**ACADEMY OF ECONOMICS**

**"Dimitar A. Tsenov" – Svishtov**

**Faculty of Finance**
**Department of Finance and Credit**

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**JULIAN HRISTOV VOYNOV**

# LAG MODELLING OF PUBLIC FINANCES TROUGH STRESS TEST

# A B S T R A C T

**of a dissertation**
**for awarding of a PhD degree**
**in the PhD program "Finance, Money Circulation, Credit and Insurance (Finance)"**

**Scientific Supervisors:**
**Prof. Yordan Vasilev, PhD**
**Prof. Rumyana Lilova, PhD**

**Svishtov**
**2022**

The dissertation has been discussed and approved for defense in accordance with the Development of Academic Staff Act and the Development of Academic Staff in AE "D. A. Tsenov" Implementation Regulations from the Department of Finance and Credit at the Academy of Economics "Dimitar A. Tsenov" - Svishtov.

The dissertation consists of 197 standard pages, 159 of which are main text. Structurally, it includes an introduction, three chapters, a conclusion, a bibliography, 70 sources, and 20 pages of appendices. In support of the presented main text 12 tables and 30 figures are included. Three publications have been made on the subject of the dissertation, including one study, one article and one report, with one more article to be published. The author took part in three scientific conferences with presentations on the topic of the dissertation. A declaration of authenticity and originality is attached.

The defense of the dissertation will take place on 31.03.2023, at 13:30, in the Rectorate Meeting Hall at the AE "D. A. Tsenov", Svishtov. at a meeting of the scientific jury, determined by order of the Rector of the Academy of Economics "D. A. Tsenov", Svishtov, composed of:

Prof. Stoyan Stanimirov Prodanov, AE "D.A. Tsenov", Svishtov

Assoc. Prof. Anelia Kirilova Radulova, AE "D.A. Tsenov", Svishtov

Prof. Rumen Yordanov Brusarski, UNWE

Assoc. Prof. Krasen Stefanov Stanchev, SU "St. Kliment Ohridski"

Prof. Tsvetka Atanasova Stoencheva, UNWE

The materials for the defense are available for those interested in the "PhD and Academic Development" Department of the Academy of Economics "Dimitar A. Tsenov" - Svishtov.

## I. GENERAL CHARACTERISTICS OF THE DISSERTATION

### 1. Relevance of the topic

The correct forecast of the main macroeconomic parameters and based on them budget variables is a serious challenge for governmental, economic and financial institutions, international financial organizations, central banks as well as for numerous analytical and academic centers and institutes. On the one hand, the correct forecasting of the budget parameters is related not only to the correct allocation of the scarce fiscal funds, but also to the implementation of policies aimed at preventing economic and financial crises and timely response when these crises are a consequence of external and unforeseen shocks.

Studying the resilience of various financial systems and institutions is relatively new approach in economic and financial analysis and research. This resilience is established by conducting stress tests on certain macroeconomic parameters to determine how the corresponding financial and fiscal balances of the organizations or countries under assessment would react. At the state level one of the main parameters that financial institutions monitor, apart from the debt, is the budget balance and especially the cyclically-adjusted budget balance (CAB). The contemporary form of CAB and the methods and tools for its assessment are relatively new in economic theory and practice and date back from the beginning of the 1990s of the previous century. Particular attention to the fiscal and budgetary sustainability of individual countries begins to be paid during the creation of the Eurozone, and the Stability and Growth Pact (SGP) that regulates its existence, in which the concept of CAB is placed as a fundamental pillar. After the global economic crisis of 2008 - 2009, stress tests as a tool for assessing the resilience of financial and banking systems and institutions from the impact of various risk factors and situations begin to be used for evaluation of the fiscal and macroeconomic resilience of individual countries and groups of countries such as EU member states.

From this point of view, the presented and analyzed concepts, methods and models for forecast and assessment of the main budget parameters and their reaction to macroeconomic shocks is an current research topic that needs development and improvement, especially in the Bulgarian institutional and academic frame in which the most modern models for forecasting and assessment of macroeconomic and fiscal parameters have not yet been implemented.

The dissertation presents and discusses theoretical and conceptual solutions on the one hand, and empirical models and tools, on the other, which represent an innovative approach to the analysis and assessment of the basic macroeconomic and budgetary parameters. In this respect an analysis is made and errors in the budget forecasts are calculated on which basis the reasons for the deviations of the reported budget balances from the initial forecasts are explained.

At the same time, the cyclically-adjusted budget balance (CAB) of Bulgaria is calculated by using a variant of the EC model and a comparison of the results of calculations of CAB and the main macroeconomic parameters included in its calculation is made against the outcomes from the model of the Ministry of Finance (MoF), which enables direct comparison of the results of the two models and the evaluation of their usefulness for conducting macroeconomic and fiscal policy.

## 2. Object and subject of the research

**The object** of the research is the main fiscal parameters contained in the government budget forecasts, on the basis of which the Consolidated Fiscal Program (CFP) of Bulgaria is prepared.

**The subject** of the dissertation is the main methods for conducting a stress test on financial parameters and on CAB.

## 3. Research thesis

**The thesis** of the dissertation is formulated as follows: *To overcome the existing imperfections of the applied budget forecasts, caused by the "discrepancy" between the budget forecast and the actual execution of the state budget, a suitable financial and econometric tool for making adequate political decisions concerning the fiscal policy of the country, is the application of a stress test to an empirical model including economic and fiscal variables and their time lags.*

## 4. Aim of the dissertation

**The aim** of the research is to analyze to what extent the main fiscal variable, in this case the cyclically-adjusted budget balance (CAB), reacts to a shock on the economic environment in short and possibly long-term, and hence the reaction of the nominal budget indicators.

At the same time a comparison of the results of the presented in the dissertation model with those obtained from a similar model used in MoF is examined. The discrepancy between the budget forecasts and the actual budget executions is also a researched objective in the dissertation, with the aim to establish the extent to which these deviations are a consequence of discretionary decisions of the government and not of cyclical economic changes.

## 5. Research tasks

To achieve the stated goals, the following **tasks** are set for implementation:

1. To systematize the main theoretical propositions for applying a stress test on financial variables and to trace their development through the various stages of their empirical application;

2. To implement a comparative analysis between the models used in the European Union to calculate the main fiscal parameters impacting the fiscal policy and assess the adequacy of the results obtained from their application.

3. To present a comparative analysis between the results of the main model used by the European Commission to evaluate fiscal indicators, including its development and upgrading over the years and an alternative model that evaluates from a different angle the results of fiscal policy in the EU;

4. On the basis of an empirical model for estimating errors in budget forecasts, to perform a thorough analysis of the budget forecasts and their actual execution based on historical data and to answer the question of whether errors made in budget forecasts are a consequence of insufficient information or have a discretionary nature due to political influences on forecasts;

5. On the basis of the Cobb-Douglas production function to build a model for calculating the cyclically-adjusted budget balance, which will be subjected to a stress test as a result of a shock on one of the main macroeconomic parameters underlying its calculation and to assess its response to the applied shock;

6. To verify the credibility of the proposed in the dissertation model to compare its results with those of the model used in MoF, evaluate their outcomes and make a comparative qualitative assessment.

