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15 August 2012

EFFECTS OF MONETARY POLICY IN ROMANIA. A VAR APPROACH

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Abstract: *Understanding how monetary policy decisions affect inflation and other economic variables is particularly important. In this paper we consider the implications of monetary policy under inflation targeting regime in Romania based on a vector autoregressive method including recursive VAR and structural VAR (SVAR). Therefore, we focus on assessing the extent and persistence of monetary policy effects on gross domestic product (GDP), price level, extended monetary aggregate (M3) and exchange rate. The main results of VAR analysis reflect a negative response of consumer price index (CPI), GDP and M3 and positive nominal exchange rate behaviour to a monetary policy shock, and also a limited impact of a short-term interest rate shock in explaining the consumer prices, production and exchange rate fluctuations.*

Keywords: monetary policy, transmission mechanism, vector autoregressions.
JEL Classification: E31, E52, E58, C32.

INTRODUCTION

Monetary policy transmission mechanism describes how traders respond to the decisions of monetary authorities in the context of future, mutual interactions between them. Such a process can be characterized as a set of monetary policy propagation channels through which the central bank influences the aggregate demand and the prices in the economy. Thus, we underline the presence of traditional channels of monetary policy transmission: the interest rate channel, the exchange rate channel, the credit (banking and balance sheet), the expectations channel, particularly important under inflation targeting regime and a series of non-standard channels such as the cost of risk taking risk.

Linked to the above, the present paper aims to empirical analyse the effects of monetary policy shocks on real economic aggregates and prices. Our approach is structured as follows. The first part offers a review of the literature focused on Central and Eastern Europe research, both at the level of individual states and for different groups within the region compared to other advanced economies; the second part explains the VAR model and data used. The third part is centred on identifying shocks with a distinction between recursive vector autoregressive (the Choleski identification) and structural autoregressive vector that implies zero restrictions freely distributed allowing for greater flexibility and a more accurate description of the considered variables interdependence. The fourth part focuses on model robustness, on its ability to provide a good image of the interactions dynamics between variables. The results on the effects of monetary policy shocks are shown in the fifth part that also presents the shock response functions (impulse response), decomposition of the variance (dispersion) and Granger causality. The sixth part contains conclusions and future directions of analysis.

1. RELATED VAR LITERATURE

Vector autoregressive models (VAR) introduced by Sims (1980) are considered to prevail in the econometric modelling of monetary policy transmission mechanism. Fry and Pagan (2005) argued that this class of models offers the ideal combination between the data-based approach and the coherent approach based on economic theory. With regard to monetary policy analysis, VAR methodology was further developed in the work of Gerlach and Smets (1995), Leeper, Sims and Zha (1998), Christiano, Eichenbaum, and Evans (1999). The latter study provides a detailed analysis of the literature on the subject in the U.S. Similarly, several researches have been undertaken in Europe to study the various aspects of the monetary policy transmission mechanism within the euro area (Angeloni, Kashyap, and Mojon, 2003). These studies focus both on the whole euro area (Peersman and Smets, 2001), and on individual member countries (Mojon and Peersman, 2001).

The analysis of the monetary policy transmission mechanism with VAR models spread to the emerging markets of Central and Eastern Europe. Again, we identify individual-level studies and comparative analyses for different groups of countries in the region.

Thus, Hurník and Arnoštová (2005) analysed the transmission mechanism of monetary policy in the Czech Republic for the period 1994-2004 using a VAR methodology. Their results show that an unexpected contractionary monetary policy shock leads to a lower production; prices increase in the first two quarters after the shock (price puzzle), exchange rate drops (appreciation) for 4-5 quarters and after it raises (delayed overshooting). The transmission mechanism of monetary policy in the Czech Republic is also studied by Morgese and Horvath (2008). The two authors take into account the period 1998-2006 (only the inflation targeting regime time) and using VAR, SVAR and FAVAR they obtain the following results: an unexpected contractionary monetary policy shock causes a decrease in production and in the price level with a maximum amplitude after about a year; and a persistent appreciation of the exchange rate followed by a further depreciation.

In Poland, Lyziak, Przystupa and Wróbel (2008) conducted an SVAR analysis of monetary policy transmission mechanism for the period 1997Q1 - 2006Q1, a period characterized by an inflation targeting regime. The empirical results obtained showed a maximum response of price level to a positive short-term interest rate shock after 16 to 20 months *ex post* the event, while the output response differs depending on the identification method used.

Demchuk et al. (2012) assessed the key characteristics of the monetary policy transmission mechanism in Poland, using VAR and SVAR during 1998-2011 (both monthly and quarterly data) and highlighted the following conclusions: an increase in short term interest rate by 1 % strongly reflects on output, price level and exchange rate (consumer price index decreases by about 0.3% after 6 quarters, the production by the same percentage after four quarters, an appreciation of the national currency that lasts 14 to 16 quarters).

