DOI: https://doi.org/10.37075/EA.2025.4.12 Economic Alternatives, 2025, Issue 4, pp. 1219-1230

Impact Assessment of EU Funds in Bulgaria: Characteristics and Evolution of the SIBILA Model

Reeceived: 21.09.2024
Available online: 30.12.2025

Kaloyan Ganev[*], **Ralitsa Simeonova-Ganeva**[**], **Andrey Vassilev**[***]

Abstract

The present study has the following objectives. First, to describe the overall structure and principles underlying the construction of SIBILA, an original macroeconomic model which was developed for Bulgaria's government to assess the impact of EU funds in the country. Second, to provide the details of the main behavioural equations in its latest version. Third, to discuss the approach used in scenario formulation, simulation, and model validation.

To this end, we review the history and evolution of the modelling framework through its three versions. We describe the modelling approach, blocks, and key relationships with a focus on the latest version of SIBILA developed by the present authors. We explain the nature of scenario design and illustrate the main ideas of effects measurement with some simulation results. A sketch of the purpose and nature of the sensitivity analysis performed to test the model is included. We conclude by listing the main areas of application of the SIBILA model and outlining its role for policy. Our assessment points out that it has helped to achieve higher efficiency of spending, as well as to increase the transparency and objectiveness of both ex-post and ex-ante evaluations of plans and programmes.

Keywords: impact assessment, EU funds, SIBILA model, Bulgaria

JEL: E17, E65, H50

Introduction

Bulgaria joined the European Union in January 2007. As a Member State, it became eligible to benefit from EU financial instruments, in particular, the Structural Funds and the Cohesion Fund. Although the availability of these funds was granted, their disbursement and application were conditional on careful programming, policy substantiation, and efficiency and effectiveness considerations. Several major issues arose in this context. First, Bulgaria did not have much experience in the management

[*] Faculty of Economics and Business Administration, Department of Statistics and Econometrics, Sofia University St. Kliment Ohridski, Sofia, Bulgaria

[**] Faculty of Economics and Business Administration, Department of Statistics and Econometrics, Sofia University St. Kliment Ohridski, Sofia, Bulgaria

[***] Faculty of Economics and Business Administration, Department of Statistics and Econometrics, Sofia University St. Kliment Ohridski, Sofia, Bulgaria

of such funds (pre-accession funds were of incomparably small size and were subject to different mechanisms). This implied a lack of historical data to design objective criteria. Second, these considerations concerned not only past developments, but also current and future periods where data are not yet available as a rule. Third, estimates of efficiency and effectiveness based on judgment or simplified (and isolated, i.e. partial) calculations bore the risk of bias and policy misguidance. Therefore, on behalf of policymakers, an objective, broad-encompassing, and powerful tool was required to provide a solid foundation for assessment, planning, and programming.

At the time of accession, there were already good examples of such tools available for other Member States or for the entire EU. More specifically, these were macroeconomic models constructed to address issues such as those mentioned above (e.g. Bradley et al., 2005, or Varga and in't Veld, 2009). However, given that the Bulgarian economy differed notably from those economies (e.g. the presence of a currency board arrangement), the mechanical application of those models implied non-negligible inconsistencies, and therefore, potential imprecision and bias. Therefore, a toolkit that is customised specifically for Bulgaria was required.

Efforts related to creating a comprehensive macroeconomic model for the impact assessment of EU funds for Bulgaria began in 2011. This development was commissioned by the Administration of the Council of Ministers and funded by the EU Technical Assistance Programme. The team consisted of Bulgarian experts with significant experience in macroeconomic modelling, policy assessment, and EU matters, which guaranteed excellent knowledge of relevant local specifics and developments. This corresponded well with the purpose of the project, which was to build the model in such a way that it objectively reflected both the data and the specifics of the Bulgarian economy. The name chosen for the model was SIBILA, an acronym for ***SI***mulating ***B***ulgaria's ***I***nvestment in ***L***ong-Term ***A***dvancement. The model was completed in the same year (Tsvetkov et al., 2011) and its application for governmental purposes began almost immediately. In 2015, the model underwent a major remake, and its version 2.0 was created (Ganev et al., 2015). In 2023, it was further upgraded to version 3.0 (Ganev, Simeonova-Ganeva, and Vassilev, 2023).