**6. Theoretical and methodological foundations of the research**

The reserach is based on a description and empirical application of the European Commission model for calculating the output gap, using the Cobb-Douglas production function and for determining the potential GDP. Based on this information the cyclically-adjusted budget balance is calculated, which is the main variable for determining the fiscal sustainability of a state.

For comparison with the model of the European Commission and as an alternative method, the results of a Dynamic Stochastic General Equilibrium model (DSGE) are presented with a detailed specification of the equations impacting the fiscal variables, according to the work of Masten and Gnip (Masten & Gnip, 2016).

The empirical analysis of budget forecast errors on the other hand closely follows the methodology used in the study of Mourre, Astarita, and Maftei (Mourre, Astarita, & Maftei, 2016), but it is necessary to note that there are also significant differences due to the scope and period of the research , access to data and objectives.

At the same time, the methodology used in the dissertation for calculation of the output gap is that developed by Kaloyan Ganev (Ganev, 2015) based on the Cobb-Douglas production function, by using the Hodrick-Prescott filter to remove the cyclical component from the dynamic time series with primary data i.e. this is a variant of the EC model, on the basis of which calculations, forecasts and the main macroeconomic parameters in the Bulgarian institutions are performed, of course with some modification regarding the application of the econometric filters. The stress on the output gap and the response of CAB, using lag modeling in a vector autoregression (VAR) model, is implemented in EViews econometric software.

**7. Research information source and data base**

The study is based on the following information source and data base: legislative and regulatory legal acts, theoretical and analytical studies, reference statistical data and analytical materials of the Ministry of Finance (MoF), the Bulgarian National Bank (BNB), the National Statistical Institute (NSI), the International Monetary Fund (IMF), the World Bank (WB), the Statistical Office of the European Union (Eurostat), the Organization for Economic Cooperation and Development (OECD) and other international organizations.

In the course of the research, a complex of logical and empirical-theoretical methods are used. Such are the historical and logical methods, the methods of induction and deduction, analysis and synthesis, descriptive and comparative analysis. The quantitative and empirical analysis in the dissertation consists of the application of the techniques of mathematical

economics, statistical analysis, mathematical methods and econometric time series models, including regression analysis and verification tests. Figures and tables are used to present the final results

**8. Limitation of the study**

The dissertation also has some limitations related to the period of the study, the availability of certain data and their revision during the research process. Thus, for example, the dissertation period covers the time interval from 2000 to 2020, but different empirical analyzes deal with different time series, which is due to the lack of certain statistical data for the entire period. For this reason, the analysis of errors in the budget forecasts has been carried out for the entire specified period, since the data are available in the Ministry of Finance and their revision has a strict and respected schedule. This is not the case for the GDP of the country, whose data has been revised several times since 1990 and the last revision is made by the NSI literally in the last days of the completion of research work, which fundamentally changes the basis of the calculations and for this reason this last revision of dynamic rows is not taken into account in the calculations. Additionally, for some of the calculated parameters lack data for the period before 2004, which affects the executed calculations and regression analyses.

In general, the current dissertation achieves the set aim and goals and presents a theoretical and empirical analysis that sheds light on the limitations and, at the same time, challenges to budget forecasts and the main models on whose basis the fiscal policy of the state is built. The achieved results of the research can provide an additional point of view and a lateral look on the budget and fiscal policy, which could be useful for its better calibration and qualitative development in order to improve the toolkit for budget programming and modeling of macroeconomic parameters.

### 9. Innovativeness and uniqueness of the research

The theoretical foundations and empirical methods used in the present study are not new in the world and the Bulgarian academic development and research thought. However, two novelties should be highlighted in the present dissertation, as far as the author is aware, which make the present study unique. **For first time** an analysis of the deviation of the actual budget execution from the budget forecast is presented and an empirical assessment of the errors in the forecasts of the Consolidated Fiscal Program of Bulgaria for the period 2000-2020 and specific sub-periods is made.

**Secondly**, for first time a comparison is made between the results obianed by the model developed in the dissertation and the results of the MoF model regarding the main macroeconomic data such as potential GDP, output gap and cyclically-adjusted budget balance, while an analysis is made about the reasons for the corresponding deviations and differences. From this point of view, the present dissertation provides an opportunity not only to compare results, but also to choose a model that may be applied when defining the country's fiscal policy and relevant decisions.

## II. STRUCTURE AND CONTENT OF THE DISSERTATION

### 1. Structure of the dissertation

The dissertation contents a total of 197 standard pages and it is structured as follows:

*First*. Contents – 5 standard pages

*Second*. List of abbreviations used - 2 standard pages

*Third*. Introduction of 9 standard page.

*Fourth*. An exposition consisting of 3 chapters with a total of 143 standard pages.

*Fifth*. Conclusion of 7 standard pages.

*Sixth*. Appendices – 20 pages.

*Seventh*. Bibliography – 8 pages. It includes 70 sources, of which 8 are in Cyrillic and 62 are in Latin