In Romania, an analysis of monetary policy transmission mechanism was conducted by Antohi, Udrea and Braun (2003). For studying the first segment namely the transmission of policy decisions on financial variables the three authors have used a vector error correction model (VEC). Their conclusion emphasized that the central bank directly influences deposit interest rate through sterilization operations interest rate, but the banks' lending rate doesn't seem to be directly sensitive to NBR policy rate, but to deposit interest rate.

More recently, the VAR and SVAR approach of monetary policy transmission mechanism in Romania was applied by Andries (2008). Considering the period 2000:1 - 2007:6 and Cholesky identification method the author's main result highlighted that a sudden increase in the effective short-term interest rate causes a decrease in consumer prices that reflects the greatest amplitude after 6 months and an appreciation of the national currency with a maximum recorded in the same period after the shock.

There are also works that analyse and compare the effects of monetary policy through vector autoregressive model in different groups of Central and Eastern European countries against other advanced economies (Creel and Levasseur, 2005; Héricourt, 2005 ; Elbourne and de Haan, 2006, Darvas, 2005). These studies underlined some specific features of the monetary policy transmission mechanism in the new EU members from Central and Eastern Europe compared to the old Member States. Such particularities include a number of elements such as: 1) financial systems relatively less developed than the old EU member states, which could lead to a weaker impact of monetary policy on the economy, 2) additional difficulties in anchoring inflation expectations, which may generate prices behaviours with highest lags, 3) an increased inflation rate with considerable impact on the monetary policy transmission mechanism because under a higher inflation environment the agents adjust their prices more often having as a result a lower prices rigidity in these countries.

At the same time, these researches stresses a common view in the literature, namely the prevalence of exchange rate channel against the other two traditional channels of monetary policy transmission mechanism (interest rate channel and the credit) in the Central and Eastern European countries. In addition, Creel and Levasseur (2005) highlighted the weak impact of monetary policy in the region on production and prices, a conclusion opposite to that supported by Elbourne and de Haan (2006).

Anzuini and Levy (2007) provided empirical evidence on the effects of monetary policy shocks in the Czech Republic, Hungary and Poland. VAR system estimates considered by the two authors have suggested that despite a weaker development of national financial systems, the responses of macroeconomic variables to a monetary policy shock are similar between the three countries, and not significantly different from those of the advanced European economies. While from a qualitative perspective the responses of EU new member states proved to be similar to those observed in the old EU member states, quantitatively they were on average, weaker.

More recently, Jarociński (2010) performed a systematic comparison of macroeconomic variables responses to monetary shocks in Western Europe and new EU member states. New Member States (Czech Republic, Hungary, Poland and Slovenia) behaviours proved to be qualitatively similar to those in developed countries sample (Finland, France, Italy, Portugal and Spain), but with interesting differences: while production responses were found to be generally similar, price reactions uncertainty included the possibility of stronger effects compared to the case of considered Eurozone members. This result suggest that when analysing differences between the Central and Eastern European countries and Western Europe states, the study should be much more in depth, beyond the rule assuming that the monetary policy is less effective in countries with less developed financial systems.

Presently there is a new wave of interest to identifying and analysing the implications of the recent financial crisis and on the monetary policy transmission mechanism based on VAR method (eg, Boivin et al. (2010), Cecioni and Neri (2010)). Central and Eastern Europe countries researches are still in their infancy. In this regard we note the study of Lyziak et al. (2011), which highlighted the impact of recent global turmoil on the effectiveness of monetary policy transmission mechanism in Poland through a VAR and a small structural model, with the mention that it depends on monetary policy and the structural characteristics of the economy. The financial crisis, which affected both components led to a change in monetary policy rule and a significant lower efficiency of monetary policy.

In the same line, Demchuk et al. (2012) pointed out that during the recent international stress, the monetary policy transmission mechanism in a small open economy such as Poland suffered extensive disturbance, with the interest rate channel being the most affected

2. MODEL SPECIFICATION

We consider the following system:

$$AY_t = C(L)Y_{t-1} + D(L)X_t + B\varepsilon_t \quad (1)$$

where: the A matrix includes all coefficients describing the simultaneous relationships between variables, the C(L) matrix includes all coefficients reflecting the lagged linkages between variables, the D(L) matrix contains all coefficients pointing out the link between endogenous and exogenous variables, the B matrix is a diagonal matrix and vector ε includes the residuals. By multiplying the VAR system with the A inverse matrix we obtain:

$$Y_t = A^{(-1)}C(L)Y_{t-1} + A^{(-1)}D(L)X_t + A^{(-1)}B\varepsilon_t \quad (2)$$

which can be re-written as:

$$Y_t = aY_{t-1} + bX_t + \mu_t \quad (3)$$

where:

$$a = A^{(-1)}C(L)$$
$$b = A^{(-1)}D(L)$$
$$\mu = A^{(-1)}B\varepsilon$$

Equation (1) describes the structural model and equation (3) is a synthetized model form, the latter being observed empirically.

Thus, the considered VAR model has the following representation (reduced form):

$$Y_t = aY_{t-1} + bX_t + \mu_t$$

where: Y_t is the endogenous variables vector, X_t the exogenous variables vector, μ_t the vector of residual terms (white noise), *a* is a matrix that includes all coefficients describing relationships between endogenous variables and *b* is a matrix that contains all the coefficients reflecting the connections between endogenous and exogenous variables.

