

FACTORS OF ECONOMIC GROWTH IN BULGARIA 1995-2019²

The Solow growth model posits that capital accumulation constitutes a fundamental determinant of economic growth, with technological advancements enhancing its impact. In contrast, endogenous growth theory emphasises the pivotal role of human capital in driving economic progress, incorporating the accumulation of knowledge and the enhancement of workforce skills. Innovation and technological development, shaped by the workforce's expertise and competencies, are recognised as essential mechanisms for fostering economic growth.

The main finding of this research is that variations in the GDP growth rate during the examined period are primarily attributable to disparities in employment growth rates. This result challenges the theoretical assertions of both neoclassical and endogenous growth models. This finding is of particular significance, as it highlights the economic growth factors that should be prioritised through the implementation of macroeconomic policies to accelerate Bulgaria's economic development.

The aim of this study is to measure the extent, dynamics, and intensity of the impact of growth factors on Bulgaria's GDP during the period 1995-2019. The study employs a methodological framework based on rolling regression analysis to provide reliable empirical insights.

Keywords: Economic growth; Economic growth factors

JEL: 04; 047; E13

1. Introduction

The Bulgarian economy experienced significant fluctuations between 1995 and 2019, largely due to a series of unforeseen events that directly and indirectly influenced the country's economic growth. The events that shaped the trajectory of economic growth in Bulgaria and the underlying factors driving it include the hyperinflation of 1997, the global financial crisis of 2008–2009, and the subsequent debt crisis that spanned the period between 2010 and 2013. Additionally, Bulgaria became a member of the European Union in 2007.

The outbreak of hyperinflation in 1997 was linked to the banking crisis and an excessive money supply. The decoupling of the real sector from the availability of credit affected the determinants of economic growth. One consequence of hyperinflation was the restriction of

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investment in the real economy. According to the Solow model, investment is an important determinant of capital formation. Hyperinflation erodes savings, leading to a reduction in investment. A reduction in business investment results in a decline in inventories and output. In addition to reducing fixed investment, hyperinflation erodes the savings and income of the population. As unemployment rises, the increase in unemployment leads to an expansion in the supply of labour. The hyperinflationary collapse of the Bulgarian economy had a limiting and negative impact on human capital and research and development.

The process of Bulgaria's accession to the European Union and the country's subsequent entry into the Union led to an increase in investment across various economic sectors. This effect, particularly in the early years, was associated with a rise in foreign direct investment (FDI) in the Bulgarian economy. The combination of EU funds and FDI enhanced the potential of human capital and research and development as factors driving economic growth. During this period, however, the greatest development occurred in labour-intensive sectors such as construction, light industry related to clothing production, and trade, which stimulated employment to the greatest extent. Accordingly, there is a pressing need to assess the resilience of the impact of individual factors on economic growth over time in the context of evolving economic conditions.

The object of the study is the Bulgarian economy during the period 1995–2019. The subject of the study is the magnitude, dynamics, and strength of the impact of economic growth factors on GDP during this period. The main objective of the study is to assess the impact of supply-side factors on economic growth in Bulgaria between 1995 and 2019.

The primary research hypothesis is that economic growth in Bulgaria was primarily driven by labour during the 1995–2019 period. Capital did not exert a predominantly positive influence on economic growth during this time frame. Human capital and research and development (R&D) are identified as potential determinants of significant economic growth in Bulgaria. The proof or rejection of the research hypothesis is achieved through the method of rolling regression.

In the field of economic research, the conventional method for measuring economic growth is through the use of the gross domestic product (GDP) metric. Rangelova (2010) notes that GDP is utilised as a metric for measuring economic growth (Rangelova, 2010, p. 3). The author posits that GDP is not an entirely accurate metric for gauging economic growth. This is because endogenous theory encompasses variables that impact GDP, yet GDP does not incorporate these variables in its calculation methodology (Rangelova, 2010, pp. 3–4). Nevertheless, the thesis developed by Rangelova does not wholly reject GDP as an indicator of economic growth, despite acknowledging that it is not a perfect measure. This study adopts GDP as an indicator of economic growth. This logic leads to the conclusion that there is an equivalence between economic growth factors and production factors. Consequently, by considering the factors of production, the factors of economic growth are also considered. As Rangelova (2010) posits, the endogenous theory of economic growth suggests that growth factors extend beyond the traditional factors of capital and labour to encompass human capital, including variables such as education, health status, knowledge, skills and qualifications. Accordingly, in this study, in addition to the conventional production factors, human capital and research and development (R&D) are also included. Although human capital and R&D are not traditional factors of production, they nonetheless exert an influence

on production. Incorporating human capital and R&D as determinants of economic growth allows for the estimation of total factor productivity, which is a residual in Solow's model. Human capital and R&D drive the technological process and the creation of new technologies.

2. Literature Review

The basic model in neoclassical growth theory is the Solow model (Renelt, 1991). The Solow model uses the Cobb-Douglas production function as its basis. Cobb and Douglas (1928) consider the participation of capital and labour in the production of a given quantity of goods. The production function is described by the following equation:

$$P^I = 1.01L^{3/4}C^{1/4} \quad (\text{Cobb \& Douglas, 1928, p.151}) \quad (1)$$

Where P^I is real production, L is the labour input, C is the capital input.

The value 1.01 is taken as an independent value from labour and capital and expresses factors that cannot be quantified. The elasticities $3/4$ and $1/4$ show what fraction of output changes when the quantity of labour changes and what fraction changes when the quantity of capital changes. Equation (1) shows that labour has a greater effect than capital in changing output. Additionally, equation (1) shows that there are other factors involved in production. Cobb and Douglas fail to point out exactly which factors are involved in production besides labour and capital. Douglas (1976) later examines returns to scale of labour and capital participation in production and points out that returns to labour participation in production are diminishing. It becomes clear that Cobb and Douglas fail to fully explain returns to scale because they do not understand that technology is a determinant of returns to scale. Tinbergen (1959) was able to reveal that technology is the factor that explains much of the growth in output that is not explained by labour and capital. According to Tinbergen, technology leads to a reduction in the participation of labour in production, replacing it with capital. Tinbergen fails to explain returns to scale. He does not fully understand the role of technology in the production process because he cannot relate technology to returns to scale.

The theoretical concepts of Cobb, Douglas, and Tinbergen became the basis of neoclassical economic growth theory. Schumpeter (1994 [1942]) points out that technological progress is the basis of economic growth, as new goods are created through new technologies, which, in turn, create economic growth. Therefore, Schumpeter derives the relationship between the production function, technology, and economic growth.

