I. FISCAL AND MONETARY POLICY INTERACTIONS IN A DSGE MODEL FOR THE ROMANIAN ECONOMY

Alina BOBAȘU[1]
Bogdan MURARAȘU[2]

Abstract

In this paper, we analyze the fiscal and monetary policy interactions using a DSGE model for an open economy. The model is estimated for the Romanian economy using Bayesian techniques and several important simulations are provided to offer valuable answers to the issues: what are the effects of fiscal policy and whether the build-up of government debt matters for the medium-term sustainability of the economy. We find that the accommodative monetary policy plays a significant role in the effects the fiscal policy exerts on the real economic activity. Moreover, the initial public debt ratio matters in model-based simulations and an above 60 per cent public debt makes the economy more vulnerable when cushioning the adverse shocks.

Keywords: fiscal and monetary policy shocks, general equilibrium, fiscal multipliers, accomodative policy, public debt

JEL Classification: C11, D58, E52, E62

1. Introduction

During the 1980's, the RBC model, whose roots may be found in Kydland and Prescott (1982), became a highly important tool for macroeconomic analysis. Specific to these models is the fact that the economy is perfectly competitive and prices adjust immediately. Despite the theoretical consistency, these models became subject to criticism mainly because the main assumptions were the perfect competitive economy and the perfect flexible prices.

Therefore, a new workhouse neoclassical DSGE, namely the New Keynesian (NK) macroeconomic model emerged. As compared to the RBC models, where prices are sticky and perfect competition exists, in the NK models we deal with monopolistic competition and nominal rigidities (firms face costs when adjusting their prices), as well as frictions and imperfections and an active role for monetary policy. Regarding the fiscal policy in these kinds of models, since they primarily focused on real economy shocks, not so much attention was paid to the fiscal instruments. In a classical RBC model, government spending is usually

[1] *Bucharest University of Economic Studies. E-mail: alina_bobasu@yahoo.com. Corresponding author.*

[2] *Bucharest University of Economic Studies. E-mail: bogdan.murarasu@fin.ase.ro.*

financed by lump sum transfers, therefore increasing the government expenditure at present means increasing the lump sum taxes in the future in order to finance the deficits.

The NK model deals with flexible prices and monopolistic competition. For the same reason of presence of forward-looking agents, a government spending shock produces a decline in consumption. Therefore, in their simple form, the NK models miss the Keynesian effect: the positive influence of government spending on consumption. The effects on labour market are quite different from the ones reported in the RBC models. However, there are many DSGE models modified from the standard NK model in order to adjust the response of consumption to a positive fiscal shock, but also the one of the real exchange rates.

The benchmark DSGE models rely hardly on the seminal works of Smets and Wouters (2003), Christiano *et al*. (2005) or Erceg *et al*. (2000) that comprise a wide range of real and nominal rigidities and imperfect competition. In the beginning, the vast majority of them aimed at analysing monetary policy, or more precisely explaining output and inflation dynamics. However, after the 2008 global financial crisis, a lot of DSGE work focused on assessing fiscal policy and its efficiency in stabilizing an economy. Nevertheless, these models were enlarged during the years, by adding, for instance, investment adjusting costs in line with Christiano *et al*. (2005). This way, some of them even developed into large scale models used at analysing more economies simultaneously, such as QUEST III from the European Comission (EC) or the European Central Bank (ECB) New Area-Wide Model.

Most of these studies focused on assessing the implications of active fiscal policy are concentrated on the developed economies, while the literature dedicated to countries from Central and East Europe is rather scarce. A study carried on the Czech Republic economy by Klyuev and Snudden (2011) finds that fiscal consolidation has a reduced effect on output, fiscal multipliers being close to 0.5 in the first year. Muir and Weber (2013) use an empirical approach in order to analyse interactions between fiscal policy and real economy and afterwards calibrate the IMF's GIMF model for the Bulgarian economy in order to assess the impact of future fiscal consolidation measures on the economy. They find that fiscal policy has a relatively small impact on the real output and they conclude that only a transparent fiscal policy can bring the desired results. Benk and Jakab (2012) conduct a thorough analysis of the fiscal consolidation effects on the Hungarian economy using a DGSE model. They show that, just like in most empirical studies, the effects of fiscal consolidation on the key macroeconomic variables are inevitable contractionary. Cem C. (2012) investigates the interactions between monetary and fiscal policy in Turkey using a small-scale DSGE model for an open economy. He finds that fiscal policy has played an important part in stabilizing public debt, but no effects on stabilizing the output gap through fiscal measures were found. Caraiani (2013) estimates an open economy DSGE model for three economies, namely the Czech Republic, Poland and Hungary and concludes that the central banks reacted to the exchange rates movements and that monetary policy was conservative in these economies.

At the same time, there are some important papers focusing on the Romanian economy. Caraiani (2008) uses a DSGE model for the Romanian economy and concludes that domestic shocks have a moderate, but not persistent impact, while supply and interest rate shocks in the euro area have more persistent effects on the Romanian inflation rate. Copaciu *et al*. (2016) develop a DSGE model for the Romanian economy and incorporate additional features as compared to the standard models, such as euroisation and extension to the foreign sector.

The contribution of this paper relies on the following. Using an open economy DSGE model estimated for the Romanian economy, the structural parameters depicting the agents' behaviour within the economy were recovered. The model incorporates a detailed fiscal block and uses a fiscal rule to stabilize the output gap and public debt. Further on, the effects of fiscal shocks on real economic activity and the implications of a high debt on the resilience of the economy in case of adverse shocks are assessed.

The rest of the paper is structured as follows. Section 2 presents the model in a simplified form. Section 3 depicts the calibration and estimation. The main results of the simulations are presented in Section 4 and Section 5 concludes.

2. A Small DSGE Model for the Romanian Economy

The new Keynesian model in this study starts from the model of Benk and Jakab (2012), which relies on the benchmark work of Smets and Wouters (2003) and incorporates nominal rigidities in line with Christiano *et al*. (2005).

The Households Sector

The economy is populated by a continuum of households. Each household has a preference towards consumption and leisure and derives its utility at a certain moment of time, ***t***, from the amount of final consumption and leisure it consumes.

