The Role of the Monetary Policy in the Context of the Macroeconomic Policies Mix – a Quantitative and Qualitative Approach for Romania

Ionita G.[1]

[1] Doctoral School in Economy and Law, Academy of Economic Studies, Bucharest (ROMANIA)
georgiana.alina.ionita@gmail.com

Abstract

The main object of the research is to analyse and identify an optimal monetary and fiscal policy model that responds to the economic problems of the countries from Central and East Europe and mainly of Romania.

Given the vulnerabilities of the economies at the beginning and during the recent global economic and financial crisis, there is an increased interest to identify the quantitative models that explain the main features of macroeconomic data, most of them based on Bayesian estimation approaches.

The analysed model involves fiscal and also monetary policy macroeconomic variables through governmental expenses and respectively interest rate and also monetary and fiscal policy shocks given the importance of the uncertainty in modelling a macroeconomic policy rule: price and interest rate shocks (as monetary policy shocks) and exogenous spending shock (including government spending as a fiscal policy instrument).

Keywords: monetary, policy, shocks, Bayesian, quantitative.

1 Introduction

Given the vulnerabilities of the countries from Central and East Europe at the beginning and during the recent economic and financial global crisis, there is an increasing interest to identify models that explain the most significant characteristics of the macroeconomic variables, such as: real GDP, consumption, investment, wages, prices, hours worked and the short-term nominal interest rate.

As a result, the main object of the research is to analyse and identify an optimal monetary and fiscal policy model that complies with the macroeconomic context and responds to financial and economic problems of Romania.

Generally, central banks put an eye on the importance of uncertainty in shaping monetary policy, uncertainty that can takes many forms. Given the importance of the uncertainty in modelling monetary policy and the fact that central banks must act in anticipation of future macroeconomic conditions, which are affected by shocks that are currently unknown, another objective of the research is to identify which are the significant shocks that influence the macroeconomic environment.

As a result during the current thesis I have proposed to consider how monetary and fiscal policy should be conducted in the face of multiple sources of uncertainty, including model and parameter uncertainty as well as uncertainty about future shocks.

For the analysis I have taken into consideration also 7 exogenous shocks: technology shock, investment shock, exogenous expenditure shock, risk premium shock, price mark-up, wage mark-up and interest rate shock.

The thesis is organized as follows: section 1-Introduction, section 2 contains the description of the model, section 3 contains the econometric quantitative estimation of the model, estimation of the parameters and of the data set and the results of the estimates, while section 4 is the section of conclusions, followed by references section.

2 The Model

The model proposed for estimation represents a New Keynesian log-linear DSGE model.

The final good Y_t is composed of a continuum of intermediate goods, $Y_t(i)$. The final good producers buy intermediate goods, package them into Y_t and sell the final good to customers, investors and the government in a perfectly competitive market. As in Calvo (1983) [5], the model assumes that each firm can readjust prices with probability 1- ξ_p in each period. For those firms that can adjust prices, the problem is to choose a price level $\tilde{P}_t(i)$ that maximizes the expected present discounted value of profits in all states where the firm is stuck with that price in the future.

The agents of the economy are: the final goods producers, intermediate goods producers, households, intermediate labour union sector, labour packers and government. An assumption of the model is that in equilibrium households will make the same choices for consumption, hours worked, bonds, investment and capital utilization. Households supply their homogenous labour to an intermediate labour union which differentiates the labour services and sets wages subject to a Calvo scheme about the wage with the intermediate labour packers. There are labour packers who buy the labour from the unions, package L_t , and resell it to the intermediate goods producers. Labour packers maximize profits in a perfectly competitive environment.

