Quantification model of the consequences of monetary policy shocks

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Abstract. *The monetary analysis based on the BVAR (Bayesian Vector Autoregression) model is extremely important in the monetary policy implementation strategy, the information provided is important not only for the Central Bank, but also for the economic agents and the population. Therefore, conducting this analysis at the level of Romania helps to understand better the mechanism by which monetary policy is transmitted in order to achieve the set target, namely inflation targeting, but it also provides us with important information regarding the accession to the euro area. The model we are trying to test helps us understand through the correlations between the interest rate, GDP and the inflation rate how monetary policy responds to shocks. The model follows the methodology presented by Sims and Zha (1998) in the paper "Bayesian Methods for Dynamic Multivariate Models and Using the Bayesian Autoregressive Vector". In the analysis of this model, quarterly data for a minimum of three years, three variables are used to make the results relevant. The data needed to model the model are used in logarithmic form, except for the interest rate, and the outcome is applied to a differentiated premium operator. Of the variables used, the interest rate is the only one that does not allow seasonal adjustment.*

Keywords: monetary policy, interest rate, inflation, econometrics, BVAR, macroeconomics, GDP, research.

JEL classification: E47, E58.

1. General considerations and research methodology

Numerous studies using BVAR techniques are presented in the literature. Kenny, Meyler and Quinn (2008) in their work "Bayesian VAR Models for Forecasting Irish Inflation" have used this model to predict inflation in Ireland. Inflation forecasting performance has been greatly improved with the results of the Bayesian regression, but it cannot be said that there is an exact prediction due to the uncertainty that characterizes this variable. The Central Bank of Ireland, following its previous analysis, has achieved similar results, which emphasizes the importance of the role played by external prices and the exchange rate in the formation of Irish prices. Gül Ergün and Sevinç (2009) in their paper "Usage of different prior distribution in Bayesian vector autoregressive models" attempted to forecast the production index and the unemployment rate in Turkey using five BVAR models that were then compared to each other the performances generated by each. Borys and Horváth (2008) analyze how the Czech economy is influenced by monetary policy changes. Thus, the results of the analysis show that after a certain period of time expressed in years, a restrictive monetary policy influences negatively the level of prices and the degree of development of the economy.

At the same time, another outcome of the two economists' analysis confirms the already existing evidence of the effect of using rigid prices at macroeconomic level, non-tradable goods do not adapt as quickly to existing prices at the sectoral level as the marketable ones. Dua, Raje and Soho have used univariate and multivariate models (VAR and BVAR) to predict short and long-term interest rates on Indian government

bonds, with maturities ranging from one year to 10 years. Multivariate models take into account factors such as liquidity, bank interest rate, inflation, credit, and external interest rates. The study found that multivariate models are superior to the VAR model over the longer forecast horizons, but compared to the BVAR model, the study concludes that the forecasting performance of this model is satisfactory for most interest rates and its superiority in performance is marked by the use of horizons of longer prognosis.

In a paper published in 200, Anzuini and Levy attempted to conduct a study on the impact that monetary policy shocks may have on the economy in Poland, Hungary and the Czech Republic. The resulting model demonstrates that although the level of financial development of these countries is inferior to developed countries, macroeconomic variables respond in a similar way to changes in monetary policy. The two economists also carried out a quantitative analysis of the intensity of these responses and concluded that their frequency is lower compared to other EU Member States, and among the three analyzed countries Poland is the one that records the most stable responses in time, irrespective of the identification scheme. Darvas conducted a similar study in 2009, analyzing the economic policy behavior of three countries that have recently joined the EU as compared to the existing euro area countries. The three studied countries have undergone important changes in the monetary policy regime, which has forced a careful research into the economic parameters that are variable over time. The results of the study highlight the fact that the new states are heavily affected by monetary policy shocks, unlike the old ones that are more stable, and a possible shock does not shake the economy of the country. One explanation is the consumer's confidence in the economic environment and in the policy promoted by the central bank and the penetration rate of foreign currency loans.