Therefore, the utility function of a representative household is given by the amount of final private consumption it uses, c_t^j, and from leisure utility, where l_t, is the amount of labour provided by a household *j*.

The expected utility function for a household *j* is:

$$\sum_{t=0}^{\infty} \beta^t [(1+\eta_t^c)[(\frac{c_t^j - hc_{t-1}^j}{1-\sigma})^{1-\sigma} - (1+\eta_t^l)\frac{l_t^{1+\varphi}}{1+\varphi}] \quad (1)$$

where: $\beta \in [0,1]$ is the discount factor that discounts the future utility and η_t^c and η_t^l are the preference shocks to consumption and labour, respectively. The habit in consumption is captured by the parameter $h \in [0,1]$, which means that consumption does not changed radically from one period to another, it rather has a certain degree of persistence. The parameter σ is the intratemporal elasticity of substitution, while φ denotes the inverse Frisch elasticity. Both σ and φ are higher than 0.

According to the budgetary constraint, households receive their wages for their work and pay an income tax, τ_t^l. The income they receive is either invested or consumed. Investments are either placed into bonds, B_t for which one receives i_t, or into physical capital for which they receive an income, r_t^k while consumption is subject to a tax, τ_t^c. $u_t(j)$ is the utilization rate of capital for a household *j*, and $\psi(u_t)$ is a function representing the cost of the capital utilization rate and takes the following form:

$$\psi(u_t) = r^k \psi \left[exp\left(\frac{u_t - 1}{\psi}\right) - 1\right] \quad (2)$$

The physical capital accumulation equation is given by:

$$K_t = (1-\delta)K_{t-1} + [1 - \phi_I(\frac{(1+\eta_t^I)I_t}{I_{t-1}})\ I_t \quad (3)$$

Solving the optimization problem yields the following first order conditions for consumption, investment and capital utilization (the Euler equation depicts the consumption dynamics):

$$\lambda_t = \beta(1+i_t)E_t[\frac{\lambda_{t+1}}{1+\pi_{t+1}}] \quad (4)$$

where: λ_t is the marginal utility of consumption and π_{t+1} the inflation rate at time *t+1*.

The other equation derived from the maximization of the utility function of households describes the dynamics of investment:

$$\frac{\lambda_t}{1+\tau_t^c}Q_t\left[1-\phi_I\left(\frac{(1+\eta_t^I)}{I_{t-1}}I_t\right)-\phi_I'\left(\frac{(1+\eta_t^I)}{I_{t-1}}I_t\right)\frac{(1+\eta_t^I)}{I_{t-1}}I_t\right]=$$
$$=\frac{\lambda_t}{1+\tau_t^c}-\ \beta E_t\frac{\lambda_{t+1}}{1+\tau_{t+1}^c}[Q_{t+1}\phi_I'\left[\left(\frac{(1+\eta_{t+1}^I)}{I_t}I_{t+1}\right)\frac{(1+\eta_{t+1}^I)}{{I_t}^2}I_{t+1}^2\right] \quad (5)$$

where: Q_t is the shadow price of capital.

The non-arbitrage condition yields the following equation that represents the choice between physical capital and bonds:

$$\lambda_t Q_t = \beta E_t\lambda_{t+1}[Q_{t+1}(1-\delta)+u_{t+1}r_{t+1}^k-\psi\big(u_{t+1}(j)\big)] \quad (6)$$

The last first order condition reveals the choice of capital utilization:

$$r_t^k = \psi'\big(u_t(j)\big) \quad (7)$$

Production

In the first stage, the intermediate product, v_t, is obtained using a CES production function and two inputs: labour, l_t, and imported inputs, m_t, which are subject to adjustment costs: ρ_1 and ρ_2.

$$v_t = \left(\bar{\alpha}^{\frac{1}{\varrho v}}[(1+\rho_1)^{-1}l_t]^{\frac{\varrho v-1}{\varrho v}}+(1-\bar{\alpha})^{\frac{1}{\varrho v}}[(1+\rho_2)^{-1}m_t]^{\frac{\varrho v-1}{\varrho v}}\right)^{\frac{\varrho v-1}{\varrho v}} \quad (8)$$

$\bar{\alpha}$ being the share of labour used in production and ϱ_v the elasticity of substitution between the two inputs. In the same stage of production, solving the cost minimization problem yields the dynamics for the marginal cost for the intermediate good (9), labour demand (10) and import demand (11):

$$m\_v_t = \left[\bar{\alpha}\dddot{w}_t^{\,1-\varrho v}+\left(1-\bar{\alpha}\right)q_t\dddot{P}m_t^{\,1-\varrho v}\right)\Big]^{\frac{1}{1-\varrho v}} \quad (9)$$

where: $\dddot{w}_t$ is the wage adjusted for adjustment costs with the following expression: $\dddot{w}_t = \frac{(1+\tau_t^S)w_t}{(1+\rho_1)^{-1}-l_t((1+\rho_1)^{-2}{\rho_1}'}$, with w_t being the real wage, and $q_t\dddot{P}m_t$ are the imports prices adjusted for adjustment costs: $q_t\dddot{P}m_t = \frac{q_tPm_t}{(1+\rho_2)^{-1}-m_t((1+\rho_2)^{-2}{\rho_2}'}$ with q_t being the real exchange rate and Pm_t the import prices.

$$l_t = \bar{\alpha}\left(\frac{m\_v_t}{\dddot{w}_t}\right)^{\varrho v}v_t(1+\rho_1) \quad (10)$$

$$m_t = (1-\overline{\alpha})\left(\frac{m\_v_t}{q_t \ddot{P}m_t}\right)^{\varrho_v} v_t(1+\rho_2) \tag{11}$$

Price Setting

Following the Calvo (1983) mechanism, prices are sticky. Only a fraction $1-\gamma_d$ of the firms are able to set their prices in an optimal manner. The rest in proportion of γ_d use a rule of thumb by indexing their prices with past or the perceived trend of inflation, with the degree of indexation being ϑ_d.