The present study has the following objectives. First, to describe the overall structure and principles underlying the construction of SIBILA, an original macroeconomic model which was developed for Bulgaria's government to assess the impact of EU funds in the country. Second, to provide details of the main behavioural equations in its latest version. Third, to discuss the approach used in scenario formulation, simulation, and model validation.

The remainder of this paper is organised as follows. The following section describes the main characteristics of the SIBILA model. As the number of model equations is large and there are differences in specifications across versions, we do not describe each equation or version. Detailed descriptions can be found in the documentation of each version of SIBILA; moreover, macroeconomic identities are trivial, and their explicit listing would be inefficient. Instead, we focus only on the key points of the modelling approach and adhere to the latest upgrades. Next, we outline the simulation approach that underlies the measurement of the impact of EU funds. We explain the nature of scenario design and its relationship with the available information set (past data). Simulation results concerning real GDP are also presented graphically as an illustration of the idea behind the quantification of the effects. A sketch of the purpose and nature of the sensitivity analysis performed to test the model is also provided. The penultimate section outlines the major limitations of this model. The final section lists the main areas of application of the SIBILA model for government purposes and summarises and concludes the paper.

Main characteristics of the SIBILA model

Various approaches, methodologies, and models can be used to analyse the macroeconomic impact of EU funds. Static or dynamic computable general equilibrium (CGE) models such as ECOMOD (Bayar, 2007) are an option. Another option is the use of dynamic stochastic general equilibrium (DSGE) models; the EC QUEST III model is a good example in this respect (Ratto, Roeger, and in 't Veld, 2009). In addition to their obvious common foundation, these two methodologies are deemed to adequately address (at least theoretically) the so-called Lucas critique raised in the 1970s (Lucas, 1976). Their success is grounded in the fact that they derive behavioural relationships from micro-foundations by considering the incentives of economic agents (e.g. households or firms) and then aggregating the results for the entire economy. A third possibility is to rely on a class of models that bear some resemblance to the Keynesian models that dominated the literature and practice until the 1970s. These models are specified as systems of simultaneous equations, some of which are econometrically estimated, whereas others are either manually calibrated or are identities. Notable examples of this class are the HERMIN models (e.g. Bradley and Untiedt, 2007) which have been applied to many 'peripheral' economies, including some of the newly acceded Eastern European Member States. A similar approach is followed in Office for Budget Responsibility (2013). Such models add value to the old Keynesian approach by allowing long-term treatment along with the short term, thus providing both a Keynesian and a classical perspective to the economy. In addition, such models simultaneously capture supply- and demand-side developments. They also have another advantage: they allow for a significant degree of disaggregation, which is often valuable in the policymaking context.

SIBILA is a macroeconomic model that belongs to the latter class. It consists of a system of simultaneous equations that describes a wide range of aspects of the Bulgarian economy. In its first version, there were 170 equations, whereas in versions 2.0 and 3.0 this number increased to 298 and 301, respectively.

Types of equations specified

Three types of equations are used in all versions of the model: macroeconomic identities, manually calibrated behavioural relationships, and econometrically estimated behavioural relationships.

Identities follow theoretical and/or methodological (accounting) considerations to reflect the principles of data aggregation and hierarchical variable relationships. For example, the breakdown of GDP at current prices by final-use expenditure is as follows:

$$Y_t \equiv C_t + I_t + G_t + Ex_t - Im_t,$$

where Y_t is GDP; C_t is aggregate private consumption; I_t is aggregate private investment; G_t is government expenditure; Ex_t denotes exports of goods and services;

and Im_t represents imports of goods and services at time t. For each component, there could be another identity (further breakdown) or specified behavioural relationship.

The manually calibrated behavioural relationships describe linkages that imply responses of a variable to changes in other variables based on well-established theoretical or empirical results, relatively stable ratios, etc. For example, if the minimum wage W_t^m is set administratively as one-half of the average wage W_t, then the equation for the former would be:

$$W_t^m = 0.5W_t$$

The econometrically estimated behavioural relationships draw on the one hand on the empirical correlations among the involved variables that are found in the data, and on theoretical foundations (specifications) and equilibrium conditions, on the other. Specifically, for econometric estimation, the preferred specification of the equations follows the so-called *error-correction form* (Sargan, 1964), which is formally summarised for the case of one independent variable as follows:

$$\Delta y_t = \delta + \alpha(y_{t-1} - \beta_0 - \beta_1 x_{t-1}) + \sum_{i=0}^{p} \gamma_i \Delta x_{t-i} + \sum_{j=1}^{q} \psi_j \Delta y_{t-j} + \varepsilon_t$$