2.1 *The Linearized Model*

The aggregate resource constraint (demand) is described by the relation: $y_t = c_y c_t + i_y i_t + z_y z_t + \varepsilon_t^g$ (1)
The dynamic of consumption following Euler equation is the following:
$c_t = c_1 c_{t-1} + (1-c_1) E_t c_{t+1} + c_2 (l_t - E_t l_{t+1}) - c_3 (r_t - E_t \pi_{t+1} + \varepsilon_t^b)$ (2)
The dynamics of investment following investment Euler equation: $i_t = i_1 i_{t-1} + (1-i_1) E_t i_{t+1} + i_2 q_t + \varepsilon_t^i$ (3)
The corresponding arbitrage equation for the value of capital is given by:
$q_t = q_1 E_t q_{t+1} + (1-q_1) E_t r_{t+1}^k - (r_t - \pi_{t+1} + \varepsilon_t^b)$ (4)
On the supply side, the aggregate production function is given by: $y_t = \phi_p(\alpha k_t^s + (1-\alpha) l_t + \varepsilon_t^a)$ (5)
Newly installed capital is described by the following equation: $k_t^s = k_{t-1} + z_t$ (6)
Cost minimization by the households that provide capital services implies that the degree of capital utilization is a positive function of the rental rate of capital: $z_t = z_1 r_t^k$ (7)
The accumulation of installed capital is not only a function of the flow of investment but also of the relative efficiency of these investment expenditures as captured by the investment-specific technology disturbance: $k_t = k_1 k_{t-1} + (1-k_1) i_t + k_2 \varepsilon_t^i$ (8)
On the monopolistic competitive goods market, cost minimization by firms implies that the price mark-up is equal with the difference between the marginal product of labour, mpl_t, and the real wage, w_t, : $\mu_t^p = mpl_t - w_t = \alpha(k_t^s - l_t) + \varepsilon_t^a - w_t$ (9).
Profit maximization by price-setting firms leads to the following New-Keynesian Philips curve:
$\pi_t = \pi_1 \pi_{t-1} + \pi_2 E_t \pi_{t+1} - \pi_3 \mu_t^p + \varepsilon_t^p$ (10)
Cost minimization by firms implies that the rental rate of capital is negatively related to the capital-labour ratio and positively to the real wage (both with unitary elasticity): $r_t^k = -(k_t - l_t) + w_t$ (11)
In analogy with the goods market, in the monopolistically competitive labour market the wage mark-up is equal to the difference between the real wage and the marginal rate of substitution between working and consumption, (mrs_t), $\mu_t^w = w_t - mrs_t = w_t - (\sigma_l l_t + \frac{1}{1-\lambda}(c_t - \lambda c_{t-1}))$ (12)
Similarly, due to nominal wage stickiness and partial indexation of wages to inflation, real wages only adjust gradually to the desired wage mark-up, μ_t^p, $w_t = w_1 w_{t-1} + (1-w_1)(E_t w_{t+1} + E_t \pi_{t+1}) - w_2 \pi_t + w_3 \pi_{t-1} - w_4 \mu_t^w + \varepsilon_t^w$ (13)
Monetary policy reaction function follow a generalized Taylor rule by gradually responding to deviations of lagged inflation from an inflation objective (normalized to be zero) and the lagged output gap defined as the difference between actual and potential output (Taylor, 1993):
$r_t = \rho r_{t-1} + (1-\rho)\{r_\pi \pi_t + r_Y (y_t - y_t^p)\} + r_{\Delta y}[(y_t - y_t^p) - (y_{t-1} - y_{t-1}^p)]) + \varepsilon_t^r$ (14)

Equations (1) to (14) determine fourteen endogenous variables: y_t, c_t , i_t , q_t , k_t^s , k_t , z_t , r_t^k , μ_t^p , π_t , μ_t^w , w_t, l_t and r_t.

The stochastic behaviour of the system of linear rational expectations equations is driven by seven exogenous disturbances: total factor productivity (ε_t^a) , investment-specific technology (ε_t^i) , risk premium (ε_t^b) , exogenous spending (ε_t^g) , price mark-up (ε_t^p), wage mark-up (ε_t^w) and monetary policy shocks (ε_t^r).

3 Econometric Estimation Methodology

3.1 *Econometric Methodology*

For the analysis of the interaction between fiscal and monetary policy and of their role in the macroeconomic stabilization I will use the Bayesian approach, using Matlab program and Dynare tool.

Based on this approach I will obtain estimations using the a-priori distributions proposed for the parameters and the observed variables of the model. Moreover, using the Bayesian approach, as proposed by Geweke J. (1998) [3] I can take into account in the analysis also the shocks proposed by the model in order to estimate the standard deviations, with a role in the interpretation of impulse response functions.

3.2 *Calibration and a-Priori Distributions of the Parameters*

In terms of the parameters of DSGE model, I will use in the research the Bayesian estimation method, using the likelihood function and the a-priori distributions of the model's parameters, in order to obtain the a-posteriori functions. This a-posteriori function is afterwards optimized through the method of Markov-Chain-Monte-Carlo simulation, for 350,000 of iterations.

In order to compute the likelihood function for the observed data series, I use Kalman filter, similarly to the proposal of Sargent T.J. (1989) and afterwards through the combination of the likelihood function with the a-priori distribution of the parameters, it will be obtained the a-posteriori distribution of parameters.

