Central European Journal of Economic Modelling and Econometrics

Modeling Macro-Fiscal Interlinkages: Case of Georgia

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Submitted: 10.10.2014, Accepted: 7.02.2015

Abstract

The global financial and European debt crises exposed the need for a new approach to fiscal modeling to support decision making analytically. With this purpose, in the following paper we present a macro-fiscal model. By capturing macro-fiscal interlinkages, especially those between fiscal variables and exchange rates, the model enables to analyze various fiscal scenarios with the focus of its impact on debt sustainability and real sector, as well as to conduct forecasting exercises, for small open economies with potentially large share of foreign currency denominated debt in the overall public debt. Finally, the model is applied to Georgian economy to interpret its' historical data, provide an optimal policy path for future and analyze debt sustainability under several stress scenarios.

Keywords: fiscal policy, macro-fiscal interlinkages, new-Keynesian modeling, Bayesian estimation

JEL Classification: E62, E37, C11

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1 Introduction

Recently, the viewpoints of global policymakers regarding the role of fiscal policy, as a countercyclical macroeconomic policy instrument, have changed substantially (see e.g. Blanchard *et al.* 2010). Additionally, the global financial and European sovereign debt crises exposed the need for a more comprehensive analysis of fiscal consolidation and debt-related issues. The crisis revealed that the existing approaches of analyzing debt, which did not include dynamic interrelationships between the fiscal sector and macroeconomic variables, could not provide a comprehensive depiction of the economy. Without these linkages it may lead to incomplete assessment of the reality, as not only macroeconomic factors influence fiscal policy, but fiscal policy determines the macroeconomic environment as well (feedback loops). Hence, the development of an optimal fiscal policy strategy requires the acknowledgement of macro-fiscal interlinkages. Furthermore, previously existing traditional approaches neglected the forward-looking nature of the variables. In order to address these issues, it is necessary to incorporate them into one framework and model them while taking their endogeneity into account. The development of an approach appropriate to these issues has been relatively sluggish for fiscal policy and its development fell behind the models for monetary policy. The following paper aims to create such a framework for countries like Georgia (small open economies where dollarization could be an issue), including the above-mentioned components.

Even though some papers do evaluate debt-sustainability using multivariate statistical models (e.g. Garcia and Rigobon, 2004), they do not provide sufficient tools for fiscal policy scenario analyses, as they are not structural. Also, while there are some studies using structural models for assessing fiscal scenarios, they usually do not take into account important channels for fiscal policy that go through exchange rates. For example, Coenen and Straub (2004), among others, develop a dynamic stochastic general equilibrium (DSGE) model for fiscal policy analysis, however most of their analyses exclude balance sheet effects due to dollarization or use of imported production factors. Also, Konopczyński (2014) presents a general equilibrium model to evaluate fiscal policy that maximizes welfare. His main result is that lower budget deficit and higher share of foreign debt in the overall debt lead to higher welfare. This starkly contradicts with our results and the exchange rate channel is mostly responsible for this.

The impacts of stress scenarios such as economic recessions, monetary and fiscal shocks and exchange rate depreciations, are important components of the analysis. The goal of the stress scenario analysis is to evaluate debt sustainability, the optimal response of fiscal policy and the short, as well as, long-term effects on the economy.

The model is based on DSGE modelling approach and belongs to the class of new-Keynesian models for small and open economies. Even though the model borrows some elements of general equilibrium approach, it is not a theoretical DSGE model itself, as it contains some ad-hoc shortcuts, on top of the microfounded structural equations, for non-Ricardian features, such as crowding-out effect, dependence of risk premium on debt level, etc. Therefore, it is semi-structural, which is characteristic of models intended for practical policy analysis. In order to portray the preferences of policymakers realistically the model also contains non-linear relationships. Models for monetary policy analysis resemble the macro-fiscal model; however, the latter is further enriched with a fiscal block, which is presented endogenously using the pro-/counter-cyclical deficit rule.

The model's microeconomic structure is based on the New-Keynesian approach regarding nominal and real frictions. Additionally, it assumes that the Ricardian equivalence does not hold. This assumption is the key element of the model and implies that the aggregate demand is not neutral with respect to budget deficit. In the case of Georgia, as well as, other developing or developed countries, the Ricardian equivalence may not hold up due to various reasons. The restrictions that exist on the credit and capital markets fail to provide economic agents with the opportunity to react fully to changes in expected income. Hubbard (1997) investigates similar type of capital market imperfections. Also, having a portion of households that follow a rule-of-thumb for consumption decisions give rise to non-Ricardian features. For example, Gali *et al.* (2007) show that these types of consumers do give rise to non-Ricardian effects. Moreover, even without the abovementioned restrictions, it is questionable, whether economic agents would desire to fully react to the expected changes in budget and tax policies. As a rule, it is believed, that there is a significant portion of economic agents in all types of economies, which can be characterized by non-Ricardian conducts. Consequently, we consider the model's assumption regarding non-Ricardian behavior relevant.

The model-based analysis of Georgian economy presented in the paper focuses on the forecasted dynamics of the budget deficit and debt, relative to GDP, considering alternative macroeconomic assumptions. The main result of the analysis states that in order to maintain the debt-to-GDP ratio at a reasonable level (around 35%), it is necessary that the total deficit-to-GDP be reduced to 2.8% in the medium term and 2.5% in the long-term. These results are largely dependent on the assumptions about the potential output growth rate and the inflation target (for the assumptions used for these results see section 4). It is noteworthy, that resulting from a stable level of debt, the reduced risk premiums lead to a drop in interest rates, which in turn decreases the portion of the total deficit spent on interest costs. Analysis also shows that the existence of the transparent debt-to-GDP target ratio is indispensable for debt sustainability, because it enables a synchronized movement of debt and deficit, while positively influencing investor sentiment. Finally, even though the framework can be used to make inferences about aggregate fiscal variables, it does not take certain details of fiscal policy into account, such as, optimal tax rates, budget expenditure effectiveness, optimal distribution among different sectors, etc.

The paper is organized in the following way: Section 2 discusses the advantages of the traditional simple approach for open economies and its limitations regarding the debt sustainability analysis. Sections 3 and 4 present the main model and the historical analysis, while sections 5 and 6 discuss the results of the macro-fiscal forecasts and influences of various macroeconomic stress-scenarios on budget deficit and debt sustainability. Finally, section 7 concludes.

2 Simple analysis and its limitations

As mentioned in the introduction, macro-fiscal models have been developing relatively slowly throughout the world. The amount of information on important fiscal variables that can be extracted using the simple analysis could be one of the reasons for this lag. To illustrate this point, let's evaluate the following debt accumulation equation for an open economy:

$$D_t^d + S_t D_t^f = (1 + i_t^d) D_{t-1}^d + S_t (1 + i_t^f) D_{t-1}^f + (G_t - T_t) \tag{1}$$

where D_t^d stands for domestic public debt in period t, D_t^f – for foreign currency denominated public debt, S_t – nominal exchange rate, i_t^d and i_t^f - domestic and foreign interest rates, G_t – budget expenditures and T_t – taxes collected by the government. Let's $BD_t = \; G_t - T_t$ denote the primary budget deficit, $D_t = \; D_t^d + S_t D_t^f$ – total public debt,

$$\epsilon_t \; = \frac{S_t - S_{t-1}}{S_{t-1}}$$

nominal exchange rate depreciation rate and

$$\mu_t = \frac{S_t \; D_t^f}{D_t}$$

share of foreign debt in total debt. Then, after simple manipulations, (1) can be rewritten in the following form:

$$D_t = D_{t-1} + \epsilon_t \mu_{t-1} D_{t-1} + \left[(1 - \mu_{t-1}) \, i_t^d + \mu_{t-1} \, (1 + \epsilon_t) \, i_t^f \right] \; D_{t-1} \; + (G_t - T_t) \tag{2}$$

Hence, in an open economy, total debt is composed of the debt from the previous period, debt valuation effect due to exchange rate movements, interest costs (which depend on domestic and foreign rates, as well as, on the exchange rate) and budget deficit.