The final Phillips curve for the final goods takes the following form:

$$\hat{\pi}_t = \frac{(1-\gamma_d)(1-\beta\cdot\gamma_d)}{\gamma_d(1+\beta\cdot\vartheta_d)}\{mc_t + \xi_t^d\} + \frac{\beta}{(1+\beta\cdot\vartheta_d)} E_t\widehat{\pi_{t+1}} + \frac{\vartheta_d}{(1+\beta\cdot\vartheta_d)}\widehat{\pi_{t-1}} \tag{12}$$

where: ξ_t^d represents the markup shock and mc_t represents the real marginal cost.

The Phillips curve for export prices is written in a similar manner, as exporters set their prices in a Calvo manner, as well as the domestic producers.

External Sector Demand

The demand for export goods (x_t) is given by:

$$x_t = (1+\eta_t^x)\cdot x^* \cdot (P_t^x)^{-\theta^x} \tag{13}$$

where: θ^x is the export price elasticity, x^* is the long-term value of exports and η_t^x is an exogenous shock to demand for exports.

The nominal exchange rate is determined according to the uncovered interest parity:

$$\frac{1+i_t}{1+i_t^x} = \frac{e_{t+1}}{e_t} \tag{14}$$

where: i_t is the nominal internal interest rate at time *t*, i_t^x is the nominal foreign interest rate at time *t* and e_t and e_{t+1} are the nominal exchange rate and the expectations regarding the nominal exchange rate for the next period.

Wage Setting

Following the same *a la Calvo* price indexation mechanism as for prices, unions can re-optimise their wage at a given period with a probability $1-\gamma_w$ when they receive a random signal to change their wages. In the case of a union that does not re-optimise its wage, then it will adjust its wage according to the following rule:

$$W_T(i) = W_t(i)\Pi_{T,t}^{I_w} \tag{16}$$

where: $\Pi_T^{I_w} = \left(\frac{\pi_t^w}{\bar{\pi}_t}\right)^{\vartheta_w} \bar{\pi}_{t+1}$ and $\pi_t^w = \frac{W_t}{W_{t-1}}$ and ϑ_w is the degree of indexation to past inflation and $\bar{\pi}_t$ is the trend of inflation.

The labour market is monopolistic and households are the ones that set wages with a certain mark-up. The wages are set in a Calvo manner, only a proportion, $1-\gamma_w$, being able to set the wages optimally, while the remaining follow a rule of thumb indexation to past inflation, the degree of indexation being denoted by ϑ_w.

The final Phillips curve for wages is then given by:

$$\hat{\pi}_t^w = \frac{(1-\gamma_w)(1-\beta\cdot\gamma_w)}{\gamma_w(1+\beta\cdot\vartheta_w)(1+\theta_w\varphi)}\left\{\varphi L_t - w_t + \eta_t^l + \frac{\sigma}{1-h}(\tilde{c}_t^l - \boldsymbol{h}\tilde{c}_{t-1}^l) + \frac{\tau^c}{1+\tau^c}\tau_t^c + \frac{\tau^l}{1+\tau^l}\tau_t^l + \boldsymbol{\xi}_t^w\right\} + \frac{\beta}{(1+\beta\cdot\vartheta_w)}E_t\widehat{\pi_{t+1}^W} + \frac{\vartheta_w}{(1+\beta\cdot\vartheta_w)}\widehat{\pi_{t-1}^W} \tag{15}$$

where: $\tilde{c}_t^l$ is the weighted marginal utility of the two types of consumers, ξ_t^l is the markup shock and θ_w denotes the labour market elasticity.

Monetary Policy

The monetary authority follows a Taylor rule that responds to inflation, output gap and the exchange rate.

$$\frac{1+i_t}{1+r} = \left(\frac{1+i_t}{1+r}\right)^{\zeta_i} ((1+\pi_t)^{\zeta_\pi} {e_t}^{\zeta_e} {y_t}^{\zeta_y})^{1-\zeta_i} + \eta_t \tag{16}$$

where: ζ_i is the weight on persistence, ζ_π the weight on inflation, ζ_e the weight on the exchange rate and ζ_y the weight on the GDP. η_t is the exogenous monetary policy shock.

Fiscal Policy

The fiscal authorities finance themselves with distortionary taxes on consumption, labour income and social contributions. The budget revenues are therefore considered to be the sum of income tax, VAT and excise duties, social contributions and lump sum taxes:

$$rev_t = pit_t + VAT_t + SSC_t + ot_t \tag{17}$$

where: $VAT = \tau_t^c c_t,\ pit = \tau_t^l w_t L_t,\ ssc = \tau_t^s w_t L_t$. As for the lump sum taxes, the following autoregressive process is assumed:

$$oc_t = \rho_{oc} oc_{t-1} + \varepsilon_{oc,t} \tag{18}$$

Expenditures are the sum of transfers, intermediate consumption and other expenditures:

$$exp_t = g_t + tr_t + oe_t \tag{19}$$

The other expenditure component is an AR(1) process:

$$oe_t = \rho_{oe} oe_{t-1} + \varepsilon_{oe,t} \tag{20}$$

The primary balance is the difference between revenues and expenditures (net of interest payments):

$$ps_t = rev_t - exp_t \tag{21}$$

The fiscal deficit is defined as:

$$t_t = ps_t + \left(\frac{1+i_t}{1+\pi_t} - 1\right) D_{t-1} \tag{22}$$

where: D_t is the government debt computed as $D_t = D_{t-1} + t_t$, this being the debt accumulation equation. t_t denotes the total fiscal deficit, as the primary deficit to which we add the interest payments at time *t*.

For the tax rates, we define the following fiscal reaction function considering that the fiscal authority reacts to the deviation of the current output from its potential level (steady state) and also to past deficit and debt:

$$\hat{\tau}_t^i = \rho^{\tau^i} \hat{\tau}_{t-1}^i + \varphi_{GDP}^{\tau^i} \widehat{GDP_t} + \varphi_T^{\tau^i} \widehat{T_{t-1}} + \varphi_D^{\tau^i} \widehat{D_{t-1}} + \xi_t^i \tag{23}$$

where: $\hat{\tau}_t^i = (pit_t, VAT_t,\ SSC_t)$ represents the vector of the tax rates included in the model.