Part of the parameters are fixed in the estimation procedure.

The depreciation rate of capital, δ is set at 0.0246 per quarter, which implies an annual depreciation rate of capital equal of approx. 10%, which is in accordance with the percentage, proposed by the authors Frank Smets and Rafael Wouters, in the article "An estimated dynamic stochastic general equilibrium model of the Euro Area" [8] and "An Estimated Two-Country DSGE Model for the Euro Area, Research" [7].

Three other fixed parameters are: the steady-state mark-up in the labour market (λ_w), which is set at 1.5, and the curvature parameters of the Kimball [4] aggregators in the goods and labour market (ε_t^w and ε_t^p), which are both set at 10. Other parameters, such as the discount factor, is calibrated to be 0.9994, which is the mean of the sample of the quarterly real interest rate, while the exogenous spending-GDP ratio is set at 18%.

The demand elasticity for labour, λ_w , is equal with 1.5, the degree of wage stickiness, ξ_w , is 0.7937, the degree of price stickiness, ξ_p , is 0.75, which is in accordance with the assumptions with the calibrations proposed by the author Mihai Copaciu (2012), in the article "Estimation of an open economy DSGE model with financial and employment frictions for Romania".

The long run reaction of monetary policy interest rate on inflation, r_π (calibrated at 1.488), and the output gap, $r_{\Delta y}$ (calibrated at 0.2239), are described by a normal distribution with mean 1.5 and 0.125 (0.5 divided by 4) and standard errors 0.125 and 0.05 respectively. The persistence of the policy rule is determined by the coefficient on the lagged interest rate, ρ , which is assumed to follow a Beta distribution, around a mean of 0.75 with a standard error of 0.1, being calibrated at 0.8258. The prior on the short run reaction coefficient to the change in the output-gap, r_Y is 0.0593.

The parameters of the utility function are assumed to be distributed as follows. The inter-temporal elasticity of substitution, σ_c is set at 1.5 with a standard error of 0.375; the habit parameter, λ , is assumed to fluctuate around 0.7 (being calibrated at 0.6361) with a standard error of 0.1 and the elasticity of labor supply, σ_l , is assumed to be around 2 with a standard error of 0.75, being calibrated at 1.9423. The prior on the adjustment cost parameter for investment, φ , is set around 4 with a standard error of 1.5 and is calibrated at 6.0144 and the capacity utilization elasticity is set at 0.5 with a standard error of 0.15. The share of fixed costs in the production function is assumed to have a prior mean of 0.5, meaning that the parameter ϕ_p which reflects the presence of fixed costs in production, calculated as one plus the share of fixed costs in production will be equal with 1.5.

Finally, there are the parameters describing the price and wage setting. The prior mean of the degree of indexation to past inflation (l_p) is also set around 3 in both goods and labour markets (l_w), being calibrated at 0.3291 and 0.3243, respectively.

In addition to the prior distribution, I have also obtained the posterior distribution of parameters and standard deviation of shocks, before and after the optimization using Metropolis-Hastings algorithm.

According with the analysis of a-priori and a-posteriori distribution graphs and t-statistics, all estimated parameters and standard errors of all the shocks are significantly different from zero and all parameters converged along the chains and between the chainsfor the mean, variance and third moment as studied by of Brooks and Gelman (1998) [6].

3.3 *Data Set*

All the real observed variables (real GDP, real consumption, real investment and real wages) are expressed in 100 times log, in order to get an evidence of the real growth rates.

For the GDP deflator, the index was computed based on the percentage change on previous period (the gross domestic product at market prices) and I have used it in the model as first difference of the natural logarithm.

For the hours worked, it was collected from Eurostat site the average number of actual weekly hours of work of employed persons. The hours worked are represented as an index of the average quarterly hours worked divided by the total number of hours from one quarter, being adjusted, by multiplying with the number of employees –[lfsq_epgais]. The data series for hours worked are expressed as a natural logarithm of the adjusted index.

In terms of monetary policy, I have computed an average interest rate for each of the 56 quarters in the period from 2000q1 to 2013 q4, using the daily rates for ROBOR at 3M, from 2000q1, until 2013 q4.

The series used in Dynare software for the observable variables were: the log difference of real GDP, the log difference of real consumption, the log difference of real investment, the log difference of real wages, the log of the index of hours worked, the log difference of GDP deflator for Romania and the quarterly interest rate-ROBOR 3M.

The observed variables were seasonally adjusted and tested for stationarity, using the Philips-Perron (PP) or Augmented Dickey Fuller (ADF) test and afterwards imported in Matlab for a further processing using Dynare 4.4.0 tool.