Then, if we divide both sides of the equation by the nominal GDP, we have:

$$\frac{D_t}{Y_t P_t} = \left[1 + \epsilon_t \mu_{t-1} + (1 - \mu_{t-1}) \, i_t^d + \mu_{t-1} \, (1 + \epsilon_t) \, i_t^f \right] \frac{D_{t-1}}{Y_{t-1} P_{t-1}} \frac{Y_{t-1} P_{t-1}}{Y_t P_t} \; + \frac{BD_t}{Y_t P_t} \tag{3}$$

where Y_t is the real GDP and P_t is the GDP deflator. If we denote debt-to-GDP ratio by $d_t = \dfrac{D_t}{Y_t P_t}$ and deficit-to-GDP ratio by $bd_t = \dfrac{BD_t}{Y_t P_t}$ and observe that

$$\frac{Y_{t-1} P_{t-1}}{Y_t P_t} = \frac{1}{(1 + \pi_t) \, (1 + g_t)}$$

where π_t is inflation (the growth rate of the GDP deflator) and g_t is the growth rate of the real GDP, then (3) can be rewritten in its equivalent form:

$$d_t = \frac{(1+\epsilon_t\mu_{t-1}+i_t^*)}{(1+\pi_t)(1+g_t)}d_{t-1}+bd_t \tag{4}$$

where $i_t^* = (1-\mu_{t-1})\, i_t^d + \mu_{t-1}(1+\epsilon_t)\, i_t^f$ is the effective nominal interest rate. Therefore, (4) describes the evolution of the debt depending on the primary budget deficit, the real rate of growth of the economy, interest rates, inflation, exchange rate and the share of foreign debt. In order to determine the level of primary deficit that makes the debt stable, we must remove the time subscript from d_t and assume, that there is no dynamic relationship between fiscal (d_t, bd_t, μ_t) and macro variables (g_t, π_t, i_t^*, ϵ_t) and the latter is exogenously given. In this case, primary deficit that makes the debt level stabilize at a given point d, considering (4), is the following:

$$bd_t = \left(1-\frac{(1+\epsilon_t\mu_{t-1}+i_t^*)}{(1+\pi_t)(1+g_t)}\right)d \tag{5}$$

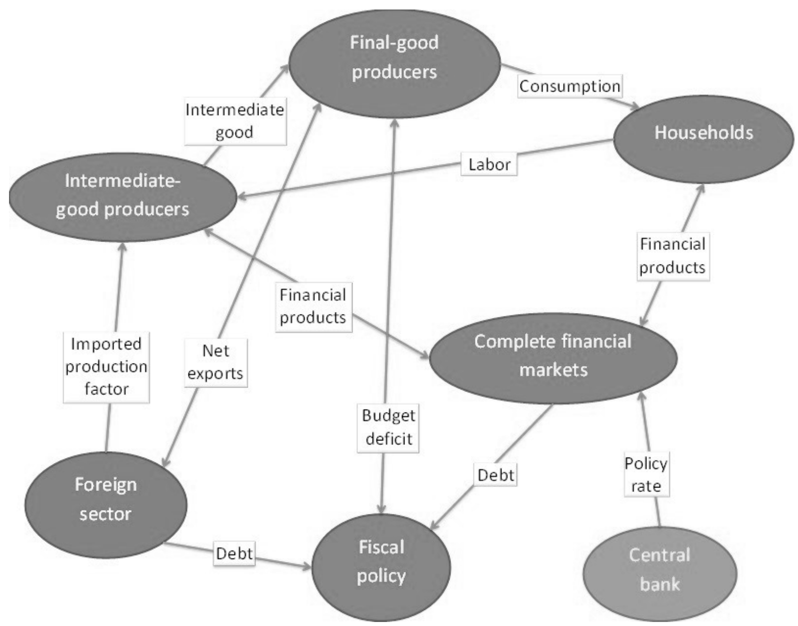
As (5) shows, even in the case of constant primary deficits, it is possible to sustain debt at a stable level, if the nominal rate of growth of the economy exceeds the nominal interest rate and valuation effect for the foreign debt.
Such simple arithmetic analysis possesses many advantageous qualities, however, its' forecasting and fiscal policy analysis abilities are significantly limited. The omission of the relationship between fiscal and macroeconomic factors is one of the main limitations. For example, a stark budget consolidation policy conducted in order to reduce debt, as suggested by this simple analysis, may have an adverse effect on economic activity and change the way budget deficit influences debt. Inversely, if the deficit rises significantly, in an attempt to stimulate total output, it could increase the level of debt and consequently increased risk premiums may limit investment and hamper economic activity. This type of limitation becomes increasingly significant, as we digress from the standard macroeconomic conditions. During these periods, the interrelationships between fiscal and macroeconomic factors become particularly sensitive.

3 Model

The fiscal forecasting and stress scenario analysis discussed in the following sections are based on the macro-fiscal model that is built using the approach developed by Kamenik *et al.* (2013). It is based on the new-Keynesian approach and takes the non-Ricardian behavior of economic agents into consideration. Translating into microfoundations' language the model structure represents households, intermediate- and final-goods producers, competitive financial markets, the foreign and fiscal sectors and the central bank. The mechanism of their behavior is exhibited in the Figure 1.

The fiscal sector in the model is presented using the public debt, which is further decomposed by maturity and currency of denomination, the interest costs on debt, yield curve and budget deficit. The latter includes the structural and total deficits, which differ from each other by automatic stabilizers. Monetary policy determines the refinancing rate according to the Taylor rule, which is based on the inflation forecast, as well as, the output gap.

Figure 1: Microeconomic structure of the model



The aggregate demand and Phillips curve equations are noteworthy components of the New-Keynesian nature of the model. Aggregate demand is presented by the dynamic IS curve, which relates the real interest rates and economic activity. The new-Keynesian Phillips curve presents the aggregate supply side. It determines inflation depending on expectations and output gap, as a measure of real marginal cost. In an open economy, a free movement of capital makes the exchange rate depend on interest rate differential. Therefore, the model determines the exchange rate using uncovered interest rate parity (UIP).

Long-term equilibrium relationships consider such non-Ricardian characteristics as the crowding-out effect and sensitivity of risk and term premiums on the debt level. The main part of the model's microeconomic foundation is similar to the theoretical DSGE models; however, the model also includes some ad-hoc features, the practical characteristics of which are better suited to the peculiarities of the Georgian economy.

This provides the opportunity to increase the quality of forecasts. Therefore, due to practical reasons, we refrain from a lengthy discussion of the model's microfoundations and focus only on its reduced form and its applications.

The main equations that are different from the original model by Kamenik *et al.* (2013) are discussed briefly in the following subsections.

3.1 Fiscal policy

According to the model, fiscal policy determines 1) the structural deficit, which is calculated using a specific rule, 2) debt-target, which is a given value of debt-to-GDP ratio, and 3) decomposition of debt according to maturity and currency.

The model is solved under the assumption of rational expectations among economic agents. Consequently, in order to ensure realistic results, it is important that the public's trust in sustainability of debt around its target is high. Due to the fact that small and open economies are often significantly impacted by external shocks and market participant sentiments, it is not sufficient to merely meet the Maastricht criteria. In this case, in order to gain investor confidence, the level of debt-target must be significantly lower than the upper-bound of debt-to-GDP ratio given by the Maastricht treaty.