Here, y_t and x_t are the dependent and independent variables, respectively; ε_t is the stochastic error term; and $\alpha, \beta_0, \beta_1, \gamma_i, i = 1, \dots, p$, and $\psi_j, j = 1, \dots, q$ are regression parameters. Equations in this form are referred to as *error-correction models (ECM).* They allow capturing both short- and long-term relationships, thus simultaneously providing the aforementioned Keynesian and classical perspectives to the modelled economy. If it is impossible to apply this form, variables are transformed appropriately (e.g. through differencing).

All econometric relationships are estimated using ordinary least squares, with residuals diagnosed for compliance with the requirements of the classical linear regression model. The variables are transformed by applying natural logs, which allows the interpretation of the regression parameters as elasticities. If heteroskedastic or autocorrelated residuals cannot be overcome by appropriate re-specification and/or re-parameterisation of the corresponding equation, robust (i.e. heteroskedasticity and autocorrelation consistent, or simply HAC) standard errors are used.

Model blocks and key equations

The model is organised into several blocks of equations. Four blocks describe the four main sectors of the national economy: real, fiscal, monetary, and external.

The real sector block specifies the supply and demand sides of the economy. In particular, the supply side is modelled using a Cobb-Douglas production function featuring increasing returns:

$$Y_t = A_t K_t^{\alpha} L_t^{\beta} H_t^{1-\alpha-\beta} T_t^{\xi} R_t^{\psi}$$

Here, Y_t denotes aggregate real output, K_t is physical capital, L_t is labour, H_t is human capital, T_t is technological capital, R_t is infrastructure capital, and α, β, ξ, and ψ are the corresponding production factor elasticities. The variable A_t denotes total factor productivity. It plays the role of a scaling factor and can be thought of as a Solow residual. Increasing returns to scale are provided by the presence of technological and infrastructure capital in the production function. For a country like Bulgaria, where infrastructure improvements are critically important for growth and R&D investment is among the lowest in the EU, such a functional form can be accepted as reasonable, at least for the simulation horizon of the model (until 2030 for version 3.0, and typically with a forward-looking component of less than 10 years).

Equations are also specified to describe the laws of motion of production factors. For physical capital, the permanent inventory method is applied:

$$K_t = GFCF_{t-1} + (1 - \delta_K)K_{t-1},$$

where $GFCF_t$ stands for gross fixed capital formation at constant prices less infrastructure, ICT, and R&D expenditure, and δ_K is the physical capital depreciation rate. A similar mechanism is exploited for infrastructure capital:

$$R_t = Z_{t-1} + (1 - \delta_R)R_{t-1},$$

where δ_R is the infrastructure capital depreciation rate, and Z_t represents investments in other buildings and structures (a variable provided by Eurostat, which has the appropriate content for this purpose). Technological capital accrues (with depreciation accounted for) ICT and R&D expenditure V_t:

$$T_t = V_{t-1} + (1 - \delta_T)T_{t-1},$$

where δ_T denotes the corresponding depreciation rate.

Human capital H_t in the model is identified with educational attainment. The latter is generated according to the relationship estimated for a group of countries in Kyriacou (1991), which links educational attainment with appropriate lags of enrolment rates in primary, secondary, and higher education. We manually introduce an intercept shift (from 0.052 to 1.2) so that the calibrated equation fits the Bulgarian data better. In further simulations, human capital is augmented by the number of vocationally trained workers (including through EU-funded programmes).

The labour production factor L_t is modelled in the labour market block and then used in the production function.

The demand side is represented by equations that reflect aggregate consumption, investment, exports, and imports. The necessary level of disaggregation is applied. Consumption and investment are split into private and public with the aim of tracking the effects of the corresponding financial flows. For real private consumption C_t^{pr}, an ECM equation is estimated, where the independent variable is real aggregate income:[2]

$$\Delta \ln C_t^{pr} = \alpha\left(\ln C_{t-1}^{pr} - \beta_1 \ln Y_{t-1}\right) + \gamma_1 \Delta \ln Y_t + \zeta_1 D_{2020} + \varepsilon_t$$

The coefficient before the dummy variable for 2020 captures the COVID-19 environment this year, both locally and internationally.