Through the BVAR model, Bhuiyan also reported to Canada the effects of monetary policy changes, concluding that the output gap is spreading through the exchange rate and the interest rate. At the same time, Bhuiyan notes a significant influence from the monetary policy of the EDF. Another worthwhile analysis is that of two ECB economists Marcel Fratzscher and Roland Straub. Their paper analyzes the effect of stock price shocks on current account positions for industrialized G7 countries between 1974 and 2007. The method used is the Bayesian VAR with sign restrictions to identify asset price shocks and to empirically test their effect on current accounts. The response of the trade balance to stock price shocks varies substantially between countries. Evidence suggests that the channels that represent this heterogeneity operate both through the effects of wealth on private consumption and to some extent on the real exchange rate of the analyzed countries.

2. Interpretation of results

The results obtained from the use of this model highlight the impact that an economic variable can have on the overall economic environment. This analysis, in light of the complexity of monetary policy, requires the use of comprehensive methodologies based on econometric modeling and mathematical processing. The program used to build the BVAR is EViews 9.0. S. V. This is actually a software that can help shape a future forecast based on input from the user. Practically, the program allows for mathematical analyzes that start from user input and continues with the presentation of several options for determining the Bayesian autoregressive vector. EViews 9.0. S. V. presents many facilities, the most significant of which are:

- a scientific research of the information input;
- measurement of data;

- performing macroeconomic or financial analyzes;
- making simulations and forecasts that highlight the timing of the data input.

The most significant feature of this software program is the ability to process and use mathematical equations, the software has an extensive database that has been pre-defined for operators and incorporating multiple mathematical functions that can be used to draw highly specialized conclusions. Thus, having as a starting point the user-set data sample, EViews 9.0. S.V. offers the possibility to calculate the series of data originally input in order to make forecasts and estimates. Econometric modeling with EViews 9.0. S. V. involves several steps, of which the first and perhaps the most important is the collection of data used and the setting of work objectives. This step is considered significant because the correctness of the forecasts is based on the correctness of the data and correlations entered by the user. Through the study, I tried to analyze the links between the monetary policy rate and the selected indicators: GDP, exchange rate and inflation, in order to highlight the correlations between them, their intensity being the element justifying the need to create the econometric model. The input data used in this analysis was defined as follows:

- GDP - quarterly data, growth rate as compared to the previous period;
- Interest rate of monetary policy (RDOBBNR);
- Inflation rate (INFR).

Estimates of BVAR models, according to the literature, may use monthly, quarterly and annual data. It should be noted, however, that the methodology underlying this macroeconomic analysis was mentioned by Sims for the first time in its 1980 "Macroeconomics and Reality" paper, and in its analysis of the interdependence between monetary policy and price developments, it used monthly and quarterly data, the reason being that this model needs a large number of observations to be eloquent. At the same time, the way in which the occurrence of a unitary shock can be analyzed depends on the frequency of the data being used. A model that uses quarterly data shows a superior impact model that uses annual data.

In order to obtain the data, the annual reports drawn up by the National Bank of Romania for the period 2007 - 2016 and those available on the website of the National Institute of Statistics were used. The data required for the computerized model are shown in table no.1.

Table no. 1 Data used in EViews 9.0. S.V modelling

Parameters used			
Year	**GDP (%)**	**RDOBBNR (%)**	**INFR (%)**
2007T1	19.71	8.08	3.83
2007T2	20.71	7.25	3.79
2007T3	19.65	7.00	4.99
2007T4	21.66	7.33	6.69
2008T1	26.7	8.83	7.95
2008T2	27.46	9.75	8.56
2008T3	28.39	10.17	8.12
2008T4	20.54	10.25	6.81
2009T1	-0.14	10.08	6.77
2009T2	-1.78	9.67	6.09
2009T3	-5.43	8.50	4.99
2009T4	-2.35	8.00	4.56
2010T1	4.94	7.00	4.63
2010T2	4.72	6.33	4.36
2010T3	6.59	6.25	7.50
2010T4	2.48	6.25	7.86