Solow (1956) was able to explain the mechanism of returns to scale of factor inputs in production, thus building on the theoretical insights of Cobb, Douglas, and Tinbergen. He points out that capital and labour inputs in production contribute their full value to the production process. Therefore, labour and capital, carrying their full value into the production process, realise constant returns to scale on the marginal quantities with which they participate in the production process. The marginal units of capital and labour in the production process decrease. Decreasing units of labour and capital over time create

diminishing constant returns, which are characteristic of the long run of production. In fact, Solow views returns to scale of inputs to production within the law of diminishing marginal utility. Solow also manages to relate the process of returns to scale from factor inputs in production to technology. The author estimates that 87.2 percent of the increase in gross output per man-hour is due to technological progress, and 12.5 percent is due to the increased use of capital at diminishing returns (Solow, 1957, p. 320). Solow, developing the theoretical framework of the production function, derived the following equation:

$$Y = F(K, L) \text{ (Solow, 1956, p. 66)} \quad (2)$$

Where: Y is total income, K is capital, and L is labour. The equation derived by Solow replaces the variable P^I that expresses real production in the production function with the variable Y, which expresses total income. Hence, Solow links output to total income by equating output with economic growth. It becomes clear that Solow understands economic growth as output growth. With equation (2), the author succeeds in transforming the production function into a model of economic growth. Solow assumes that economic growth depends on constant returns to scale of labour and capital. He derives the following equation:

$$K = sY \text{ (Solow, 1956, p. 66)} \quad (3)$$

The variable sY represents savings, while K represents aggregate capital. Equation (3) illustrates the process by which savings are accumulated and transformed into capital. The conversion of savings into capital is a fundamental economic principle. This principle is also valid for a closed economy. An increase in savings will inevitably result in an increase in capital. This logic, as posited by Solow, suggests that capital formation is the most crucial factor in the generation of total income or economic growth. Solow elucidates the relationship between capital and labour, as well as the impact of returns, through the following mathematical notation:

$$K = sF(K, L_0 e^{nt}) \text{ (Solow, 1956, p. 67)} \quad (4)$$

Where: K is capital, s is savings, L is labour, e is the residual, which includes technology, and n is the return. Equation (4) shows that capital will fully utilise labour in the production process in creating economic growth. Therefore, returns to scale of labour and capital impact the production process, which leads to economic growth. Technology manages to maintain a constant rate of return as the capital-labour ratio changes, thus optimising production and leading to economic growth. According to Solow (1957), technology is the factor that determines the dynamics not only of production but also of labour and capital. Solow's thesis that the relationship between technology and returns leads to the creation of long-term economic growth is embraced by Diamond. Diamond (1965) points out that technology determines the constant returns to scale, which determines the required ratio of labour to capital, and this ratio is determinant in sustaining long-run economic growth. The constant contribution of the value of capital to output creates the "Golden Age Path" (Diamond, 1965, p. 1128) or long-term economic growth. Diamond's conclusion that capital does not depreciate departs from Solow's conception because it rejects Solow's thesis that returns are constant but diminishing. Diamond fails to explain why returns to capital do not decline.

Savings are an important determinant of economic growth in Solow's model. This logic is adopted by authors such as Ramsey (1928) and Cass (1965), who argue that the optimal magnitude of savings determines economic growth. However, Ramsey and Cass assume that savings are converted into consumption of goods, whereas in Solow's model, savings are converted into investment in production.

In the theoretical concepts of Solow and Diamond, knowledge does not participate as a factor that determines the development of technology. Kuznets (1973) states that technology is the most important factor for economic growth, but its effectiveness depends on human knowledge. By singling out human knowledge as an important determinant of economic growth, the author reveals a weakness in Solow's model by questioning the leading role of capital in creating economic growth. This weakness in Solow's model is overcome by Mankiw, Romer, and Weil (1992), who divide capital into physical capital and human capital. The introduction of a factor such as human knowledge leads to the strengthening of the accounting logic in Solow's model. The accounting logic in Solow's model is described by the following mathematical notation:

$$Q = f(K, L, A) \tag{5}$$

Where Q represents total output, K represents capital, L represents labour, and A denotes total factor productivity (TFP), reflecting changes in the function f.

Equation (5) introduces total factor productivity (A), a component that encompasses advancements in technology, improvements in labour education, and increased labour specialisation (Solow, 1957). Deriving the Solow residual as total factor productivity overcomes the initial limitations of the Solow model. Denison (1985), following the logic of economic growth accounting, points out that knowledge and motivation influence labour and lead to changes in its quality, efficiency, and qualification. According to Rangelova (2009, p. 7), Denison derived sub-factors of the main factors. Kendrick (1994) modifies the accounting model of economic growth by replacing capital with capital stock and implements new content in the Solow residual. He assumes that the Solow residual contains intangible factors.

The implicit assumption in Solow's model that technological change is exogenous is challenged by endogenous economic growth theory (Romer, 1994). The main theoretical issue that delineates the apparent boundaries between neoclassical growth theory and endogenous economic growth theory comes down to whether technology is an exogenous factor or an endogenous factor. According to Solow (1994), the notion in endogenous theory that the dynamics of technology cannot be explained as an exogenous factor is wrong. According to Lucas Jr. (1988), endogenous capital accumulation is a prerequisite for economic growth, and there need not be an exogenous factor for economic growth. Arrow (1962) argues that economic growth is determined by technological progress. Technological progress is created by the accumulation of stocks of knowledge. Knowledge, through technological progress, leads to increasing productivity. Increasing productivity leads to constant returns. Constant returns lead to constant economic growth. According to Solow's model, returns to scale are diminishing, and endogenous theory rejects Solow's proposition. Arrow (1962) considers the stock of knowledge as the main factor that determines technological progress. However, he fails to explain the factors that determine the speed of

the dynamics of technological progress. Shell (1966) was able to explain the factors that determine the speed of technical change. He starts from an eclectic viewpoint and assumes that new ideas, entrepreneurship, new gross investment, the introduction and adoption of new methods of production, training, experience, new technical knowledge, and the innovations that are associated with the application of new knowledge contribute to explaining the speed of technical development and economic growth. Arrow and Shell point to knowledge and technological progress as two related factors that create economic growth. However, the authors fail to point out the factor that leads to the accumulation of knowledge and the generation of new knowledge that is so necessary for the creation of technological development. Romer (1986) fails to point out that the factor that stimulates the development of all other factors is research.

Frankel's economic growth model assumes that capital and labour contribute equally to economic growth and that the speed and evolution of economic growth depend on the "development modifier" (Frankel, 1962, p. 998). Under the category of "development modifier", the author understands the effects of technological development, production organisation, changes in social capital and quality of labour input, as well as external economies of scale. In fact, Frankel retreats from Romer's theses.

Lucas Jr. (1988) relates knowledge to human capital; hence, it follows that human capital is the carrier of knowledge. Therefore, the logic derived by Lucas Jr. illustrates that human capital is created by knowledge. This logic of Lucas Jr. links knowledge, through human capital, to the technological process that creates economic growth. By including knowledge as an indirect determinant of economic growth, Lucas Jr. lays the foundation for the single-factor endogenous model of economic growth. Barro and Sala-i-Martin (2004) extend the single-factor endogenous model by including government spending as a determinant of economic growth. The authors argue that, provided government spending stimulates capital and the rate of dynamics of the two variables is the same, there is a constant rate of return, which condition satisfies the endogenous growth model requirement. The logic of Barro and Sala-i-Martin is that if government spending stimulates knowledge, which creates capital, then returns will be constant.

