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# Determinants of inflation in Romania: empirical analysis using the vector error correction model

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**Abstract**

*A variety of causes are found behind the occurrence of the inflationary phenomenon and they can be divided into monetary and non-monetary causes. In 2005, the National Bank of Romania adopted the strategy of direct inflation targeting that has as main objective to maintain the price stability. The purpose of this paper is to estimate a model to quantify the long-term relationship between the inflation rate and the main determinants, the reference real interest rate, the money supply in a narrow sense, the exchange rate and monthly net average nominal wage. The analysis is performed using monthly data from August 2005 – December 2013, by using the vector error correction methodology. Also, through the function of response to shocks, we analyzed the response of the inflation rate to a shock produced in the other variables considered in the study. The results obtained indicate that the reference real interest rate has a significant influence on the inflation rate on long-term during the analyzed period, in Romania.*

Keywords: inflation rate, real interest rate, vector error correction model, impulse response function

## 1. Introduction

In Romania, the evolution of the inflationary process can be divided into two distinct periods. Thus, in the interval between 1990-2004, amid some important structural imbalances of the national economy, the inflation rate has recorded extremely high values (reaching the value of 295% in December 1993, 177% in June 1997 or 56% in January 2000).

The increase of the inflation rate was caused, among others, by the lack of correlation between labor productivity and the increases of wages, by the lack of financial discipline of the economic agents, by the delay of the price liberalization and the granting of credits directed to certain sectors such as agriculture and export.

Until August 2005, the monetary policy regime in Romania was the one based on the targeting of monetary aggregates (monetary targeting), adopted in the early 1990. The efficiency of the transmission mechanism of the monetary policy was negatively influenced by the uncertainty induced by the unstable relationships between the macroeconomic variables and real variables.

Meeting the specific criteria for the transition to a new monetary policy regime led to the adoption of the direct inflation targeting strategy in August 2005. Thus, the monetary authority focuses its attention on the fundamental objective, namely to assure and maintain price stability, the interest rate becoming the main transmission tool of the monetary policy.

The implementation of the direct inflation targeting strategy has brought a number of benefits, such as increasing the credibility of the monetary authority and therefore the effectiveness of the monetary policy, a greater flexibility in the appropriate choosing of the monetary policy instruments to be used, and represents a strategy easily understood by the population.

This study is structured as follows: Section 2 presents an overview of the literature on the subject proposed. Section 3 outlines the methodological issues related to the vector autoregressive model. The empirical results for the proposed research are presented in Section 4. The last part indicates the main conclusions of the study.

## 2. Literature review

In the countries of the Central and Eastern Europe, the inflation rate registered a significant variation during the economic transition, the econometric relationships between the monetary supply, interest rate, exchange rate and inflation rate being very unstable. Kim (2001) analyzes the determinants of inflation in Poland using the vector autoregression method (VAR), for the period 1991-1999, the conclusions being that the inflationary phenomenon is influenced by the labour sector and the international transactions sector.

Also in Poland, the study conducted by Lyziak, Przystupa and Wrobel (2008) for the period 1997-2006 shows that an interest rate shock causes a negative response with the highest amplitude of the inflation rate at a time horizon of 16 months.

In the Czech Republic, Hurnik and Arnostova (2005) study the response of macroeconomic variables to a monetary policy shock for the period 1994-2004. Results indicate that a short-term increase in interest rates affects the exchange rate appreciation. In addition, a temporary decline of production and prices, reaching maximum amplitude after about seven quarters, takes place. The reaction of prices at the decrease of production is explained by the important role of the exchange rate channel in the Czech economy.

Using the same methodology, but for 1998-2006, Morgese and Horvath (2008) find that a shock produced in the monetary policy causes a decrease in production and in the price level, with a maximum amplitude reached after one year, and the exchange rate appreciates in this time horizon.

Popescu (2012) studies using VAR and Structural VAR type models the effects of the monetary policy on the gross domestic product, on the broad money supply, on the exchange rate and price level in Romania. The author concludes that the Consumer Price Index (CPI), Gross Domestic Product (GDP) and broad money supply (M3) react negatively to a monetary policy shock, compared with the exchange rate, which is influenced positively.

Andries (2008) analyzes for the period January 2000 - June 2007, the response of the economic variables to monetary policy innovation in Romania. An increase in short-term interest rate causes a reduction of inflation. At a time horizon of 6 months, this decrease reaches the highest level. Also, the national currency appreciates and the Gross Domestic Product is not significantly influenced, while private consumption decreases. Cocriş and Nucu (2013) find that monetary shocks are an important factor in explaining industrial production and exchange rate, after 24 month, for the period January 2003 – Juin 2012.

Gul and Ekinci (2006) use the Vector Error Correction (VEC) model to analyze the relationship between the interest rate and inflation rate in Turkey, for the period 1984-2003, obtaining a unidirectional and causal connection between the inflation rate and interest rate. Also, Alexova (2012) uses the VEC model by analyzing the determinants of inflation in the countries that joined the European Union after 1996. The countries like Slovakia, Czech Republic, Hungary, Poland and Bulgaria are characterized by cost-push inflation. The inflation by request is predominant in Romania, Slovakia, Estonia, Latvia and Lithuania.