2011T1	6.32	6.25	7.53
2011T2	4.71	6.25	8.23
2011T3	7.71	6.25	4.18
2011T4	4.74	6.08	3.38
2012T1	3.12	5.50	2.57
2012T2	7.27	5.25	1.88
2012T3	5.24	5.25	4.07
2012T4	5.44	5.25	4.82
2013T1	6.88	5.25	5.62
2013T2	5.36	5.25	5.33
2013T3	7.14	4.67	3.32
2013T4	8.49	4.08	1.75
2014T1	6.41	3.58	1.05
2014T2	5.66	3.50	0.94
2014T3	4.43	3.33	1.11
2014T4	3.49	2.83	1.18
2015T1	8.08	2.33	-0.55
2015T2	3.78	1.83	-0.52
2015T3	7.23	1.75	-2.47
2015T4	6.71	1.75	-2.6
2016T1	4.69	1.75	-1.24
2016T2	9.94	1.75	-1.76
2016T3	5.15	1.75	0.09
2016T4	8.28	1.75	0.53

Source: author adaptation and processing according to the existing data in the 2006 - 2010 National Bank Report, www.bnr.ro, website accessed on 08.31.2017

The following results were obtained from the research for the estimated BVAR model for the interval 2007. T1 - 2016. T4:

Bayesian VAR Estimates
Date: 09/26/17 Time: 16:52
Sample (adjusted): 1/11/2007 2/01/2016
Included observations: 27 after adjustments
Prior type: Sims-Zha (normal-Wishart)
Initial residual covariance: Diagonal VAR
Hyper-parameters: L0: 1, L1: 0.1, L3: 1
Standard errors in ( ) & t-statistics in [ ]

	RDOBBNR_...	RINF_____	PIB_____
RDOBBNR_____(-1)	1.042624	-0.001396	0.003377
	(0.05471)	(0.02208)	(0.02122)
	[19.0590]	[-0.06323]	[0.15912]
RINF_____(-1)	0.055428	0.816075	-0.013954
	(0.19997)	(0.08072)	(0.07758)
	[0.27719]	[10.1102]	[-0.17988]
PIB_____(-1)	0.230988	0.044187	0.927509
	(0.21138)	(0.08533)	(0.08200)
	[1.09275]	[0.51787]	[11.3105]
C	-0.567013	0.084293	0.055185
	(0.28040)	(0.11318)	(0.10878)
	[-2.02217]	[0.74474]	[0.50732]
R-squared	0.957188	0.754582	0.686572
Adj. R-squared	0.951604	0.722570	0.645691
Sum sq. resids	5.049875	0.764379	0.774449
S.E. equation	0.468572	0.182302	0.183498
F-statistic	171.4123	23.57250	16.79407
Mean dependent	5.915926	0.558635	0.900998
S.D. dependent	2.129966	0.346110	0.308277
Data marginal log-likelihood		-4.636208	
Data marginal log posterior		14.34753	
Coef marginal posterior estimate		311.3395	

Figure no. 1. The estimated BVAR model

Source: author data processed with Eviews application

The data presented in Table no.1 is represented by the input parameters used in Eviews 9.0. S.V, and their evolution was represented graphically in figure no. 2 taken from the program window.

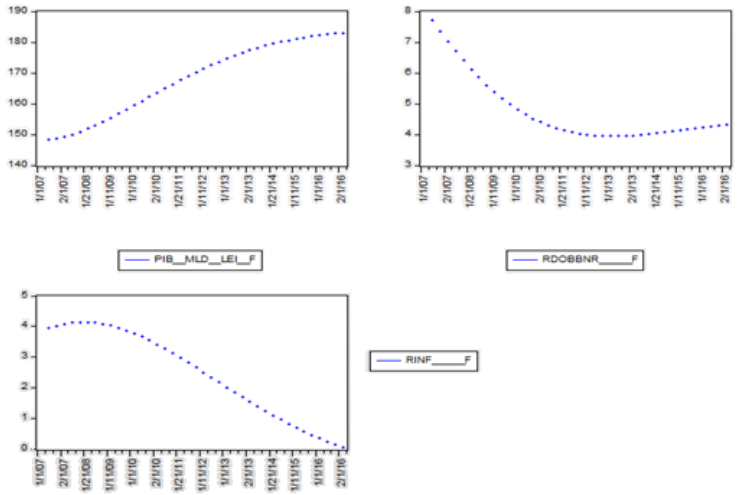

Figure no. 2 Graphical interpretation of input parameters using BVAR

Source: author data processed with Eviews application

The BVAR model has a very high probability of being a correct one, a conclusion resulting from the analysis of the values obtained through the Eviews program in the R Squared (0.95) and Adjusted R Squared (0.95) tests. Eviews also helps to get a clear picture of the impact that a positive change of one of the variables has on the evolution of the other two.

