds to assert that equation (3) leads to sufficiently precise results in cases of the current type. Equation (9) is found to be more precise only in cases when the income components' dynamics are substantial in the short run.

5 Conclusions

According to the obtained results,[21] the dynamics of total factor productivity growth are the main determinant of economic growth in Bulgaria. The low and unstable values of TFP in the years until 1997 determine the unstable development of the gross domestic product (Figure 5). Respectively, its high values after the introduction of the currency board arrangements are the main reason for the relatively high rate of growth of the gross domestic product.

Figure 5: Total factor productivity and GDP growth rates (%)



The results are expected and largely match the developments of the economy

[21]Comparable results on the total factor productivity are presented in Minassian (2004) (see Ch. 8, pp. 240-247), where a similar approach has been used. The estimations obtained there are close to those in the current paper calculated using the original Solow approach with geometric capital depreciation. The differences between the two sets of estimates are mostly due to the initial assumptions on the capital-output ratio, as well as to the different approaches of the authors in the determination of the elasticity coefficients of capital and labor. The estimates in the current paper obtained using linear capital depreciation, as well as those using a trans-logarithmic production function lead to more substantial differences. Nevertheless, the total factor productivity dynamics remain similar.

during the period under consideration. They are expected as far as the speed of transition from an inefficient to an efficient type of production in a growing competition environment implies the corresponding magnitude of the rates of growth of total factor productivity. It is exactly the increase in the economy's efficiency as a result of the reforms made after 1997 that leads to values of the indicator of about 4-5 % per annum. These values are higher than the values for the developed industrialized economies but should be viewed as normal because of the below-listed reasons and factors determining total factor productivity. For 2000 even substantially higher values of 8-9 % are observed (depending on the method used), which is fully in accordance with the factual developments. It was exactly in 2000 when a substantial share of the reforms in the Bulgarian economy took place - a substantial volume of assets was privatized and optimization of employment was carried out, leading to an increase of unemployment in the country. Probably this is the main reason for the differences between the values for this year and the values for the rest of the years. With a viewpoint of scale this optimization of the various types of production can be considered as a one-time shock, although the effect is present with a smaller magnitude in other years, too.

Although theory does not provide a definitive answer on how to identify the factors that determine the residual changes in total factor productivity, the causes can be deduced from logic taking again into account the structural changes in the economy of the country.

In the first place, the changes in the structure of production and its orientation towards markets imply a tendency to optimize production costs. The latter is emphasized by the lack of government subsidies which are characteristic of the inherent features of a planned economy. Secondly, the type and the quality of investments change radically, which is a consequence of the increased share of the private sector and the tendency to use modern technologies.[22] Next, the inflow of foreign direct investments is a major factor increasing total factor productivity, since through this inflow technological transfer and transfer of production and managerial knowledge and skills are carried out, which otherwise a large share of the domestic investors could not afford. To a lesser extent technological transfer, although mostly indirect by nature, is carried out through the imports of investment goods. We can assume that to the smallest extent technological transfer is carried out through the imports of consumer goods and possibly after a consequent application of "reverse engineering" on them to indirectly study production techniques.

An undoubtedly positive role for the GDP growth and consequently for the total factor productivity growth in Bulgaria after 1997 was played also by financial stability. The latter is not surprising since relations of this type have been thoroughly studied also in world literature.[23] The low values of the fluctuations in the price level, the budget discipline and the imposed confidence in the national currency through pegging the exchange rate to the Deutsche Mark (consequently to the common EU currency euro) unquestionably provided the secure environment necessary for planning and making investments, respectively for the recovery and expansion of the normal functioning of the economy.

An important factor complementing financial stability is institutional building. As far as the establishment and the development of institutions in Bulgaria in the transition period is incomplete, to some extent half-way and sometimes without a long-term vision, as well as due to the fact that a punctual and stringent law enforcement has not been achieved yet, it can be inferred that in this direction the

[22]In this respect it can be considered that to model this period of economy transformation is it more appropriate to use models with heterogeneous capital, such as the so-called *vintage* models.

[23]See for example Fischer (1993) – in this publication he shows that economic growth is negatively related to inflation, excessive budget deficits and to the existence of serious foreign exchange disequilibria.

influence is rather limited, although positive in general.