In his study, Jarocinski (2010) compares the response of the macroeconomic variables from five Western European Countries (Finland, France, Italy, Portugal and Spain) and four EU member states from Central and Eastern Europe (Czech Republic, Hungary, Poland and Poland) to a monetary policy shock. The obtained results indicate that the responses of the macroeconomic variables from the western countries are similar to those of the countries from Central and Eastern Europe.

## 3. Data and methodology

In order to capture the causality between inflation and the main macroeconomic variables, we used the vector autoregression (VAR) methodology. This type of system analysis can highlight the connections between the variables.

The study conducted is based on the following data sets on a monthly basis recorded for the period January 2005 – December 2013:

- Time series of inflation rate (%)
- Time series of the reference real interest rate (%)
- Time series of exchange rate Leu/Euro
- Time series of money supply in a narrow sense (lei)
- Time series of monthly net average nominal wage (lei)

The data were taken from the annual reports of the National Bank of Romania, and we used the statistical soft EViews for the empirical study.

The choice of the period of analysis is justified by the change of monetary policy regime in 2005 in Romania, by switching to a direct inflation targeting regime.

The analysis starts from using a VAR (vector autoregressive) model, but taking into account the cointegration relationship between variables, we use a vector error correction (VEC) model.

### 3.1. The vector autoregression model (VAR)

In modeling the economic phenomena, cases when the macroeconomic variables influence each other, whether they are considered to be dependent or independent variables, are frequently encountered.

Sims (1980) considers that all variables must be treated in the same way, by not making the distinction between dependent variables and independent variables. In the analysis based on the vector autoregression (VAR) suggested by Sims, all variables are considered to be endogenous and are modeled together. The main purpose of using the vector autoregression models is the dynamic impact analysis of various shocks (innovations) on the system of considered variables.

We consider the system consisting of *m* variables, each of which is expressed as a linear function of *k* lags of the eigenvalues and of the other *m-1* variables, plus the error term. A VAR model with 2 variables, $X_t$ and $Y_t$, can be defined as:

$x_t = \beta_{10} + \beta_{11} x_{t-1} + \ldots + \beta_{1k} x_{t-k} + \alpha_{11} y_{t-1} + \ldots + \alpha_{1k} y_{t-k} + u_{1t}$ (1)

$y_t = \beta_{20} + \beta_{21} y_{t-1} + \ldots + \beta_{2k} y_{t-k} + \alpha_{21} x_{t-1} + \ldots + \alpha_{2k} x_{t-k} + u_{2t},$ (2)

where $\beta, \alpha$ represents the coefficients of $X_t$ and $Y_t$ at one k lag

$u_{1t}$ and $u_{2t}$ are the shocks (innovations) in t period, on the variables $x_t$ and $y_t$.

If each variable is influenced only by the immediate preceding values of $x_t$ and $y_t$ plus the error term, then *k* takes the value 1, and relationships (1) and (2) become:

$x_t = \beta_{10} + \beta_{11} x_{t-1} + \alpha_{11} y_{t-1} + u_{1t}$

$y_t = \beta_{20} + \beta_{21} y_{t-1} + \alpha_{21} x_{t-1} + u_{2t}$

The error terms are those parts of $x_t$ and $y_t$ that are not explained by past values of the two variables and are called shocks or innovations in each variable.

The advantages of using the autoregressive model include the ease of the estimation of the model, meaning that each equation can be estimated separately using the method of least squares. Also, all the system variables are considered to be endogenous variables. The forecasts obtained using VAR models are often more accurate than those of the structural models containing simultaneous equations (Asteriou, 2011).

On the other hand, VAR models have received criticisms concerning the fact that they are not based on any economic theory, compared to simultaneous equations models in which the inclusion or exclusion of variables have an essential role in the estimation of the model.

Also, by using VAR models the degrees of freedom are lost. We assume that we have a three-variable VAR model and decide to include 12 lags for each variable in each equation. This will lead to the estimation of 36 parameters in each equation. In the case where the sample size is not large enough, the estimation of a large number of parameters will result in the loss of several degrees of freedom, which creates problems in estimation.

Because VAR model coefficients are difficult to interpret due to the lack of theoretical background, the shock response function is inserted. It describes the response of a variable to a shock on the error term of the other variables.

The VAR analysis also includes variance decomposition, a method used for observing the dynamics of the equations system. Variance decomposition provides information about the effects of each shock on the variables analyzed. For example, an innovation in the variable X has an effect on the variable concerned but also on other variables in the system. The proportion from the total of the variation that is due to shocks (innovation) from each variable in the system is determined.

### 3.2. Defining and testing of the cointegration relationship

The term of cointegration was first defined by Granger (1981). The cointegration is a property of the non-stationary time series. We say that two time series integrated by order 1 are cointegrated if a linear combination of those two is stationary (integrated by order 0), although each of them is not stationary.

The cointegrating relationship can be seen as a long term relationship of equilibrium between variables. In the short term, there are deviations from this equilibrium due to unforeseen shocks, but on the long-term the cointegrating relationship between variables tends towards equilibrium.

In the case where variables from a regression model are non-stationary, the result may be affected by the phenomenon of "spurious regression" (false regression).