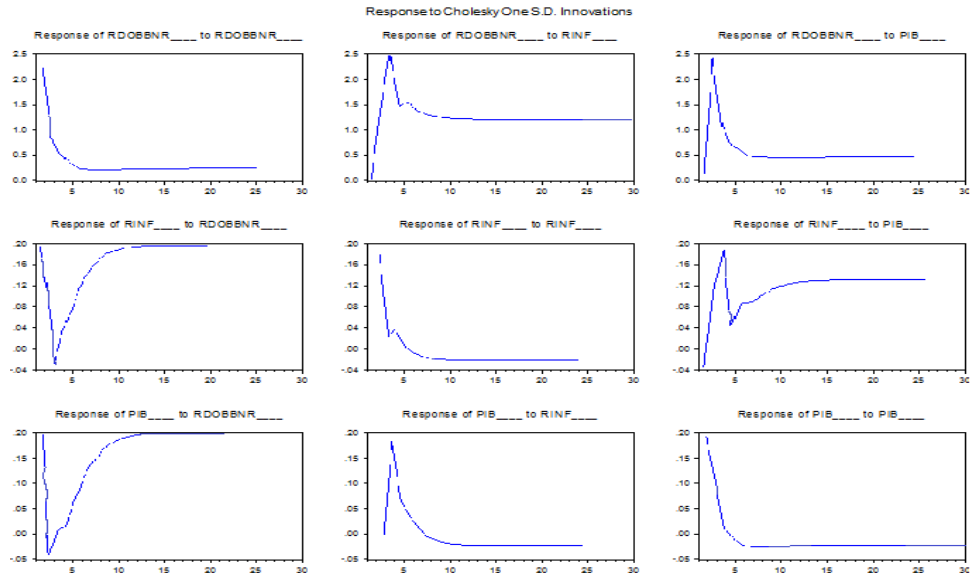

Figure no. 3 Reaction of economic variables analyzed to a positive shock of interest rate, inflation and GDP

Source: author data processed with Eviews application

Hence, the rise in the interest rate, as can be seen in Figure no. 3, translates into an increase in inflation and an increase in GDP. The economy is encouraged in this situation by supporting consumption and investment. The results obtained are in line with the literature, but also with the economic reality related to Romania during the analyzed period. The low interest rate over the past 2 years has led to negative inflation. Through this strategy, the NBR attempted to restore the country's economy and reach the expected inflation level, further reductions in reserve requirements have resulted in excess liquidity in the market.

The analysis continued with the impact of the inflation rate on GDP and the interest rate. As can be seen from figure no. 3, the NBR's response to the increase in inflation is to increase the interest rate, which is aimed at eliminating inflationary tensions and maintaining the level of inflation at the value set by the monetary policy strategy. The GDP's response to this increase in inflation is different from that provided in the literature, in the sense that although there should be a decrease, according to the data, we can notice an increase.

The last shock analyzed is the impact of GDP growth on the other two variables analyzed: interest rate and inflation rate. In this case, the result obtained is similar to the literature, in the sense that an unusual increase in gross domestic product leads to an increase in the inflation rate and the interest rate. An increased GDP can be a major pressure on prices, a pressure that is triggered by a higher supply demand in the market and leading to the emergence of inflationary tensions. Theoretically, the NBR, in order to maintain inflation in established parameters, increases the interest rate, which results in lower inflation, consumption and cycle resumption. In the economic reality of recent years, the NBR has supported consumption and investment, with benchmark interest rates in the last two years (2015 -2016) of historical minimum.

3. Conclusions

It is important to have a correlation between the use of econometric models and the economic reality, as there may be factors that cannot be quantified through econometric modeling. At the same time, the economy may surprise the data from econometric modeling, as is the case with the influence of GDP on the interest rate, and so it is particularly important to link them to the central bank's monetary policy objectives.

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