Exogenous variables vector contains the following variables: euro area consumer price index (ipc_ea), real GDP in the euro area (y_ea) and Eurozone short-term interest rate (i_ea).

$$X_t = [\,ipc\_ea_t \;\; y\_ea_t \;\; i\_ea_t\,] \quad (4)$$

These variables are used to control the evolution of demand and inflation in the euro area. Their inclusion helps solve the so-called *price puzzle* (e.g. the empirical results currently identified in the VAR literature showing that the interest rate rise results in an increase of price levels). Treating these variables as exogenous means, implicitly, that there is no impact from the endogenous to the exogenous variables. At the same time it allows for the contemporary impact of exogenous on endogenous variables.

Endogenous variables vector contains the following: Romanian real gross domestic product (y_ro), the national consumer price index (ipc_ro), M3 monetary aggregate (m3_ro), domestic short-term interest rate (i_ro) and nominal exchange rate EUR / RON (s_ro).

$$Y_t = [\, y\_ro_t \;\; ipc\_ro_t \;\; m3\_ro_t \;\; i\_ro_t \;\; s\_ro_t \,] \qquad (5)$$

2.1 DATA

The data sample is restricted, including data from mid-2005, at which point the NBR adopted inflation targeting strategy. Before this moment, during 1990-1997 the central bank applied a monetary targeting strategy and between 1997 and 2005 a combined strategy targeting both monetary aggregates and the exchange rate (eclectic strategy). Thus, the sample covers the period between 2005: Q3 and 2012: Q1 with a quarterly frequency. As a result, we have 27 observations provided by Eurostat (www.eurostat.ec.europa.eu).

The analysed variables include:

- the national real gross domestic product and the euro area (y_ro_t, y_ea_t);
- fixed-base index of domestic consumer prices and the euro area indicator(y_ro_t, y_ea_t);
- M3 monetary aggregate in Romania($m3\_ro_t$);
- the national and Eurozone short-term interest rates with ROBOR as proxy, and respectively 3-month EURIBOR (i_ro_t i_ea_t);
- EUR / RON nominal exchange rate (s_ro_t).

All series except the interest rates and exchange rates have been adjusted to eliminate seasonal factors based on the X12 procedure used by the U.S. Census Bureau. Also all series except interest rates were put under logarithms.

The VAR variables should not be stationary. Sims (1980), *inter alia*, argued against differentiation, even if the series contain a unit root, causing informational losses. What matters for VAR results robustness is the system general stationarity (Lütkepohl, 2006).

If the considered endogenous variables are stationary, meaning integrated of order zero, I (0), the VAR estimation is supported by level-specified variables. If the variables are nonstationary but cointegrated, the estimation is allowed with level-specified variables or autocorrection model (VEC). Finally, if the variables are nonstationary and not cointegrated it is necessary to specify them as differences.

We test the stationarity with the help of Augmented Dickey - Fuller test and Phillips – Perron test; their results indicate that variables are not stationary: y_ro_sa: I (2), y_ea_sa: I (2), ipc_ro_sa: I (1), ipc_ea_sa: I (2), i_ro: I (1), m3_ro: I (0), i_ea: I (2), s_ro: I (1).

Cointegration testing based on the methodology developed by Johansen indicate that there are three cointegration equations at a significance level of 0.05 (outcome based on both Trace and

Maximum Eigenvalue Tests). This result, in conjunction with the stationarity tests conclusions underlines the possibility of model estimation with level-specified variables.

The number of lags considered must capture the system dynamics without consuming too many degrees of freedom. If the lag number is too small, the model will not be specified correctly and if the number is too high, too many degrees of freedom would be lost (Codirlaşu, 2007). Choosing the number of lags was based on results synthesis of several methods: the sequential testing of lags significance, minimizing the final prediction error and information content evaluation criteria (Akaike, Schwartz and Hannan-Quinn). Most criteria indicate the existence of 1 lag. We check the result by excluding non-significant lags based on lag exclusion tests. Lag Exclusion Wald test confirmed the retaining of 1 lag.

3. SHOCKS IDENTIFICATION

Shocks identification is based on imposing zero-restrictions for A and B matrices coefficients in $\mu = A^{(-1)} B\varepsilon$ relation. The minimum number of zero restrictions to be imposed to identify structural innovations is n (n-1) / 2, where n is the number of endogenous variables (in this case n = 5). So, if we impose a number of 10 zero-restrictions, the VAR system is precisely identified and if the number of zero restrictions is higher than 10, the system will be over-identified. The determination of the appropriate number of zero restrictions (innovation decomposition or orthogonalization), which is actually equivalent to setting assumptions about the endogenous variables can be done in several ways.