We consider the equation of the regression model:

$Y_t = \beta_1+\beta_2X_t+u_t$ (3)

In order to eliminate the problem of spurious regression, the difference operator is applied in order to obtain stationary series. If we consider the two variables $X_t$ and $Y_t$, both I (1), and apply the difference operator, we have $\Delta Y_t \sim I(0)$ si $\Delta X_t \sim I(0)$ , and the regression model becomes:

$\Delta Y_t = a_1+a_2\Delta X_t+\Delta u_t$ (4)

In the model above, only the short term relationship between the two variables is represented. Economists are especially interested in the long-term relationship and therefore the error-correction mechanism is introduced.

The existence of the cointegrating relationships between variables is done using the Johansen test (introduced by Johansen and Juselius in 1990).

We consider three endogenous variables $Y_t$, $X_t$, Wt. We note $Z_t = [Y_t, X_t, W_t]$ – the variables vector. The autoregressive model equation is the following:

$Z_t = A_1Z_{t-1}+A_2Z_{t-2}+..+A_kZ_{t-k}+u_t$

Where $A_i$, i=1,2,…k is the matrix of the coefficients associated with the $Z_{t-I}$ vector.

If the component variables of the Zt vector are stationary in differences, the reparametrization of the model is done. Thus, we obtain a model of autocorrection vector type (vector error correction) as:

$\Delta Z_t = \Gamma_1 \Delta Z_{t-1}+ \Gamma_2 \Delta Z_{t-2}+\ldots.+ \Gamma_{k-1} \Delta Z_{t-k-1}+ \Pi Z_{t-k}+ u_t$

Unde $\Gamma_1 = (I-A_1-A_2-\ldots.-A_k)$ , i=1,2,..k-1

$\Pi = - (I- A_1-A_2-\ldots.-A_k)$

The $\Pi X_{t-k}$ component describes the linear combinations of variables in $X_t$ in levels, so that $\Pi$ contains information on the long-term properties of the model. The range of the $\Pi$ matrix indicates the existence and number of long-term balance relationships (cointegration) between the variables in $X_t$. The sum of elements on the main diagonal and its maximum eigenvalue ($\lambda_{max}$) are statistics used to evaluate the number of cointegration relationships.

### 3.3. The error-correction model

If $Y_t$ si $X_t$ are cointegrated, by definition $u_t \sim I(0)$. With the help of the error correction model, the relationship between the two variables can be expressed as following:

$\Delta Y_t = a_0+b_1\Delta X_t – \pi\, \hat{u}_{t-1}+e_t$ (5)

where $\hat{u}_{t-1} = Y_{t-1} - \hat{\beta}_1- \hat{\beta}_2X_{t-1}$ is error correction term

Equation (5) includes both the short term relationship and long-term relationship between the two variables. The $b_1$ coefficient measures the impact (on the short term) of a shock in $X_t$ which influences the variable $Y_t$. On the other hand, $\pi$ quantifies the speed of adjustment to the long-term equilibrium between the two variables.

The advantages of the error correction model (Gujarati, 2003):

- With the help of the error-correction model the disequilibrium of the relationship between variables due to the occurrence of short-term shocks can be measured. This has positive implications in interpreting the relationships between the analyzed macroeconomic variables;

- Allows the long-term linkage between variables analysis as well as of the linkages on the short / medium term around these equilibrium relationships

- If the cointegrating relationship between variables does exist, then error correction model is formulated in terms of the first difference, which involves eliminating the problem of "spurious regression" (false regression).

We consider the linear autoregressive model with a lag of 1 lag, where the value of the dependent variable is influenced by both its own stock at an earlier time as well as by the values of the independent variable. :

$Y_t = a_0 + a_1 Y_{t-1} + b_0 X_t + b_1 Xt\text{-}1 + u_t$ (6)

where $u_t \sim N(0,\sigma^2)$

By the reparametrization of equation (6), we obtain the estimated equation of an error vector correction model type:

$\Delta Y_t = b_0 \Delta X_t - (1\text{-}a_0)[Y_{t-1} - \beta_0 - \beta_1 X_{t-1}] + u_t$ (7)

If we note $(1\text{-}a_0) = \pi$, equation (7) becomes:

$\Delta Y_t = b_0 \Delta X_t - \pi [Y_{t-1} - \beta_0 - \beta_1 X_{t-1}] + u_t$

The long term equilibrium between the two variables is given by the expression $Y_{t-1} - \beta_0 - \beta_1 X_{t-1}$, and all the terms of the error vector correction model are stationary (if a cointegrating relationship exists between X and Y, X and Y being stationary after the first difference, then the term $Y_{t-1} - \beta_0 - \beta_1 X_{t-1}$ is integrated of order 0).

The coefficient $(1\text{-}a_0) = \pi$ indicates the speed of adjustment to the equilibrium, in the event of short term shocks. When the term $Y_{t-1} - \beta_0 - \beta_1 X_{t-1}$ is negative, the overall effect is to stimulate $\Delta Y_t$ to return to the long-term equilibrium. The speed of adjustment is given by coefficient $\pi$.

### 3.4. Estimating vector error correction model (VEC)

Several steps have be followed to estimate a VEC model.