In the model structural deficit is defined by the following equation:

$$sd_t = \alpha_t \left(sd_{t-1} + f_4 \hat{y}_t \right) + \left(1 - \alpha_t \right) \; sd_t^{tar} + \varepsilon_t^{sd} \tag{6}$$

where sd_t is the ratio of the (overall) structural deficit to GDP, $\hat{y}_t$ is the output gap, f_4 is a fiscal policy parameter, which defines the cyclicality of the fiscal rule, α_t is a policy preference parameter and ε_t^{sd} is the discretionary shock of the structural deficit. sd_t^{tar} defines the level of overall deficit, which is consistent with the debt target:

$$sd_t^{tar} = \left(1 - \frac{1 + \epsilon_t^e \mu_t^e}{1 + ny_t^e} \right) d_t^{tar} \tag{7}$$

ny_t^e is the expected growth rate of the nominal GDP in the future time periods, ϵ_t^e – expected nominal exchange rate depreciation rate and μ_t^e – expected share of foreign debt, whereas d_t^{tar} is the target debt-to-GDP level. On the other hand, debt-to-GDP accumulates according to the following law-of-motion:

$$d_t = \frac{1 + \epsilon_t \mu_t}{1 + ny_t} \; d_{t-1} + od_t \tag{8}$$

where d_t is the actual debt-to-GDP, od_t – overall deficit-to-GDP and the rest are the same as in the equation (7), but without e superscript, indicating actual values instead of expected.

One of the most important differences between our paper and Kamenik *et al.* (2013) is the inclusion of terms $\epsilon_t^e \mu_t^e$ and $\epsilon_t \mu_t$ in the equations (7) and (8). These terms capture, in our view, very important channel through which exchange rate movements may influence debt-sustainability for countries where foreign currency denominated debt has a high share in overall debt. Thus, the equations (7) and (8) do not overlook the debt revaluation effect resulting from exchange rate fluctuations and follow naturally from the analysis in section 2.

It must be noted, that according to equation (6) the deficit is calculated by taking not only debt sustainability into account but also the business cycle. The fiscal policy follows a counter-cyclical rule if $f_4 < 0$ and pro-cyclical rule if $f_4 > 0$. The model allows for both possibilities, because despite the theoretical arguments against it, we often find pro-cyclical fiscal policy episodes, at least, in developing countries (see e.g. Ilzetzki and Vegh, 2008). Similar types of suboptimal policy is explained by credit limitations, however a much more plausible explanation is political pressure on governments from the public, to increase expenditures during a boom and not during a recession (see Alesina and Tabellini, 2005). Therefore, with strengthening of government institutions, fiscal policy must become more counter-cyclical.

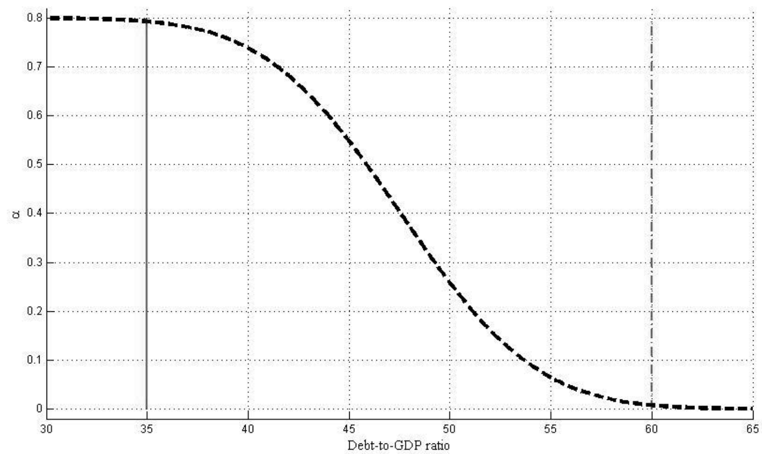
In equation (6), the α_t parameter carries a special importance. It defines what priority the fiscal policy assigns to the business cycle. According to the model, α_t is non-linearly dependent on the level of debt. As debt grows, more attention is paid to the stability of it. Therefore, as long as the debt level is below the target debt level, α_t is high, which means that according to (6), fiscal policy determines the deficit using pro- or counter-cyclical objectives. When the debt level rises above the target, the government starts to prioritize debt sustainability issues, which means that α_t decreases. Functional form for α_t is assumed and calibrated to satisfy the following points: 1) when debt is low, most of the state budget (around 80%) concerns medium-term economic goals; 2) when debt-to-GDP reaches the level somewhere in the region of 35% people start to talk about debt and its dynamics and so do fiscal authorities (like it has been happening in Georgia for the last couple of years) and 3) it is politically (as well as economically) very costly to have debt-to-GDP greater than 60%. For example, Ilzetzki *et al.* (2013) show that debt level as low as 60% could still make fiscal expansion actually contractionary. Specifically, α_t is given by:

$$\alpha_t = \frac{0.8}{2}\, e\left(\frac{d_t - 47.5}{7.5}\right) \tag{9}$$

where, d_t is debt-to-GDP ratio and $e(\cdot)$ is the complementary error function. It is illustrated in Figure 2. As shown in the figure, fiscal policy is increasingly attentive towards the issue of debt if the debt-to-GDP ratio exceeds 35%. Debt sustainability becomes the only priority when the debt ratio reaches 60%. It must be noted that this relationship is just an approximation of reality and is meant to be consistent with the common sense.

It is worth mentioning, that structural deficit is the main fiscal policy instrument in the model. It then gives rise to the total deficit, after adjusting for automatic stabilizer effects. The latter is determined by the business cycle and the debt deviation from

Figure 2: Sensitivity of the structural deficit to the business cycle



the target:

$$od_t = sd_t - f_1\hat{y}_t - f_2\ d_t^{dev} \tag{10}$$

In this equation, od_t denotes the ratio of the overall budget deficit to GDP, $\hat{y}_t$ is the output gap and d_t^{dev} – deviation of debt from its target. The reason why overall deficit may be different from its structural level is that during booms tax collections are high, expenditures (like social benefits) are low and, because of lower debt-to-GDP, interest costs are smaller. The opposite is true during recessions. Why output may deviate from its potential level, in turn, is discussed in the subsection 3.4.

Deficit is financed by borrowing funds from domestic as well as international markets. Specifically, on the domestic market, there are bonds denominated in domestic currency, with maturities of 1, 2 and 5 years; on the international market, there are Eurobonds, denominated in foreign currency. Interest costs to be paid on the domestically borrowed funds are determined by domestic interest rates, whereas the amount to be paid on foreign debt is impacted not only by the interest rates, but also by the exchange rate.

In order to describe the effect of fiscal policy on the economic cycle, the model introduces the notion of fiscal impulse, which is given by the sum of the deviation of the structural deficit from its long-term level (as opposed to its shock as in Kamenik *et al.*, 2013) and shock to the debt target (as a signal to the agents for future deficits).

$$f_t^{imp} = \left(sd_t - sd_t^{tar}\right) + g_1\ \varepsilon_t^b \tag{11}$$

The fiscal impulse influences the aggregate demand depending on the magnitude of the multiplier and introduces dynamics in the output gap (see subsection 3.4). It must be noted, that opinions regarding multipliers in the economic literature are very heterogeneous. Its significance is highly dependent on the characteristics of an economy, like the level of development and the size of the economy, as well as, the exchange rate regime and the level of debt. For example, Ilzetzki *et al.* (2013) document that long-run fiscal multipliers could be as low as -3 (for highly-indebted countries) and as high as 1.4 (in economies with fixed exchange rates). Additionally, the multiplier depends on the type of expenditure as government investments tend to have a higher multiplier than consumption. For example, Baxter and King (1993) show that public investment indeed has a very high multiplier. In the model, we do not differentiate between the multipliers for investment or consumption, and the interpretation of the value used here should be as an average figure consistent with the structure of expenditures in Georgian economy throughout history.