Considering the almost complete lack of reforms and the existence of serious problems in Bulgarian education, it cannot be claimed that as a result of the activities carried out in this branch of the economy an increase in the human capital stock is provided. The most optimistic variant that can be accepted is that the education system produces human capital that can barely cover the natural depreciation, respectively the decrease of this factor in the economy. Equally, it can be claimed that the increases in total factor productivity are not positively related to the output of the education system. Of course, until the time when a thorough quantitative study of human capital formation is done, the magnitude and the direction of this influence remain hypothetical.

The so-called ‘brain drain' is often viewed as a separate factor, which exacts an influence on the level of human capital and consequently on total factor productivity in our case. As far as emigration is formed mainly by young people who are not professionally established it can be inferred that this process would rather have a strong long-term effect on the increase of total factor productivity due to the weakening of human capital and the deformation of the demographic structure of the population. For the period since 1990, however, no strong effect of emigration on the current levels of total factor productivity can be inferred. Of course, it should be emphasized once again that precise results and the relevant comments can be obtained only after a thorough quantitative and qualitative study of the emigration process and its effects on the economy.

What is the expected direction of the future total factor productivity developments? To answer the question, we have to comment the expected developments of the remaining two production factors - capital and labor. Due to commonly known demographic reasons, as well as due to the current qualification characteristics of the labor force, a significant increase in the number of employed persons is not expected; respectively the contribution of labor to economic growth is not expected to be substantial. The obtained results on physical capital show that the quantity of this factor increases from a certain point onwards. For the values obtained with the linear method of depreciation (which in this paper has been regarded as more accurate), the increase in the capital stock starts from 2005. In this respect we can expect a corresponding positive contribution to economic growth. Considering the fact that the availability of more capital increases labor productivity, this would automatically mean that an increase in total factor productivity is also expected. It is appropriate to ask whether this increase can continue to be higher than that in the developed industrialized countries in the long run. It was already mentioned that for a typical economy in transition to market-based relations such as Bulgaria, the restructuring itself has a significant contribution to the changes in this production factor. It is clear that this restructuring cannot go on forever, i.e. the optimization of production will come to an end in a finite and possibly imminent moment in time. Eventually, in the medium- and long run an increase in total factor productivity is expected only on behalf of the future technology and knowledge transfers from the developed industrialized economies - a phenomenon, which is often qualified as exogenous in the neo-classical economic growth theory. In this respect, from the standpoint of the potential for internal influence on the indicator, a substantial role can play the reform of the education system, which will allow for a certain degree of endogenizing the process of creation and implementation of new knowledge and technologies.

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Appendices

Appendix 1

Calculation of the Solow residual

The result in equation (2) is obtained in the following way. First, we take logs of both sides of equation (1):

$$\ln Y(t) = \ln A(t) + \ln F[K(t), L(t)]$$

We use the fact that $\dfrac{d \ln x(t)}{dt} = \dfrac{\dot{x}(t)}{x(t)}$ and after differentiation of the latter equation with respect to time we obtain:

$$\frac{\dot{Y}(t)}{Y(t)} = \frac{\dot{A}(t)}{A(t)} + \frac{F_K}{F[K(t), L(t)]}\dot{K}(t) + \frac{F_L}{F[K(t), L(t)]}\dot{L}(t)$$

We use the identity $F[K(t), L(t)] = Y(t)/A(t)$:

$$\frac{\dot{Y}(t)}{Y(t)} = \frac{\dot{A}(t)}{A(t)} + \frac{A(t)F_K}{Y(t)}\dot{K}(t) + \frac{A(t)F_L}{Y(t)}\dot{L}(t)$$

The latter is the same as:

$$\frac{\dot{Y}(t)}{Y(t)} = \frac{\dot{A}(t)}{A(t)} + \frac{A(t)K(t)F_K}{Y(t)} \cdot \frac{\dot{K}(t)}{K(t)} + \frac{A(t)L(t)F_L}{Y(t)} \cdot \frac{\dot{L}(t)}{L(t)}$$

If we assume that capital and labor markets are competitive then the marginal product of each of the factors equals their respective price. Then we have:[24]