#### *3.4.1. Testing the order of integration*

Closely related to the test for the existence of the cointegration, this step is necessary for choosing the econometric model. If all the variables are stationary - integrated by zero order - then the estimation using the variables with the initial specification does not have any problem. In most cases, the macroeconomic variables are non-stationary. If the series are non-stationary but cointegrated, then it is applied the error correction model. If the variables are non-stationary, neither cointegrated, it is necessary to specify the variables as differences (changes from one period to another).

#### *3.4.2. Lag length selection*

Choosing the number of lags is based on the results synthesis of several methods: sequential testing of the lags significance (LR), the criterion to minimize the error of final prediction (EFP) and the evaluation criteria of the information content (Akaike, Schwartz, Hannan -Quinn).

The information criteria quantify the part of the endogenous variable that is not explained by the model. These indicators are based on the principle of minimizing the number of parameters of the model and the modeling error variance.

### *3.4.3. Testing for the existence of cointegration*

The test is carried out using Johansen methodology, and the results obtained in conjunction with the stationarity tests show the option for the use of the autoregressive type of model or a vector error correction model.

### *3.4.4. Estimating VEC model*

The model has been taken defined by the relation:

$\Delta Y_t = b_0 \Delta X_t - \pi \, [Y_{t-1} - \beta_0 - \beta_1 X_{t-1}] + u_t$

The method of least squares has been used as a method of equation estimation.

### *3.4.5. Testing the validity of the model*

The estimated model is subjected to tests for validation. At this stage, the hypotheses are verified for the error variable of the model: average error should be zero; the errors should be normally distributed, without the phenomenon of autocorrelation. If errors do not respect the classical assumptions, we return to the model identification stage

## 4. Empirical results

### *4.1. The analysis of the series stationarity*

In the first part of the study, we test the stationarity of series using Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests.

Hypothesis: $H_0$:the time series has a unit root

$H_1$: the time series is stationary

**Table 1** *Augmented Dickey-Fuller test*

| Variable | t-statistic | Prob. | t-statistic (first differenced series) | Prob. |
|---|---|---|---|---|
| Inflation rate | -2.7139 | 0.0750 | -8.4622 | 0.0000 |
| Real interest rate | -2.1453 | 0.2277 | -8.7483 | 0.0000 |
| Money supply in a narrow sense (M1) | 2.0292 | 0.9896 | -7.1203 | 0.0000 |
| Monthly net average nominal wage | 3.3964 | 0.9998 | -10.9820 | 0.0000 |
| Exchange rate | -0.9519 | 0.7679 | -7.5441 | 0.0000 |

* critical value for the rejection of the unit root null hypothesis at the 5% significance level is -2.88

**Table 2** *Phillips Perron test*

| Variables | t- statistic | Prob. | t-statistic (first differenced series) | Prob. |
|---|---|---|---|---|
| Inflation rate | -2.5684 | 0.1027 | -8.5012 | 0.0000 |
| Real interest rate | -2.4949 | 0.1197 | -8.8320 | 0.0000 |
| Money supply in a narrow sense (M1) | 2.0988 | 0.9913 | -7.1683 | 0.0000 |
| Monthly net average nominal wage | -2.1624 | 0.2213 | -16.0677 | 0.0000 |
| Exchange rate | -0.7549 | 0.8272 | -7.5625 | 0.0000 |

* critical value for the rejection of the unit root null hypothesis at the 5% significance level is -2.88

**Source:** *E-views*

The above tables show that the inflation, leu/euro exchange rate, real interest rate, money supply and monthly net average nominal wage series are non-stationary, and by applying the unit root test for the differentiated series, it is shown that series are stationary; therefore, basic series are integrated of the first order.

### *4.2. Selection of the model number of lags*

Choosing the number of lags was based on the synthesis results of several methods: sequential testing of lags significance (LR), the criterion of final prediction error minimization (FPE) and evaluation criteria for information content (Akaike, Schwartz, Hannan-Quinn).

To select the lag, we considered the test VAR Lag Order Selection Criteria, which indicates that for 12 theoretical lags, most of the criteria recommend a lag equal to 10 for the chosen model.

### *4.3. Test for the existence of cointegration*

To test the two series cointegration the Johansen test has been used.

**Table 3** *Johansen test for cointegration vectors*

| Hypothesize No.of CE(s) | Eigenvalue | | Trace statistic | Max-Eigen Statistic | 0.05 critical value | | Prob.** | |
|---|---|---|---|---|---|---|---|---|
| | Trace test | Max-Eigen Test | | | Trace test | Max-Eigen Test | Trace test | Max-Eigen Test |
| None* | 0.3765 | 0.376 | 113.14 | 43.46 | 69.81 | 33.87 | 0.000 | 0.002 |
| At most 1* | 0.3011 | 0.301 | 69.68 | 32.96 | 47.85 | 27.58 | 0.000 | 0.009 |
| At most 2* | 0.2192 | 0.219 | 36.72 | 22.76 | 29.79 | 21.13 | 0.006 | 0.029 |

*denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis p-values

**Source:** *E-views*

As it can be seen from the table, both the Trace test and the maximum eigenvalue test reveal that there is a single co-integration at the 5 percent level of significance.

Corroborating stationarity test results to those of the cointegration test, it can be appreciated that the option for estimating a vector error correction model is suitable.