3.2 Yield curve

Interest rates, and generally, yield curves are one of the most important overlaps in macroeconomic and fiscal policy. The model clearly defines the structure of debt maturity. The interest rate on 1-year securities is i_t^1. It is the sum of the monetary policy rate and the time-varying spread. The 2-year interest rate i_t^2 is determined according to the current and expected 1-year interest rates, as well as, the term premium (i.e. combining expectations hypothesis and liquidity premium theory):

$$i_t^1 = i_t + spread_t \tag{12}$$

$$i_t^2 = \frac{i_t^1 \ + \ E_t\left(i_{t+1}^1\right)}{2} + tp_t^2 \tag{13}$$

where, $E_t\left(i_{t+1}^1\right)$ denotes the expected future 1-year interest rate, under rational expectations based on information from the current period. tp_t^2 is the term premium for 2-year securities. The interest rate on 5-year securities is determined similarly.
The interest rate on foreign securities is determined by risk premiums. Specifically, the interest rate on foreign debt is given by:

$$i_t^{fcy} = i_t^f + p_t^{fcy} \tag{14}$$

where i_t^f is the foreign interest rate and p_t^{fcy} - a currency risk premium.
The risk premium, in turn, depends on its long-term equilibrium value and deviation of debt from the level perceived by investors as stable.

3.3 Aggregate supply

On the supply side, inflation is determined by the new-Keynesian Phillips curve. For deriving it from microeconomic principles, one may start from profit maximization problem of the firms operating under monopolistic competition, taking such factors as imported intermediate goods, price stickiness and indexation into account. Moreover, overall inflation includes domestic as well as imported prices:

$$\pi_t = e_1 \ E_t\left(\pi_{t+1}\right) + e_2 \pi_t^{import} + \left(1 - e_1 - e_2\right) \pi_{t-1} + e_3 \hat{y}_t + e_4 \hat{z}_t + \varepsilon_t^{\pi} + \gamma_{\pi,y} \varepsilon_t^{y} \quad (15)$$

Due to unit root in inflation, maintenance of it on its target is the result of monetary policy, which is achieved by satisfying the Taylor principle. Using imported intermediate goods in the production function introduces real exchange rate $\hat{z}_t$ in the Phillips curve and in this regard the equation differs from the corresponding one in Kamenik *et al.* (2013). Additionally, supply ε_t^{π} and technological progress ε_t^{y} shocks also affect inflation.

3.4 Aggregate demand

In the model, the demand side is presented by the dynamic IS curve, which relates economic activity and real interest rates. The relationship could be derived from standard microeconomic foundations. While Gali (2008) derives the basic dynamic IS equation, Gali and Monaccelli (2005) incorporate foreign economic activity and exchange rate in the equation and Smets and Wouters (2003) introduce sluggishness (i.e. lag) of demand in the equation. On top of that balance sheet effect, which may be important if the economy is dollarized, and fiscal impulse are considered:

$$\hat{y}_t = k_1 E_t\left(\hat{y}_{t+1}\right) + k_2 \hat{y}_{t-1} - k_3\left(\hat{r}_t + \hat{p}_t\right) + k_4 \hat{z}_t + k_5 \hat{y}_t^* + \ k_6 f_t^{imp} + \varepsilon_t^{\hat{y}} + \gamma_{\hat{y},g} \varepsilon_t^{g} \quad (16)$$

Thus, output depends on its expected future and past values, effective real interest rate $\hat{r}_t$, which combines domestic and foreign rates and risk premium $\hat{p}_t$, real exchange rate $\hat{z}_t$, foreign economic activity $\hat{y}_t^*$ and fiscal policy impulse f_t^{imp}. On the shock side, there are demand $\varepsilon_t^{\hat{y}}$ and expected economic activity ε_t^{g} shocks. The latter describes the wealth effect on current demand.

It is worth emphasizing how we define potential output and, hence, output gap. In the literature to obtain output gap, usually it is either estimated with the Hodrick-Prescott filter (i.e. data is pre-filtered to exclude trends before going into structural model) or it is defined as the difference between actual and potential output, where the latter is entirely model-implied (output level in no-frictions economy), which could be as volatile as the actual level itself, like in real business cycle frameworks. Our approach is to take somewhat balanced approach and we define potential output as fairly heavily depended on its past value but also determined by the long-term real interest rates, as a proxy for crowding-out effect. It could also be hit by some shocks, like in times of crises, which change potential activity and have long-lasting effects. Finally, the equation for the potential output is fed into the Kalman filter along with the rest of the structural equations. In this way potential level is estimated both as a smooth function of time, like in HP filter, and as a level consistent with the structure of the model economy, like in RBC literature. Therefore, actual output may deviate from its potential level because of short-term shocks, that affect actual values but not

potential, as well as long-term shocks, that first affect potential and only than actual activity. Similar approach has been used by Cayen *et al.* (2009).
In addition to the main equations discussed above, the model contains various other equations, some of which are identities and some are other structural equations (e.g. imported inflation with the Balassa-Samuelson effect, Taylor rule for the monetary policy, UIP equations for nominal as well as real exchange rates). A part of the equations are exogenous by nature, but technically they are given by simple autoregressive processes. This relates to the non-essential variables, which are not the focus of the analysis and including them endogenously within the model will not have any practical advantage. For the full list of these remaining equations see Kamenik *et al.* (2013).

4 Calibration and historical analysis

For countries such as Georgia or generally, developing countries, which are going through significant structural changes in a short period of time, it is difficult to evaluate the model using a classic econometric approach. In some cases, data is not available or covers a short period, which stemming from the size of the model, provides insufficient basis for purely empirical research.
In this case, the advantage of a calibrated model is evident. In addition to the scarcity of historical data, which determines the superiority of calibration, it is important to consider, that there is a significant amount of knowledge accumulated in the field of economic modelling over the past two decades.
Our approach is to calibrate the main part of the structural parameters and to use the Bayesian estimation technique for the rest. The latter is mostly used to evaluate standard deviations of shock and persistence parameters. Additionally, in order to incorporate country specific fiscal policy better in the model, parameters surrounding the fiscal sector are estimated using the Bayesian techniques as well. Documentation and detailed results of estimation are delegated to appendix A.
Fitting the model to historical data and observing its dynamic characteristics is the next stage of the estimation process. Kalman filter is used for this purpose, which identifies unobserved variables and shocks.
After estimating the model using the Georgian data it can be seen in Figure 3 that economic growth was above the estimated potential level and excess demand was positive during 2005-2007. From the present point of view, this is well in line with the intuitive perception of that period. Additionally, after the war and global financial crisis, recession in 2008-2009 is remarkable, implying that the model adequately evaluates these events. Historical analysis shows a decrease in the potential output by 2 percentage points, following the global financial crisis, which is also observed in many other countries.
Figure 4 shows the estimation results for fiscal variables. Overall deficit and debt are observables in the model, whereas structural deficit, deficit consistent with the debt

target and the hypothetical level of debt target itself are estimated using the Kalman filter. Firstly, as was expected, the biggest difference between the structural deficit and actual overall deficit is during 2007-2010; which is related to a boom and then a crisis period. This difference is due to automatic stabilizer that reduces the overall deficit during the boom and the other way around during the recession. Additionally, the structural deficit dynamics correspond to the Bayesian estimation results for f_4 parameter (see Appendix A), which indicates the pro-cyclical nature of the fiscal policy.

The hypothetical level of debt target estimated by the model starts to decrease in 2008 and goes down to 35%. This development influences the corresponding deficit level, which, as estimated by the model, also decreases by 2 percentage points until 2013.

In addition to dynamics of deficit itself, the factors that determined that level of deficit are also interesting. Figure 5 shows the decomposition of the overall deficit; the blue line is the deficit and the colored bars depict its decomposition. As the result shows, the automatic stabilizer influences the deficit significantly, when output diverges from its potential level. Additionally, a high debt target pushes deficit levels to rise. However, the main determinant of the overall deficit is structural deficit, which is in turn influenced by several other factors.

Decomposition of the structural deficit is shown on Figure 6. In addition to the abovementioned observations, the structural deficit shock plays an important role in determining the fiscal impulse. Even though the parameters governing the structural deficit rule were estimated empirically (by Bayesian approach) the deficit still does not tend to follow a specific rule. This implies that fiscal policy often took discretionary measures as a response to current events.