For real private investment, a regression in first differences to real output is run, where the two dummy variables in parentheses reflect the recessionary environment in the country following the global economic and financial crisis, known as the Great Recession:

$$\Delta \ln I_t^{pr} = \alpha + \beta_1 \Delta \ln Y_t + + \zeta_1 (D_{2009} + D_{2010}) + \varepsilon_t$$

[2] Note that coefficient notation is generic, i.e., letters are used in other equations, too, but their meanings and values may differ. Likewise, error terms are everywhere denoted by the same letter, but their values are not implied to be the same. Dummy variables are denoted by D_i where the lower index indicates the year(s) for which it takes the value of one. Their purpose is to capture the influence of aberrant observations arising for example from unusual events.

Real exports of goods and services are modelled through an ECM equation, where the long-term relationship is with real output, while in the short term, the variable is influenced by the GDP growth rate of the EU:

$$\Delta \ln Ex_t = \alpha(\ln Ex_{t-1} - \beta_1 \ln Y_{t-1}) + \\ + \zeta_1 D_{2004} + \zeta_2 \Delta \ln Y_t^{EU} + \zeta_3 D_{2009} + \varepsilon_t,$$

where Y_t^{EU} is EU's real GDP.

Concerning real imports of goods and services, in the long term, they are linked to real exports, while in the short term, they are additionally affected by real gross investment:

$$\Delta \ln Im_t = \alpha(\Delta \ln Im_{t-1} - \beta_1 \ln Ex_{t-1}) + \\ + \gamma_1 \Delta \ln Ex_t + \zeta_1 \Delta \ln I_t + \zeta_2 D_{2020} + \varepsilon_t$$

Public (government) consumption and investment are generally treated as policy (exogenous) variables; therefore, no behavioural equations are specified for them (the few exceptions are described in the fiscal block).

The fiscal sector block models budget revenues (such as taxes and nontax revenues), expenditures, balances, and fiscal reserve accounts. Most of these relationships are identities. Some manually calibrated behavioural equations are also used to project variables up to the forecast horizon. The aim is to generate a no-policy-change setup for the baseline. The only exceptions mentioned earlier are interest payments Sp_t^r and Bulgaria's contributions to the EU budget Sp_t^{EU}. The former is modelled by exploiting its correlation with the size of government debt, while the latter obeys a long-term ECM relationship with gross national disposable income Y_t^d:

$$\Delta \ln Sp_t^r = \alpha \Delta \ln GD_t + \zeta_1 D_{2014} + \varepsilon_t$$

$$\Delta \ln Sp_t^{EU} = \alpha(\ln Sp_{t-1}^{EU} - \beta_1 \ln Y_{t-1}^d) \\ + \zeta_1 D_{2010} + \zeta_2 D_{2016} + \zeta_3 D_{2021} + \varepsilon_t$$

The fiscal reserve account in the model behaves according to the following rule. There is a minimum level of the fiscal reserve that is set; if the sum of the fiscal balance and the amount of the fiscal reserve from the previous year falls short of the minimum, a government debt issue is triggered to fill the gap.

The monetary sector block consists of a set of equations that describe the balance of the Issue Department of the Bulgarian National Bank and selected monetary aggregates. Of the monetary aggregates, quasi-money, money outside banks, and overnight deposits are considered. This choice is determined by the need to use these variables in the equations concerning the balance of the Issue Department. In particular, the quasi-money aggregate M_t^q follows an ECM equation, where nominal GDP is the independent variable:

$$\Delta \ln M_t^q = \alpha[\ln M_{t-1}^q - \beta_0 - \beta_1 \ln(P_{t-1}^Y Y_{t-1})] \\ + \gamma_1 \Delta \ln(P_{t-1}^Y Y_{t-1}) + \zeta_1 D_{2020} \\ + \zeta_2 D_{2022} + \varepsilon_t$$

Here, P_t^Y is the GDP deflator (i.e. the product $P_t^Y Y_t$ yields nominal GDP). The 2022 dummy variable corresponds to the unusual inflationary environment in that year associated with increased energy prices and government spending.