The single-sector model of endogenous theory does not take into account that capital is divided into physical capital and human capital. This weakness of the one-sector model of endogenous theory is overcome by the two-sector model of endogenous economic growth theory. The two-sector model assumes that capital is a broad concept and includes both physical capital and human capital. The two-sector model of endogenous economic growth theory forms the basis of R&D models. One sector considers conventional production, while the other sector focuses on knowledge creation. Investment in R&D creates innovation, which drives the technological process.

Epstein and Macchiarelli (2010) point out that, in the face of negative economic shocks, labour is the factor that determines economic growth the most. This conclusion of Epstein and Macchiarelli contradicts the neoclassical model of economic growth and the endogenous theory of economic growth. Cororaton (2002) takes the position of the endogenous growth theory, arguing that total factor productivity contributes to the increase in economic growth, provided that education is of good quality and labour is skilled. Corroration's thesis is criticised by Felipe (1997), who argues that total factor productivity cannot fully explain

economic growth. Authors such as Arora and Bhundia (2003) support Cororaton's thesis that total factor productivity determines economic growth.

Neoclassical growth theory is supported by Everaert and De Simone (2003), who argue that capital is the main factor that enhances economic growth. Barro (2003) presents empirical arguments that human capital is a determinant of economic growth. In fact, he challenges the thesis of Everaert and De Simone. The link between education and total factor productivity, as proposed by Everaert, De Simone (2003), and Barro (2003), is further developed by Abdih and Joutz (2005), who examine the relationship between knowledge and total factor productivity within an endogenous model of economic growth. They include R&D as a determinant of economic growth and relate knowledge to total factor productivity, thus viewing economic growth within the logical framework of the R&D endogenous model.

The theoretical concepts discussed, which address the factors of economic growth, naturally raise the question of how these factors manifest under the specific conditions of the Bulgarian economy. The contextualisation of the relationship between the factors of economic growth and Bulgaria's unique characteristics has been the focus of numerous applied studies.

Minasyan argues that, in the period 1997-2007, economic growth in Bulgaria was determined by employment, followed by capital and scientific and technological progress (Minasyan, 2008, p. 286). He expands the factors that contribute to total factor productivity by stating that, in addition to scientific and technological progress, political governance (Minasyan, 2010, p. 42) also determines economic growth. Dimitrov (Dimitrov, 2016) complements Minasyan by arguing that the institutional environment is an important factor influencing economic growth. Ganev (Ganev, 2005) argues that investment, the private sector, FDI inflows, the institutional environment, and financial stabilisation are important for the positive effect of total factor productivity on economic growth.

The neoclassical approach in the study of the factors of economic growth in the Bulgarian economy is also adopted by Raleva (2013), Todorov (2015), and Durova (Todorov & Durova, 2016), who come to the general conclusion that capital and total factor productivity have a determining influence on economic growth. Petranov et al. (2022) point out that the informal economy leads to a reduction in GDP per capita, negatively impacting labour, capital, and total factor productivity.

Yotzov (2020) elaborates on the thesis of Raleva, Todorov, and Durova on total factor productivity by arguing that the effect of FDI on economic growth depends on the absorptive capacity of the economy, the quality and quantity of the labour force, the degree of openness and freedom of the economy, fiscal policy, and the financial development of the economy (Yotzov, 2020, p. 3).

Rangelova (2006; 2013) identifies the following factors that influence economic growth in Bulgaria: globalisation, integration of the Bulgarian economy, information technology, new technologies (Rangelova, 2006, pp. 167-168), and the service sector (Rangelova, 2013, p. 7). She argues that changes in economic structure give rise to factors that serve as determinants of economic growth. In her 2014 study, Saryisky and Rangelova (2014) examine the impact of banking institutions in Bulgaria on economic growth. The authors conclude that the Bulgarian banking system does not facilitate economic growth. Rangelova and Saryisky

extend and complement the factors that influence economic growth in Bulgaria, arguing that the synergistic effect between exogenous and endogenous factors is a crucial factor for economic growth in Bulgaria. Chobanova (2020) develops the thesis that knowledge and innovation have become the main factors of economic growth. The author constructs a model of economic growth based on R&D, departing from the theoretical synthesis of Rangelova and Saryisky.

Zareva (2020) discusses human capital as a set of knowledge, skills and competencies. She argues that education stimulates competitive economic growth, as well as social development (Zareva, 2007). Zareva further develops her reasoning by revealing that physical and mental health, along with education, are major factors that influence the formation of human capital (Zareva, 2024). Kirova supports Zareva's position by adding that investments in higher education and science would create human capital, which is essential for economic growth, especially in the process of the convergence of the Bulgarian economy towards the eurozone (Kirova, 2011). The author points out that the relationship between education and economic growth depends on the structural elements of investment in human capital (Kirova, 2023, p. 185). Kirova, Zareva, and Matev argue that conditions must be created through which human capital can be preserved, as it is a determinant of economic growth in Bulgaria (Kirova et al., 2012). Verenikin et al. stand by Zareva's position, arguing that investments in health and education are the greatest determinants of human capital development (Verenikin et al., 2023). Zlatinov and Atanasov (2021) argue that Bulgaria's economic growth, in the context of convergence to the euro area, can be stimulated by the development of vocational education. In fact, the authors adopt Kirova's position that education and investment in human capital are important for economic growth, especially in conditions of integration into the euro area.

3. Methodology and Data

The main methods applied in examining the impact of factors on economic growth are cross-sectional regression analysis, two-step regression analysis, the fixed-effects regression model, the two-way fixed-effects regression model, and the fully modified least squares model combined with the autoregressive distributed lag model (Chirwa & Odhiambo, 2016).

Epstein and Macchiarelli (2010) apply regression analysis, non-linear regression analysis, and dynamic regression analysis by creating the variables, applying Kalman decomposition, and considering the non-accelerating inflation rate of unemployment.

Kloudová (2016) applies a similar approach by creating the variables using the Hodrick-Prescott filter and the non-accelerating inflation rate of unemployment model. A

complication with the approach used by Kloudová, Epstein, and Macchiarelli is the calculation of potential values, which in many cases are incorrect.

Barro (1996), Tolo (2011), and Ledyeva and Linden (2008) apply regression analysis based on a production function.

Arora and Bhundia (Arora & Bhundia, 2003) examine potential economic growth by simultaneously applying the Hodrick-Prescott filter and a bivariate structural autoregressive model.

3.1. *Econometric survey technology*

The econometric techniques applied in the implementation of the study are regression analysis and rolling regression, which are mathematically described by the following equations:

$$y = \alpha + \beta x + \varepsilon \tag{6}$$

$$\begin{cases} Y = \alpha + \beta_1 x_t + \beta_2 x_{t-1} + \beta_3 x_{t-2} + \dots + \beta_n x_{t-n} + \varepsilon \\ Y = \alpha + \beta_1 x + \beta_2 x_{t-1} + \varepsilon \\ Y = \alpha + \beta_3 x_{t-2} + \beta_4 x_{t-3} + \varepsilon \\ Y = \alpha + \beta_5 x_{t-4} + \beta_n x_{t-n} + \varepsilon \end{cases} \tag{7}$$

Where: Y is the dependent variable, α is the regression term, β is the regression coefficient, x is the independent variable, and ε are the residual. Equation (6) describes the ordinary least squares method, and equation (7) describes the rolling regression. Tsanov points out that an important feature of the rolling regression is that it captures the adjustment dynamics of the economic system (Tsanov, 2018).