Finally, it is also interesting to see what variables influenced output and how it was affected by the fiscal impulses. Figure 7 shows similar decomposition for output (blue line). In 2007-2009, demand shock was the main cause of the low level of output compared to its potential, which corresponds to a boom-bust picture. Additionally, demand shock raised the output growth in 2011-2012 and marginally depressed it in 2013. Thus, it could be seen as the most important driving force of the model. The real interest and exchange rates play relatively small roles, however, their counter-cyclical effect points to the monetary policy playing macroeconomic stabilizer's role. Global economic activity had a positive effect until 2008 and a negative influence afterwards. It implies that the foreign economic activity was very important for the Georgian economy, which is a characteristic of small open economies. Fiscal impulse had a significant impact on economic activity as shown in the decomposition by the model. The largest negative contribution was in 2004 (1.9 pp of output gap) and the largest positive one in 2009 (1.6 pp of output gap). The former was the result of new fiscal consolidation strategy after the Rose Revolution in Georgia, which addressed high level of debt at that time, while the latter highlights the fiscal expansion after the financial crisis and the Russian-Georgian war in 2008. It should be noted that this expansion is the exception from the observation of budget pro-cyclicality, since in 2009 deficit played significantly counter-cyclical role and it is reflected in structural deficit shock in that period (see Figure 6).

Figure 3: Output gap and growth rates

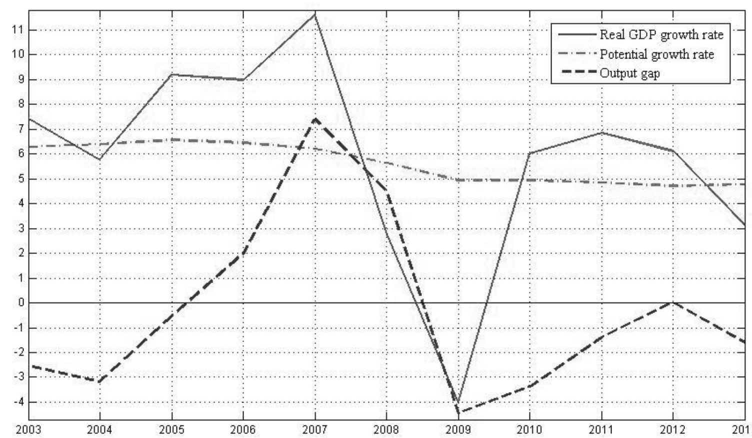


Figure 4: Budget deficit and debt

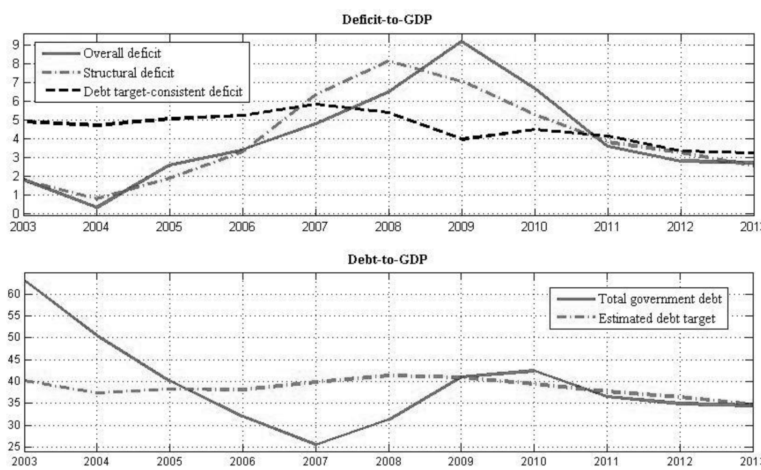


Figure 5: Overall deficit and its decomposition

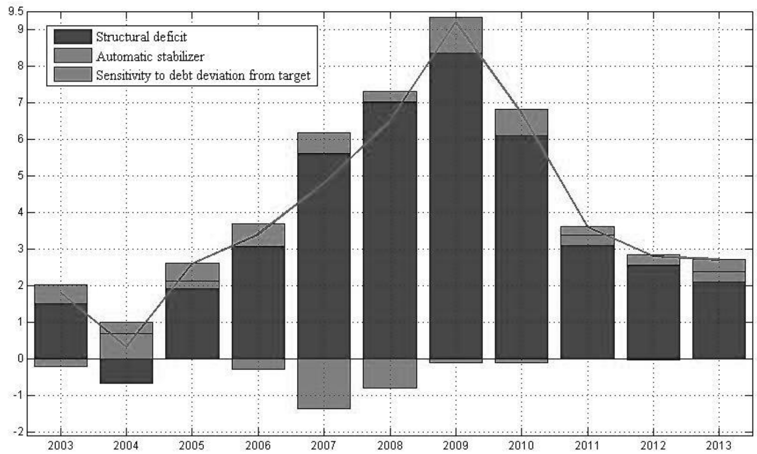


Figure 6: Structural deficit and its decomposition

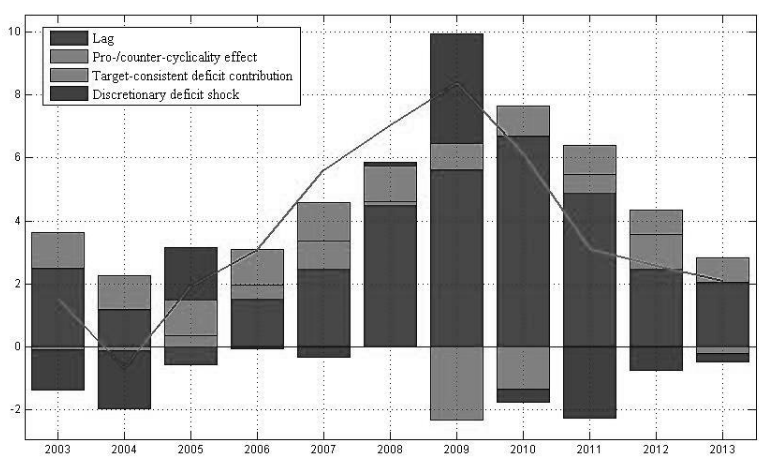
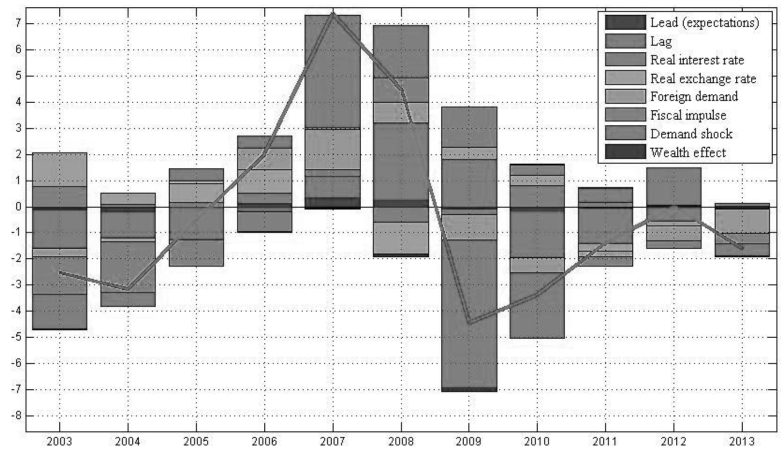


Figure 7: Output gap and its decomposition



5 Forecasting and fiscal policy analysis

The macro-fiscal model, used in the paper, provides an opportunity for forecasting and analyzing macroeconomic scenarios. Specifically, forecasting involves the evaluation of the budget deficit and debt dynamics for the future under a set of assumptions for the short- medium- and long-term periods. Deficit is set according to the specific rule, parameters of which are determined based on historical analysis. In order to introduce the model in practice and improve it for fiscal policy analysis, it is important that the viewpoints of policymakers be fully represented in the model's parameters, as well as, in the corresponding assumptions of the forecast. This research provides a baseline framework, which can be adapted and suited to specific institutions, according to necessity.