Money outside banks M_t^o is regressed in first differences on real GDP, and overnight deposits ON_t are regressed in first differences on money outside banks:

$$\Delta \ln M_t^o = \alpha + \beta_1 \Delta \ln Y_t + \zeta_1 (D_{2009} + D_{2010}) + \varepsilon_t$$

$$\Delta \ln ON_t = \alpha \Delta \ln M_t^o + \zeta_1 D_{2008} + \zeta_2 D_{2020} + \varepsilon_t$$

Concerning the Issue Department liability items, the deposit of the government at the BNB is set as a fixed percentage (90%) of the fiscal reserve, following the observed stable empirical regularity. A similar approach is followed for liabilities to banks, whose level is set to equal a fixed amount plus a fixed share of the sum of overnight deposits and quasi-money. Econometric relationships are estimated only for the Banking Department deposit BD_t and for notes and coins NC_t. For the former, it is an ECM, where the variable is linked to quasi-money in the long term:

$$\Delta \ln BD_t = \alpha\left(\ln BD_{t-1} - \beta_1 \ln M^q_{t-1}\right) + \zeta_1 D_{2009} + \zeta_2 D_{2013} + \zeta_3 D_{2021} + \varepsilon_t$$

For the latter, the linkage with the *Money Outside Banks* aggregate is exploited similarly, with a short-term dependency added:

$$\Delta \ln NC_t = \alpha(\ln NC_{t-1} - \beta_1 \ln M^o_{t-1}) + \gamma_1 \Delta \ln M^o_t + \zeta_1 D_{2007} + \varepsilon_t$$

The external sector block directly borrows the quantitative relationships related to exports and imports of goods and services from the real sector block. It only adds an equation estimated in first differences for gross national disposable income, with real GDP and the GDP deflator as regressors:

$$\Delta \ln Y^d_t = \zeta_1 \Delta \ln Y_t + \zeta_2 \Delta \ln P^Y_t + \varepsilon_t$$

The current account balance is then obtained as the difference between gross national disposable income and the sum of gross nominal aggregate consumption and gross nominal aggregate investment.

In addition, there is a price block in which the Harmonised Index of Consumer Prices (HICP) and all necessary deflators of aggregates are modelled. For the HICP (denoted by P_t), its correlations with international energy prices P^{NRG}_t, the previous year's aggregate real consumption, and its own first lag (capturing inflation inertia) are considered as follows:

$$\Delta \ln P_t = \zeta_1 \Delta \ln P^{NRG}_t + \zeta_2 \Delta \ln C_{t-1} + + \zeta_3 \Delta \ln P_{t-1} + \zeta_4 D_{2022} + \varepsilon_t$$

The private consumption deflator P^{Cpr}_t is regressed (in first differences) on the HICP, whereas the public consumption deflator P^{Cpub}_t follows an ECM relationship linking it to the average nominal wage in the country and the nominal current budget expenditure Sp^{curr}_t:

$$\Delta \ln P^{Cpr}_t = \zeta_1 \Delta \ln P_t + \zeta_2 D_{2022} + \varepsilon_t$$

$$\Delta \ln P^{Cpub}_t = \alpha\left(\ln P^{Cpub}_{t-1} - \beta_1 \ln W_{t-1} - \beta_2 \ln Sp^{curr}_{t-1}\right) + \zeta_1 \Delta \ln W_t + \zeta_2 \Delta \ln Sp^{curr}_t + \varepsilon_t$$

The deflator of gross investment P^I_t, which is used for all types of investments in the model, is linked in an estimated equation to HICP and real GDP as follows:

$$\Delta \ln P^I_t = \zeta_1 \Delta \ln P_t + \zeta_2 \Delta \ln Y_t + \zeta_3 D_{2010} + \zeta_4 D_{2020} + \varepsilon_t$$

The equations estimated for the deflators of exports and imports of goods and services (denoted by P^{Ex}_t and P^{Im}_t) are specified as follows:

$$\Delta \ln P^{Ex}_t = \alpha\left(\ln P^{Ex}_{t-1} - \beta_1 \ln P^{NRG}_{t-1}\right) + + \gamma_1 \Delta \ln P^{NRG}_t + \zeta_1 D_{2006} + \zeta_2 D_{2022} + \varepsilon_t$$

$$\Delta \ln P^{Im}_t = \zeta_1 \Delta \ln P^{NRG}_t + \zeta_2 \Delta \ln Im_t + \zeta_2 D_{2022} + \varepsilon_t$$