As for the government expenditure:

$$\hat{x}_t = \rho^x \hat{x}_{t-1} + \varphi_{GDP}^x \widehat{GDP_t} + \varphi_T^x \widehat{T_{t-1}} + \varphi_D^x \widehat{D_{t-1}} + \xi_t^x \tag{24}$$

with $\hat{x}_t = (g_t, tr_t)$.

3. Bayesian Estimation

Certain parameters were calibrated due to identification issues and mainly because estimation depends on the magnitude of the parameters space and, therefore, by estimating only some of them, we avoid dimensionality. In this vein, other studies are consulted to rely on a wide variety of approaches developed either on the Romanian economy or on economies which are similar. Table 1 reports the calibrated parameters.

The discount factor was set to 0.97, which implies a steady state of 3 per cent of the nominal interest rate. The depreciation rate of private capital was set to 3 per cent. The inverse of the intertemporal elasticity of consumption was set at 2, in line with other studies (Storck and Zavacka, 2010; Schmitt-Grohe and Uribe, 2003), while the capital utilization parameter, ψ, was calibrated at 0.5 following the value to which is centered in the study of Smets and Wouters (2007). The investment adjustment cost, φ_{inv}, was set to 4 in line with Copaciu *et al*. (2016). As far as for the other adjustment costs, recall that the intermediate good is produced by using the CES function that uses two inputs, namely labour and imports. These two inputs are adjusted by adjustments costs, ρ_1 and ρ_2, which were set to 3 in line with Baksa *et al*. (2009).

The elasticity of substitution between capital and labour was set at 0.8 and the elasticity of substitution between imports and labour at 0.5. The share of Ricardian households $\bar{\omega}$ was set at 0.4; a value close to the one used in the study of Storck and Zavacka (2010).

As regards the fiscal rules, we estimate outside the model various fiscal type rules and conclude that the degree of persistence is relatively high (see Appendix 2). Also, what it is worth calibrating at the value provided by the estimation is the coefficient of public debt as all relevant models yield similar results (Table A2 in Appendix 2). Cem Cebi (2012) calibrates the persistence in the fiscal rule at 0.5 and the response of debt at 0.03 (in the case of tax shocks). For the output gap, the mean of the coefficients is chosen at zero and low standard deviation (0.05), so as to let the data speak about what regards the pro-cyclical or contra-cyclical fiscal policy.

The parameters of fiscal rule for the present model were calibrated using the values reported in Table 1, namely persistence around 0.8, the reaction to the debt ratio at 0.05 and the reaction to the output gap at -0.02. The public debt to GDP ratio was calibrated at 25 percent and the steady state of budgetary deficit at 3.3 percent.

The model is estimated using Bayesian techniques. In order to estimate the model, we use quarterly data for the following variables: real GDP, real exports, real imports, real consumption of households, real private investment, wage inflation, core inflation excluding first order impact of VAT and excise duties changes, foreign demand proxied by the euro area GDP, the Romania main trading partner, imports and exports deflators, monetary policy nominal interest rate, public debt and VAT revenues. To make the data stationary, we detrend them using the Hodrick Prescott filter and employ the deviations from the trend values in the estimation process. The data covers the period between 2000Q1 and 2018Q4 and the data source is Eurostat[3].

---

[3] *To make the data stationary, we use the Hodrick Prescott filter. There are, however, several methods one may use to obtain stationary data, among which the most popular are: using growth rates, using deviation from the trend, using deviation from the mean.*

Table 1

Calibrated Parameters

Parameters	*Description*	*Calibrated value*
β	Discount factor	0.97
δ	Depreciation rate	0.03
θ_w	Elasticity of different types of labour	1.5
ψ	Parameter of capital utilisation	0.5
φ_{inv}	Investment adjustment cost	4
$\bar{\omega}$	Share of optimisers (ricardian households)	0.4
ϕ	Intertemporal elasticity by hours	2
ϱ_z	Elasticity of inputs by composite production function (labour and imports)	0.8
ϱ	Elastcity of inputs by final good production function (capital and v, the demand for intermediate goods)	0.5
ρ_1	Labour input adjustment cost	3
ρ_2	Import input adjustment cost	3
fix	Fix cost	0.25
γ_n	Employement measurement equation parameter	0.7
η	Foreign credit curve parameter	0.7
ρ^{τ^i}	Persistence in fiscal rule	0.9
$\varphi^{\tau^i}_{GDP}$	Reaction to GDP in fiscal rule	-0.02
$\varphi^{\tau^i}_{T}$	Reaction to deficit in fiscal rule	0.05
$\varphi^{\tau^i}_{D}$	Reaction to debt in fiscal rule	0.05
D_ss	Public debt (share in GDP)	0.25
T_ss	Budgetary deficit (share in GDP)	0.033
G_GDP	Govenmnet consumptiong (share in GD	0.06
C_GDP	Private consumption (share in GDP)	0.8
qm_GDP	Imports (share in GDP)	0.73

Source: Authors' calculation.

The results for the estimated parameters are reported in Table 2. For each parameter, we report the modes and standard deviation obtained via maximizing the kernel. We also report the mean and the 5% and 95% percentiles of the posterior.

The domestic inflation Calvo parameter estimates are in line with the values reported by other studies conducted on the Romanian economy (Copaciu *et al*., 2016, report a posterior mean of 0.464 and confidence interval between 0.374 and 0.550) and in line with other studies concentrating on the emerging economies (Grabek *et al*., 2011, report values between 0.5 and 0.8 in the case of Poland). Also, Baksa *et al*. (2009) find the degree of price stickiness close to 0.8 in the case of the Hungarian economy and Cem Cebi (2012) reports a coefficient of 0.59 in the case of Turkey. In this case, the results point towards a value close to 0.45 with a confidence interval going up to 0.63, describing thus a relatively high degree of stickiness in the case of domestic prices. The estimated mean value of the degree of indexation to past inflation in the case of domestic prices stands a little bit lower than the prior (at about 0.49), while for wages inflation, although the posterior mean is relatively close to the prior, it goes down to 0.29.