Rolling regression is applied to examine the stability of statistical dependencies over time. It captures time-varying economic relationships by allowing regression parameters to change dynamically (Cai & Juhl, 2023). The study of time series often involves heterogeneity and structural changes that emerge over time. Heterogeneity arises from the increase in the number of statistical observations, which, in turn, leads to structural changes in the time series. Limiting structural changes and heterogeneity can be achieved by reducing the number of statistical observations. However, this reduction increases the variance of the regression parameter estimates, which raises the mean squared errors (Clark & McCracken, 2009). To adequately account for the structural changes in time series caused by the heterogeneity of a large number of statistical observations, the rolling regression method is employed. This approach captures changes in economic relationships resulting from structural shifts in the time series without distorting the regression coefficient estimates, despite the associated increase in variance and mean squared errors.

This study seeks to assess the magnitude, dynamics, and strength of the impact of economic growth factors on GDP over time, under varying economic conditions. The application of the

rolling regression method is therefore appropriate, as it accommodates the structural changes in the dynamic relationship between economic growth factors and GDP. These changes influence both the magnitude and strength of the impact of economic growth factors on GDP.

The two equations (6) and (7) must satisfy the following conditions (Enders, 2015, p. 52):

$$E(y_t) = E(y_{t-s}) = \mu \quad (8)$$

$$E[(y_t - \mu)^2] = E[(y_{t-s} - \mu)^2] = \sigma_y^2 \quad (9)$$

$$E[(y_t - \mu)(y_{t-s} - \mu)] = E[(y_{t-j} - \mu)(y_{t-j-s} - \mu)] = y_s \quad (10)$$

Where : μ are the residuals, σ_y^2 the dispersion of the residues, and y_s is the dynamic order. The presence or absence of stationarity of the variables is checked by the Augmented Dickey-Fuller (ADF) test (Appendix). In order for the regression analysis estimates to be adequate and reliable, multiple tests for the presence of homoskedasticity, autocorrelation of residuals, and multicollinearity test are applied.

3.2. Limitations and specificity of the statistics used

The time period of the study is 1995-2019. The statistical databases of the National Statistical Institute of Bulgaria and Eurostat are used. The sources use the same methodology, from which it follows that the data are homogeneous. The statistics used in the study are quarterly, seasonally adjusted growth rates. These features of the statistic allow for data integration, and the data are first-order integrated because there are variables that do not satisfy the Gaussian and Laplace normal distribution condition.

Economic growth is expressed in terms of real GDP, calculated using the final consumption method (expenditure method) at 2015 prices. The data source is the National Statistical Institute (NSI).

Capital is expressed in terms of gross fixed capital formation at the previous year's prices. The data source is the National Statistical Institute. In this study, the constant inventory method is applied, as applied by Kaloyan Ganev (Ganev, 2005):

$$K_t = I_t + (1 + \delta)K_{t-1} \quad (11)$$

$$K_0 = \frac{I_0}{\delta} \quad (12)$$

Where K is capital, I is gross fixed capital formation, t represents time, and δ depreciation is assumed to be 0.05 per year. Labour is measured in terms of the number of persons employed. The data source is the National Institute of Statistics.

In the present study, human capital is quantified in terms of enrolments and graduates at different levels of education. The data source is the National Statistical Institute.

In the present study, research and development is quantified by gross domestic expenditure on R&D. The source of the statistics is Eurostat.

4. Empirical Results and Discussion

The econometric model of economic growth based on supply factors takes the following form:

$$D(Y_t) = \alpha + \beta_1 D(K_t) + \beta_2 D(L_t) + \beta_3 D(H_t) + \beta_4 D(R_D_t) + \varepsilon_t \quad (13)$$

Where: $D(Y_t)$ is the first difference of the GDP growth rate; $\beta_1, \beta_2, \beta_3, \beta_4$, are regression coefficients; $D(K_t)$ is the first difference of the gross fixed capital formation rate, $D(L_t)$ is the first difference of the employment rate; $D(H_t)$ – first differences of the rate of change of students and graduates in the three levels of education, and $D(R_D_t)$ – first difference of the rate of change of gross domestic R&D expenditure.

The variables "real GDP rate (Y)", "gross fixed capital formation rate (K)", "employment rate (L)", and "human capital rate (H)" exhibit non-stationarity. The null hypothesis $H_0: |p| \geq 1$ holds (Appendix). Only the variable "R&D rate (R_D)" is stationary, satisfying the alternative hypothesis $H_1: |p| < 1$ (Appendix). The application of the rolling regression model requires all variables to be stationary. Converting the non-stationary variables to first differences satisfies the stationarity condition $|p| < 1$ (Appendix).

Table 1. Estimation of regression parameters for the period 1995-2019.

Dependent Variable: D(Y)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000146	0.000573	0.255660	0.7988
D(K) (Capital)	0.025145	0.004728	5.318729	0.0000
D(L) (Labour)	2.490898	0.249344	9.989796	0.0000
D(R_D) (R&D)	0.004403	0.027716	0.158847	0.8741
D(H) (Human capital)	-0.278172	0.215764	-1.289242	0.2007
R-squared	0.645548		Mean dependent var	-4.44E-05
Adjusted R-squared	0.629617		S.D. dependent var	0.009091
S.E. of regression	0.005533		Akaike info criterion	-7.504456
Sum squared resid	0.002725		Schwarz criterion	-7.369174
Log likelihood	357.7094		Hannan-Quinn criter.	-7.449812
F-statistic	40.52294		Durbin-Watson stat	1.823322
Prob(F-statistic)	0.000000	Heteroskedasticity Test: Breusch-Pagan-Godfrey		
		F-statistic	1.595136	0.1826
		Obs*R-squared	6.288190	0.1786

Source: author's calculations.

The coefficient of multiple correlation is not very high (0.63), which means that the variables included in the model do not explain the changes in economic growth to a high degree (Table

1). The standard error of the model is within the margin of error, as is the adequacy of the model as a whole (F-statistic and F-likelihood) (Table 1). The tests conducted for the residuals' state (ϵ_t) show a lack of autocorrelation (the Durbin-Watson test is close to 2) and a lack of heteroscedasticity (the Breusch-Pagan-Godfrey test shows that the p-value (0.183) is greater than the chosen critical value of 0.05) (Table 1). In addition to these estimates, it can certainly be argued that the choice of variables does not generate multicollinearity. The multicollinearity test conducted shows that the estimated VIF values of the variables are not greater than the critical values of 5 and 10 (Table 2).