[24] In the present case the marginal products are respectively $\dfrac{\partial Y}{\partial K} = A\dfrac{\partial F}{\partial K} = AF_K$ and $\dfrac{\partial Y}{\partial L} = A\dfrac{\partial F}{\partial L} = AF_L$.

$$\frac{\dot{Y}(t)}{Y(t)} = \frac{\dot{A}(t)}{A(t)} + r\frac{K(t)}{Y(t)} \cdot \frac{\dot{K}(t)}{K(t)} + w\frac{L(t)}{Y(t)} \cdot \frac{\dot{L}(t)}{L(t)},$$

where r is the price of capital and w is the price of labor. The expressions $r\frac{K(t)}{Y(t)}$ and $w\frac{L(t)}{Y(t)}$ represent respectively the shares of payments to each production factor in total income. If we assume that production is characterized with constant elasticity to scale then those two shares sum up to one, and thence we get:

$$\frac{\dot{Y}(t)}{Y(t)} = \frac{\dot{A}(t)}{A(t)} + a(t) \cdot \frac{\dot{K}(t)}{K(t)} + b(t) \cdot \frac{\dot{L}(t)}{L(t)}, \quad a(t) + b(t) = 1$$

The Solow residual is derived directly from the latter equation.

Appendix 2

Tables

Table 1: Capital stock (in thousands of 1998 BGN)

Year	GM[a]	LM[b]
1990	96479537	96479537
1991	95517940	95517940
1992	94321427	94080229
1993	92560103	91838911
1994	90918284	89481294
1995	89839264	87455076
1996	88079059	84520378
1997	85835356	80877584
1998	84463363	77886302
1999	83768585	75357647
2000	83653057	73197083
2001	84492473	71782041
2002	85715674	70541653
2003	87627298	69778456
2004F	90414459	69676506
2005F	93931405	70085274
2006F	98139664	70959318
2007F	103161461	72412071

[a] Geometric depreciation method

[b] Linear depreciation method

Source: Own calculations

Table 2: Capital/output ratio

Year	GM[a]	LM[b]
1990	3.36	3.36
1991	3.63	3.63
1992	3.86	3.85
1993	3.85	3.82
1994	3.71	3.65
1995	3.57	3.47
1996	3.86	3.70
1997	3.98	3.75
1998	3.77	3.47
1999	3.65	3.29
2000	3.46	3.03
2001	3.36	2.85
2002	3.25	2.67
2003	3.18	2.54
2004F	3.13	2.41
2005F	3.09	2.30
2006F	3.07	2.22
2007F	3.06	2.14

[a] Geometric depreciation method

[b] Linear depreciation method

Source: Own calculations

Table 3: Total factor productivity growth (%)

	Equation 3		Equation 9	
Year	GM[a]	LM[b]	GM[a]	LM[b]
1991	-0.03	-0.03	0.15	0.15
1992	-1.41	-1.33	-1.59	-1.50
1993	0.20	0.38	0.20	0.37
1994	2.10	2.39	2.06	2.35
1995	2.56	2.99	2.54	2.95
1996	-8.64	-8.05	-8.67	-8.10
1997	-2.28	-1.49	-2.26	-1.49
1998	4.86	5.86	4.83	5.81
1999	3.75	4.94	3.76	4.93
2000	7.18	8.57	7.21	8.57
2001	3.76	5.24	3.76	5.24
2002	3.97	5.61	3.98	5.60
2003	2.44	4.15	2.44	4.15
2004F	2.73	4.45	2.73	4.45
2005F	2.31	4.01	2.31	4.01
2006F	2.45	4.12	2.45	4.12
2007F	2.18	3.76	2.18	3.76

[a] Geometric depreciation method

[b] Linear depreciation method

Source: Own calculations

Table 4: Labor and capital income shares in total income

Year	$a(t)$	$b(t)$
1989	0.63	0.37
1990	0.64	0.36
1991	0.61	0.39
1992	0.67	0.33
1993	0.66	0.34
1994	0.63	0.37
1995	0.61	0.39
1996	0.58	0.42
1997	0.55	0.45
1998	0.52	0.48
1999	0.51	0.49
2000	0.49	0.51
2001	0.50	0.50
2002	0.49	0.51
2003	0.48	0.52

Source: NSI, AEAF, own calculations