Table 2

Bayesian Estimation of the Structural Parameters

Parameters	*Description*	*Type*	*Priors* *Mean*	*Std.dev*	*Mean*	*Std.dev*	*Metropolis Hastings sampling confidence interval* *5%*	*95%*
h_c	Habit in consumption	beta	0.65	0.1	0.68	0.0468	0.5952	0.7627
σ	Intertemporal elasticity of consumption	invg	2	0.1	1.2523	0.216	0.8558	1.6311
h_x	Exports smoothing parameter	beta	0.8	0.2	0.6083	0.0378	0.5887	0.6179
ϑ_d	The degree of indexation to past inflation of domestic inflation	beta	0.5	0.1	0.4876	0.0984	0.4578	0.7398
γ_d	Inflation Calvo parameter	beta	0.5	0.1	0.456	0.2826	0.2935	0.6342
ϑ_w	The degree of indexation to past inflation for wages	beta	0.5	0.1	0.4623	0.0873	0.2863	0.5668
γ_w	Wage Calvo parameter	beta	0.667	0.1	0.582	0.0147	0.4151	0.7151
ϑ_x	The degree of indexation to past inflation of export prices	beta	0.5	0.1	0.5862	0.0938	0.4337	0.735
γ_x	Export prices Calvo parameter	beta	0.8	0.1	0.8252	0.0258	0.7787	0.8708
ζ_i	interest rate smoothing in Taylor rule	normal	0.8	0.1	0.4576	0.2981	0.2115	0.7255
ζ_π	Interest rate reaction to inflation	normal	1.7	0.1	1.4902	0.0986	1.3289	1.6526
ζ_e	Interest rate reaction to exchange rate	beta	0.1	0.1	0.052	0.0817	0.0231	0.14231

Source: Authors' calculations.

The estimation of the Calvo parameter, degree of indexation to past inflation at the calibration of the discount factor at 0.99 implies a coefficient of 0.67 for the forward-looking component and 0.33 for the backward-looking one in the Phillips curve for domestic prices.

The habit persistence in consumption is relatively high, namely 0.68, significantly above the values reported for other emerging economies (for instance, 0.4 for Hungary in the study of Baksa *et al*., 2009).

The interest rate smoothing parameter in the Taylor rule has an estimate mean value of 0.45, lower than the one reported by Copaciu *et al*. (2016), of 0.7 for Romania. The reaction of nominal interest rate to inflation points towards a coefficient of about 1.5, in line with Baska *et al*. (2009) for Hungary.

The autoregressive coefficients for the structural shocks' posterior mean estimation are relatively close to the prior mean of 0.8, depicting in almost all cases a relatively high degree of persistence.

The model estimation is validated through a set of tests. Figure A1 in Appendix 1 depicts a graphical representation of the parametrical convergence of the Metropolis Hastings algorithm. For reasons of space, we provide only a general convergence for the entire model; the methodology relies on a similar structure that provides the convergence diagnosis for each parameter, except that now the diagnosis is based on the posterior likelihood function.

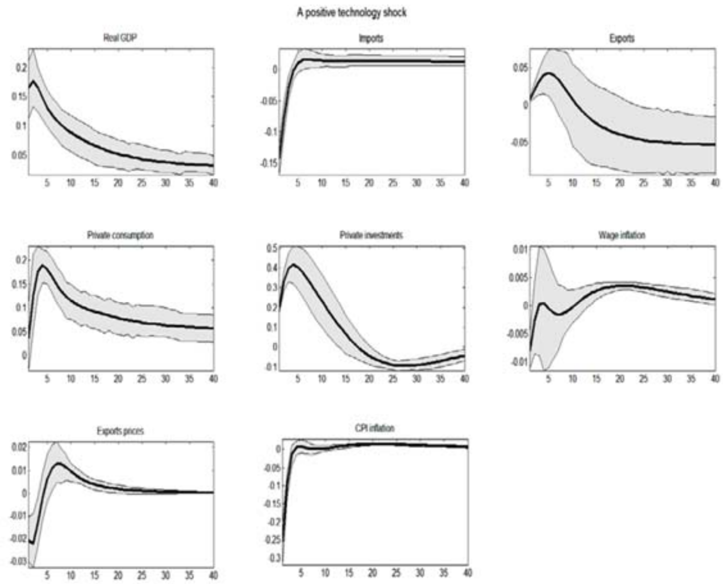
4. Model Simulations: Active versus Accommodative Monetary Policy

4.1 Impulse Response Functions

Having estimated the model, we can next check the performance by looking at impulse-reponse functiosn to different shocks. For space reasons, we only show selective results next.

Figure 1

IRFs to a Positive Consumption Shock



Source: Authors' calculations.

The IRFs simulated for temporary shocks of one standard deviation show that the variables return to their steady state value in the long run, confirming the Blanchard Quah condition that the model is stationary and does not exhibit an explosive behavior. In this stage, the IRF analysis is done only with the goal of validating or invalidating the model specification and its consistency with the economic theory.

Following a positive shock in productivity, GDP and its components rise (with the highest increase in investment). Inflation decreases in the first periods mainly due to the decrease in production costs (as the shock in productivity decreases real marginal costs), but soon it starts to increase due to the excess demand created in the economy and the wage pressures. Nominal interest rate follows an upward path in response to the increases in demand and inflation and slowly converges to the steady state as the economy stabilizes[4] (Figure 1).

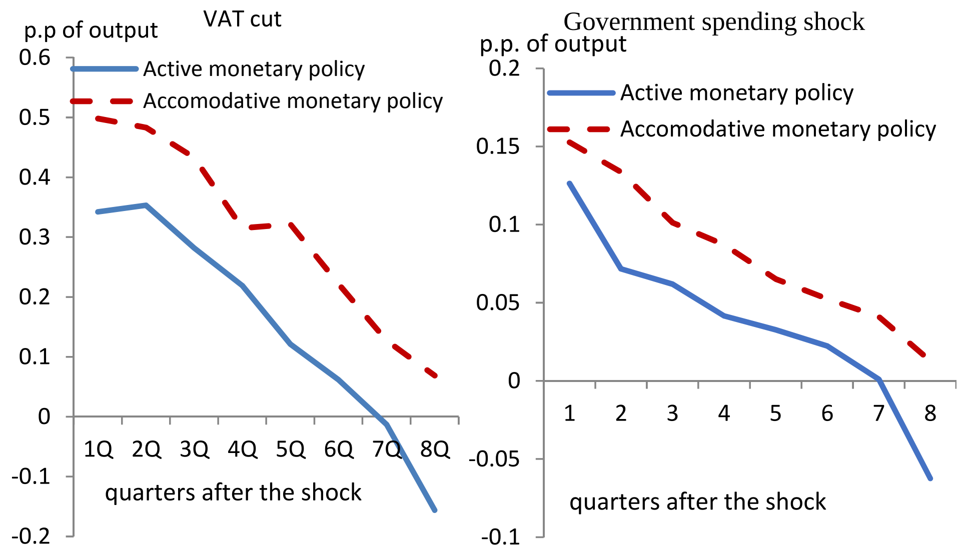
4.2 Fiscal Shocks and Fiscal Multipliers under Active versus Accommodative Monetary Policy