3.4 *Results*

In terms of model summary, based on the linearized equations the model is formed by: 40 variables, 7 stochastic shocks, 20 state variables, 12 jumpers (forward looking variables or non-predetermined variables) and 14 static variables.

I have analyzed the historical variance decomposition of the endogenous variable-GDP for Romania.

Figure 1 illustrate the deviation of the smoothed value of the endogenous variable from its steady state.

As resulted from the variance decomposition figure, the most significant shock that influences the GDP is total factor productivity, followed by risk premium, monetary policy shocks (price shock and interest rate shock) and investment shock.

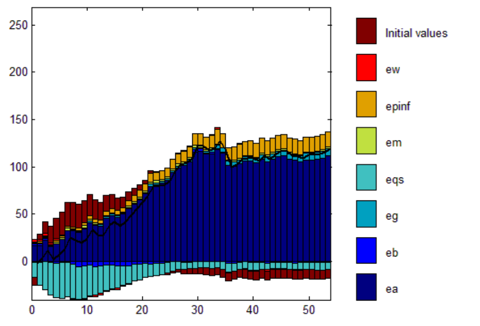

Figure 1: Variance decomposition
Source: Matlab results

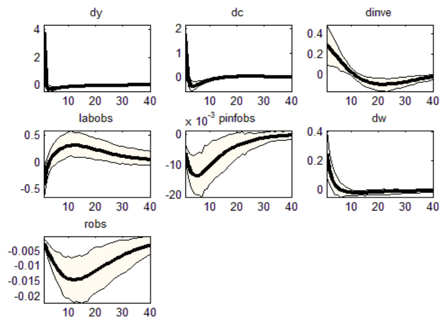

Figure 2-IRF -productivity shock
Source: Matlab results

As can be seen from the variance decomposition figure, the stochastic behaviour of the system of linear equations is driven by the following: total factor productivity shock: 74.36%, investment shock: 9.25%, interest rate shock: 6.39%, monetary policy shock-price shock: 5.42%, risk premium shock: 2.42%, exogenous spending shock: 1.68% and wages mark-up shock:0.47%.

I have also analysed in the current thesis the impulse responses of the various structural shocks and their contribution to the economy of Romania. The Bayesian IRF's are the mean of the distribution responses of the variables in the model to the mean standard deviation estimated for the 7 structural shocks. All variables start from 0 steady state, as the model is linearized.

Figure 2 shows that, following a positive productivity shock, output, consumption and investment rise, while employment (quantified as the number of hours worked) falls. Due to the rise in total factor productivity, the marginal cost falls on impact. As monetary policy does not respond strongly enough to offset this fall in marginal cost, inflation falls, but not very strongly. Finally, real wages rise following the positive productivity shock.

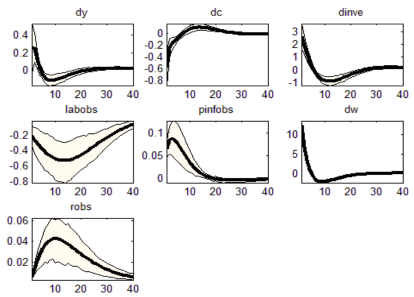

Figure 3-IRF- wage mark-up shock

Source: Matlab results

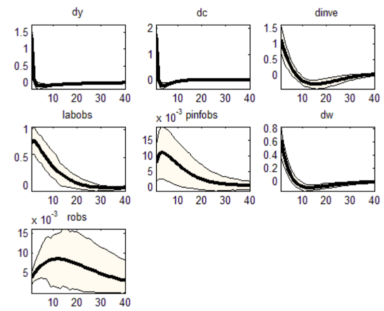

Figure 4-IRF- risk premium mark-up shock

Source: Matlab results

In case of a positive wage mark-up shock (as described in figure 3), real wages grow significantly. This significant increase of the real wages leads to an increase in the marginal cost and inflation. The real interest rate rises reflecting the fact that the wage mark-up shock creates a trade-off between inflation and output gap stabilization.

The risk premium shock helps explaining the co-movement (correlated movement) of consumption and investment. As results from the figure 4, a positive risk premium shock leads to an increase of the GDP, and increase of consumption and investment, too. Moreover, there is also an increase of employment indicator (the hours worked index) and an increase of real wages.