**2. Content of the dissertation**

**LIST OF ABBREVIATIONS USED**

**INTRODUCTION**

**I. THEORETICAL BASIS AND DEVELOPMENT OF THE TOOLKIT FOR THE STRESS TEST ON FINANCIAL VARIABLES AND ON PUBLIC FINANCE**

1. Prerequisites and theoretical foundations for the initial development of the financial risk stress test toolkit

2. Micro- and macro-prudential objectives of stress tests

3. Tools for public debt sustainability analysis

3.1. Public debt as an indicator of deteriorated fiscal sustainability

3.2. Toolkit for forecasting the changes in public debt

3.3. Methods for assessing debt sustainability

3.4. A stochastic algorithm for debt sustainability analysis

4. Development of the toolset for fiscal sustainability surveilance - the approach of the European Union

5. Cyclically-adjusted budget balance - a main indicator for the condition of the state budget

5.1. Nature of the cyclically-adjusted budget balance

5.2. Theoretical grounds for choosing the cyclically-adjusted budget balance and methodological development

5.3. Advantages and disadvantages of using the cyclically-adjusted budget balance

5.4. Nature and development of the EU methodology for calculating the cyclically-adjusted budget balance

6. Public finance stress test models

6.1. The model of the European Commission

6.2. A dynamic stochastic general equilibrium model

**II. EMPIRICAL ANALYSIS OF ERRORS IN BUDGET FORECASTS**

1. Deviation of forecasts from reported values of budget revenues - errors in budget forecasts

1.1. Difference between forecasts and reported values of budget indicators and macroeconomic parameters

1.2. Definition of budget forecasting errors

1.3. Value of errors by budget indicators and specific time periods

1.4. Errors in nominal budget revenue forecasts and their relation to GDP forecasts

2. Tests for accuracy, impartiality and efficacy of forecast

2.1. Test for consistency of forecast errors

2.2. Test for determing availability of bias in making forecast errors

2.3. Test of the efficiency of forecasts

3. Main risk factors for Bulgaria's budget forecasts

**III. MODEL AND RESULTS FROM STRESS TEST ON PUBLIC FINANCE**

1. Approach and stages in the stress test process on public finances

2. Calculation of the output gap using the Cobb-Douglas production function

2.1. Calculation of the employed production capital

2.2. Calculation of potential employment and potential unemployment

2.3. Calculation of potential total factor productivity

2.4. Calculation of potential GDP and the output gap

2.5 Methodological characteristics, changes and peculiarities in calculating the potential GDP and the output gap

2.6. Results of the calculations of the potential GDP and the output gap

2.7. Comparison between the estimated output gap deom the dissertation model and that of the MoF model

3. Approach and peculiarities in the calculation of the cyclically-adjusted budget balance (CAB)

3.1. Calculation of budget semi-elasticity

3.2. Calculation of the cyclically-adjusted budget balance (CAB)

4. Lag modeling of the cyclically-adjusted budget balance and stress test implementation

4.1. The original VAR model

4.2. Determining the optimal model lags

4.3. Checking for cointegration between the variables (CAB and OG) in the model by Johansen Cointegration Test

4.4. The VAR model with one lag of variables

4.5. Defining/specifying the Model

4.6. The model with the coefficients from the calculations

4.7. Tests of model validity

4.8. Impulse-Response Function

**CONCLUSION**

**APPENDIXES**

**BIBLIOGRAPHY**

## III. BRIEF DESCRIPTION OF THE DISSERTATION

### INTRODUCTION

The introductory section presents the general overview of the research topic, the actuality and relevance of the topic, outlines the theoretical and practical framework of the research area and reveals the challenges and alternative tools that can be used to realize the aim and tasks in the research area related to the implementation of correct budgeting forecasts and the calculation of the main variables of public finances. The main elements of the

scientific research are defined: object, subject and the research thesis of the dissertation, the aim of the research is formulated, as well as the research tasks, the methodology and limitation of the research and the contribution of the study to the development of the topic.

## CHAPTER I. THEORETICAL FOUNDATIONS AND DEVELOPMENT OF THE TOOLKIT FOR THE STRESS TEST OF FINANCIAL VARIABLES AND PUBLIC FINANCE

Based on an in-depth analysis and research of the scientific literature, the main stages in the development of the stress test toolkit of financial, fiscal and macroeconomic variables and parameters are presented. The stages that are thoroughly examined concern not only the time periods during which the mentioned toolkit develops, but also the evolution of the area of its application, which changes its focus from assessment of individual financial risks to forecasts of sustainability of public finances of individual countries and groups of countries.

The theoretical and empirical foundations of stress tests as a macroprudential tool are laid down in the 1990s. Initially, the stress tests are applied by financial institutions and assess their loss in an event of a deterioration in economic conditions. Subsequently, stress tests become part of the capital planning models of banks and gradually become an integral part of the toolkit of banking regulation. Of particular importance for the state of the financial system is the condition of systemically important financial institutions (SFIs). Financial and economic crises impose the understanding that problems in individual institutions or countries can quickly be transferred to global level, forcing supranational institutions such as IMF and WB to adopt tools of stress testing in their Financial Risk Assessment Program (FSAP). .

Public finances accumulate risk in many different ways, bearing in mind that the debt is a dynamic quantity, the level of which is the outcome of the

excess of budget expenditures over budget revenues (Захариев, 2012). One of the ways to accumulate risk is through the influence of the tax burden on the government debt. There is a relationship between the two indicators, and the impact of the level of taxation on the government debt in long-term aspect is stable (Лилова & Благоева, 2012).

At a certain stage, stress tests are also used in the analysis of one of the main macroeconomic indicators, which often leads to currency and economic crises, such as the public debt. Stress test models of public debt under economic downturns are key to proper forecasting. The European Commission also possesses such a model, which is used to analyze the sustainability of the debt (Debt Sustainability Analysis).

The main indicator for the condition of the state budget is the **cyclically-adjusted budget balance (CAB)**, and it is the focus of the dissertation. CAB shows to what extent the state of the budget balance is due to discretionary decisions implemented in of the government's fiscal policy, in contrast to the cyclical component, which reflects the influence of the automatic stabilizers laid down in the legislation.

In principle, **two approaches are possible for determining the CAB**. **The first is purely statistical**, as used by the European Commission until 2002, which is based on smoothing the dynamic series with a Hodrick-Prescott filter. **The second approach represents usage of economic models** for calculation of CAB, and two types of this approach are possible. **One type** of economic models, as implemented by the EC, is based on the usage of a production function and various smoothing filters on the dynamic series trend.

As the main indicator for assessing the state budget in the EC model, the structural or cyclically-adjusted budget balance (CAB) is used, representing the ratio of the budget deficit/surplus to GDP when the economy is developing at the level of its potential. CAB represents the difference between the ratio of the budget balance (BB) to GDP and the estimate of the cyclical component of

the budget balance (CC), the cyclical component being a product of the budget semi-elasticity (ε), representing the percentage change in the ratio of the nominal budget balance to GDP at the change of GDP by 1%, and the deviation of GDP from its potential level or its long-term trend - the output gap (OG):

$$CAB_t = BB_t - CC_t = BB_t - \varepsilon OG_t \quad (1.1)$$

The assessment of the cyclical position of the economy, which is the **first main parameter** in the calculation of the CAB, is carried out by calculating the difference between nominal and potential GDP as a ratio to potential GDP, which is the output gap.

$$OG_t = \frac{Y_t - Y_t^p}{Y_t^p} \quad (1.2)$$

**The second main parameter** is the budget semi-elasticity, which measures the response of the budget balance to OG. Budget semi-elasticity has a corrective function in relation to the budget balance, removing the influence of the cyclical effects of the underlying economic processes under the assumption that the economy is operating at its potential level.

$$\varepsilon = \frac{d\frac{B}{Y}}{\frac{dY}{Y}} \quad (1.3)$$

By multiplying it by OG and subtracting the result from the current budget balance, the value of CAB is obtained without the influence of cyclical deviations.

The European Commission's model for estimating and calculating potential GDP uses the two-factor Cobb-Douglas production function with a unit elasticity of factor substitution. Formally, potential GDP is represented by a combination of the factors of production - labor (optimal level of employment) - L and capital (capital base) - K, which are adjusted for the degree of utilization ($U_L$, $U_K$) and smoothed by efficiency ratio ($E_L$, $E_K$):

$$Y = (U_L EE_L)^{\alpha} - (U_K EE_K)^{1-\alpha} = L^{\alpha} K^{1-\alpha} TFP \quad (1.4)$$

where TFP is the total factor productivity, which summarizes both the degree of use of the input factors and their technological level (D'Auria, et al., 2010).