### 4.4. Estimating the VEC type model

The results indicate either the option to use a VAR model when cointegrating relationships do not exist or to use a vector error correction type of model otherwise.

The estimated equation of the model is:

D(L_INFLATION) = -0.262*( L_INFLATION(-1) + 0.123*REAL_INTEREST(-1) - 12.999*L_EURO(-1) - 5.903*L_M1(-1) + 16.803*L_WAGE(-1) - 79.149) + 0.686*D(L_INFLATION(-1) - 0.051*D(L_INFLATION(-2)) + 0.017*D(L_INFLATION(-3)) – 0.166*D(L_INFLATION(-4)) - 0.152*D(L_INFLATION(-5)) - 0.497*D(L_INFLATION(-6)) + 0.532*D(L_INFLATION(-7)) + 0.057*D(L_INFLATION(-8)) - 0.308*D(L_INFLATION(-9)) + 0.461*D(L_INFLATION(-10)) + 0.101*D(REAL_INTEREST(-1)) - 0.037*D(REAL_INTEREST(-2)) + 0.003*D(REAL_INTEREST(-3)) - 0.011*D(REAL_INTEREST(-4)) - 0.006*D(REAL_INTEREST (-5))-0.109*D(REAL_INTEREST(-6))+0.084*D(REAL_INTEREST(-7))-0.019*D(REAL_INTEREST(-8))- 0.056*D(REAL_INTEREST(-9)) + 0.069*D(REAL_INTEREST(-10)) - 3.336*D(L_EURO(-1)) + 0.146*D(L_EURO(-2)) - 5.733*D(L_EURO(-3)) - 0.953*D(L_EURO(-4)) - 0.182*D(L_EURO(-5)) - 3.868*D(L_EURO(-6)) - 1.033*D(L_EURO(-7)) + 0.156*D(L_EURO(-8)) - 2.489*D(L_EURO(-9)) - 0.683*D(L_EURO(-10)) - 1.497*D(L_M1(-1)) - 0.872*D(L_M1(-2)) - 1.095*D(L_M1(-3)) - 0.804*D(L_M1(-4)) - 1.122*D(L_M1(-5)) - 0.855*D(L_M1(-6)) - 0.189*D(L_M1(-7)) + 0.133*D(L_M1(-8)) - 0.732*D(L_M1(-9)) - 0.236*D(L_M1(-10)) + 3.397*D(L_WAGE(-1)) + 3.341*D(L_WAGE(-2)) + 2.588*D(L_WAGE(-3)) + 2.552*D(L_WAGE(-4)) + 1.954*D(L_WAGE(-5)) + 1.973*D(L_WAGE(-6)) + 1.714*D(L_WAGE(-7)) + 0.929*D(L_WAGE(-8)) + 0.914*D(L_WAGE(-9)) + 0.563*D(L_WAGE(-10)) -0.004.

The coefficient C(1) of the model has a negative value equal to -0.262 and is statistically significant.

**Table 4** *Estimation of model coefficients*

| | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C(1) | -0.262606 | 0.124722 | -2.105536 | 0.0419 |
| C(2) | 0.686144 | 0.356856 | 1.922748 | 0.0620 |
| C(3) | -0.051684 | 0.394257 | -0.131091 | 0.8964 |
| C(4) | 0.017097 | 0.398051 | 0.042952 | 0.9660 |
| C(5) | -0.166108 | 0.485695 | -0.342001 | 0.7342 |
| C(6) | -0.152365 | 0.440474 | -0.345910 | 0.7313 |
| C(7) | -0.497919 | 0.423008 | -1.177089 | 0.2465 |
| C(8) | 0.532241 | 0.466225 | 1.141597 | 0.2608 |
| C(9) | 0.057729 | 0.469302 | 0.123010 | 0.9027 |
| C(10) | -0.308070 | 0.442191 | -0.696689 | 0.4902 |
| C(11) | 0.461303 | 0.389177 | 1.185330 | 0.2432 |
| C(12) | 0.101966 | 0.071855 | 1.419049 | 0.1640 |
| C(13) | -0.037008 | 0.077223 | -0.479242 | 0.6345 |
| C(14) | 0.003839 | 0.078239 | 0.049062 | 0.9611 |
| C(15) | -0.011545 | 0.089855 | -0.128487 | 0.8984 |
| C(16) | -0.006231 | 0.078088 | -0.079795 | 0.9368 |
| C(17) | -0.109791 | 0.075534 | -1.453542 | 0.1543 |
| C(18) | 0.084425 | 0.084009 | 1.004954 | 0.3213 |
| C(19) | -0.019527 | 0.083727 | -0.233223 | 0.8168 |
| C(20) | -0.056462 | 0.077805 | -0.725685 | 0.4725 |
| C(21) | 0.069269 | 0.070169 | 0.987161 | 0.3298 |
| C(22) | -1.497521 | 0.720815 | -2.077538 | 0.0446 |
| C(23) | -0.872674 | 0.734529 | -1.188073 | 0.2422 |
| C(24) | -1.095905 | 0.732437 | -1.496245 | 0.1428 |
| C(25) | -0.804577 | 0.729543 | -1.102851 | 0.2770 |
| C(26) | -1.122480 | 0.670867 | -1.673179 | 0.1025 |
| C(27) | -0.885825 | 0.685866 | -1.291544 | 0.2043 |
| C(28) | -0.189449 | 0.601454 | -0.314986 | 0.7545 |
| C(29) | 0.133682 | 0.536315 | 0.249261 | 0.8045 |
| C(30) | -0.732581 | 0.555568 | -1.318616 | 0.1952 |
| C(31) | -0.236888 | 0.496513 | -0.477103 | 0.6360 |
| C(32) | -3.336998 | 2.180455 | -1.530414 | 0.1342 |
| C(33) | 0.146046 | 2.091405 | 0.069832 | 0.9447 |
| C(34) | -5.733406 | 2.164484 | -2.648856 | 0.0117 |
| C(35) | -0.953097 | 2.243786 | -0.424772 | 0.6734 |
| C(36) | -0.182001 | 1.799566 | -0.101136 | 0.9200 |
| C(37) | -3.868710 | 1.723005 | -2.245327 | 0.0306 |
| C(38) | -1.033461 | 1.862249 | -0.554953 | 0.5822 |
| C(39) | 0.156758 | 1.700530 | 0.092182 | 0.9270 |
| C(40) | -2.489540 | 1.679856 | -1.481996 | 0.1466 |
| C(41) | -0.683706 | 1.558408 | -0.438721 | 0.6633 |
| C(42) | 3.397952 | 1.866377 | 1.820614 | 0.0765 |
| C(43) | 3.341294 | 1.659332 | 2.013638 | 0.0512 |
| C(44) | 2.588139 | 1.482110 | 1.746253 | 0.0888 |
| C(45) | 2.552099 | 1.312154 | 1.944970 | 0.0592 |
| C(46) | 1.954905 | 1.205998 | 1.620985 | 0.1133 |
| C(47) | 1.973704 | 1.069045 | 1.846231 | 0.0727 |
| C(48) | 1.714431 | 1.011031 | 1.695725 | 0.0981 |
| C(49) | 0.929879 | 0.898789 | 1.034590 | 0.3074 |
| C(50) | 0.914372 | 0.768272 | 1.190166 | 0.2414 |
| C(51) | 0.563743 | 0.660439 | 0.853588 | 0.3987 |
| C(52) | -0.004576 | 0.034916 | -0.131060 | 0.8964 |