As usual model forecast is based on some assumptions. The main ones here are: initial conditions, current short-term forecasts (or nowcasts), the forecast of the foreign sector and the long-term equilibrium values. Initial conditions represent the evaluation of the current period economic cycle, which are estimated using the Kalman filter based on historical data. Current short-term forecasts include the 2014 level of the budget deficit and inflation. The forecasted output gaps of trade partners are relevant when considering the foreign sector (here we use Eurozone output gap forecasts by IMF), while long-term equilibrium indicators carry even more importance, such as the potential GDP growth rate and central bank's inflation target. The forecast's main assumptions are:

1. Overall deficit-to-GDP in 2014 is 3.7%. This is in line (at the time of writing) with the planned budget deficit by the Georgian fiscal authority. Worth noting that, since deficit is endogenous in the model, for fixing it to a particular value the following trick is used: the algorithm searches for the most likely values of shocks that will bring deficit-to-GDP to a given level (i.e. combination of shocks that maximizes the log-likelihood subject to the deficit-to-GDP tune for the year 2014).

2. Potential real GDP growth rate in the medium term is 5% and in the long-term it reduces to 4%, in line with convergence. Trend real exchange rate appreciation also decreases from 3% to 1% as a result of convergence. These convergences in steady state values are implemented in the model by applying the following trick: instead of treating steady states of potential growth and real exchange rate appreciation as parameters, they are modeled as random walks with small standard deviations for shocks. This means that whatever the starting values are for these processes, these values continue to be steady states until a one-time shock hits them, which, then, permanently changes steady-states. For example, if we tell the Kalman filter to start with 5% steady state of potential growth and then apply a one-time shock of the magnitude of -1 to it in 10 years' time, it will reduce the potential growth to 4% after 10 years from the first period, but will maintain 5% value until that time. Cayen *et al.* (2009) show that modeling trend growth rates as random walks, clearly defining transitory and permanent shocks and, in general, estimating trends consistent with the model structure can be more efficient than estimating them entirely independently.

3. Inflation target is 5% and in the long-term is gradually reduced to 3%. This is based on the strategy of monetary policy developed by the Georgian monetary authority and published on their webpage. Technically, this is implemented in the model like the previous assumptions.

4. Targeted debt-to-GDP ratio is 35%. This is in line with the "Strategy 2020" constructed by the Georgian government (available only in Georgian) referring to debt-to-GDP less than 40% as reasonable. Also, informal statements indicate that the implicit debt-target of the government is somewhere 35%.

5. Foreign output in 2014-2015 is below the potential level by 2.2% and 1.4%, respectively, according to IMF forecasts (at the time of writing). After 2015 the gap closes gradually at an autoregressive coefficient of 0.5.

Figure 8 shows the forecasts of main macroeconomic and fiscal variables for 2015-2040. From the fiscal variables, the necessary level of deficit to maintain debt on its target is one of the most important. Under the assumptions of the forecast, the acceptable level of the overall deficit in the long-term is around 2.5% of GDP. As the debt level stabilizes around its target interest rates on debt start to decrease gradually in the long-term, which is caused by two factors: i) inflation decreases steadily along with its target ii) low and stable debt reduces the risk premiums. The latter, in turn, influences the long-term interest rate downwardly.

Worth noting, that the above mentioned forecast abstracts from the uncertainty resulting from macroeconomic shocks. This implies that it focuses on the average values of the variables and does not take their stochastic nature into account. In order to include this uncertainty in the analysis, one can simulate various shocks in the model for the future to get a stochastic forecast. Figure 9 shows the fan charts, which represent the stochastic distribution of the forecast. Shocks are generated on the basis of probabilistic distribution, which is in turn based on historical data.

Stochastic forecast shows that, taking the main unexpected events into account, the budget deficit-to-GDP ratio may vary between 2.1-3.4%, which corresponds to fluctuation of debt-to-GDP ratio in 31-38% range. It should be noted, that in the graph each color of the bands represents 20% chance of happening. Therefore, it does not consider extreme cases, some of which are discussed in the next section.

Finally, as part of fiscal policy analysis, it is interesting to ask a question of what happens if the debt target is not trustworthy or transparent and economic agents (incorrectly) think government intends to maintain a higher debt. In this case, investors price higher risk premium in interest rates and, hence, larger part of the overall deficit is diverted to interest costs. Consequently, even though fiscal policy is still able to maintain debt at its implicit target (by reducing primary deficit), the objective is achieved at a higher cost. Therefore, making debt-target public and anchoring debt-expectations plays similar role in fiscal policy as anchoring inflation-expectations - in monetary policy.

Figure 8: Output, deficit, debt and interest rate forecasts

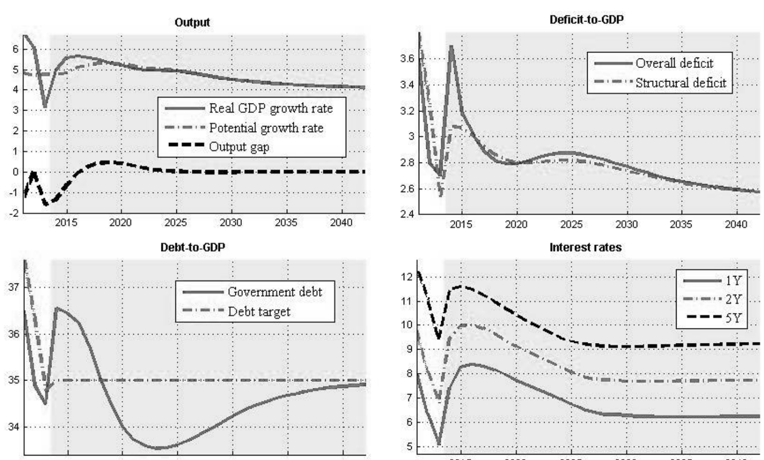
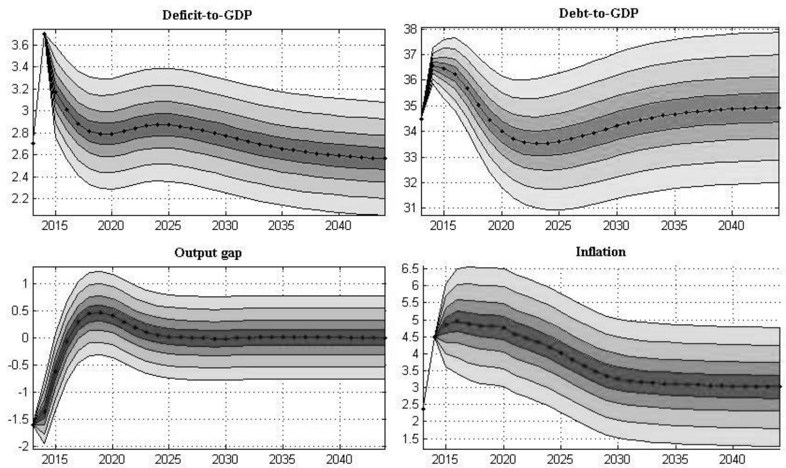


Figure 9: Fan charts for deficit, debt, output and inflation



6 Stress scenario analysis

In addition to forecasts, the model gives an opportunity to study the influence of macroeconomic shocks on fiscal variables. This type of analysis is especially relevant for debt sustainability analysis. Potential investors, as well as, policymakers may benefit equally from evaluating the influence exogenous shocks may have on fiscal variables and what the fiscal policy should look like, in order to minimize the negative consequences.

The analysis uses hypothetical (and arbitrary) assumptions on external demand, country risk premium and exchange rate shocks. Specifically, stress scenarios are:

1. Reduction of the output growth rate in partner countries by 10 percentage points (demand shock). After the impact year growth rates in those countries revert back to normal at an autoregressive rate of 0.5, which means that the shock dies out in about 3 years.