The labour market block contains equations that describe labour supply, labour demand, and average wage. Labour supply is identified with the active population (i.e. the labour force) LF_t and is considered a function of labour demand (identified with employment). In other words, labour supply increases when there are more employment opportunities, and decreases otherwise:

$$\Delta \ln LF_t = \zeta_1 \Delta \ln L_t + \zeta_2 (D_{2015} + D_{2016}) + \varepsilon_t$$

Labour demand is a function of real aggregate output, implying that when the economy is in an upswing, it increases; it decreases when the economy enters a slump:

$$\Delta \ln L_t = \zeta_1 \Delta \ln Y_t + \zeta_2 (D_{2009} + D_{2010} + D_{2011}) + \zeta_3 D_{2021} + \varepsilon_t$$

The 2021 dummy variable captures atypical negative effects on unemployment arising from the COVID-19 pandemic. The average nominal wage in Bulgaria is modelled as a function of the unemployment rate u_t and HICP developments:

$$\Delta \ln W_t = \alpha + \beta_1 u_t + \beta_2 \Delta \ln P_t + + \zeta_1 (D_{2007} + D_{2008}) + \zeta_2 D_{2022} + \varepsilon_t$$

The unusually high growth rates of average wages in 2007 and 2008 are modelled through the two dummy variables in parentheses.

Several other blocks either extend the main functionalities or ensure the operation of the above blocks. One describes a small computable general equilibrium model which allows sectoral decomposition of effects by ten economic activities. However, this block is not essential for the core model solution in SIBILA versions 2.0 and 3.0. The other blocks are auxiliary in nature and are related to the importation of data, specification of model scenarios, and model solutions.

Software implementation and data used

The model is implemented in two complementary software environments, EViews and MS Excel. While the former is used for all modelling work, the latter serves as a means of data management and interaction with EViews software code. Starting from version 2.0, the VBA language is used to automate a range of user-related actions.

The model uses a wide range of data indicators and sources. Data from national accounts, supply and use tables, R&D expenditures, demographics, educational attainment, vocational training, and public debt data from the National Statistical Institute and Eurostat are used as inputs. Data on the minimum wage in Bulgaria are extracted from the Council of Ministers regulations. Concerning monetary aggregates, BNB data from monetary surveys, Issue Department balance sheets, and Bulgaria's international investment position are used. The European Central Bank database is the source of euro-dollar exchange rates and the Euribor time series. The IMF WEO database provides data on external environment variables. The consolidated fiscal programme and fiscal reserve account figures are imported from the Ministry of Finance tables. Finally, data on EU funds are obtained from the Information System for Management and Monitoring of EU Funds in Bulgaria and the Ministry of Agriculture and Food.

Scenarios and simulations

After the data are imported and all relationships calibrated, the model is solved in EViews using the Broyden numerical method (Broyden, 1965). EViews also offers the Newton method and the Gauss-Seidel method. The latter was used to solve the 2011 version of the SIBILA model. Two major scenarios are formulated: a baseline scenario and an alternative scenario. In some cases, more than one alternative scenario is specified. In fact, the number of alternative scenarios that can be created is unlimited. The purpose of the baseline scenario is to simulate the observed developments of the Bulgarian economy as closely as possible to provide a basis for comparison. The alternative scenario is designed to create counterfactuals, implying the presence or absence of certain EU funds' financial flows. The differences between the baseline and alternative scenarios constitute measures of the effects of these funds.

The design of the model allows for a significant degree of customisation of alternative scenarios. The software tools built for this purpose provide options to select exactly which funds' effects will be tracked. It is equally possible to assess the impact of all EU funds and to go down to the level of individual operational programmes, priority axes, and even separate policy measures and projects; all combinations of the latter can be run in simulations.

As the different versions of the model were created at different stages of EU membership, the conceptual design of the scenarios also varied. In 2011, when the first version of the model appeared, there was practically no solid historical record of EU funds' investments (disbursements started almost two years after EU accession). Put differently, historical developments implied an economy which was not yet affected by the implementation of the Social and Cohesion Fund (SCF) programmes. Therefore, in this first version of the model, the baseline scenario corresponded to an economy where EU funds were absent. Correspondingly, the counterfactuals (i.e. the alternative scenarios) featured a fictional reality in which those funds were disbursed and channelled accordingly.