**Source:** *E-views*

It results from here, that there is a long-term causality, the reference real interest rate, the exchange rate, the money supply and monthly net average nominal wage influence the inflation rate.

With the Wald test, the short-term link between between inflation and the other variables used is checked.

**Table 5** *Wald test*

| | | | |
|---|---|---|---|
| F-statistic | 0.7653 | Prob. F(41,38) | 0.7991 |
| Obs*R-squared | 31.3804 | Prob. Chi-Square(41) | 0.8608 |

**Source:** *E-views*

The null hypothesis is accepted according to which all tested coefficients are statistically significant because the associated probability is higher than the chosen significance entry level and thus, the reference real interest rate, the leu / euro exchange rate, the money supply and monthly net average nominal wage do not influence short-term inflation rate.

### 4.5. Testing model validity

#### *4.5.1. Testing the hypothesis of errors normality*

Residual terms analysis shows that the residuals are not normally distributed according to Jarque Bera test. Since the hypothesis of coefficients stability was not rejected, we decided to keep the model as a basis for analysis.

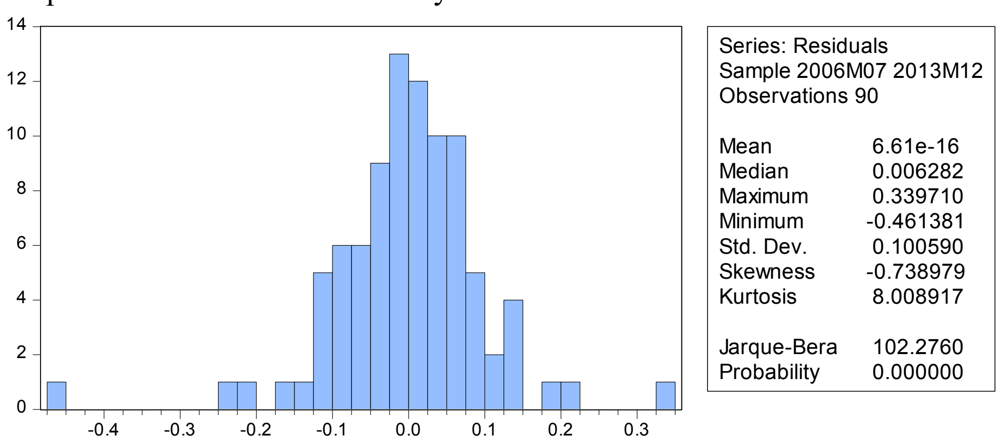


***Figure 1*** *Histogram errors*

#### *4.5.2.Testing the hypothesis of homoscedasticity*

The two tested hypotheses are:

$H_0$: There are no effects ARCH

$H_1$: There are ARCH effects

**Table 6** *Breusch-Pagan-Godfrey Test*

| | | | |
|---|---|---|---|
| F-statistic | 0.4651 | Prob. F(55,34) | 0.9944 |
| Obs*R-squared | 38.6428 | Prob. Chi-Square(55) | 0.9538 |

**Source:** *E-views*

According to the test, the null hypothesis is accepted with a probability of 95%. (0.9538 > 0.05).