Table 2. Test for multicollinearity

Variance Inflation Factors			
Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	3.28E-07	1.007535	NA
D(K)	2.23E-05	1.130052	1.129807
D(L)	0.062173	1.118309	1.117316
D(R D)	0.000768	1.132954	1.126924
D(H)	0.046554	1.059985	1.058408

Source: author's calculations.

The results indicate that the expansion of the employment rate exerts the most substantial influence on the growth rate of GDP over the 1995-2019 period. An increase in the employment rate gap of one percentage point is associated with an increase in the GDP growth rate gap of 2.5 percentage points. This finding can be interpreted as a particular case of Okun's law in Bulgaria for the period 1995-2019. The nature of the results is influenced by the use of first differences of the employment rate instead of the unemployment rate. The interpretation of the results can be summarised as follows:

The Bulgarian economy is small, with services and trade as the dominant sectors. The industries shaping its structure – such as construction, agriculture, mining, and manufacturing – are labour-intensive and predominantly rely on a low-skilled workforce. Consequently, an increase in employment, other factors being equal, results in a significant and measurable increase in GDP.

The other factor that has a positive effect on economic growth is the growth rate of capital. An increase in the differential of the capital growth rate by one unit is associated with an increase in the differential of the economic growth rate by 0.03 percentage points. The remaining two factors, namely the growth rate of human capital and the growth rate of R&D, are statistically insignificant. Therefore, the growth rates of employment essentially determine the change in the dynamics of the differential in the growth rates of economic growth during the period 1995-2019 (Table 1).

The employment growth rate differential exerts the most significant influence on the GDP growth rate differential dynamics, given that the labour force represents the most substantial resource available to the Bulgarian economy. Additionally, the relatively low wages in Bulgaria make the country's labour market an attractive destination for both domestic and foreign investors. It can thus be argued that the marginal return on labour input is two and a half times higher. This conclusion corresponds with the context of the research in the paper,

which aims to assess the impact of supply-side factors on economic growth. The quantitative argument of the derived proposition is illustrated in Table 1. This finding is due to the fact that the main goods and products produced in Bulgaria are labour-intensive and less capital-intensive. Another argument supporting this statement is that the majority of Bulgarian exports consist of goods that do not have high added value. This implies that labour is the main source of the creation of these goods, and it should be specified that the labour input in the production of the goods is mostly low-skilled.

According to the assessment, the small contribution of capital growth rates to GDP growth clearly stands out. The marginal return on capital is therefore small. One of the most important reasons for the weak impact of capital on economic growth is the structural imbalance of the Bulgarian economy, which is a consequence of privatisation. Another reason for the weak impact of capital on economic growth is depreciation, which outpaces capital renewal.

The growth rate of human capital does not have an optimal impact on economic growth because it declines over the period under consideration. Population decline and the poor quality of education in Bulgaria have a cumulative negative effect on human capital. The demographic crisis has a negative effect on human capital. The demographic crisis affects economic growth primarily through labour and human capital. In Bulgaria, the specific structural characteristics of this crisis create a unique transmission mechanism impacting economic growth via these two factors. The crisis is marked by a shrinking young population and a growing elderly population. This demographic shift introduces several distinct effects on key transmission variables. One major consequence is the limitation on human capital development. The younger population, more inclined to pursue education and enhance their qualifications, is diminishing, while the older population is increasing. This dynamic reshapes the labour force structure. In Bulgaria, the proportion of young and highly skilled workers is declining, whereas the share of low-skilled workers and those nearing or exceeding retirement age is rising. Furthermore, an increasing retirement age has led to a substitution effect, whereby older workers remain in the workforce longer, partially offsetting the reduction in younger workers. During the period under consideration (1995–2019), this trend resulted in a slower decline in the labour force relative to the overall population. While the labour force has been shrinking, it has done so at a more gradual pace than the population as a whole. Importantly, a decrease in the labour force does not necessarily equate to a reduction in employment. This is because Bulgaria's rising retirement age and economic structure predominantly generate jobs in sectors such as services, trade, and construction, which typically require lower qualifications. Additionally, there is a slow but positive process of technological renewal. While not highly advanced, it has nonetheless contributed to supporting employment during the demographic crisis. As a result, the primary negative effect of the demographic crisis on GDP during this period stems from its impact on human capital rather than employment. This explains why employment – representing labour's effect on GDP during 1995–2019 – has been the key driver of positive contributions to GDP growth.

The rate of change in R&D illustrates that science, innovation, and technology did not develop significantly in Bulgaria during the period under review. This is because firms in Bulgaria do not maintain R&D departments to deal with innovation and technological

developments. On the other hand, the government itself has, for many years, neglected the country's scientific units. Estimating the impact of the capital growth rate, the labour growth rate, the human capital growth rate, and the research growth rate on the GDP growth rate over time requires a rolling regression. Economic systems are inherently dynamic, meaning that the relationships between factors driving economic growth and GDP evolve over time. Between 1995 and 2019, the Bulgarian economy faced a series of economic shocks, including the hyperinflationary crisis and the financial crisis. Furthermore, Bulgaria's accession to the EU significantly influenced the dynamics and stability of the relationship between economic growth factors and GDP. These evolving changes, which impact both the stability and the dynamics of these relationships, highlight the necessity of applying rolling regression. The rolling regression is implemented with quarterly data covering the first quarter of 1995 to the fourth quarter of 2019, with an initial step of twelve quarters and rolling in steps of four quarters. The resulting estimates are presented in Table 3.

Table 3. Estimation of the parameters of the rolling regression model

Dependent Variable: D(Y) GDP growth rate						
Year/Variable	C	D(K) (Capital)	D(L) (Labour)	D(H) (Human capital)	D(R_D) (R&D)	R ²
1995Q1-1997Q4	-0,01			-14,41	-0,43	1,00
1996Q1-1998Q4	-0,01			-14,77	-0,47	1,00
1997Q1-1999Q4		0,03				0,90
1998Q1-2000Q4	-0,00		6,46	1,67	-0,39	0,96
1999Q1-2001Q4	-0,01		12,32	1,13	0,47	0,97
2000Q1-2002Q4	0,00		-0,45		0,13	0,99
2001Q1-2003Q4					0,13	0,98
2002Q2-2004Q4						0,92
2003Q1-2005Q4				-0,48	-0,13	0,88
2004Q1-2006Q4						0,63
2005Q1-2007Q4			1,17		-0,25	0,54
2006Q1-2008Q4		-0,31	2,64	-0,33		1,00
2007Q1-2009Q4	-0,00		1,23		0,89	0,99
2008Q1-2010Q4	-0,00	-2,10	5,25		0,53	0,97
2009Q1-2011Q4	-0,00	-0,84		7,60		0,98
2010Q1-2012Q4						0,94
2011Q1-2013Q4	-0,00	-3,06			0,10	0,96
2012Q1-2014Q4	-0,01	-8,37	3,53	-8,49	0,19	0,92
2013Q1-2015Q4	-0,00	-7,77	-2,24		0,14	0,98
2014Q1-2016Q4		-8,80			0,15	0,89
2015Q1-2017Q4		-1,40	-1,03	0,87	0,01	0,91
2016Q1-2018Q4		-0,83	-0,78	0,83		0,98
2017Q1-2019Q4	0,00	-0,36	-0,60	0,59	0,06	1,00
F-statistic: 40.52294		Prob(F-statistic): 0.000000		Durbin-Watson stat: 1.823322		

Legend: The table presents the coefficients that are statistically significant. The values of the coefficients are rounded to the second digit. Detailed results are in the Appendix.