One of the methods is the recursive Choleski identification. In this case, the A matrix has a triangular structure, the all elements above the main diagonal equal to zero. Under Choleski approach, the two matrices, A and B, have the following representation:

$$A = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 \end{bmatrix} \qquad B = \begin{bmatrix} b_{11} & 0 & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 & 0 \\ 0 & 0 & b_{33} & 0 & 0 \\ 0 & 0 & 0 & b_{44} & 0 \\ 0 & 0 & 0 & 0 & b_{55} \end{bmatrix}$$

The ordering of the variables in the context of equation (5) requires implicit assumptions about: (i) what the monetary authority considers when making monetary decisions, and (ii) which variables simultaneously respond or not respond to monetary policy decisions. This ordering also implies that when deciding, the central bank takes into account the current level of production, prices and monetary developments. At the same time, monetary policy actions have no impact on production and prices contemporary. Because the exchange rate is ordered after the interest rate, the latter should have an immediate impact on the exchange rate. On the other hand, the interest rate does not respond in the same period to changes in nominal exchange rate.

The considered recursive VAR model (the Choleski identification) requires a rigid structure of causal relationships between variables and as a result, its ability to correctly describe dependencies between variables is put under question. To eliminate these drawbacks, namely to allow greater flexibility of connections between variables, it is necessary to use a structural VAR identification with Sims (1986) and Bernake (1986) identification method. Under this orthogonalization approach the zero restrictions can be freely distributed. In the case of structural VAR, the two matrices, A and B, are represented as follows:

$$A = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & a_{34} & 0 \\ a_{41} & 0 & 0 & 1 & a_{45} \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 \end{bmatrix} \qquad B = \begin{bmatrix} b_{11} & 0 & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 & 0 \\ 0 & 0 & b_{33} & 0 & 0 \\ 0 & 0 & 0 & b_{44} & 0 \\ 0 & 0 & 0 & 0 & b_{55} \end{bmatrix}$$

The number of zero restrictions imposed in this case is also 10, therefore the system is exactly identified. The first two equations represent the slow reaction of the real sector (GDP and prices) to monetary sector shocks (M2, interest rates and exchange rates). There is no contemporary impact of monetary policy shocks, M2 and exchange rate on production and prices. M2 is influenced by GDP contemporary innovations, price level and short-term interest rate. The central bank sets the interest rate taking into account the contemporary innovations of production (a_{41}can be interpreted as a pressure indicator of excessive demand) and exchange rate (a_{45}can be interpreted as the exchange rate fluctuations that influence inflation expectations), but it does not respond simultaneously to monetary aggregate shocks (under a monetary targeting regime) and to price level (price information is available only with a certain lag). Finally, the exchange rate as price of an asset immediately reacts to all the innovations of the other variables.

4. ANALYSIS ROBUSTNESS

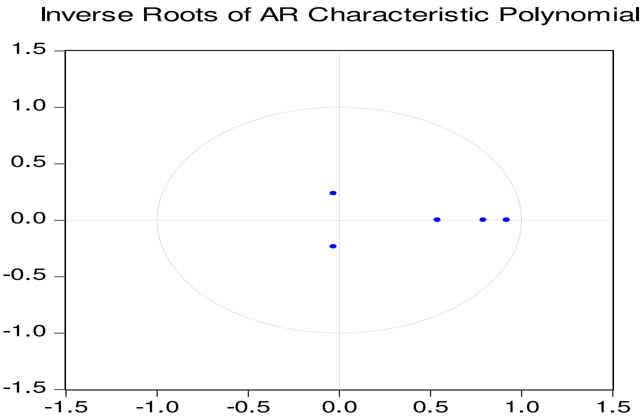
The VAR is confirmed if it is stable and the residuals are "white noise".

4.1 Testing the model stability

The considered model should be stationary. If not, the confidence intervals for impulse-response functions cannot be built. The VAR stability is confirmed when the inverses of estimated coefficients matrix characteristic roots have modules less than 1 or alternatively, they lie within the circle of radius 1. We test the model stability with the help of AR roots test as a graph and table.

Figure 1 – Testing the model stability using *AR table and AR Graph*

Roots of Characteristic Polynomial	
Endogenous variables: LOG(Y_RO_SA) LOG(IPC_RO_SA) LOG(M3_RO_SA) I_RO LOG(S_RO)	
Exogenous variables: LOG(Y_EA_SA) LOG(IPC_EA_SA) I_EA	
Root	Modulus
0.920318	0.920318
0.793025	0.793025
0.541869	0.541869
-0.029740 - 0.235721i	0.237589
-0.029740 + 0.235721i	0.237589
No root lies outside the unit circle. VAR satisfies the stability condition.	



Source: authorial calculations

According to figure 1, the VAR model has five roots: 3 real and 2 complex. If the roots values in module are subunit, the model is stable. In this case, the hypothesis of model stability is checked. The AR table graphical representation provides the same conclusions. The VAR is considered to be stable because none of the points exceeds the circle.

4.2 The diagnosis of residual terms

Under considered VAR model, the μ_t errors must be "white noise" (the absence of autocorrelation, the distribution normality and homoscedasticity).