### *4.5.3.Testing the autocorrelation errors*

Q-statistic and its associated probability is a statistical test, the null hypothesis of which is that there is no autocorrelation up to lag k. The probability associated with the Q-statistic test superior to the level of relevance, the null hypothesis is accepted (absence of autocorrelation errors).

**Table 7** *Correlogram of the errors*

Sample: 2006M07 2013M12
Included observations: 90

| Autocorrelation | Partial Correlation | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|---|
| | | 1 | 0.074 | 0.074 | 0.5137 | 0.474 |
| | | 2 | 0.056 | 0.051 | 0.8066 | 0.668 |
| | | 3 | -0.016 | -0.024 | 0.8321 | 0.842 |
| | | 4 | 0.125 | 0.126 | 2.3349 | 0.674 |
| | | 5 | -0.032 | -0.049 | 2.4343 | 0.786 |
| | | 6 | -0.080 | -0.089 | 3.0667 | 0.800 |
| | | 7 | -0.084 | -0.062 | 3.7624 | 0.807 |
| | | 8 | -0.073 | -0.074 | 4.3003 | 0.829 |
| | | 9 | -0.017 | 0.006 | 4.3309 | 0.888 |
| | | 10 | 0.040 | 0.068 | 4.4971 | 0.922 |
| | | 11 | -0.030 | -0.028 | 4.5898 | 0.949 |
| | | 12 | -0.385 | -0.399 | 20.364 | 0.061 |

**Source:** *E-views*

According correlogram errors, there is no serial autocorrelation of errors up to lag 12.

Given the favorable results of the diagnostic analysis of the model, we can move to the last stage of modeling, the impulse-response analysis.

### 4.6. Identification of structural innovations

Figure 2 presents the responses of the inflation rate to shocks from all the other analyzed variables, in the form of shock response function, for a horizon of 18 months.

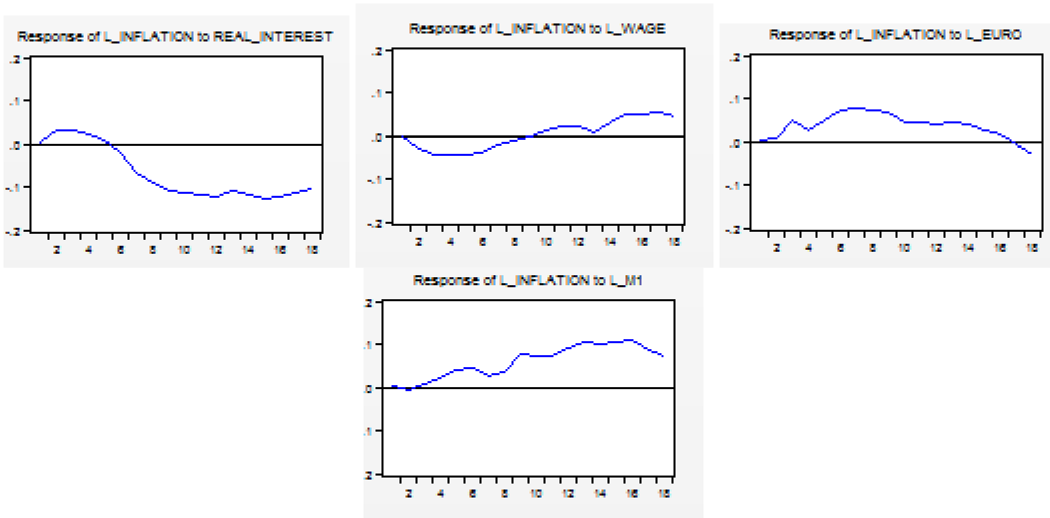


**Figure 2** *Response of inflation rate to standard deviation shocks*

It can be seen that the inflation rate responds positively to a narrow monetary supply shock even from the first month, this increase reaching a maximum after 16 months. When the exchange rate leu/euro increases, the inflation rate has an upward evolution in the first 10 months after the depreciation took place. If an increase in the real rate of the benchmark interest takes place, the inflation rate decreases after 5 months after the shock, reaching a maximum amplitude after 12 months.

A shock to the net average monthly nominal wage causes a negative response of the inflation rate in the first 5 months. After a time horizon of 8 months, the inflation rate has a rising trajectory, reacting positively to a net wage shock.

The forecast of variance decomposition provides additional information on the dynamic behavior of the variables in the system.