Source: author's calculations

According to the data in Table 3, the differences in the growth rates of capital and labour for the periods 1995-1997 and 1996-1998 are statistically insignificant, meaning that they do not have a noticeable impact on the difference in the GDP growth rate. This empirical result illustrates, on the one hand, the structural problems in the Bulgarian economy and, on the

other hand, the emerging demographic crisis in Bulgaria caused by the hyperinflation that "exploded" in 1997. These processes find empirical justification in Table 3, which shows that, in the period 1995-1997, a unit increase in the human capital growth rate gap leads to a 14.4 percentage point (p.p.) decrease in the GDP growth rate gap. On the other hand, the shock to the dynamics of the R&D growth rate differential from the outflow of scientific potential again registered a negative impact on the GDP growth rate differential, reducing economic growth by 0.4 p.p. In the period 1996-1998, the growth rate differentials of human capital and R&D continued to have a negative impact on the GDP growth rate differential. The empirical results illustrate a 14.8 percentage point decrease in the GDP growth rate differential as a consequence of a one-unit increase in the human capital growth rate differential over the years 1996-1998, with the dynamics of the R&D growth rate differential over the same period also leading to a 0.5 percentage point decrease in the economic growth rate differential. Consequently, the economic growth in Bulgaria during the period 1995–1998 cannot be fully accounted for by conventional economic growth theory, as it fails to address the unique structural and transitional challenges faced by the economy at the time.

The results for 1998–2000 illustrate how pre-accession European remittances, increased exports, FDI inflows, and economic stabilisation create an environment where a one-unit increase in the employment growth rate differential raises the GDP growth rate differential by 6.5 p.p. Similarly, the growth rate of human capital contributes to a 1.7 p.p. increase in the GDP growth rate differential. This supports the argument that graduates from various education levels during this period preferred entering the Bulgarian labour market, boosting economic growth.

However, the R&D growth rate differential reduces the GDP growth rate differential by 0.4 p.p., highlighting persistent negative trends in the scientific sphere and the early constraints on innovation and science-driven growth. During 1999–2001, the positive effects of employment and human capital growth differentials on GDP growth are complemented by the R&D growth rate's contribution.

The capital growth rate differential has no significant impact on GDP growth. Notably, the human capital growth rate differential declined compared to the previous period, indicating a loss of skilled labour in the Bulgarian economy. While the R&D growth rate differential has a small but positive contribution to GDP growth, its overall impact remains limited.

In the period 1998–2001, economic growth in Bulgaria was mainly driven by labour. Other factors contributing to GDP growth included human capital and R&D. This structure of economic growth does not fully align with the strict postulates of the neoclassical growth model. According to the Solow model, capital and technology are the primary determinants of economic growth. Although Bulgaria's growth characteristics during this period show some overlap with endogenous growth theory, they do not fully meet the criteria of steadily increasing returns to capital and R&D. These dynamics are likely not fully captured by either the Solow model or endogenous growth theory, as 1998–2001 represents a period of significant economic reform in Bulgaria's recent history.

The regression coefficients, which represent the difference in the capital growth rate between 2002 and 2011, indicate either a neutral or a negative effect on the GDP growth rate

differential. In contrast, the employment growth rate gap exhibits overwhelmingly positive regression coefficients.

In 2011, the human capital growth rate differential had a positive effect on the GDP growth rate differential, whereas in other years, the effect was either negative or statistically insignificant. The R&D growth rate differential during 2002–2011 had a varied impact on the GDP growth rate differential.

Notably, none of the supply factors had a statistically significant impact on GDP during the period 2010–2012. This result likely reflects the adverse effects of the "Great Recession" on the Bulgarian economy in 2009, coupled with the debt crisis's spillover effects from key trading partners. The negative debt spillovers from the euro area into the Bulgarian economy were exacerbated by the Currency Board.

According to the results obtained (Table 3), the growth rate of capital during 2012–2019 results, in all years except 2012, in a narrowing of the GDP growth rate gap. During this period, changes in employment growth rates positively affect the GDP growth rate only in 2014. In 2014, changes in human capital rates had a negative impact on the GDP growth rate differential, while in the remaining years, the effect was either statistically insignificant or positive, though the positive impact was minimal.

Changes in R&D rates consistently result in positive growth in the difference in GDP growth rates. During 2012–2019, the negative impact of capital could not be fully offset by variables positively affecting GDP growth. Bulgaria's economic growth during this period featured endogenous elements but was not fully consistent with endogenous growth theory.

The analysis of the impact of supply factors on changes in the GDP growth rate over time requires more detail and depth. Therefore, the next section presents estimates of the impact of each factor separately by examining the dynamics of the regression coefficient of the rolling effect of each economic growth factor.

The differences in capital growth rates (D_K) (Figure 1) between 1995 and 2000 are zero, but positive. This is due to the fact that fixed capital formation is slower than depreciation. In the period 2005–2007, fixed capital formation was highly volatile, with the highest capital stock accumulation occurring in 2005. In the period 2008–2010, the impact of changes in the growth rate of capital on economic growth declined. In the period 2013–2016, there was a very sharp and large reduction in the impact of changes in the rate of capital on changes in the rate of GDP. These negative trends continued to operate in the period 2017–2019, and therefore, the coefficients in this period have negative values.