The verification of the serial non-correlation hypothesis of residuals is supported by Portmanteau and LM autocorrelation test. Portmanteau test verifies the partial correlation up to a specified lag, usually with a higher order than the VAR model (in the present case we check the first 3 lags). The null hypothesis states the absence of autocorrelation.

Table 1 – Residuals autocorrelation verification Portmanteau test

VAR Residual Portmanteau Tests for Autocorrelations					
Null Hypothesis: no residual autocorrelations up to lag h					
Sample: 2005Q3 2012Q1					
Included observations: 26					
Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	27.75312	NA*	28.86325	NA*	NA*
2	53.99395	0.1954	57.29081	0.1228	46
3	80.93088	0.1969	87.74125	0.0865	71
*The test is valid only for lags larger than the VAR lag order.					
df is degrees of freedom for (approximate) chi-square distribution					
*df and Prob. may not be valid for models with exogenous variables					

Source: authorial calculations

The p-value higher than 5% allows us to accept the null hypothesis and say that there is no serial correlation between residuals. This result is confirmed by multivariate LM test for partial correlation up to a certain lag.

Testing the distribution normality of errors is supported by Jarque-Bera test that compares the skewness and kurtosis coefficients with those of a normal distribution.

Table 2 – Testing the normality of errors distribution

VAR Residual Normality Tests				
Orthogonalization: Cholesky (Lutkepohl)				
Null Hypothesis: residuals are multivariate normal				
Sample: 2005Q3 2012Q1				
Included observations: 26				
Component	Skewness	Chi-sq	df	Prob.
1	0.931599	3.760801	1	0.0525
2	0.500628	1.086057	1	0.2973
3	0.329713	0.471079	1	0.4925
4	0.153983	0.102747	1	0.7486
5	0.556588	1.342425	1	0.2466
Joint		6.763109	5	0.2389
Component	Kurtosis	Chi-sq	df	Prob.
1	3.320329	0.111162	1	0.7388
2	4.025600	1.139510	1	0.2858
3	2.646240	0.135575	1	0.7127
4	1.771195	1.635793	1	0.2009
5	2.733395	0.077001	1	0.7814
Joint		3.099041	5	0.6847
Component	Jarque-Bera	df	Prob.	
1	3.871962	2	0.1443	
2	2.225567	2	0.3286	
3	0.606654	2	0.7384	
4	1.738540	2	0.4193	
5	1.419426	2	0.4918	
Joint	9.862149	10	0.4527	

Source: authorial calculations

Table 2 presents the results of residuals testing distribution. All normality assumptions are accepted due to a p-value greater than the significance threshold (5%) for all situations. The homoscedasticity of residual terms was verified based on White's test. The null hypothesis states that all errors are homoscedastic (their variation is constant.).

Table 3 – Testing the residuals homoscedasticity

VAR Residual Heteroskedasticity Tests: No Cross Terms (only levels and squares)					
Sample: 2005Q3 2012Q1					
Included observations: 26					
Joint test:					
Chi-sq	df	Prob.			
236.3719	240	0.5541			
Individual components:					
Dependent	R-squared	F(16,9)	Prob.	Chi-sq(16)	Prob.
res1*res1	0.537509	0.653739	0.7805	13.97523	0.6006

res2*res2	0.662557	1.104450	0.4567	17.22649	0.3711
res3*res3	0.491493	0.543679	0.8622	12.77881	0.6889
res4*res4	0.368720	0.328546	0.9748	9.586711	0.8873
res5*res5	0.596612	0.831938	0.6420	15.51190	0.4875
res2*res1	0.603138	0.854871	0.6248	15.68160	0.4754
res3*res1	0.430507	0.425221	0.9350	11.19319	0.7974
res3*res2	0.471987	0.502816	0.8897	12.27167	0.7251
res4*res1	0.649271	1.041303	0.4954	16.88105	0.3933
res4*res2	0.543754	0.670388	0.7675	14.13761	0.5885
res4*res3	0.406260	0.384885	0.9540	10.56276	0.8356
res5*res1	0.639280	0.996883	0.5242	16.62129	0.4105
res5*res2	0.487442	0.534938	0.8683	12.67350	0.6965
res5*res3	0.419257	0.406086	0.9444	10.90067	0.8156
res5*res4	0.494114	0.549410	0.8582	12.84696	0.6839

Source: authorial calculations

The p-value of greater than 5% allows us to accept the null hypothesis and say that the residuals do not broke the homoscedastic hypothesis.

The results of stability testing and residual terms indicate that the considered model is able to provide a good picture of the dynamics of interactions between variables.