2. Deterioration of a country's (investment) risk premium by 10 percentage points (premium shock). The persistence of this shock is the same as in the demand shock scenario.

3. Depreciation of the currency by 25% (exchange rate shock). Unlike the previous two cases, this scenario is hit by a one-time nominal exchange rate depreciation shock.

Figure 10 presents the results of the stress testing simulations for deficit, debt, exchange rate and output gap.

Assuming that the model economy is a good approximation of reality implies that fiscal policy responses to different shocks suggested by the model are, by definition, optimal, given the objectives of fiscal authorities. Therefore, as the results show, the demand and premium shocks lead to a temporary increase in deficit as part of the optimal fiscal policy reaction, compared to the baseline scenario, which then creates a need for consolidation after the demand recovers. As a result the initially increased debt, which grew to 37-38%, returns to the target level in a few years. In the case of such shocks, the negative output gap closes entirely by 2017. As for the exchange rate shock, in this case the optimal reaction of deficit is to maintain it at a lower level than the baseline scenario for a few years. There are two explanations for this: (I) because a large portion of the debt is denominated in foreign currency, depreciation of the domestic currency increases the debt-to-GDP ratio to 43% on impact and, consequently, there is a need for fiscal consolidation to ensure debt sustainability; (II) with a devaluation of the currency, there is an increase in foreign demand, which influences the output gap positively and provides an opportunity to reduce the deficit more painlessly. Finally, by combining the baseline and exchange rate scenarios, it can be seen that even if fiscal policy does not reduce the deficit after the exchange rate shock (i.e. follows the path from the baseline scenario), the debt level still goes back to its target level. However, that takes an additional 4-5 years.

As the analysis shows, despite the severe shocks, disciplined fiscal policy can fully control the issue of debt sustainability. However, it must be noted, that defeating the shocks does not come without costs. Figure 11 shows the expenditures resulting from the above mentioned shocks, as measured by additional interest costs, relative to GDP and compared to the baseline scenario, that are to be paid on debt.

As can be seen, the largest cost comes from the exchange rate shock. Additionally, despite the fact that debt goes back to its target rate anyways, this type of shock costs additional 4% of GDP spent on debt service, when fiscal policy is not conducted optimally (i.e. when deficit follows the baseline path, even though exchange rate shock scenario was calling for tighter fiscal policy). Finally, during the demand shock, there are no additional funds diverted to debt service, which is the result of eased monetary policy that reduces interest rates as a response to weak economic activity.

7 Conclusions

Fiscal modelling is an important component of fiscal policy analysis. For this purpose, the paper presents a new-Keynesian, DSGE approach-based, macro-fiscal model. Fiscal policy is endogenously presented in the model and its main instrument, the budget deficit, is set according to a certain rule. The approach takes into account the dynamic and stochastic interrelationships between macro-fiscal variables. With the calibrated parameters, the model adequately interprets the historical data. In addition to calibration, Bayesian estimation technique is used, which provides additional empirical ground for parameter values.

In order to illustrate the applied features of the framework presented here, the

Figure 10: Stress scenario simulation results

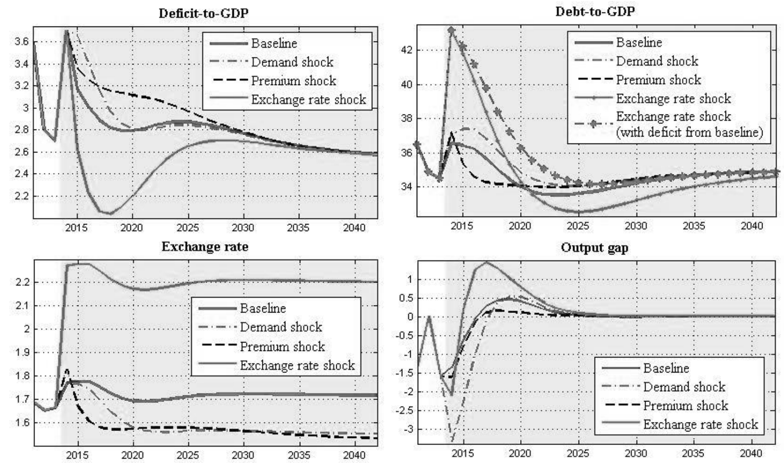
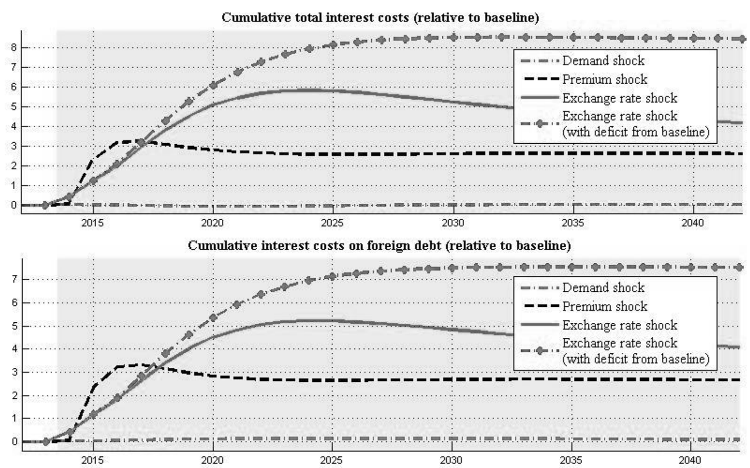


Figure 11: Additional interest costs



paper discusses the fiscal forecast for the short-, medium- and long-run horizons for Georgian economy. The level of deficit that stabilizes the debt around its target is also evaluated. The long-term analysis of the forecast shows that the average overall deficit-to-GDP should be 2.5% - the result largely depending on the potential output growth. Additionally, it is important to analyze the influence of macro stress-scenarios on fiscal variables. Demand, investment risk premium and exchange rate shocks are among the ones discussed. According to the analysis, the demand and premium shocks create a need for an increase in the deficit in the short-run, in order

to neutralize the negative effects on output. However, afterwards there is a need to consolidate for debt sustainability reasons. In case of the exchange rate shock, foreign debt increases significantly on impact, which creates a need for reducing the deficit right away. Foreign debt's high share in the total debt increases fiscal vulnerability with respect to exchange rate, which in turn is partly offset by higher GDP growth due to increased net exports as a result of the weakened currency. The hypothetical stress-scenario analysis shows that if the fiscal policy has a suboptimal response to the exchange rate shock, by setting the deficit as if no shock happened, costs of debt service may increase significantly.
The analysis presented in the paper also points to the importance of the trustworthy debt target, as an essential tool for controlling investor sentiment and risk premiums, that consequently has a favorable impact on interest rates. At the same time, counter-cyclical fiscal policy reduces macroeconomic fluctuations and promotes long-term economic growth.

Acknowledgements

We are very grateful to the anonymous referee for many helpful comments. We also want to thank Mariam Tabatadze, intern at the National Bank of Georgia, for her valuable language and data-related help as well as discussants at the NBG's Department of Macroeconomics and Statistics.
Any errors and omissions remain with the authors. The views expressed in the paper are those of the authors and do not necessarily reflect the views of the National Bank of Georgia.