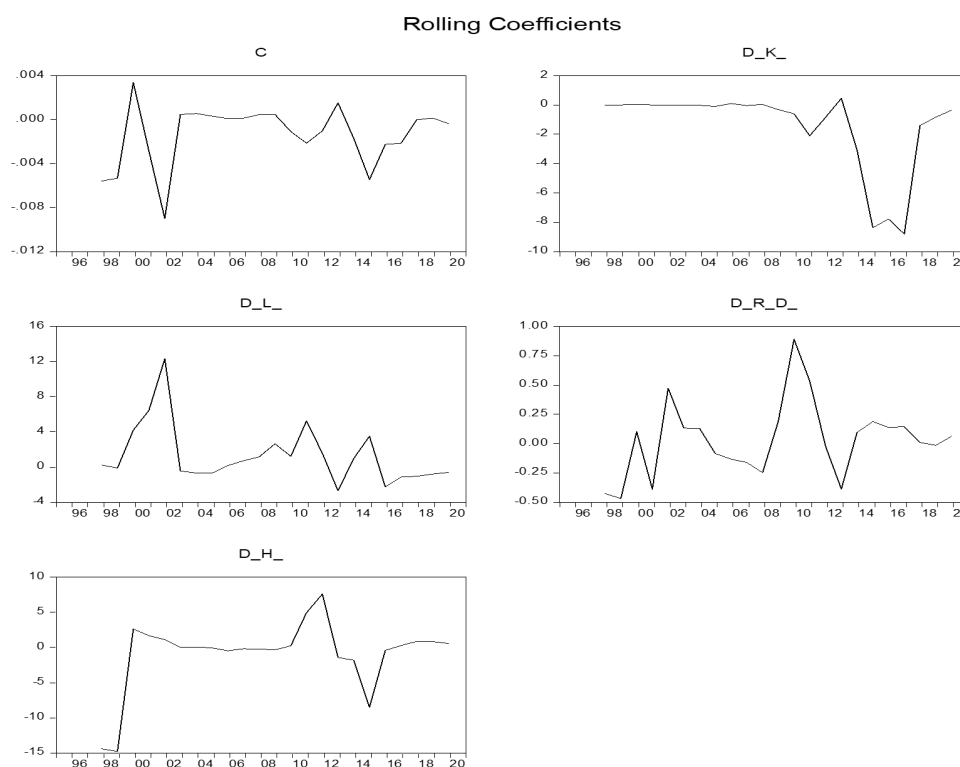
Employment growth rates (D_L) have been highly volatile (Figure 1) but have predominantly followed a positive trajectory. Between 1998 and 2001, the dynamic employment rate ranged from 0.1 percentage points (p.p.) in 1998 to 12.3 p.p. in 2001. The positive change in employment growth rates during the period 2005–2007 continued, contributing to an increase in economic growth. After 2014, the employment growth rate recorded only negative values, ranging from (-2.2 p.p.) to (-0.6 p.p.).

The impact of changes in the human capital rate (D_H) on the change in the GDP rate is characterised by periods of sharp fluctuations within both positive and negative ranges

(Figure 1). Between 2000 and 2008, there was a gradual shift of the coefficients towards negative values. After 2009, a sharp change in the coefficient is observed, ranging from 0.3 percentage points (p.p.) in 2009 to 7.6 p.p. in 2010, before dropping to (-8.5 p.p.) in 2014. By the end of the period (2017–2019), the impact of human capital on GDP dynamics stabilises, with the coefficient taking values between 0.3 and 0.9 p.p.

The impact of changes in R&D growth rates (D_R_D) on economic growth rates has been characterised by high volatility over the period (Figure 1). On the positive side, this variation occurs within a very narrow range, from (-0.5) percentage points (p.p.) in 1998 to 0.9 p.p. in 2010.

Figure 1. Variation of the coefficients of factors of production



Legend: C is a constant; D_K is the first difference of the rates of capital growth; D_L is the first difference of the rates of employment growth; D_H is the first difference of the rates of human capital growth; D_R_D is the first difference of the rates of R&D growth;

Source: author's calculations.

The returns that the supply factors realise from the change in their dynamics register values around zero, except for employment. Supply factors are characterised by large and sharp variability, which creates uncertainty in the trajectory of economic growth. The synthesis and synchrony of volatility among the factors of economic growth significantly constrain economic growth in Bulgaria during the period under consideration.

As Tables 1 and 3 and Figure 1 illustrate, the return on capital is low in both static and dynamic contexts. This outcome arises because the return on capital is contingent upon technological renewal, which in turn relies on investment in technology and innovation, as well as an efficient innovation process. Investment in technology is determined by savings, which, according to Solow, are transformed into investment. However, in Bulgaria, savings are not converted into domestic investment but instead flow abroad – a phenomenon exacerbated by the fixed exchange rate regime and the currency board arrangement. In a small open economy with a fixed exchange rate and capital mobility, savings, in the form of capital, flow out of the economy in search of superior returns. Consequently, savings are not effectively transformed into capital investment. Another critical driver of technological progress is the innovation process, which stems from the accumulation of knowledge. In Bulgaria, the development of human capital has been hindered by several factors, including suboptimal remuneration and challenging working conditions in scientific institutions, ongoing reforms in higher education, and the significant outflow of human capital abroad during the period 1995–2019. As a result, technology and the technological process have not developed at an efficient rate, culminating in suboptimal returns on capital. Other factors that hinder the return on capital include high levels of corruption and an ineffective judicial system, both of which contribute to uncertainty within the economic environment. This uncertainty deters investors, leading to a decline in capital investment.

Slow rates of technological advancement, combined with high depreciation rates, foster conditions that necessitate greater reliance on labour in the production of goods. Additionally, a significant proportion of investment by domestic firms is directed towards sectors that are not associated with high-technology production but are labour-intensive, such as construction, hospitality, and garment manufacturing. Outsourcing companies operating in Bulgaria seek a workforce that is significantly less expensive than that in Germany, the United States, or the United Kingdom. This reflects the structure of the Bulgarian economy, which facilitates conditions that enable labour to generate a comparatively higher return on capital.

The two-sector model of endogenous growth theory elucidates the relationship between R&D and the production process. The creation of new technologies depends on R&D investment; thus, negative R&D outcomes curtail technological progress and diminish the return on capital. The statistically insignificant or negative ramifications of R&D represent a primary impediment to implementing an efficacious macroeconomic policy that fosters conditions for augmenting economic growth in Bulgaria.

A review of the Eurostat statistics reveals that Bulgaria spends the least on R&D as a percentage of GDP compared to the Czech Republic, Hungary, and Poland. During the period 2012–2019, Bulgaria's average expenditure was 0.76% of GDP, whereas the Czech Republic spent 1.83% of GDP on R&D, and Poland spent 1.03% of GDP. Hungary, on average, allocated 1.35% of its GDP to research and development during the same period. Another specificity that affects Bulgarian economic growth is the lower FDI inflow into the Bulgarian economy compared to the economies of the Czech Republic, Hungary, and Poland. Additionally, the large emigration that took place between 1995 and 2019 led to a decrease in human capital in Bulgaria compared to the Czech Republic, Hungary, and Poland.

5. Conclusion

The empirical analysis of the determinants of economic growth in Bulgaria from 1995 to 2019 reveals several significant findings. The most substantial contributor to GDP growth during this period is the growth rate of the labour force. Human capital growth, while impactful, positively influences GDP growth only during certain periods. Research and development (R&D) demonstrates considerable potential to boost GDP growth, yet this potential remains largely unrealised. Furthermore, the growth rate of fixed capital tends to exert a dampening effect on GDP growth during most periods. Capital formation, therefore, requires stimulation to achieve a more pronounced positive effect on GDP. Additionally, creating conditions that optimise the contributions of human capital and R&D is crucial for long-term economic growth.