A crucial aspect in analyzing the impact of fiscal policy shocks on aggregate demand is the monetary policy behavior. In this sense, in line with Forni *et al*. (2010) we test whether the accommodative stance of the monetary policy, simulated by employing a flat trajectory of the monetary policy interest rate can or cannot influence the size of fiscal multipliers.

[4] For reasons of space, the responses of variables to other macroeconomic shocks are available upon request.

Figure 2

Fiscal Policy in an Accommodative vs. Active Monetary Policy



Note: OX axis represents the number of quarters, OY axis represents the magnitude of response.
Source: Authors' calculations.

Figure 2 plots the fiscal multipliers for a positive government spending shock and a tax cut in VAT[5], for the benchmark scenario (with active monetary policy) and an alternative scenario (with accommodative monetary policy[6]), respectively. In each case, the fiscal reaction functions use the instrument, namely VAT rate and government spending, in order to stabilize debt and output. In the case of a reduction in the VAT rate or an increase in the government spending in the benchmark model, the increase in the output gap with inflationary pressures is counteracted by a reaction in the monetary interest rate. In the former case, the positive effects come from a higher private consumption of households as the real disposable income is higher due to lower consumption tax rates. In the latter case, the impact on the total output is a direct one. In both cases, the active monetary policy leads to real interest rates increasing and, therefore, diminishing the positive effects stemming from the fiscal stimulus on the total output. In the alternative scenario, the lack of reaction from the central bank calls of the contractionary effects of the real interest rate channel as in the case of the benchmark model. Therefore, fiscal policy fully transmits its effects on real economic activity, the VAT and government fiscal multipliers being higher in the accommodative monetary policy scenario than in the benchmark model.

What Are the Effects of High Public Debt in the Process of Stabilizing the Economy?

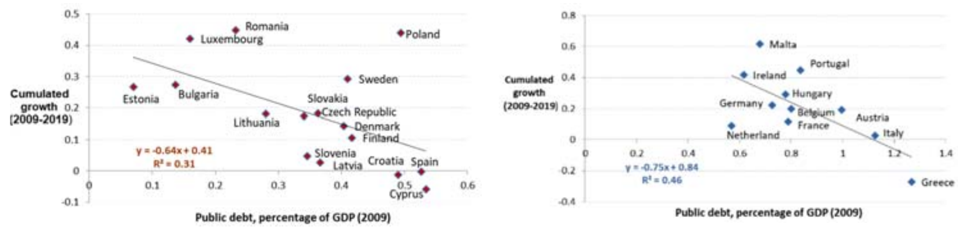
In a second step, the focus will be on assessing the implications of high public debt in the case of adverse shocks hitting the economy. More specifically, we simulate an adverse

[5] *Both shocks are calibrated, so that the magnitude of impact is 1 percent of GDP.*
[6] *The monetary policy interest rate is kept unchanged.*

shock on technology in the benchmark scenario and in an alternative one considering a different initial value for public debt. Further on, special attention will be paid to the stabilization process in the case of the negative shock in the path of economic growth.

Figure 3

Growth and Public Debt



Source: Authors' calculation, Eurostat data.

Figure 3 plots the negative relationship between economic growth and the starting level of public debt to GDP ratio for two sub-sample of countries: the EU countries with the initial level of public debt-to-GDP below 60 per cent (red dots), and the EU countries with the initial level of public debt-to-GDP above 60 per cent (blue dots). The initial level is the one in 2009, the start of the sovereign debt crisis in the euro area. The results seem to support the conclusion previously stated: countries with lower initial debt-to-GDP experienced less economic growth losses in the years following the onset of the financial and economic crisis.

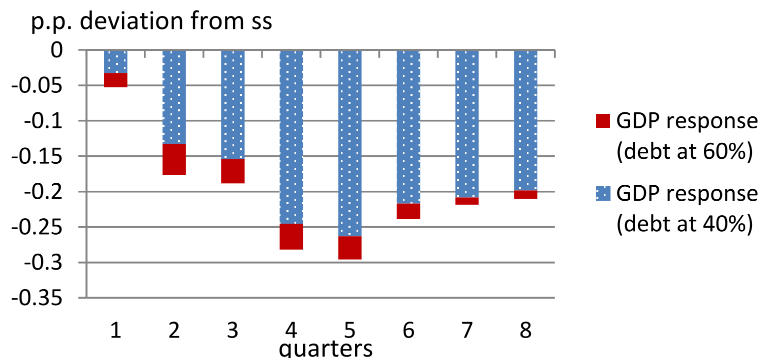
In order to assess the implications of high public debt on the resilience of the economy, two scenarios are simulated: the benchmark scenario (in which the steady state of the share of public debt was calibrated at 25 percent) and an alternative scenario (with the steady state of the share of public debt in nominal GDP calibrated at 60 percent). The figure of 60 percent is chosen as the reference value of the Maastricht criteria, but, nevertheless, it could go even higher.

4.3 Results for Simulation with a Higher Debt-to-GDP Ratio

The analysis is divided into two parts: first, assessing in the benchmark model how the economy stabilizes after an adverse shock in the preference for consumption. The simulation implies changing the initial point of the public debt to a higher value of 60 percent and assessing how the economy stabilizes in this situation for the same adverse shocks. An alternative scenario uses the model solution from the benchmark model and simulate a contra factual scenario with a higher debt-to-GDP ratio.