At the time of the creation of versions 2.0 and 3.0, there was a significant amount of historical data on the implementation of EU funds. Thus, the conceptualisation of the scenarios was reversed. More specifically, these versions adopted the notion that the baseline scenario would reflect the presence of EU funds, while the alternative would be built to feature a counterfactual state of the economy where there are no such funds.

Figure 1 illustrates the logic behind the comparison of the scenarios and the measurement of the effects that underlie the SIBILA 3.0 model. In this example, real GDP (at constant 2010 prices) is considered. The two curves correspond to the values of

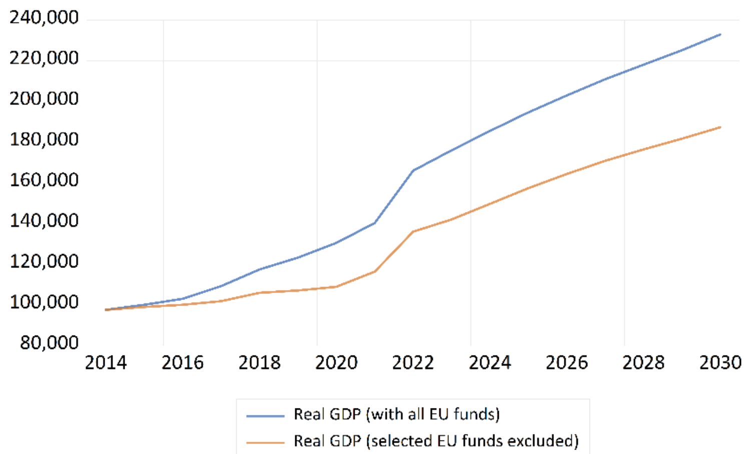

Figure 1. Graphical illustration of baseline and alternative scenarios simulation results for a selected variable

this variable in two instances: one with all EU funds present, and one where selected EU funds are removed. For each year of the simulation period, the difference between the two curves provides a measure of the effect of the corresponding (removed) EU funds.

Such simulations are performed for each endogenous variable of the model, and correspondingly similar graphs can be produced for each variable.

Each version of the model was tested on completion for sensitivity to a range of shocks. The analysis allows us to assess the sensitivity of the results to changes in the underlying modelling assumptions, exogenous variables, and so on. For SIBILA 3.0, the reaction of endogenous model variables to shocks to TFP, fiscal variables (real government consumption and investment financed through resources other than EU money), international energy prices, and real ICT investment were studied. Given the open-source nature of the entire model, users can also attempt other shocks whose effects need to be assessed. Of course, the latter can be done with a range of exogenous variables that play a role in the model.

Major limitations of the modelling framework

SIBILA is a macroeconomic model that works with aggregate relationships. It is subject to the Lucas critique in the sense that these relationships are not derived from microeconomic foundations and rely heavily on past statistical data. At the same time, it should be clear that this limitation is not absolute, as long as the Lucas critique does not offer an ultimate solution. In particular, it is not clear whether microeconomic behaviour can be aggregated in the fashion that is followed by modern macroeconomic literature. Therefore, criticism of this kind would represent in a sense criticism to the state of development of macroeconomic modelling.

Another limitation of SIBILA is that, being a simulation model, it is not suitable for forecasting exercises. Therefore, the simulation results concerning the future should not be treated as forecast values by any means. In addition, it cannot be used for general-purpose policy simulations, as it is customised for one specific type of usage only: that of EU funds investments' (and similar) impact assessment.

Finally, the model cannot assess the effects of policies that allot amounts targeted purely at boosting consumption, while simultaneously having no effect on production. This is because it is generally unclear what such amounts are spent on (e.g. on domestic goods, imported goods, or directed to savings).

Model applications and conclusions

All versions of the SIBILA model have been actively applied by the government for various tasks. The main and incessant one has been to quantitatively assess the impact of the funds corresponding to the first, second, and third programming periods of the EU in which Bulgaria has been involved. It directly stems from the requirement to evaluate past and present efficiency and effectiveness of spending EU funds, but also to program for the future. Regular biannual evaluation reports on the macroeconomic effects of EU-financed programmes have been published on the European Structural and Investment Funds Portal webpage.[3] Another important

[3] https://www.eufunds.bg/en/node/12127.

application was its use in the elaboration of the Bulgaria 2020 National Development Programme, where programming of both the EU and national funds was involved. Concerning the second programming period, the model was particularly useful in negotiating the parameters of the Multilateral Financial Framework at the EU level. It helped considerably to substantiate the position of the Bulgarian government, which eventually managed to negotiate additional funds for the Bulgarian economy. At the government administration level, it enormously facilitated the elaboration of strategic documents and evaluations related to the different operational programmes. The latest version of the SIBILA model was employed to assess the potential impact of the EU Recovery and Resilience Plan on the Bulgarian economy and to optimise the channelling of funds to the most productive uses. Both SIBILA 2.0 and SIBILA 3.0 were used for the purposes of the National Development Programme Bulgaria 2030.