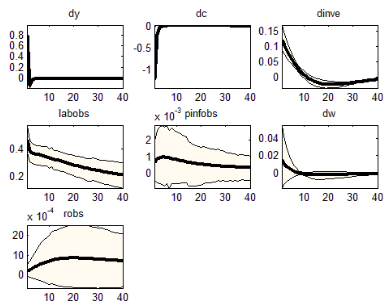

Figure 5-IRF-exogenous spending shock

Source: Matlab results

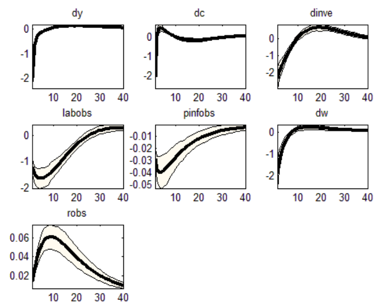

Figure 6-IRF to an interest rate shock

Source: Matlab results

In case of an exogenous spending shock (as illustrated in figure 5) consumption falls significantly, while GDP and investment increase. Real wages are not much affected because of the greater willingness of households to work.

The model accounts for a positive effect of exogenous spending on GDP, as documented for United States in Blanchard O. and Perotti R. [1].

The temporary shock of interest rate (as a monetary policy shock) leads to a rise in the nominal short-term interest rate. This leads to a fall in output, consumption and investment. The effects of the interest rate increase, as a monetary policy measure proposed by the Central Bank, can be seen in the decrease of inflation, as resulted from figure 6. Moreover, following a monetary policy shock, real wages fall. The impact of a positive price mark-up shock on inflation and interest rates is very similar with the effect of a positive wage mark-up shock (both increasing) and will affect the real marginal cost, real wages and the rental rate of capital in the opposite sense, decreasing. First, there is no liquidity effect, as nominal interest rates start decreasing immediately as a result of the decreased inflation expectations (as the nominal interest rate is influenced by the evolution of the estimated real interest rate, plus the inflationary expectations). Second, because the change in policy is implemented gradually through the dynamics in the monetary reaction function, expectations have time to adjust and the output effects of the change in inflation are much small (as can be seen also from the figure 7).

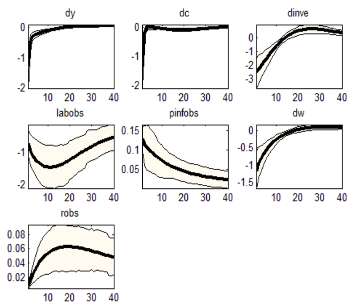

Figure 7-IRF to a price shock
Source: Matlab results

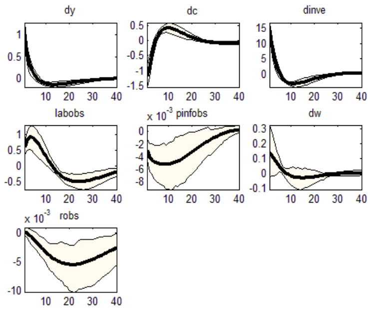

Figure 8-IRF to an investment shock
Source: Matlab results

A positive investment shock (as illustrated by figure 8) leads to a rise in output and decrease of consumption (to the detriment of investment), while employment (quantified as the number of hours worked) and real wages increases too. The inflation decreases, as a result of the monetary policy that consists of the increase of the short-term interest rate.

In terms of stability analysis, the system is stable, as Blanchard-Kahn conditions are met, meaning that the number of non-predetermined variables (12) equals the number of eigenvalues higher than one (forward looking variables).

4 Conclusions

The proposal of this working paper is to analyze whether the model proposed by Frank Smets and Raf Wouters for the economy of United States ("Shocks and Frictions in US Business Cycles- A Bayesian DSGE Approach"-February 2007) [11] and for the Euro Area ("An Estimated Two-Country DSGE Model for the Euro Area"-2005) is suitable for the economy of Romania [2].

Taking into consideration the tests performed: stability analysis (Blanchard-Kahn condition), the analysis of the economic sense of the impulse response functions, and of the smoothed shocks and variance decomposition I conclude through the current working paper that the results of the model are effective for the economy of Romania.

Moreover, the model can be analysed taking into account the policy shocks involved: exogenous spending shock (that includes government spending, an instrument of the fiscal policy), price and interest rate shocks (as monetary policy shocks).

Regarding the monetary policy, I can conclude that the Taylor rule proposed by the model approximates the behaviour of the central bank of Romania.

In addition to the model proposed by Smets & Wouters [9], [10] in terms of openness of the economy, the model assumes that beyond labour and capital an additional imported input is needed for domestic production. On the other hand, another assumption is that part of domestic production is exported.

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