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5. ESTIMATION RESULTS

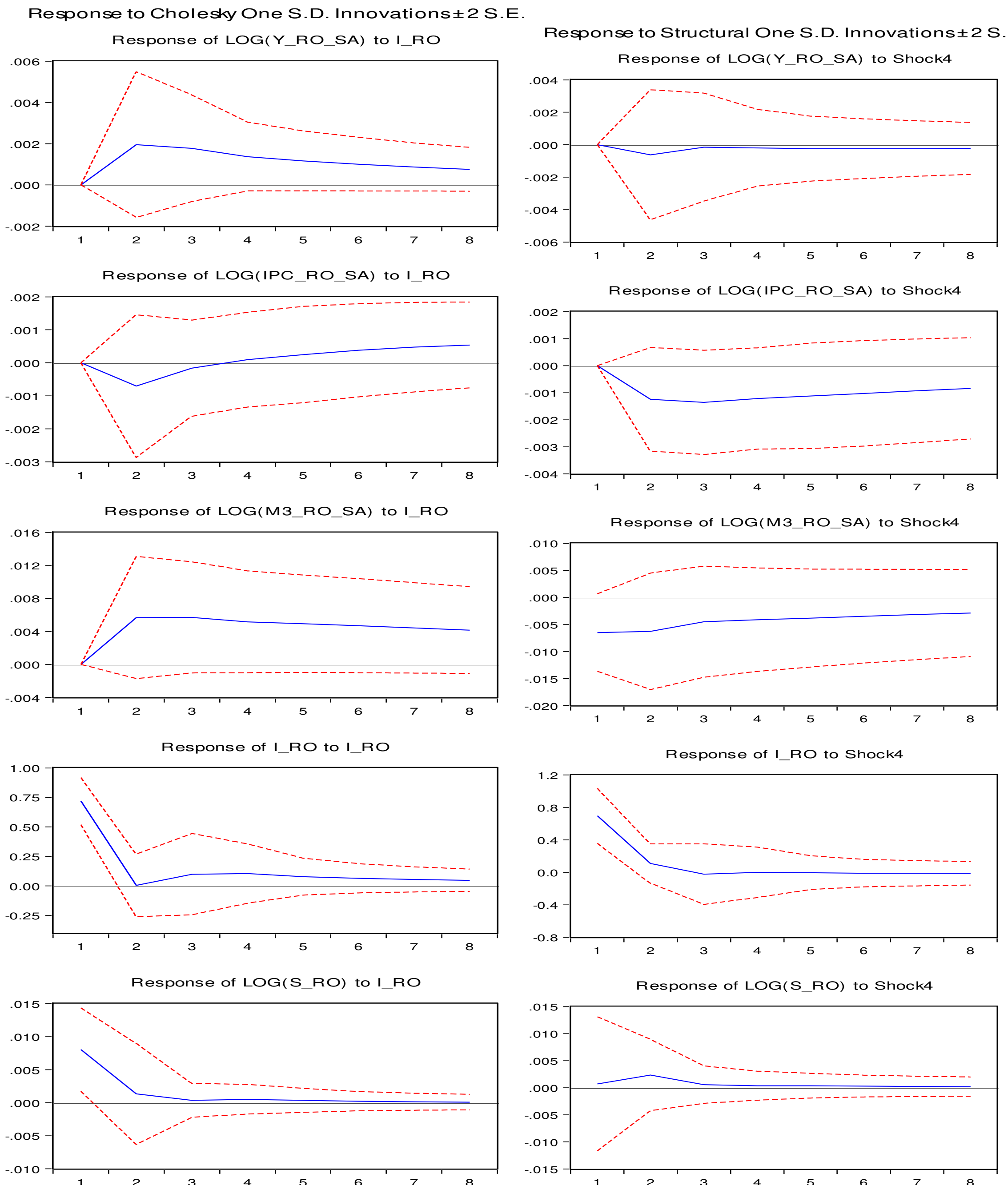
VAR analysis provides three important results: the shock response function (impulse response), variance decomposition (dispersion) and Granger causality.

5.1 Impulse response function

The shock response function presents the results on the effects of a monetary policy shock on the economic variables of interest for the monetary authority. The confidence interval is 95%, the shock is a standard deviation, and the time on the horizontal axis is expressed in quarters. The figure 2 shows the impulse-response function for considered recursive VAR and structural models. The graphical representation points out that when using recursive VAR, a quarter of monetary policy leads to a positive response (the same sign) of GDP, M3 and nominal exchange rate, results that are counterintuitive.

The application of a structural VAR, for which the shock identification was achieved by the free distribution of zero restrictions allowing for a more accurate description of the variables interdependencies led to a negative response of GDP, CPI and M3 and positive nominal exchange rate.

Figure 2 - Variables response variables to a contractionary monetary policy shock (recursive VAR- on the left, structural VAR- on the right)



Source: authorial calculations

In the case of an unexpected contractionary monetary policy shock (a sudden increase in short term interest rate) we emphasize the following behaviours of the interest variables:

- A GDP decline, that reaches a maximum after about a quarter and a half;
- A broader decrease of consumer price index, with a maximum level after about two quarters;
- A negative M3 response, with a peak during the first two quarters from the short-term interest rate rise;