Figure 4

Benchmark and Alternative Scenario in the Case of Adverse Shock



Source: Authors' calculations.

The fiscal rule uses the VAT rate to stabilize debt and output, in both the benchmark and alternative scenario. Alternatively, the other fiscal instruments might be used, but the qualitative conclusions remain valid. The adverse shocks are simulated with a one standard deviation of the shock.

When the debt-to-GDP ratio is calibrated at 60 percent, the economy is worsening off as the impact of the adverse technology shock is higher (Figure 4). Inflation is going down and monetary policy reacts by lowering the policy rate, which translated favourable into the economy. However, the lower interest rates in the alternative scenario are not able to compensate the negative effects coming from a higher debt, which requires increasing the fiscal instrument and, therefore, affecting the real GDP more than in the benchmark scenario. In this case, the model needs a stronger reaction in order to bring the variables to the steady state.

5. Conclusions

This paper tries to draw important conclusions on the structural parameters that characterize the Romanian economy, using a DSGE model for a small open economy. A particularly important attention was given to the fiscal block and its impact on various macroeconomic variables. In this sense, we simulated various fiscal shocks and examined how the main macroeconomic variables responded.

In the context of an upward public debt path in recent years given the increasing primary deficits[7], a remarkably interesting aspect is how a higher starting point of public debt-to-GDP ratio might affect the stabilization process of the economy in the event of adverse shocks. These conclusions are in line with the results provided by the empirical literature in the area that show that the economy becomes more vulnerable and less resilient to shocks in an unstable fiscal environment. As compared to the benchmark scenario, where public debt is calibrated at 40 percent, in the adverse scenario with a higher starting point for debt the economy needs more time to stabilize and the impact of adverse shocks on real GDP is higher.

[7] *And despite a favourable interest growth differential.*

References

Baksa, D., Benk, S. and Jakab, M. Z., 2010. Does The Fiscal Multiplier Exist? Fiscal and Monetary Reactions, Credibility and Fiscal Multipliers in Hungary, published by Office of the Fiscal Council.

Benk, S. and Jakab, Z., 2012. Non keynesian effects of fiscal consolidation: An analysis with an estimated DSGE model for the Hungarian economy. *OECD Economic Department Working Paper*, 945.

Caraiani, P., 2008. An analysis of domestic and external shocks on Romanian economy using a DSGE model. *Romanian journal of Economic Forecasting,* 5(3), pp.100-114.

Caraiani, P., 2013. Comparing monetary policy rules in CEE economies: A Bayesian approach. *Economic Modelling*, 32(1), pp.233–246.

Cebi, C., 2012. The interaction between monetary and fiscal policy in Turkey: an estimated New Keynesian DSGE model. *Economic Modelling*, 29, pp. 1258-1267.

Christiano, L. J., Eichenbaum, M. and Evans, C. L., 2005. Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy. *Journal of Political Economy*, 113, pp. 1–45.

Copaciu, M., Nalban, V. and Bulete, C., 2016. R.E.M. 2.0. A DGSE model with partial euroization estimated for Romania. *Journal of Political Economy*, National bank of Romania Occasional Paper, 21.

Erceg C., Henderson, D. and Levin, A., 2000. Optimal monetary policy with staggered prices and price contracts. *Journal of Monetary Economics,* 46, pp.281-313.

Forni, L., Gerali, A. and Pisani, M., 2010. The macroeconomics of fiscal consolidations in a monetary union: the case of Italy, *Banca d'Italia Working Paper,* 747.

Grabek, G. and Klos, B., 2013. Unemployment in the Estimated New Keynesian Soe PL-2012 DSGE Model. *NBP Working Paper,* 144.

Klyuev, V. and Snudden, S., 2011. Effects of fiscal consolidation in the Czech Republic. *IMF Working Paper,* 65.

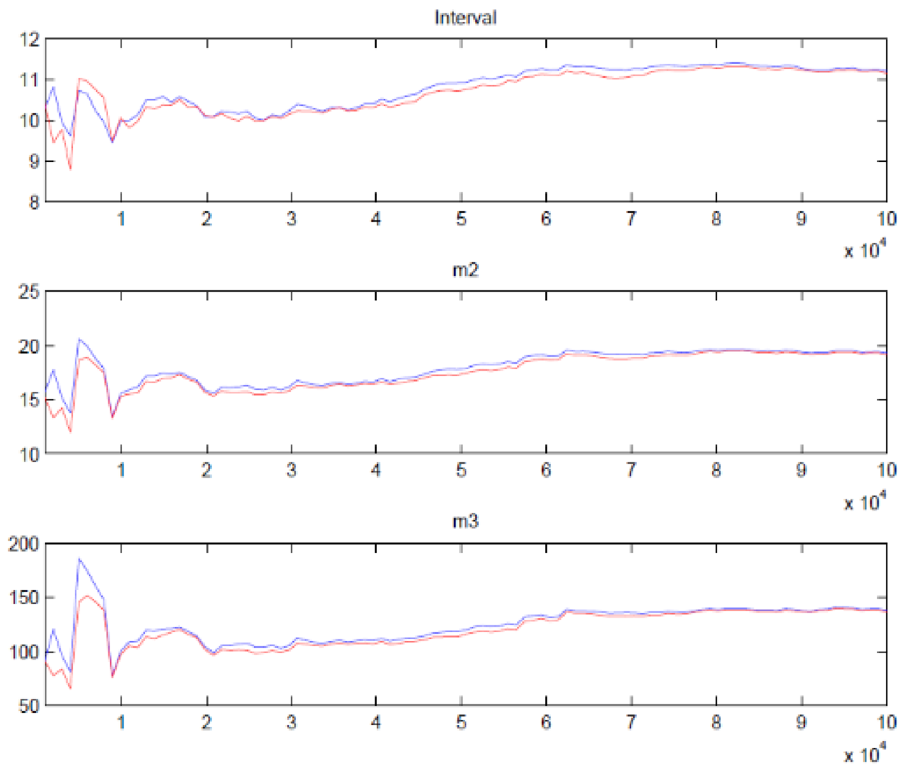
Muir D. And Weber, A., 2013. 2.0. Fiscal multipliers in Bulgaria. Low, but still relevant. *IMF Working Paper,* 49.