**Table 8** *Variance decomposition of inflation rate*

Variance Decomposition of L_INFLATION:

| Period | S.E. | L_INFLATION | REAL_INT... | L_EURO | L_M1 | L_WAGE |
|---|---|---|---|---|---|---|
| 1 | 0.153942 | 100.0000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| 2 | 0.231664 | 96.15029 | 1.682698 | 0.118911 | 0.115466 | 1.932632 |
| 3 | 0.301472 | 92.06057 | 1.914218 | 2.686312 | 0.133421 | 3.205474 |
| 4 | 0.353666 | 91.26771 | 1.805063 | 2.557288 | 0.377913 | 3.992024 |
| 5 | 0.391539 | 89.05703 | 1.512270 | 3.686117 | 1.250016 | 4.494566 |
| 6 | 0.420025 | 85.36975 | 1.517061 | 6.169810 | 2.170577 | 4.772800 |
| 7 | 0.445715 | 81.31357 | 3.761901 | 8.271718 | 2.219671 | 4.433140 |
| 8 | 0.476012 | 77.04184 | 6.937397 | 9.585068 | 2.505248 | 3.930448 |
| 9 | 0.520590 | 72.40921 | 10.39673 | 9.749609 | 4.154443 | 3.290010 |
| 10 | 0.564168 | 69.97505 | 13.04618 | 8.963800 | 5.158525 | 2.856440 |
| 11 | 0.607232 | 68.23906 | 15.12370 | 8.265808 | 5.805261 | 2.566171 |
| 12 | 0.653783 | 66.71178 | 16.61777 | 7.515233 | 6.841004 | 2.314217 |
| 13 | 0.690126 | 65.02039 | 17.37876 | 7.119112 | 8.390154 | 2.091583 |
| 14 | 0.721460 | 63.01416 | 18.50805 | 6.847261 | 9.563185 | 2.067350 |
| 15 | 0.750259 | 60.56540 | 19.92970 | 6.442027 | 10.76641 | 2.296467 |
| 16 | 0.778032 | 58.46488 | 21.01469 | 6.045565 | 11.93273 | 2.542146 |
| 17 | 0.802594 | 57.35900 | 21.77794 | 5.692170 | 12.36660 | 2.804291 |
| 18 | 0.824526 | 56.80074 | 22.28206 | 5.529553 | 12.47258 | 2.915066 |

**Source:** *E-views*

The results in Table 8 indicate that at a time horizon of 18 months, 22% of the inflation rate variation in is explained by the variation of the real rate of the benchmark interest.

On the other hand, the inflation rate variation is explained in an insignificant proportion by the variation of the average net monthly nominal wage and by the exchange rate leu/EUR.

## 5. Conclusion

Monetary policy is a key component of economic policy that has as the main objective to ensure and to maintain price stability. In Romania, the monetary authority adopted inflation targeting strategy that provided for the explicit price stability in 2005.

In this study, we used the vector error correction methodology (vector error correction) to assess the causes of inflation in Romania between January 2005 and December 2013. A model with three variables has been estimated, and that after applying the Johansen test, showed that these are cointegrated (inflation rate, leu/euro exchange rate, the reference real interest rate, money supply and monthly net average nominal wage ).

Using vector error correction methodology is justified by the nature of research. Macroeconomic phenomena are complex dynamic systems. Consequently, analyses of the system type (simultaneous equations) are able to capture the connections between variables.

Among advantages of the VEC model is the analysis of both long-term links between variables (steady relationship) and short/middle-term dynamic links around these steady relationships. The main limitations of the proposed model are: residuals are not normally distributed according to Jarque-Bera test and the reduced number of variables in the system that fail to capture all the necessary information.

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**References**

[1] Alexova, M.(2012). Inflation in new EU members. *Working Paper of National Bank of Slovakia*, No.6

[2] Andries, M.A.(2008). Monetary policy transmission mechanism in Romania – a VAR approach. *Theoretical and Applied Economics*, No.11, pp.250-260

[3] Asteriou, D., Hall, S.(2011). Applied econometrics. Palgrave Macmillan

[4] Cocriş, V., Nucu, A.(2013). Interest rate channel in Romania: assessing the effectiveness transmission of monetary policy impulses to inflation and economic growth. *Theoretical and Applied Economics*, 20(2), pp. 37-50

[5] Granger, C.(1981). Some properties of time series data and their use in econometric model specification. *Journal of Econometrics*, No.16, pp.121-130

[6] Gujarati, D.(2003). Basic econometrics (fourth edition). McGraw-Hill Higher Education, New York

[7] Gul, E., Ekinci, A.(2006). The causal relationship between nominal interest rates and inflation: The case of Turkey. *Scientific Journal of Administrative Development*, No.4, pp.54-69

[8] Hurnik, J., Arnostova, K.(2005). The monetary transmission mechanism in the Czech Republic (evidence from VAR analysis). *CNB Working Paper Series*, No. 4

[9] Kim, B.(2001). Determinants of inflation in Poland: a structural cointegration approach, *Working Paper of National Bank of Finland*, No. 16

[10] Lyziak, T., Przystupa, J., Wrobel, E.(2008). Monetary policy transmission in Poland: a study of the importance of interest rates and cresit channels. *SUERF Studies*, No.1

[11] Morgese, M., Horvath, R.(2008). The effects of monetary policy in the Czech Republic: an empirical study, *CNB Working Paper Series*, No.4

[12] Jarocinski, M.(2010). Response to monetary policy shocks in the east and the west of Europe. A comparison. European Central Bank, *Journal of Applied Econometrics*, Vol.25, No.5, pp.833-868

[13] Popescu, I.V.(2012). Effects of monetary policy in Romania. A VAR approach. *MPRA Paper*, No. 41686

[14] Sims, C.A. (1980). Macroeconomics and reality. *Econometrica*, Vol.48, pp.1-48

[15]*** Annual reports, National Bank of Romania (1998-2013), *www.bnr.ro*