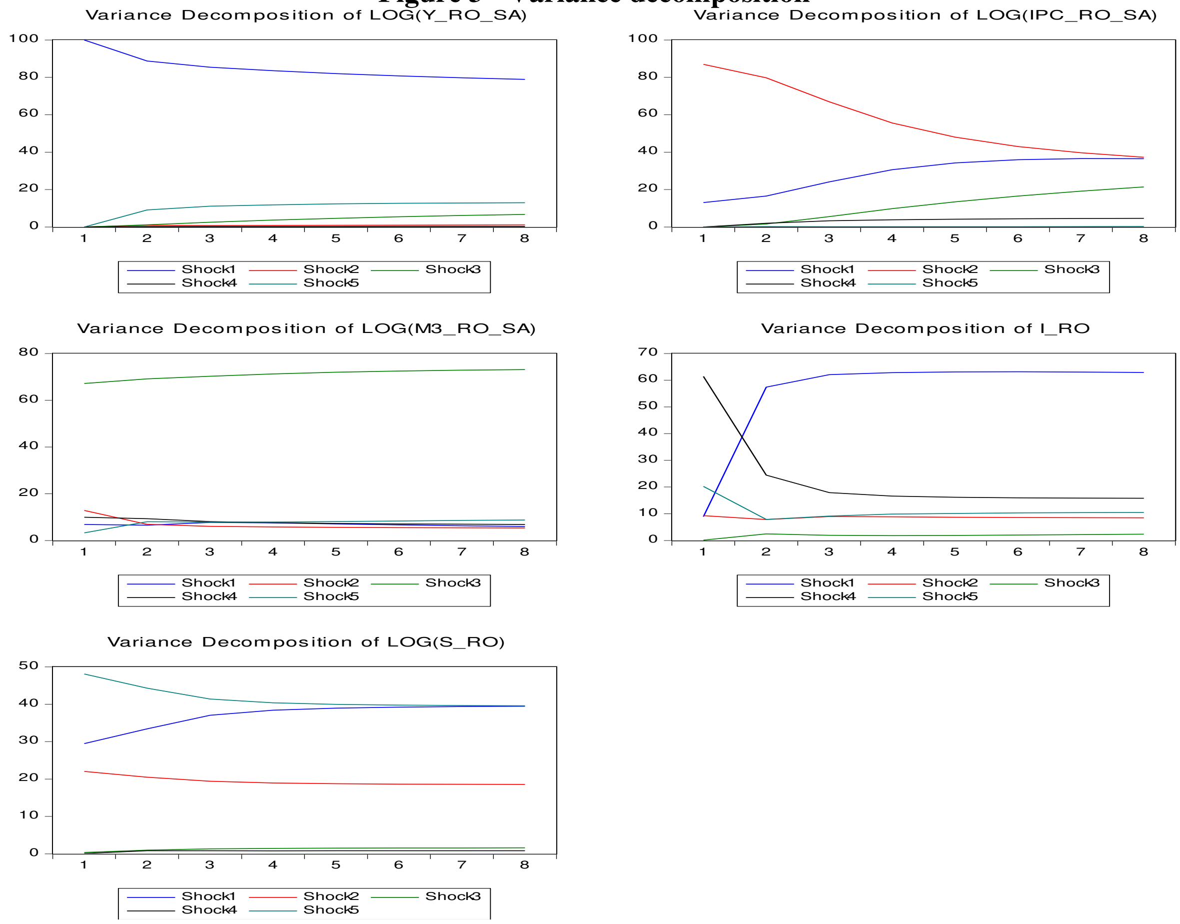
• A positive behaviour of the exchange rate (domestic currency depreciation). Such a counterintuitive result (an increase in short-term interest rates followed by the national currency depreciation) is often found when using vector autoregressive methods, known as the "exchange rate puzzle". This *puzzle* leads to higher import prices enhancing the acceleration of domestic inflation, especially in a small open economy as Romania.

However, the results can be challenged as we note the presence of the 0 value within the confidence interval, which translates into a lack of response to shocks (results are not statistically significant).

5.2 Decomposition of variance (dispersion)

The proportions of the variations of an endogenous variables caused by its own shocks and shocks due to other variables within the system are presented in figure 3. Because the use of structural autoregressive vector has generated superior results both from a qualitative and a quantitative perspective, as we have seen previously, the variance decomposition is presented only for this case.

Figure 3 - Variance decomposition



Source: authorial calculations

Figure 3 reveals that short-term interest rate shocks have a limited contribution in explaining the variation of consumer prices, production and exchange rate. For example, considering a time horizon of two quarters, the CPI variation is explained by approximately 80% of GDP shocks, 15% by its own innovations and 2% by the monetary aggregate M3 innovations, interest rate short-term, and nominal exchange rate. For a longer time span (8 quarters), the CPI variation is explained by 40% of GDP shocks, 40% by their innovations, 15% of innovations in M3 and less than 2% by short-term interest rate and nominal exchange rate shocks. In the same period, the GDP variation is explained by approximately 80% of its own innovations, 10% by the nominal exchange rate shocks, 5% by the innovations of M3 and less than 2% by the consumption price index shocks and short-term interest rate.

5.3 Granger causality test

The identification of variables that contain useful information to predict other variables within the VAR system is shown in table 4.