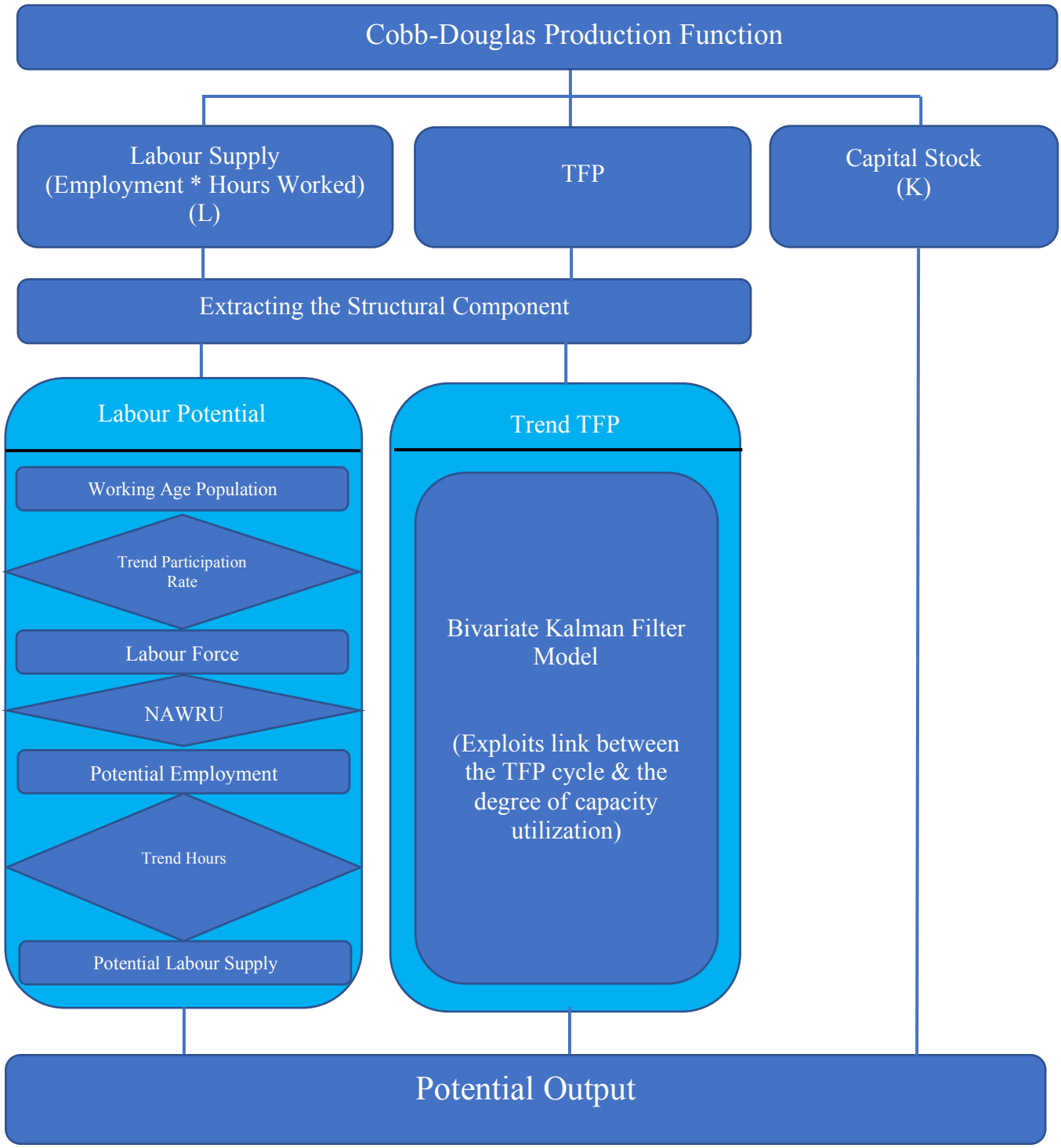



**Figure 1.** A method for calculating potential GDP using the Cobb-Douglas production function

The technical specification of the model used by the European Commission can be presented in the following form:

**NDEPENDENT (EXOGENE) VARIABLES**

- POPW - (Population of Working Age)
- PARTS - (Smoothed Participation Rate)
- NAWRU - (Structural Unemployment)
- IYPOT - (Investment to Potential GDP Ratio)
- SRK - (Kalman Filtered Solow Residual)
- HOURST – (Trend, Average Hours Worked)

**DEPENDENT (ENDOGENE) VARIABLEИ**

- LP - (Potential Labour Input)
- I - (Investment)
- K - (Capital Stock)
- YPOT - (Potential Output)

1. **POTENTIAL LABOUR INPUT**

   LP = (POPW *PARTS *(1− NAWRU))*HOURST

2. **INVESTMENT AND CAPITAL**

   I = IYPOT *YPOT

   $K = I + (1-dep)K(-1)$[10]

3. **POTENTIAL OUTPUT**

   $YPOT = LP^{0.65}K^{0.35}SRK$

4. **OUTPUT GAP**

   YGAP = (Y/YPOT −1)

(Havik, et al., 2014).

**The second type of models** is a DSGE (Dynamic Stochastic General Equilibrium) model with a detailed specification of the equations affecting fiscal variables, characterized by a structural representation of automatic changes in budget revenues and expenditures (Masten & Gnip, 2016).

The main advantage of this model is the structural representation of the elements of the fiscal policy, while in the first type, according to the methodology of the EC, an attempt is made to empirically establish the transmission mechanism of the fiscal policy in an unstructured way. At the same time, precisely due to the introduction of these structural elements in a DSGE model, the impact on any variable is carried out in full interdependence and interaction with all other variables, in this case between the state budget and the private sector.

DSGE models also make it possible to trace empirically the consequences on the economy of a series of structural shocks. Through the simulation of such shocks, the macroeconomic sustainability of an economy and especially its fiscal position sustainability as measured by the condition of CAB, can be tested.

In their working paper, Masten and Gnip compare data from the method used by the EC and that from using their DSGE model. Based on a comparison between the two approaches – that of the EC and that using a DSGE model, described in detail in (Masten & Gnip, 2016), it can be concluded that the EC methodology considers a significant part of the cyclical changes in the budget balance as consequence of discretionary measures of the governments.

**In conclusion, from the comparison of the two models** for determining CAB, namely according to the official EC methodology and the DSGE model, as well as based on the decisions of the EC in relation to the management of the fiscal sustainability of the member states during the health crisis of 2020 - 2021, the question can be raised whether the fiscal surveillance model used by the EC correctly determines the true state of fiscal policy in individual member states and whether it does not send wrong signals regarding a violation of the criteria, according to the SGP, concerning the structural deficit.