These findings underscore the need for targeted macroeconomic policies aimed at optimising capital formation, enhancing the quality of human capital, and promoting R&D. Overcoming structural distortions in capital investment and stimulating capital formation were pivotal to Bulgaria's economic development between 1995 and 2019. Macroeconomic policies to address these structural imbalances may include the following measures:

- Promoting public-private investment initiatives within key sectors such as organic farming and livestock production, which are fundamental to Bulgaria's economic structure.
- Encouraging public-private partnerships in innovative industries, particularly those related to hardware and software development, which have the potential to enhance both domestic and global competitiveness.
- Increasing public investment in life-saving and life-sustaining pharmaceuticals to bolster public health and the pharmaceutical sector.
- Restricting the outflow of savings abroad to optimise capital formation and address investment distortions. This can be achieved through targeted tax policies, such as tax incentives for investment in technological assets and production processes. Moreover, creating a more conducive business environment and strengthening the legal framework will attract foreign investment to Bulgaria's economy.

Activating the full potential of R&D requires targeted measures, including:

- Increasing government expenditure on R&D to exceed 2 percent of GDP.
- Raising salaries for personnel in scientific institutions to foster a more competitive research environment.
- Implementing tax policies that incentivise private sector investment in research and development.

Improving the quality of human capital is another critical area. This can be achieved through the following initiatives:

- Reforming education financing to raise standards and expectations for degree attainment.

- Increasing public funding for universities, ensuring that institutions have the resources to maintain high educational standards.
- Implementing policies to guarantee graduates' employment in their respective fields, bridging the gap between higher education and the labour market.
- Enacting legal measures to create employment opportunities for both young graduates and individuals over fifty, ensuring an inclusive labour market.
- Developing targeted government financial and social policies to retain the workforce domestically, addressing the challenge of brain drain.
- Enhancing the quality of and access to modern medical services, which are crucial for maintaining a healthy and productive workforce.

While this research has provided valuable insights and policy recommendations, it also has certain limitations. The primary limitation is the time period analysed, which may not fully capture more recent trends in Bulgaria's economic growth. Additionally, the study focuses primarily on supply-side factors and does not consider demand-side and policy-related factors that may also influence GDP growth. Future research could expand on this by exploring the impact of demand and policy factors on GDP. Furthermore, future studies should investigate the influence of supply-side factors on GDP in the post-2019 period. Additionally, research could delve into the distinctive features of economic growth in former socialist countries.

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APPENDIX

Test for stationarity of the real GDP growth rate variable

Variable	ADF Statistics with constant	Probability (p-value)	ADF Statistics with constant and trend	Probability (p-value)	ADF Statistics no constant	Probability (p-value)
Real GDP growth rate - Y	-2.322	0.167	-1.957	0.6165	-1.728	0.0795
First real GDP growth rate differential -D(Y)	-14.672	0.0001	-14.851	0.0000	-14.770	0.0000

Data source: author's calculations.

Test for stationarity of the variable rate of capital

Variable	ADF Statistics with constant	Probability (p-value)	ADF Statistics with constant and trend	Probability (p-value)	ADF Statistics no constant	Probability (p-value)
Capital growth rate – K	-2.330	0.165	-1.504	0.821	-3.495	0.0006
First capital growth rate difference D(K)	-4.452	0.0005	-4.530	0.0024	-4.224	0.0000

Data source: author's calculations.

Test for stationarity of the employment rate variable

Variable	ADF Statistics with constant	Probability (p-value)	ADF Statistics with constant and trend	Probability (p-value)	ADF Statistics no constant	Probability (p-value)
Rate of employment growth – L	-2.232	0.196	-2.229	0.468	-2.219	0.026
First employment growth rate gap –D(L)	-9.615	0.000	-9.564	0.000	-9.639	0.000

Data source: author's calculations

Test for stationarity of the human capital rate variable

Variable	ADF Statistics with constant	Probability (p-value)	ADF Statistics with constant and trend	Probability (p-value)	ADF Statistics no constant	Probability (p-value)
Human capital growth rate –H	-0.700	0.8409	-1.117	0.9201	0.472	0.8150
First differences of human capital growth rates - D(H)	-4.723	0.0002	-4.909	0.0007	-4.477	0.0000

Data source: author's calculations

Test for stationarity of R&D growth rate

Variable	ADF Statistics with constant	Probability (p-value)	ADF Statistics with constant and trend	Probability (p-value)	ADF Statistics no constant	Probability (p-value)
R&D growth rate R D	-4.644	0.0002	-4.549	0.0022	-3.134	0.0020
First difference in R&D growth rate D(R D)	-9.786	0.0000	-9.798	0.0000	-9.785	0.0000

Data source: author's calculation

Estimation of the parameters of the rolling regression model

Dependent Variable: D(Y) Method: rolling regression						
	C	D(K)	D(L)	D(H)	D(R D)	R ²
1995Q1-1997Q4	-0,006*	0,003	0,243	-14,414*	-0,425**	0,996
1996Q1-1998Q4	-0,005*	0,005	-0,102	-14,767*	-0,468*	0,995
1997Q1-1999Q4	0,003	0,028*	4,199	2,637	0,103	0,902
1998Q1-2000Q4	-0,003***	0,010	6,455*	1,666*	-0,387**	0,959
1999Q1-2001Q4	-0,009*	-0,001	12,317*	1,129*	0,473*	0,965
2000Q1-2002Q4	0,000*	0,005	-0,453*	0,033	0,132*	0,986
2001Q1-2003Q4	0,001	-0,019	-0,664	0,069	0,129*	0,977
2002Q2-2004Q4	0,000	-0,098	-0,682	-0,069	-0,084	0,922
2003Q1-2005Q4	0,000	0,097	0,178	-0,475**	-0,132***	0,878
2004Q1-2006Q4	0,000	-0,041	0,740	-0,177	-0,160	0,629
2005Q1-2007Q4	0,000	0,050	1,169***	-0,221	-0,248**	0,54
2006Q1-2008Q4	0,000	-0,307*	2,643*	-0,332*	0,189	0,999
2007Q1-2009Q4	-0,001**	-0,596	1,234***	0,253	0,891*	0,99
2008Q1-2010Q4	-0,002**	-2,104*	5,245**	4,932	0,534*	0,965
2009Q1-2011Q4	-0,001**	-0,843*	1,574	7,600**	-0,021	0,983
2010Q1-2012Q4	0,002	0,454	-2,693	-1,428	-0,388	0,942
2011Q1-2013Q4	-0,002*	-3,058*	1,005	-1,818	0,095*	0,961
2012Q1-2014Q4	-0,005*	-8,370*	3,528*	-8,494*	0,189*	0,917
2013Q1-2015Q4	-0,002*	-7,770*	-2,237*	-0,410	0,139*	0,983
2014Q1-2016Q4	-0,002	-8,802*	-1,130	0,298	0,146**	0,891
2015Q1-2017Q4	0,000	-1,398*	-1,030*	0,870*	0,010***	0,905
2016Q1-2018Q4	0,000	-0,828*	-0,783*	0,828*	-0,014	0,981
2017Q1-2019Q4	0,000***	-0,356**	-0,604*	0,588*	0,063***	0,997
F-statistic: 40.52294				Durbin-Watson stat : 1.823322		
Prob(F-statistic): 0.000000						

Legend: * statistical significance at 10 percent, ** statistical significance at 5 percent, *** statistical significance at 1 percent.
Source: author's calculations