Table 4 - Granger causality test

VAR Granger Causality/Block Exogeneity Wald Tests							
Sample: 2005Q3 2012Q1							
Included observations: 26							
Dependent variable: LOG(Y_RO_SA)				Dependent variable: LOG(IPC_RO_SA)			
Excluded	Chi-sq	df	Prob.	Excluded	Chi-sq	df	Prob.
LOG(IPC_RO_SA)	0.379230	1	0.5380	LOG(Y_RO_SA)	0.029221	1	0.8643
LOG(M3_RO_SA)	5.079878	1	0.0242	LOG(M3_RO_SA)	3.881607	1	0.0488
I_RO	0.005624	1	0.9402	I_RO	0.783785	1	0.3760
LOG(S_RO)	7.949480	1	0.0048	LOG(S_RO)	0.108132	1	0.7423
All	12.10176	4	0.0166	All	6.675855	4	0.1540
Dependent variable: LOG(M3_RO_SA)				Dependent variable: I_RO			
Excluded	Chi-sq	df	Prob.	Excluded	Chi-sq	df	Prob.
LOG(Y_RO_SA)	3.856640	1	0.0495	LOG(Y_RO_SA)	29.21581	1	0.0000
LOG(IPC_RO_SA)	0.422210	1	0.5158	LOG(IPC_RO_SA)	2.561936	1	0.1095
I_RO	0.036068	1	0.8494	LOG(M3_RO_SA)	10.67442	1	0.0011
LOG(S_RO)	12.96658	1	0.0003	LOG(S_RO)	0.108535	1	0.7418
All	20.40120	4	0.0004	All	30.13475	4	0.0000
Dependent variable: LOG(S_RO)							
Excluded	Chi-sq	df	Prob.				
LOG(Y_RO_SA)	1.069117	1	0.3011				
LOG(IPC_RO_SA)	0.001136	1	0.9731				
LOG(M3_RO_SA)	1.144530	1	0.2847				
I_RO	0.207741	1	0.6485				
All	11.80676	4	0.0188				

Source: authorial calculations

Granger causality tests highlight the following results:

- The consumer price index variable is Granger caused by the gross domestic product variables, short-term interest rate and nominal exchange rate, but not the monetary aggregate and it Granger determines all other variables.

- The gross domestic product is Granger caused by the consumer price index variables and short-term interest rate, but not the nominal exchange rate and monetary aggregate M3 and it Granger determines the nominal exchange rate and consumer price index variables.
- The M3 variable is Granger caused by short-term interest rate variables and the consumer price index, but not the nominal exchange rate variables and gross domestic product and it Granger causes only the nominal exchange rate.
- The interest rate term is Granger caused by the nominal exchange rate and consumer price index, but not the GDP and M3 variables and it Granger determines all other variables.
- The nominal exchange rate is Granger caused by all other variables and it Granger determines the short-term interest rate and consumer price index variables.

However, it should be stressed that the Granger causality cannot be interpreted as a structural causality, it is only consistent with (it is neither necessary nor sufficient for) true causality, the effect must succeed in time to cause Botel (2002).

CONCLUSIONS

The three important results provided by the VAR analysis of monetary policy transmission mechanism were:

- **Shock response function (impulse response):** under the considered recursive VAR approach (the Choleski identification) a monetary policy shock causes a response of the same sign from the GDP, M3, nominal exchange rate, results that are counterintuitive and a negative response of price level. The free distribution of zero restrictions to identify shocks in the structural VAR model revealed the negative behaviour of GDP, consumer price index and monetary aggregate M3 and a positive reaction of nominal exchange rate. Thus, in case of SVAR, the results of an unexpected short-term interest rates translate into a decrease in GDP, that reaches a maximum level after about a quarter and a half after the event; a reduction of the broad consumer price index, with a maximum reached after about two quarters ex post the shock; a decrease of monetary aggregate M3, with a maximum during the first two quarters after the short-term interest rate rise and an increase of the exchange rate (the depreciation of the domestic currency), known as the so-culled "exchange rate puzzle".
- **Decomposition of variance (dispersion):** short-term interest rate shocks have a reduced role in explaining the variation of consumer prices, production and exchange rate. Regarding the price level, for a time horizon of two quarters, the CPI variation is explained by approximately 80% of GDP shocks, 15% of its own innovations, under 2% of M3 innovations, short-term interest rate and nominal exchange rate. For a longer time span (8

quarters), the CPI variation is explained by approximately 40% of GDP shocks, 40% of its own innovations, 15% of innovations in M3 and less than 2% of short-term interest rate and nominal exchange rate shocks.

- **Granger causality test type**: short-term interest rate Granger causes CPI, GDP and M3 monetary aggregate and nominal exchange rate is Granger caused by nominal exchange rate and consumer price index and but not by the gross domestic product and the M3 monetary aggregate.

As future directions of analysis we propose an evaluation based on the technique using an autoregressive structural vector of the disturbance degree of monetary policy transmission mechanism on both its segments, in the light of the recent economic and financial crisis impact and also the determination of its efficiency under the current international financial stress.

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