## CHAPTER II. EMPIRICAL ANALYSIS OF ERRORS IN BUDGET FORECASTS

One of the main challenges in the management of public finances is the confrontation with the traditional difficulties for adequate forecasting of budget revenues and their components. There is usually always a difference between the forecast and the reported data at the end of the period. This difference is generally due to an overestimation or underestimation of economic activity. In the analysis of these deviations, however, it is important to check whether the differences made are due to completely random, unforeseen and unforeseeable circumstances or are the result of same systematically repeated errors, which may have an even deeper reason for their existence than purely procedural and technical grounds (Mourre, Astarita, & Maftei, 2016).

Bulgaria occupies one of the first places among the countries in the European Union in terms of the errors of its budget forecasts, measured as the difference between the reported budget revenues and their initial forecasts. In its 2013 study on the importance and efficiency of national fiscal frameworks, the ECB places Bulgaria in second place in regard to the size of errors in its budget forecasts, after Estonia, and for the period 2000 - 2011 the discrepancy between forecast and reported budget revenue is 3.5% of GDP, while for the period between 2000 and 2007, i.e. before Bulgaria's entry into the EU, this deviation is 2.3% (ECB, 2013). It should be borne in mind, however, that during the global financial crisis and economic recession of 2008 - 2009, deviations in budget forecasts are drastic.

For this purpose, **in the second chapter the errors that are made over the period 2000 - 2020 in public revenues are estimated**, including the total budget revenues and their components, namely the budget revenues from direct taxes, from indirect taxes and from social and health insurance contributions (SHIC). On the basis of the obtained results, an in-depth analysis of budget

revenue forecasting errors is made, using a set of additional summarised statistics and standard accuracy tests through an econometric analysis aimed at shedding light on the possible drivers of inaccuracies in budget revenue forecasts.

**The methodology** used in the study closely follows that developed in (Mourre, Astarita, & Maftei, 2016), but there are also significant differences due to the scope and period of the study, access to data, and the objectives set.

Based on the results of the econometric analysis, the following **main characteristics** stand out regarding the authenticity of the budget forecasts prepared by the Ministry of Finance:

**First**, the entire study period from 2000 to 2020 is generally characterized by an underestimation of economic development and, accordingly, budget revenues. The brakedown of the errors by sub-periods clearly shows that the underestimation of the potential of the Bulgarian economy happened mainly between 2000 and 2007, before Bulgaria's entry into the EU and before the beginning of the global economic recession. For the period of the economic recession from 2008 - 2010, the budget forecasts follow exactly the opposite pattern, namely a serious overestimation of the economic development and, accordingly, of the expected budget revenues. This pattern continues immediately after the end of the global recession, when in the period 2011 - 2014 Bulgaria experiences suppressed economic development and a slower recovery compared to other EU countries due to typical Bulgarian factors and management faults. The end of this period is marked by the bankruptcy of CTB (Corporate Trade Bank) and a delay in the payment of guaranteed deposits, which blocks a huge monetary resource out of economic circulation. All factors taken together suppresses economic activity. In the period 2015 - 2020, the situation before the global financial crisis repeats and the budget revenues start to be underestimated again, although the amplitude of the error is smaller, but still significant. For the entire post-financial crisis period between 2011 and

2020, the average forecast error is minimally negative at -0.4%, although this value is due to the mutual cancellation of larger negative errors in the 2011-2014 period and almost double the size of positive errors for 2015 - 2020.

**Second**, in terms of which budget items contribute the most to budget forecast errors, it is clear that these are direct tax revenue forecast errors, although the forecasts of the other main budget parameters are also strong. Estimates of revenues from indirect taxes are the second group with the largest deviations, followed by errors in the forecasts of social and health insurance contributions, which are forecast with relatively the greatest accuracy and de facto for the entire period considered, the average forecast error is zero. It is clear that the reason for this interesting result is the mutual annihilation of this error in the different sub-periods of the study. At the same time, in absolute terms, the estimated errors of the revenues from the SHIC, although smaller compared to the other budget parameters, do not differ significantly in their amplitude from them, with the most significant errors again during the first and second sub-periods.

**Third**, with respect to the periods during which forecast errors are the largest, it is clear that they are significantly larger in periods of economic turbulence than in times of economic growth. A particularly drastic discrepancy between forecasts and reported values is observed for direct tax revenues, with the average forecast error for the period of the Great Recession exceeding 10%. In a period of economic growth, the error in the forecasts of direct tax revenues is also significant, which means that not only the errors in forecasting economic activity in general matter, but the opportunities of economic agents to change their tax behavior depending on the economic situation have also an impact, which is probably a consequence of the high share of the gray economy in the country.

**Fourth**, in general, the forecast of tax revenues, which repesent a lower share of total budget revenues is significantly more imprecise and volatile than

the forecast of tax revenues representing a higher share of total budget revenues.

On the basis of the results presented in the second chapter, it can be argued that **Bulgaria's budget forecasts suffer from certain shortcomings related to the persistence of estimated errors, especially in certain sub-periods and bias in the assumptions behind which political motives may be hidden.** The main shortcoming of the budget forecasts is due to a serious underestimation of the country's economic development in periods of economic upswing. During periods of economic decline, such persistence and bias is not observed, although there is an overestimation of the economic growth.