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A Bayesian Estimation Results

In the process of a Bayesian estimation, data is combined with the prior distribution, with the latter representing both economic theory and expert knowledge. As a result, we have a posterior distribution, the mode of which gives the point estimate of the parameter. Literature on Bayesian estimation has grown rapidly. For example, An and Schorfheide (2007) and Guerrón-Quintana and Nason (2012) provide very good surveys of Bayesian estimation techniques for forward-looking economic models. Given this fact and that this paper uses Bayesian estimation only for a small subset of model parameters, we do not discuss the estimation process into great details. Instead, we emphasize couple of important issues. First of all, Markov Chain Monte Carlo (MCMC) method is used to obtain an approximation to the exact posterior distribution, which is proportional to the product of data likelihood and prior distribution. More specifically:

$$f(\theta|\,Y) \propto f(Y|\,\theta)P(\theta)$$

where $f(\theta|\,Y)$ is the posterior distribution of the parameter vector θ, $P(\theta)$ is the prior distribution, specified by the modeler, and $f(Y|\,\theta)$ is the data likelihood for given parameter values. Secondly, data likelihood is obtained using Kalman filter where model equations are linearized and transformed into state-space representation. Thirdly, for a range of parameter values draws are made from the posterior distribution, which enables us to maximize it with respect to parameter vector and obtain final estimates. Finally, our approach indicates that we emphasize the importance of non-linearities mainly when forecasting and simulating scenarios. If the aim is to estimate parameters based on data that contain major non-linear events, like sovereign debt crisis, then non-linear filters have to be used. For example, Fernández-Villaverde and Rubio-Ramírez (2004) develop a Sequential Monte Carlo algorithm that delivers an estimate of the data likelihood in a non-linear model. Indeed, Fernández-Villaverde and Rubio-Ramírez (2005) show that this approach is superior to standard Kalman filtering if the aim is to better suit the model to the data. Fortunately, Georgian data does not contain the type of events when non-linear effects would be especially active and, thus, our approach focuses on analyzing these types of effects only for forecasting and stress-testing.

As for the statistical data, Table 1 lists the series along with their sources and sample periods used for the estimation procedure. The data is yearly and fed into the model without detrending, since the model estimates the trends with the rest of the structural equations (as described for GDP series in section 3.4).

Figure 12 shows the results of estimating fiscal sector parameters using this approach for f_1, f_2, f_4, k_6, g_1 and the standard deviation of the deficit shock (however, technically the estimation is simultaneous for all parameters). The dashed blue line shows the prior distribution, red line – posterior distribution and green – the point estimate of the variable.

The estimate of the automatic stabilizer parameter f_1 shows that each percentage point increase in output gap leads to a 0.57 pp reduction in total deficit. f_2 shows that deficit is relatively less sensitive to debt deviation from the target. As for the pro/counter-cyclicality parameter, f_4, the estimate shows that the fiscal policy was somewhat pro-cyclical. The latter result is based entirely on data and not on prior distribution, since the prior was $f_4 = 0$, while the posterior is f_4=0.15.
The k_6 parameter estimate (0.6) is more than the prior (0.5). Therefore, data confirms, that the fiscal stimulus is an important determinant of economic activity. Finally, g_1 shows the importance of the debt target for the fiscal impulse. The estimate of the standard deviation of the shock to deficit-to-GDP ratio is 0.33.
Table 2 shows all estimated parameters with their prior distributions (with μ being the mean and σ – standard deviation of the prior distribution).

Figure 12: Bayesian estimation results for fiscal policy parameters

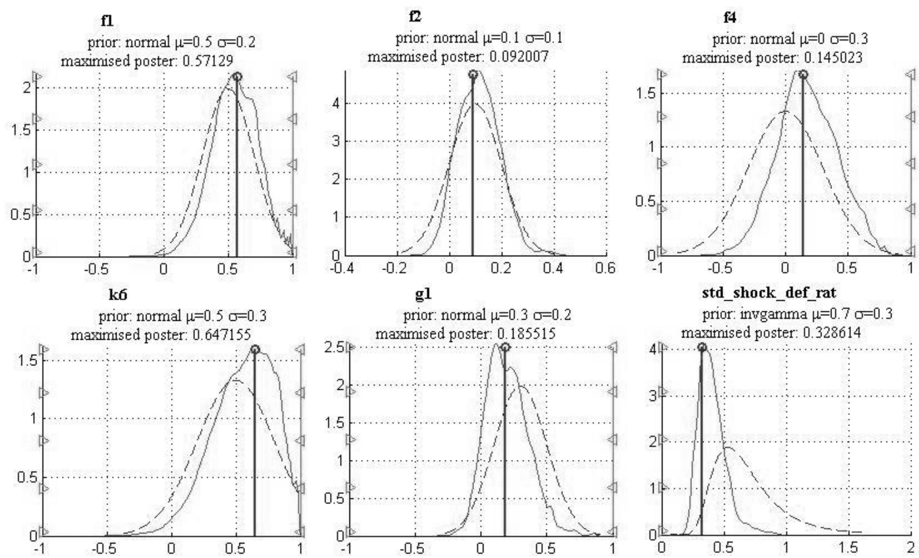

Table 1: Data Used for Estimation

Data	Source	Sample
Real GDP	National Statistics Office of Georgia	2003 - 2013
GDP deflator	National Statistics Office of Georgia	2003 - 2013
CPI inflation	National Statistics Office of Georgia	2003 - 2013
Inflation target	National Bank of Georgia	2009 - 2013
GEL/USD exchange rate	National Bank of Georgia	2003 – 2013
Monetary policy rate	National Bank of Georgia	2008 - 2013
Newly issued 1 year debt-to-GDP	National Bank of Georgia	2009 - 2013
Newly issued 2 year debt-to-GDP	National Bank of Georgia	2010 - 2013
Newly issued 5 year debt-to-GDP	National Bank of Georgia	2011 - 2013
Overall deficit-to-GDP	Ministry of Finance of Georgia	2003 - 2013
Debt-to-GDP	Ministry of Finance of Georgia	2003 - 2013
Interest costs-to-GDP	Ministry of Finance of Georgia	2003 - 2013
Foreign interest costs-to-GDP	Ministry of Finance of Georgia	2004 - 2013
EMBI Georgia sovereign spread	Bloomberg	2008 - 2013
US 3-month interest rate	Bloomberg	2003 - 2013
US CPI inflation	Bloomberg	2003 - 2013
EA output gap (IMF estimates)	Bloomberg	2003 - 2013

Table 2: Bayesian Estimation Results

Parameter	Prior Distribution $Dist(\mu, \sigma)$	Estimated Values	
		Point Estimate	Standard Deviation
f_1	Normal (**0.5** , 0.2)	**0.5713**	0.2882
f_2	Normal (**0.1** , 0.1)	**0.0920**	0.0698
f_4	Normal (**0** , 0.3)	**0.1450**	0.2401
k_6	Normal (**0.5** , 0.3)	**0.6472**	0.1998
g_1	Normal (**0.3** , 0.2)	**0.1855**	0.1004
σ_s	Inv.Gamma (**2** , 0.5)	**1.2761**	0.1382
σ_{dt}	Inv.Gamma (**3** , 0.5)	**2.5816**	0.3483
σ_{sd}	Inv.Gamma (**0.7** , 0.4)	**0.3019**	0.0780
σ_{tp2}	Inv.Gamma (**0.2** , 0.1)	**0.1428**	0.0605
σ_{tp5}	Inv.Gamma (**0.2** , 0.1)	**0.1429**	0.0548
σ_z	Inv.Gamma (**0.3** , 0.2)	**0.1540**	0.0600
σ_y	Inv.Gamma (**0.1** , 0.05)	**0.0699**	0.0340
σ_g	Inv.Gamma (**0.4** , 0.2)	**0.2130**	0.0552
σ_π	Inv.Gamma (**1** , 0.4)	**1.4306**	0.1422
$\sigma_{\hat{y}}$	Inv.Gamma (**1.5** , 0.4)	**0.8497**	0.2532
σ_m	Inv.Gamma (**0.5** , 0.2)	**0.3002**	0.1215
σ_{spread}	Inv.Gamma (**0.5** , 0.2)	**0.3295**	0.1417
σ_{premg}	Inv.Gamma (**0.5** , 0.4)	**0.3807**	0.1047
σ_{premt}	Inv.Gamma (**0.1** , 0.4)	**0.0486**	0.0250
σ_{r*}	Inv.Gamma (**0.5** , 0.3)	**0.2379**	0.0760