Smets, F. And Wouters, R., 2003. An estimated dynamic stochastic general equilibrium model of the euro area. *Journal of the European Economic Association,* MIT Press, 1, pp. 1123-1175.

Appendix 1

Figure A1

Metropolis Hastings Convergence Diagnosis



Source: Authors' calculations.

Appendix 2

There is a long-lasting debate regarding the fiscal reaction functions that authorities should use to provide sustainable medium-term public finances. While there has been agreed that a typical Taylor rule may ensure an optimizing behavior of the monetary policy, in the case of fiscal policy rules no agreement has been reached so far. Usually, a fiscal policy rule captures the response of fiscal policy (usually measured by the primary or structural balance) to the lagged value of the debt and the current cyclical conditions assessed through the output gap. Fiscal policy may be important to be stated with valuable fiscal stabilizers acting in a counter-cyclical way, while discretionary fiscal policy may prove to be a safe tool when the monetary policy has no reaction space in a zero-bound framework.

The emerging countries, where fiscal policy usually has a very active role, are interested in assessing how the fiscal policy stance (captured by various fiscal instruments, but the most often by primary or structural balance) responds to the changes in public debt and other macroeconomic developments. Fiscal rules are usually related to the fiscal sustainability issue and the most important question that arises related to this matter is whether the fiscal authorities engage in higher budgetary surpluses when public debt increases (or in other words they reduce deficits or increases primary surpluses).

The framework we rely on implies a panel setup for estimating fiscal rules for the CEE countries (Romania, Bulgaria, the Czech Republic, Poland and Hungary). The data set comes from the AMECO database (for reasons of consistency in what concerns the estimation of the output gap, for instance) and refers to: primary/structural deficit, output gap (AMECO evaluations), debt-to-GDP ratio, inflation and short-term nominal interest rate. The data covers the period between 2000 and 2018. Most of the papers use as a fiscal instrument the primary balance. However, for robustness check purposes, the structural balance is also employed and this seems to not affect the sign and significance of the response of the fiscal instrument to public debt.

The baseline specification is:

$$pb_{it} = \alpha + \beta pb_{it-1} + \gamma d_{it-1} + \sum_{j=1}^{p} \delta_j X_{j,it} + \epsilon_{it}$$

where: pb_{it} stands for the primary structural balance (although only primary balance may also be used, see for instance Checherita and Zdarek, 2017), d_{it-1} is the public debt ot GDP ratio at t-1, $X_{j,it}$ is a vector of control variables (output gap, inflation, interest rate, etc), ϵ_{it} is the error term. The baseline specification also includes fixed effect in one of the models depicted next in the table. However, due to severe criticism of including a fixed effect estimator in a relatively small sample (the “Nickell’s bias”) as pointed by Bruno (2005), this approach is mainly provided for comparative purposes.

The estimation is done using various instrumental variables techniques due to potential endogeneity problems. Another feature of the estimation is the option of robust standard errors in order to deal heterogeneity and serial correlation. The Arellano Bond (AB) estimator (1988) is also employed as a special part of the GMM estimation that involves differencing regression in order to take into account potential unobserved effects. We basically used several IV techniques in order to test the robustness of the results.

The responses of the fiscal stance to all variable included in the regression are significant in most cases, except for the output gap when considering the instrumental variables and the AB estimator for primary balance models.

The persistence of primary structural balance seems to be quite important in all models. Also, the primary balance seems to respond negatively to the output gap (which is an aspect not expected, as for many CEE countries the fiscal policy turned out to be pro-cyclycal during the years) in most cases for the structural balance models, while for the instrumental variables model in case of primary balance the response is positive. Also, the responses to inflation are positive in all cases. The constant term is significant and negative in all cases, implying that the primary balance is stabilizing at a positive figure in the long run.

Table A2

Estimation Results Based on Different Instrumental Variables Methods

Variables	IV	IV FE	Arellano Bond	IV	IV FE	Arellano Bond
	FR based on primary balance			FR based on structural balance		
Lagged primary or structural balance	0.55	0.43	0.36	0.57	0.48	0.43
	(.078)*	(0.088)*	(.11)*	(0.07)*	(.079)*	(0.103)*
Output gap	-0.06	0.035	0.07	-0.30	-0.25	-0.22
	(.066)	(0.076)***	(.084)	(0.06)*	(.073)*	(0.073)*
Lagged debt	0.029	0.077	0.089	0.024	0.06	0.074
	(0.011)*	(0.022)*	(0.032)*	(0.011)**	(0.021)**	(.028)*
Inflation	0.40	0.27	0.32	0.35	0.25	0.29
	(0.089)*	(0.108)**	(0.124)*	(0.092)*	(0.107)**	(0.108) *
Short term niominal i.r.	-0.31	-0.18	-0.288	-0.27	-0.17	-0.24
	(.078)*	(0.097)**	(0.149)**	(0.079)*	(0.096)***	(0.131)***
Cons	-1.55	-3.81	-4.01	-1.33	-3.13	-3.42
	(0.57)*	(1.01)*	(1.749)**	(0.558)	(1.009)**	(1.689)**
Observations	80	80	75	80	80	75
Adjusted R suqared	60%			69.7%		
Prob>chi2	0.00	0.00	0.00	0.00	0.00	0.00
Sargan Test P value			0.12			0.204
Country fixed effects	no	yes	no	no	yes	no

*Note: * significance at 1 percent level, ** significance at 5 percent level, *** significance at 10 percent level. In the brackets are reported the standard errors. The instruments are lagged values of the regressors. The Arellano Bond estimations is also confirmed by the outcome of the Sargan (overidentifying restrictions) test that validates the instruments.*

The focus, however, is the response to debt-to-GDP ratio. This seems to be quite small in all models, ranging from 0.03 to almost 0.09. The relatively small impact is validated by other empirical studies focused on the emerging economies, such as Berti *et al*. (2016), who find the coefficient near 0.06 in their benchmark model for 12 CEE countries (among which are also the countries considered in the current paper).