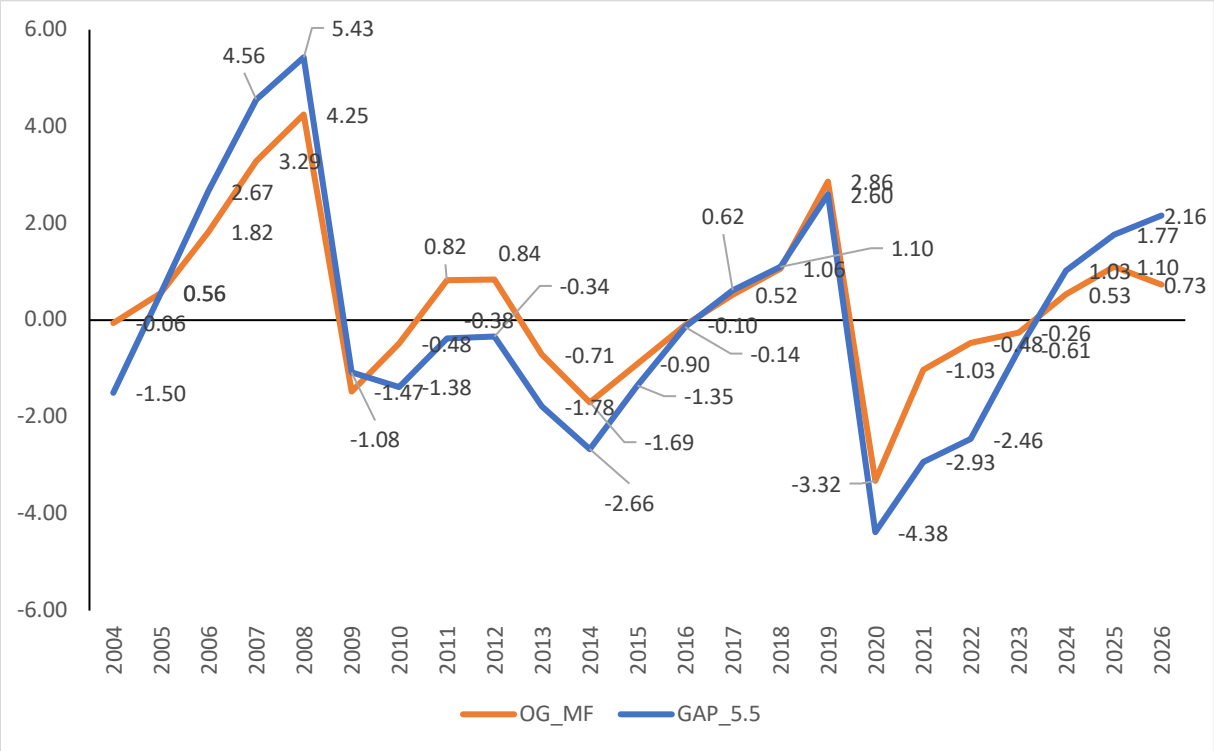
## CHAPTER III. MODEL AND RESULTS OF STREE TEST ON PUBLIC FINANCES

**The cyclically-adjusted budget balance (CAB),** which represents the ratio of budget deficit/surplus to GDP when the economy is developing at the level of its potential GDP, is a key indicator of the state and sustainability of the budget. The level of CAB reflects the government's discretionary actions regarding fiscal policy. At the same time, CAB can be used as a main indicator of the state of public finances when they are subjected to a stress test, assuming a critical deterioration of the main economic parameters characterizing the development of the country.

There is no institution in Bulgaria that uses a Dynamic Stochastic General Equilibrium Model (DSGE). Although such models have been developed at the academic level (Iordanov & Vasilev, 2008) or are in the process of being developed, neither the Ministry of Finance nor the BNB has implemented such a model. In the dissertation the approach chosen to evaluate the sustainability of the public finances is a performance of a stress test on individual economic and financial parameters, in this case CAB and the output gap. A variant of the EC model is applied using the Cobb-Douglas production function. The stress

test is performed through a vector autoregression (VAR) model created in the specialized econometric software EViews, using the built-in Impulse-Response Function (IRF). The results of the calculations of the potential GDP and of the output gap are fully consistent with the results presented in the second chapter.

In the third chapter, **a comparison** is made between the result of the output gap calculations according to the designed model in the dissertation and those from the model of the MoF. The comparison is shown in Figure 2.



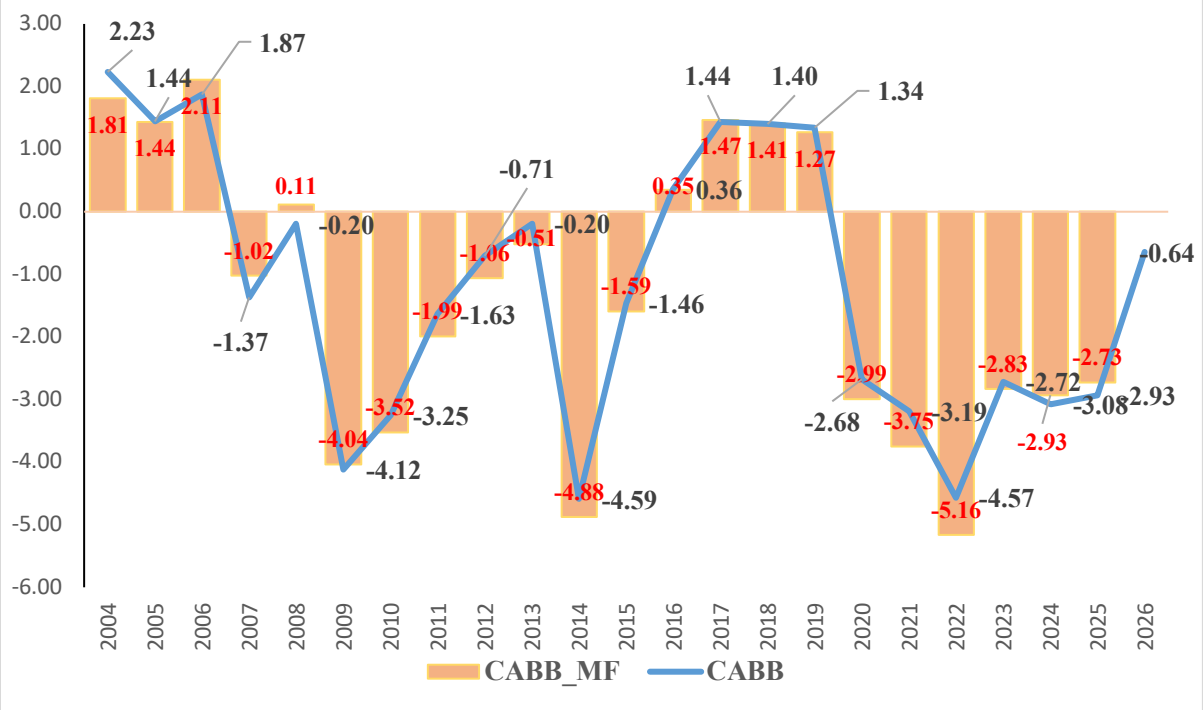

Source: MoF, calculations in R Studio

**Figure 2.** Comparison of estimated output gap from dissertatiomn and MoF models

**The conclusions** that can be drawn from the present comparative analysis between the output gap results of the two models are, **first**, that the model used in the dissertation, although perhaps not as sophisticated as that used by the Ministry of Finance, delivers results that are closer to the real situation and, **secondly**, if the results of the model presented in the study are taken into account, it would possibly stimulate the government to conduct a better

targeted and more calibrated fiscal countercyclical policy than the one it has applied or is about to apply.

Figure 3 shows a comparison of CAB from the model in the dissertation and that from the MoF model.




Source: MoF, calculations of the authir

**Фигура 3.** Cyclically-adjusted budget balance – comparison with the MoF model

**In summary, the main conclusion** that can be drawn from the comparison between results for CAB from the dissertation model and that of the MoF is that the MoF model calls for a more conservative management of fiscal policy in times of crisis, while in times of rapid economic growth it does not imply a tighter anti-cyclical and anti-inflationary policy. This does not seem like a particularly good fiscal policy option from a managerial and political point of view.