Overall, the SIBILA model has been a key tool for policy programming and formulation. It has been an example of excellent cooperation between government administration, private consultancy, and academia. Likewise, it has empowered decision makers by providing them with a solid understanding of how EU funds operate in the Bulgarian economy and guidance where it would be best to direct them. Furthermore, in addition to helping to achieve higher efficiency of spending, it has added a degree of transparency and objectiveness to both ex-post and ex-ante evaluations of plans and programmes, thus benefiting society.

The evolution of the model over the years is substantial. However, it is a tool that requires periodic updates and improvements to address emerging challenges. There is already a good foundation established by the government in terms of staff and routines to apply it. All accumulated experience points toward the direction of upgrading what has been achieved thus far. The continuity of good practices on the part of policymakers is the key component needed to guarantee it.

References

Bayar, A., 2007. Study on the Impact of Convergence Interventions 2007–2013, Working Paper. ULB/EcoMOD, May.

Bradley, J., Gács, J., Kangur, A., and Lubenets, N., 2005. HERMIN: A Macro Model Framework for the Study of Cohesion and Transition, in J. Bradley, G. Petrakos, and I. Traistaru (eds.), Integration, Growth and Cohesion in an Enlarged European Union, Boston: Springer, 207–242.

Bradley, J., and Untiedt, G., 2007. The COHESION System of Country and Regional HERMIN Models: Description and User Manual, Report prepared for the European Commission, DG-Regional Policy, Brussels, April.

Broyden, C. G., 1965. A Class of Methods for Solving Nonlinear Simultaneous Equations. *Mathematics of Computation, 19*(92), 577–593.

Ganev, K., Simeonova-Ganeva, R., and Vassilev, A., 2023. *Net Impact of EU Funds on Economic Development, 2014-2030. SIBILA 3.0: Methodology, Technical Documentation, Model Manual and Estimated Effects.* Sofia: Sigma Hat. (forthcoming)

Ganev, K., Simeonova-Ganeva, R., Vassileva, I., and Vassilev, A., 2015. *Methodology for Net Impact Assessment of European Funds on Economic Development. SIBILA 2.0: Methodological Framework and Technical Documentation.* Sofia: Ecorys, Sigma Hat.

Kyriacou, G., 1991. Level and Growth Effects of Human Capital: A Cross-Country Study of the Convergence Hypothesis. Economic Research Reports 19-26, C.V. Starr Center for Applied Economics, New York University.

Lucas, R. E. Jr., 1976. Econometric Policy Evaluation: A Critique, *Journal of Economic Theory, 1,* 19–46.

Office for Budget Responsibility, 2013. The Macroeconomic Model, Briefing Paper No. 5. Available online at https://obr.uk/forecasts-in-depth/obr-macroeconomic-model/

Ratto, M., Roeger, W., and in 't Veld, J., 2009. QUEST III: An Estimated Open-economy DSGE Model of the Euro Area with Fiscal and Monetary Policy, *Economic Modelling, 26,* 222–233.

Sargan, J. D., 1964. Wages and Prices in the United Kingdom: A Study in Econometric Methodology, in P. E. Hart, G. Mills, and J. N. Whittaker (eds.), Econometric Analysis for National Economic Planning, London: Butterworths, 16, 25–54.

Tsvetkov, S., Vasilev, D., Ganev, K., Simeonova-Ganeva, R., and Chobanov, P., 2011. *Model for Impact Assessment of the Structural Funds and the Cohesion Fund of the European Union in Bulgaria. SIBILA: Simulation model of Bulgaria's Investment in Long-term Advance, Technical Documentation,* Sofia: Ecorys, CPM, NEWi.

Varga, J., and in't Veld, J. 2009. A Model-based Assessment of the Macroeconomic Impact of EU Structural Funds on the New Member States, Economic Papers 371, European Commission.