**The lag modeling** of the equations of the cyclically-adjusted budget balance and the performed stress test are carried out with the econometric software EViews by building a VAR model and using the Impulse-Response

Function (IRF), which is a characteristic of VAR models and is built into the software. Vector autoregression is a standard tool for analyzing interactions between variables through a stress test and formulating inferences about the development of a system of variables, in this case the dependence of the cyclically-adjusted budget balance on the output gap.

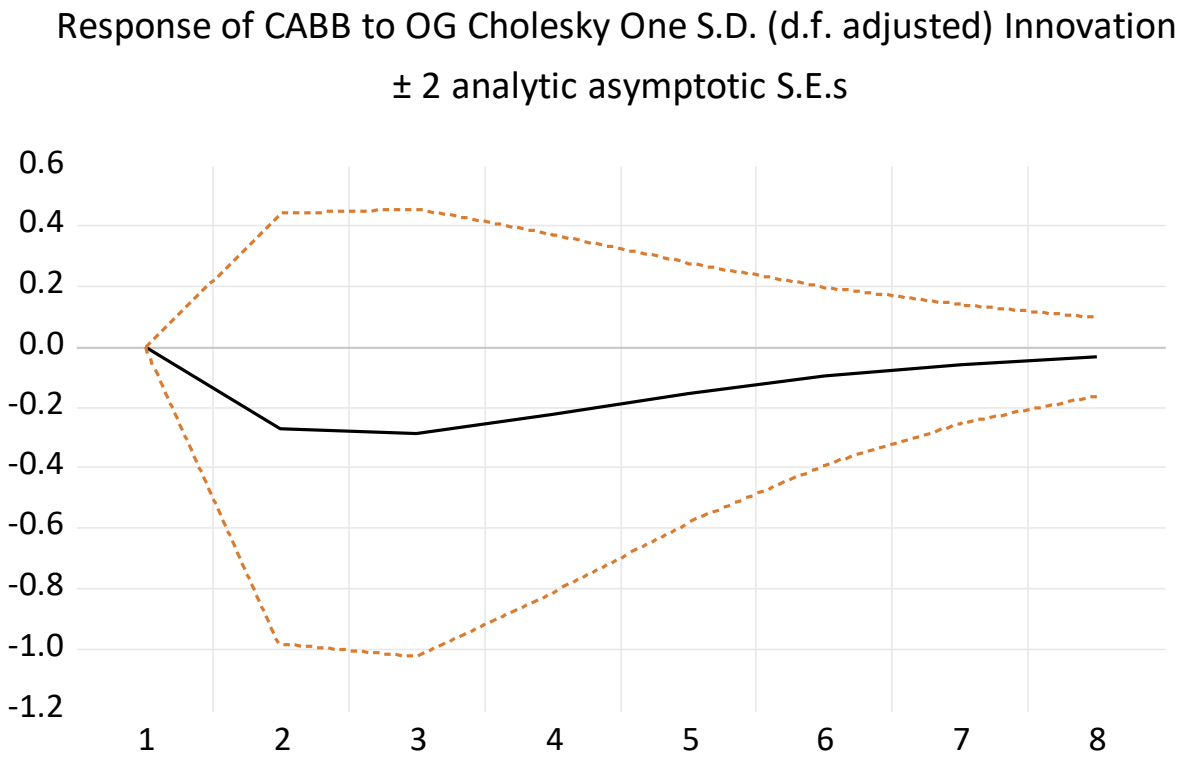



**Figure 4.** IRF of CAB on impact of OG – the dissertation model

Figure 4 presents the graph of the Impulse-Response Function in the model presented in the research, which shows the result of applying a one standard deviation shock to OG and what is the response of CAB to this shock. At least three conclusions can be drawn about the response of CAB under the output gap impact.

**First**, CAB change is more negative when OG alters, and this change appears to be a consequence of discretionary government policy rather than autonomous one. This conclusion is due to the fact that, theoretically, the CAB should change in both directions around zero line during a shock to the OG, since the change in the OG can be both positive and negative.

**Second**, the wide confidence interval does not reject the hypothesis that CAB varies in both directions, although the black solid line is only in the negative field. The probability that the CAB would be above zero is not negligible at all.

**Third**, it should be noted that VAR models require relatively long time series, by the order of 100 or more observations. In the present analysis, the number of observations is 23, which may have biased the results due to the small number. Unfortunately, these are the available data for Bulgaria from the national statistics, used by the models in the country, due to the fact that the values of the variables in the 1990s are unreliable. There is a break in the dynamic rows due to a change in methodology, and several significant revisions have a negative impact on the length of the lines, as the revisions do not cover the whole period back to 1990 and are quite often shorter.

It should be noted that the length of the dynamic rows in the dissertation used to build the current model are the same as those used by the MoF and other institutions, which in turn enables comparability of the results. From this point of view, the results of the MoF model suffer from the same limitations and, as can be seen from Figure 5, are roughly the same as of the dissertation model with the relevant minor differences mentioned below.

Figure 5 shows an image of the IRF of CAB from impact of OG in the MoF model. It is very similar in form to that of the model in the dissertation, but there are three **main differences**.

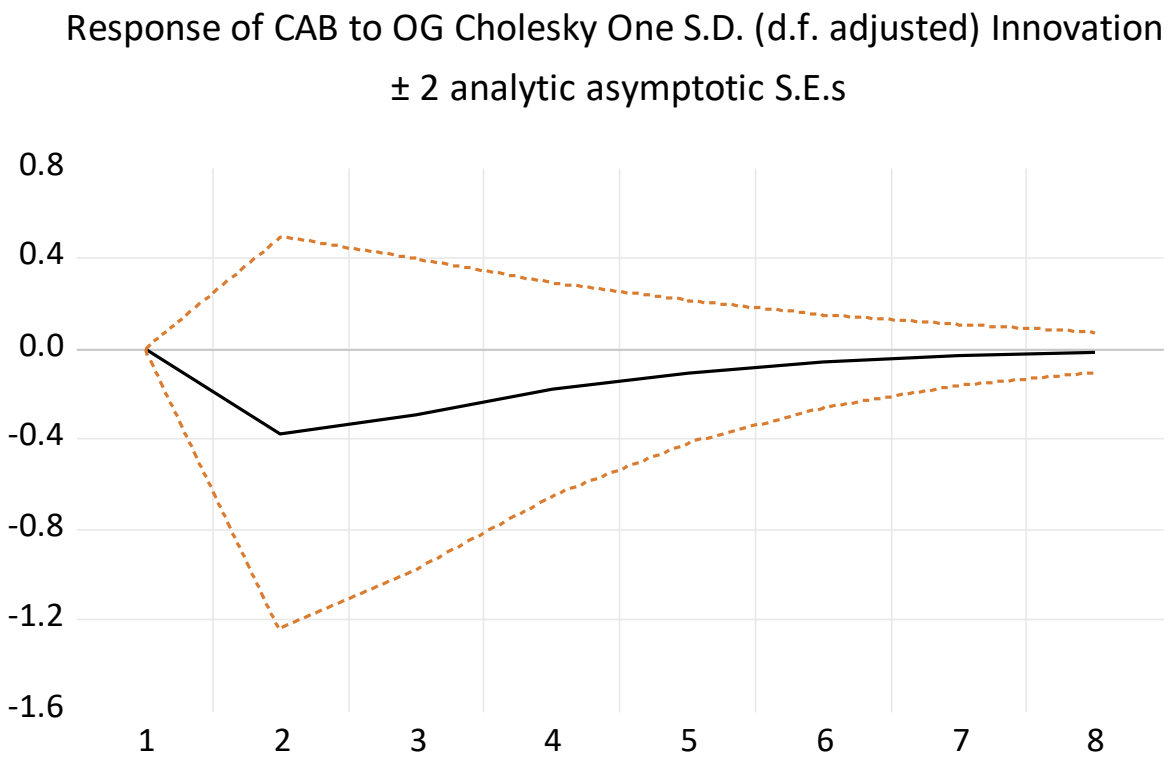



**Figure 5.** IRF of CAB to impact of OG – MoF model

**Firs of all**, the reaction of CAB, when analyzing the solid black line from the shock of the output gap is much deeper, i.e. the CAB reacts much strongly in the negative direction than it does in the dissertation model.

**Secondly**, unlike the steady state in which the CAB remains in the dissertation model between the second and third period, its response in the MoF model does not fall into such state, but accelerates asymptotically to its initial state immediately after reaching its trough level.

**And thirdly**, it can be seen that at the end of the period the CAB is almost at its initial level, while in the dissertation model it remains, although minimally, below its initial state.

It should be pointed out that the 95% confidence interval represented by the dashed red lines lies on either side of the zero axis, the difference with the dissertation model being that the depth of the negative part is slightly greater. From this perspective, **the three conclusions presented above also apply to the result of the MoF model.**

However, it should be noted that this stronger negative reaction of CAB in the MoF model in the initial period also implies a more conservative fiscal policy in periods of crises. This to a certain extent limits the fiscal freedom of action of the government, which is forced in periods of economic decline to conduct a consolidating fiscal policy, which is pro-cyclical and deepens the negative economic processes. A similar approach was observed during the financial and economic crisis of 2008 - 2009. At the same time, the faster expected recovery from the economic shock implies more optimistic forecasts for economic recovery and growth that in turn leads to an overestimation of budget revenues, which is the situation observed in the first years of the recovery from the economic crisis at the beginning of the second decade of the 21st century.

## IV. DIRECTIONS FOR FUTURE RESEARCH ON THE DISSERTATION TOPIC

The dissertation makes an in-depth comparison between the economic models used at both national and EU level for forecasting key macroeconomic and especially fiscal variables, highlighting their advantages and disadvantages. From this point of view, a **challenge** before the state and its fiscal and monetary institutions, as well as before the scientific and academic development of respective theory and practice in Bulgaria, is the introduction of much more modern methods for analysis and forecasting of economic processes, such as Dynamic Stochastic General Equilibrium Models- DSGE, which give a much greater opportunity to calibrate political decisions in the field of fiscal and monetary policy and would definitely be a better prospect for the academic development and expert potential in the country. This is a challenge that deserves efforts at a high state level and mainly at an academic

level in order to improve the scientific and empirical potential for the development of public finance and policies in Bulgaria.

## V. REFERENCE ON THE SCIENTIFIC AND SCIENTIFIC-APPLIED CONTRIBUTIONS IN THE DISSERTATION

**First**. The relevance of the issue related to the application of a stress test on the main macroeconomic categories, in order to correctly forecast and evaluate the main budgetary and fiscal parameters, has been proven.

**Second**. On the basis of studied theoretical propositions regarding the necessity and essence of the models applied in practice globally for forecasting and assessment of a cyclically-adjusted budget balance, the specific characteristics and limitations of their application are derived.

**Third**. From the conducted empirical study of the deviations between the estimated and reported values of the fiscal budgets of the state (Bulgaria) for the period from 2000 to 2020, an in-depth analysis of the reasons that caused the identified deviations is carried out.

**Fourth**. An empirical model for calculating errors in budget forecasts is built and the main reasons for their appearance are outlined.

**Fifth**. Based on the Cobb-Douglas production function, a model for calculating a cyclically-adjusted budget balance is constructed and a stress test is conducted on one of the main macroeconomic parameters to check the reaction of the CAB.

**Sixth**. On the basis of a comparative analysis between the model presented in the dissertation and the MoF model, the credibility of the calculations and results are verified and the reasons for the established deviations between the estimated and reported values of the fiscal budgets are evaluated and analyzed.

## VI. LIST OF PUBLICATIONS OF THE STUDENT

**1. Effects of replacing proportional taxation with progressive taxation in Bulgaria, Yearly almanac "Scientific research of PhD students", volume. XIII, 2020, issue 16, c.255-266**
**https://almanahnid.uni-svishtov.bg/title.asp?title=2648**

**2. Forecast of public finances – deviation of actual performance of Consolidated fiscal programme versus budget act of Bulgaria, Report at the International scientific-applied conference "Sustainable development and socio-economic cohesion in 21 century– trends and challenges“, Svishtov, 8-9.11.2021, vol. 1, pp. 501-508**
**https://dlib.uni-svishtov.bg/handle/10610/4505**

**3. Determinats and theoretical foundations for development of stress testing toolbox of public finances, Yearly almanac "Scientific research of PhD students", 2021, (forthcoming – official notification submitted)**

## VII. REFERENCE FOR COMPLIANCE WITH THE NATIONAL REQUIREMENTS UNDER THE REGULATIONS FOR THE IMPLEMENTATION OF THE LAW ON THE DEVELOPMENT OF THE ACADEMIC STAFF IN THE REPUBLIC OF BULGARIA

National requirement in number of points: 30

Number of articles indexed in NACID: 1 pc.
Number of points from articles indexed in NACID: 10.00

Number of studies indexed in NACID: 1 pc. (in print)
Number of points from studies indexed in NACID: 15.00

Number of reports indexed in NACID: 1 pc.
Author-reported points from scientific reports: 10.00

Total points: 35.00 > 30.00

## VIII. DECLARATION FOR ORIGINALITY OF DISSERTATION

The dissertation consisting of 197 pages under the title: "Lag modeling of public finances through a stress test" is authentic and represents the author's own scientific production. It uses author's ideas, texts and visualization through figures, tables and formulas, and all the requirements of the Copyright and Related Rights Act are observed by properly citing and referring to other author's thoughts, as well as data, including:

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Julian Voynov

PhD student

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